APPLICATION OF MULTI-CRITERIA DECISION MAKING USING FUZZY-TOPSIS IN DRUG DISTRIBUTION CENTER LOCATION SELECTION

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Thesis
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APPLICATION OF MULTI-CRITERIA DECISION MAKING USING FUZZY-TOPSIS IN DRUG DISTRIBUTION CENTER LOCATION SELECTION

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ABSTRACT

Due to the 2011 flood crisis in Thailand, a number of drug manufacturers were inundated with flood water for a few months. Some drug manufacturers were not directly impacted by the flooding, but they could not distribute of drug products to their customers due to the transport disruptions. This resulted in a shortage of drugs supplies to many hospitals, especially those in the remote areas of the country. The purpose of this research is to identify the essential criteria for drug supply distribution; and determine and propose the best district in Bangkok for establishing a drug distribution center that will be able to operate during a flood crisis. The 15 criteria were finalized, and nine experts were asked to rate the criteria. The 50 districts were evaluated using fuzzy TOPSIS in order to select the best location for establishing drug distribution center. Sensitivity analysis was conducted to measure the weight of criteria impacts on the drug distribution center location. However, the result may be different as the weight of each criteria changes.

KEY WORDS: DRUG DISTRIBUTION CENTER / LOCATION SELECTION / DISRUPTION / MULTI-CRITERIA DECISION MAKING

220 pages

การประยุกต์ใช้ MULTI-CRITERIA DECISION MAKING ด้วยวิธี FUZZY-TOPSIS ในการเลือกที่ตั้งศูนย์กระจายยา

APPLICATION OF MULTI-CRITERIA DECISION MAKING USING FUZZY-TOPSIS IN DRUG DISTRIBUTION CENTER LOCATION SELECTION

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บทคัดย่อ

ในปี พ.ศ.2554 เกิดวิกฤตการณ์อุทกภัยในประเทศไทย ผู้ผลิตยาถูกน้ำท่วมนานหลายเดือน ผู้ผลิตยาบางรายไม่ได้รับผลกระทบโดยตรงแต่ไม่สามารถกระจายยาได้เนื่องจากการขนส่งไม่สะดวก ซึ่งส่งผลเกิดการขาดแคลนยาในโรงพยาบาลโดยเฉพาะอย่างโรงพยาบาลที่อยู่ไกล งานวิจัยนี้จึงมีจุดประสงค์เป็นการค้นหาเกณฑ์ที่สำคัญและเขตที่ดีในกรุงเทพมหานครสำหรับจัดตั้งศูนย์กระจายยาที่สามารถดำเนินงานในระหว่างน้ำท่วมได้ เกณฑ์ที่ครบถ้วนทั้ง 15 เกณฑ์และถูกควบคุมโดยผู้เชี่ยวชาญทั้ง 9 ท่านนำมาใช้ในการให้คะแนน การเลือกที่ตั้งศูนย์กระจายยาจาก 50 เขตใช้วิธี fuzzy TOPSIS ส่วน sensitivity analysis ใช้ในการทดสอบถึงน้ำหนักเกณฑ์ที่มีผลต่อการเลือกที่ตั้งอย่างไรก็ตามผลของที่ตั้งมีการเปลี่ยนแปลงเมื่อน้ำหนักของเกณฑ์เปลี่ยน

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CHAPTER I
INTRODUCTION

1.1 Background and problem

The drug distribution center is one of the important players in healthcare supply chain which distributes drugs to the hospitals before the drugs are prescribed to the patients. The efficiency of distribution is necessary for patients safety and professional services because drug is one of the four necessities for people living. There are many reasons that distribution centers cannot operate effectively, hence drugs cannot be delivered to customers correctly. Cause of the disruption may be from natural disasters such as flooding, earthquake, storming, and tsunami or from other made disruption. The top 10 national disaster based on the number of killed and the economic damage costs during 1990-2012 are shown in Table 1.1 and Table 1.2. From both tables, flooding has been the important problem in Thailand for 112 years in term of skilled and cost. The recent flooding during 2011 and mid-January 2012 cause more than 800 people died and 13.6 million people were affected by the flood (Emergency Operation Center for Flood, Storms and Landslide, 2012). From the World Bank report, there were 65 provinces in Northern, Northeastern and Central of Thailand damaged and costed about 1,425 billion Baht. Of which, the manufacturing sector suffered the biggest damages and loses of 1,007 billion Baht (The World Bank, 2011) (Figure1.1).

According to the Ministry of Public Health, over 10 drug factories of 393 drugs manufacturers in Bangkok and surrounding provinces were affected directly from the flood (The Government Public Relations Department, 2011). Like other organizations and industries, many of drug manufacturers had shut down during crisis due to the factories had been under the flood water or their employees could not go to work. The production lines were down for shortage of materials, energy or labors. Some drug manufacturers did not get the direct impact from the flooding, but they could not operate and distribute drugs to their customers due to transport disruption.

Although some drug manufacturers in flood–free area did not get the direct impact from the flood, the raw material suppliers could not distribute raw material for their production. Some main roads were inaccessible and indirect routes were used for transportation instead. The transportation interruption increased travel time and costs. These had a big impact on the entired hospital supply chain including manufacturers, distributors, hospitals, and the end customers-the patients (Liangrokapart, 2012). As a result, a lot of hospitals have experienced the stock shortage of drugs and medical supplies due to the transport disruption and the end customers had got all the shortage risks. In particular, the patients in emergency department or intensive-care units may get the worst impact from the drug shortage.

As the transportation disruption was the major problem on the drug shortage in many hospitals, it was challenging to find solutions for solving the problem. The Minister of Public Health, Wittaya Buranasiri has instructed to the government on 1 November, 2011 to solve the problems urgently. The alternatives are to find new drug manufacturers distributors for replacement, to import drugs and to distribute the drugs fast to the target hospitals (Irin, 2011). This is corresponded with the perspectives and recommendation from hospital executives, drug manufacturers, drug distributors, and representatives of the Food and Drug Administration (FDA) on the open public session and personal interview. Thus, one possible solution is to build a new drug distribution center located on the flood-free zone area with full accessibility during the crisis so that the distribution center could continue transfer drugs to the customers without any disruption. In order to find the best new location for the distribution center, a number of factors should be identified and considered.

Therefore, research questions are

1) What are the factors to be considered for establishing a drug distribution center?

2) Where is the best location to establish a drug distribution center to be saved from disruption?

Table 1.1 Top 10 Natural Disasters in Thailand for the period 1900 to 2012 sorted by numbers of killed (The Global Emergency Events Database (EM-DAT), 2012)

Disaster	Date	Numbers of Killed
Earthquake (from tsunami in the southern area)	December 2004	8,345
Flood (65 provinces)	August 2011	813
Storm (made landfall in Nakhon Si Thammarat Province)	October 1962	769
Flood (Nakhon Si Thammarat province)	November 1988	664
Earthquake (near Patani province)	June 1955	500
Tropical Storm Gay (the coast of Chumphon Province)	November 1989	458
Flood (in the southern area)	October 2010	258
Flood (in the north center area)	January 1975	239
Flood (in the center area**)**	August 1995	231
Flood (Uttaradit, Sukhothai, Phrae, Lampang and Nan Provinces)	August 2006	164

Table 1.2 Top 10 Natural Disasters in Thailand for the period 1900 to 2012 sorted by economic damage costs (The Global Emergency Events Database (EM-DAT), 2012)

Disaster	Date	Damage (1000 US$)
Flood (65 provinces)	August 2011	40,000,000
Flood (Nakhon Si Thammarat Province)	November 1993	1,261,000
Flood (affected from tsunami)	December 2004	1,000,000
Earthquake (in southern area)	November 1989	452,000
Tropical Storm Vicente (Bangkok)	January 2005	420,000
Drought (in north-east area)	December 1993	400,100
Flood (in northern area)	August 1978	400,000

Table 1.2 Top 10 Natural Disasters in Thailand for the period 1900 to 2012 sorted by economic damage costs (continued)

Disaster	Date	Damage (1000 US$)
Flood (in northern and center area)	January 1984	400,000
Flood (Nakhon Si Thammarat Province)	October 1993	319,850

This research presents the location selection concept for drug distribution center using multi-criteria decision making. It is used to manage information and difference decision makers' opinion for choosing alternative. It applied fuzzy theory to model multiple criteria decision. The vagueness or unclear information which qualitative criteria and the rating of each alternative location from decision makers can be converted to fuzzy number. Then, the fuzzy number was analyzed and used for location selection for drug distribution center.

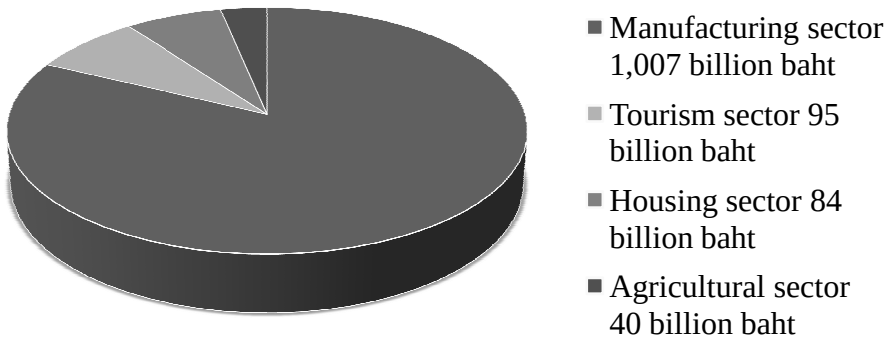


Figure 1.1 The total economic damages and losses from the 2011 flood in Thailand as of December 1, 2011 (The World Bank, 2011)

In this research, we use the technique called TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) which has been used to solve fuzzy multi-criteria decision making problems in several industries (Perçin (2008), Krohling *et al.* (2011), Ho (1993) and Shyjith *et al.*, (2012))

1.2 Objectives

The objectives of this research are following:

1.2.1 To identify the essential criteria for selecting a drug distribution center location.

1.2.2 To propose the best district in Bangkok for establishing a drug distribution center which can still operate during flood crisis.

1.3 Scope of work

This research considers only the 50 districts in Bangkok as possible location for establishing a drug distribution center which can still operate during flood crisis. The other unavoidable situation such as war, civil war, overthrow, protest, terrorism, sabotage, rebellion, closed road, riot or other natural disasters are not included in this study.

1.4 Expected results

1.4.1 A list of the essential criteria to be considered for location selecting for a drug distribution center.

1.4.2 The proposed best district in Bangkok for establishing a drug distribution center which can still operate during flood crisis.

1.5 Organization of the study

In this study is divided as follows. Chapter 2 presents literature reviews. In chapter 3, presents the research methodology. In chapter 4, presents result and discussion. Finally, the conclusion is presented.

CHAPTER II
LITERATURE REVIEWS

This chapter shows the related literature reviews for this research. We separate this chapter into four sections: 1) Distribution center 2) Hospital supply chain and the role of Drug Distribution Center 3) Theory of methodology 4) The Criteria for Location Selection and 5) The flooding situation in 2011.

2.1 Distribution center

2.1.1 Distribution center : the definition

A distribution center (DC) is defined as a warehouse or specialized building which stores the products under the suitable type, dimension, volume, temperature and humidity to deliver to the customers (Sorat, 2009). It links between manufacturers and customers to flow finish products in the supply chain (shown in Figure 2.1). The good practice of distribution centers resulted in reducing inventory level, inventory carrying cost, the final price of the product and processing time in order processing. The key factors for location decision that affect retailers' decisions to choose the manufacturer's products are delivery time, quality, total cost, and ability to meet consumers' urgent/special needs (Korpela and Lehmusvaara, 1999).

2.1.2 The activity of distribution center involves the four processes as follows (Shiau and Lee, 2010; Sorat, 2012).

2.1.2.1 Receiving

Figure 2.1 Distribution center in supply chain (Raksri, 2010)

The receiving process is the first process that the products arrive to distribution center, the receiving department should order to get products out of the carrier to the specific area. Next, inspect the products such as number, size, weight, condition, and price follow distribution center's invoice or the invoice that come with the trucks. After that, indicate the product code and the position of product.

2.1.2.2 Storing

Move products to the shelf in the right position. The condition of storage is suitable for especially products. Such as, grain can keep fresh if store in low temperature (Liu and Ma, 2012).

2.1.2.3 Picking

This process is to retrieve the products from their storage locations to satisfy customer orders and group the products that ordered from the same customer.

2.1.2.4 Dispatching

This process is to redistribute the finished products to the retailers, wholesalers, or consumers. The products before distributed are checked follow the order, packed, and loaded in carrier. The distribution center provides the customer to deliver with 5Rs - Right Time, Right Place, Right Quantity, Right Quality, and Right Price.

2.1.3 The advantage of distribution center (Shiau and Lee, 2010)

1) Distribution center consolidates the products from many manufacturers to distribute the same customers.

2) Distribution center chooses the appropriate intermodal transshipment to proper each customer region.

3) Distribution center assorts products and packs allowed customer orders.

4) Distribution center helps supply chain to flow products thus, the supply chain is perfectly.

2.2 Hospital supply chain and the role of Drug Distribution Center

2.2.1 Hospital supply chain

Gui-sheng (2010) described the hospital supply chain composed of participants, activities, and the three flows - logistic flow, capital flow and information flow. The main participants are suppliers, the hospital and patients which involve the value-added activities and processes to planning, coordinating, controlling and optimizing (shown in Figure 2.2). The aim of the service to patients is 6 Rs - right product, right quantity, right quality, right state, right time, and right place. Bourlakis *et al.* (2011) presented the supplier provided drugs and services to the customers-the hospitals, and the hospitals deliver the service to the end customers-the patients.

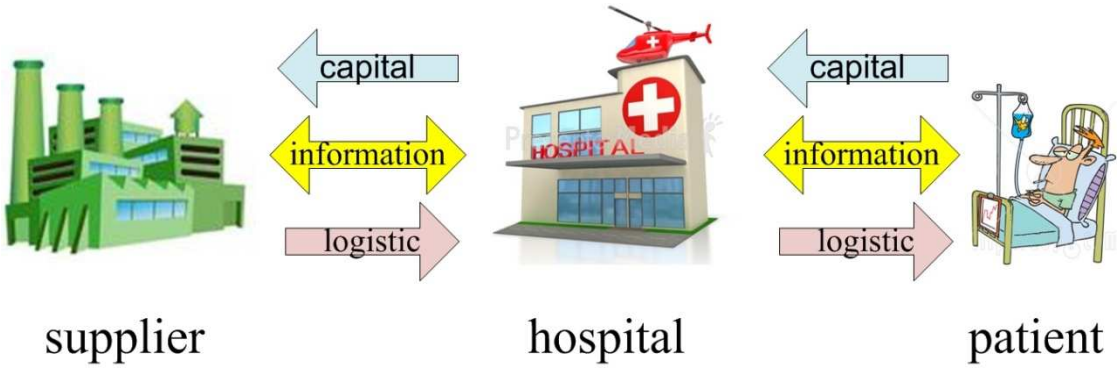


Figure 2.2 Hospital supply chain

The pharmaceutical supply chain which comprise of organizations, processes, and operations shown in Figure 2.3. The supply chain is composed of one or more suppliers, manufacturers, warehouses/distribution centers, wholesalers, and retailers-the hospitals (Shah, 2004). The manufacturer orders the raw material from suppliers, produces drug and supply to the distributor. The raw material suppliers produce chemical for drug production. The drugs in supply chain are domestic drug and imported drug. The distributor supports drugs to the retailers-the hospitals, pharmacies, clinics but the retailer in this research is hospital. However, the pharmaceutical supply chain is not similar to other supply chain because required high follow to ensure security and strict regulations such as good manufacturing practice (GMP) (Yadav *et al.*, 2011). Vibulpolprasert *et al.*(2002) defined drug distribution center as a warehouse or specialized building to distribute drugs to customers.

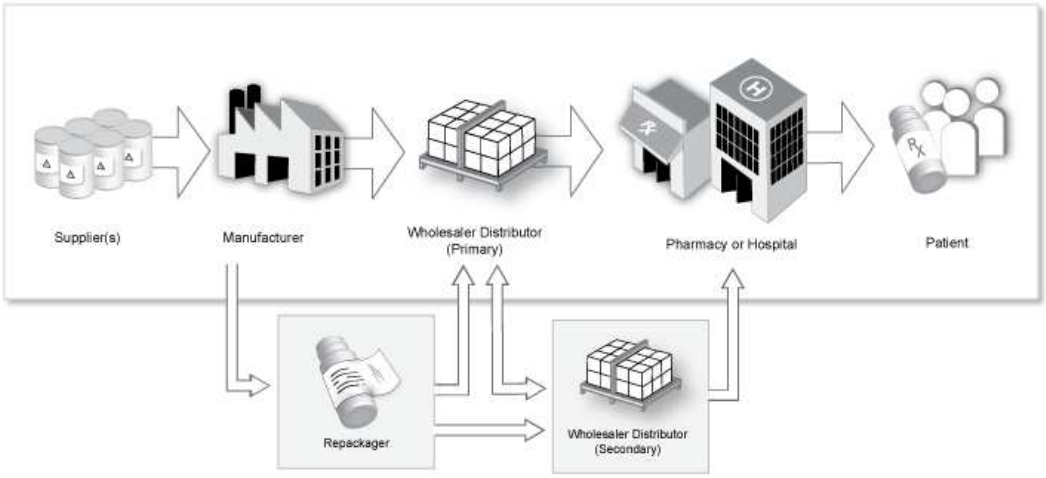


Figure 2.3 Pharmaceutical supply chains from supplier to patient (U.S. Food and Drug Administration, 2011)

2.2.2 Drug distribution center

Most of the drug distribution centers are belonged to private organization except one belong to the government. There are totally 116 drug distribution centers and a Government Pharmaceutical Organization (GPO) (Vibulpolprasert *et al.*, 2002). According to companies' directory in MIMS (Thailand) (2008), the main private drug distribution centers are Zuellig Pharma Ltd., DKSH (Thailand) Ltd., and BJC

Healthcare Co, Ltd. Zuellig Pharma Ltd. is the distributor for 46 pharmaceutical manufacturers, DKSH (Thailand) Ltd. is the distributor for 39 pharmaceutical manufacturers and BJC Healthcare Co, Ltd. is the distributor for 16 pharmaceutical manufacturers.

U.S. Food and Drug Administration (2003) and Deloitte Consulting LLP (2008) explained three models of the drug movement through the drug distribution system (Figure 2.4). Model 1 is the simplest that manufacturer sell directly to the retailer. This model is suitable for high-price drugs with a limited provider. Many manufacturers use model 2, there are one distributor or even a repackager but model 3 differ from model 2 that there are more distributors. The manufacturer delivers bulk drug containers to distributor and the distributor often repackages into smaller containers before sale to the retailer.

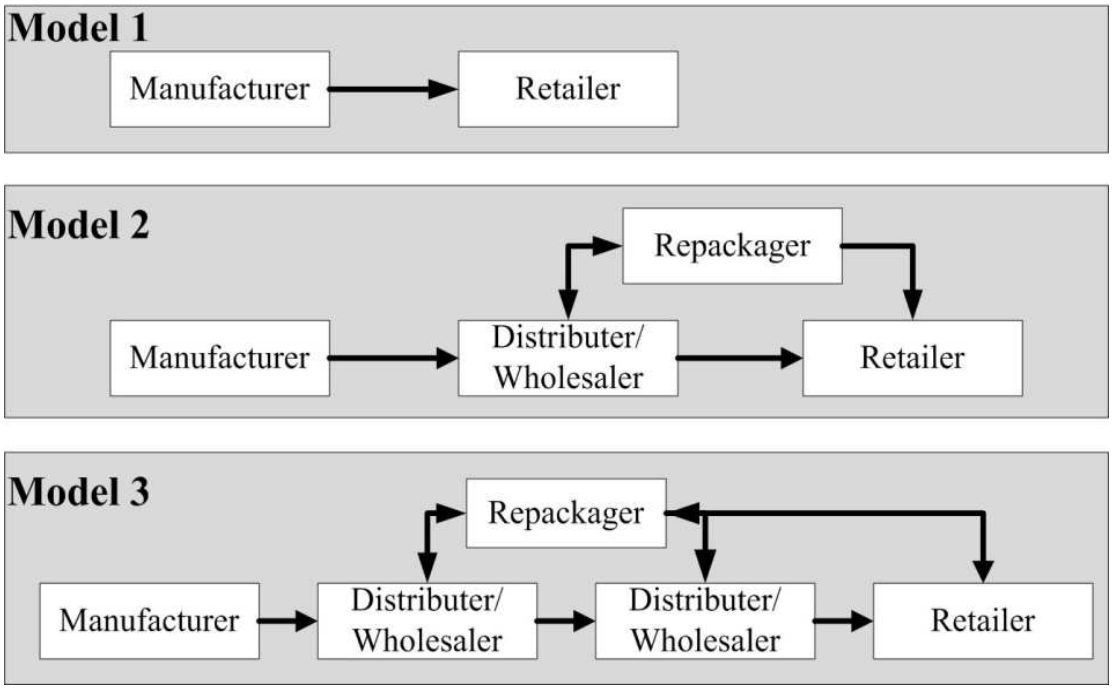


Figure 2.4 Drug distribution model
(U.S. Food and Drug Administration, 2003)

2.2.2.1 The tasks of drug distribution center (World Health, 2010)

The task of distribution center is depended on agreement between the drug owner and distributor. Drug distributors are classified into the drug owner' distributor and employ distributor (third party logistics). The services of distributor are procuring, purchasing, holding, storing, selling, supplying, importing, exporting, or movement of drugs, with the exception of the dispensing or providing drugs directly to a patient.

2.2.2.2 The advantage of drug distribution center (Marr, 1989)

Increase convenience to the hospital/pharmacies to order drugs. A service from efficient distribution is greater increasing opportunity for activities at the retail level, ensuring a competitive advantage. Drug distribution center services specific requirement, such as relabeling and insert the necessary information drug depending on country.

2.2.2.3 Why is the location selection for establishing drug distribution center important?

In hospital executives' opinion for Healthcare Supply Chain Disaster Management seminar (2012), the director of hospitals agree with establishing a new drug distribution center for supporting hospital during flood crisis (Metetrirat *et al.*, 2012). Bangkok Hospital changed the number of stocked drugs from using 90 days to 110 days. Songklanagarind Hospital also changed the number of stocked drugs from two months to four months because they afraid drug shortage. The new location of a drug distribution center that able operate during flood crisis is used to solve this problem.

2.3 Theory of methodology

2.3.1 Multi-Criteria Location Problem

Many criteria are considered for best location selection that is important to manage scientific, social, and economic, and to reduce the wrong decision. The location selection is one of multi-criteria decision making (MCDM) problem due to many criteria considered in decision process. The main task of decision making is to

collect related information, rank the bound of the feasible alternatives, and select appropriate alternative (Zhou *et al.*, 2011). There are many techniques to solve multi-criteria decision making problem. The example of widely utilized techniques areas are Analytic Hierarchy Process (AHP), Analytic network process (ANP) as follow:

Analytic Hierarchy Process (AHP) is one of multi-criteria decision making method. AHP technique was developed by Thomas L. Saaty in 1970s that compare the relative elements in each level of the hierarchy and evaluates the alternatives in the lowest level of the hierarchy to select the best decision among multiple alternatives (Sipahi and Esen, 2010; Triantaphyllou and Mann, 1995). The weight of important criteria is obtained by using a set of pair wise comparisons. The example for application of AHP technique that Tsita and Pilavachi (2012) used AHP to choose the fuel for the Greek road transport sector. Triantaphyllou and Mann (1995) used to find the best alternative to upgrade the computer system of a computer integrated manufacturing (CIM) facility. Wu, Chen et al. (2012) used AHP to weight the performance evaluations of higher education combined VlseKriterijumska Optimizacija I KompromisnoResenje (VIKOR) method to rank the performance of each university.

Analytic network process (ANP) is proposed by Thomas L. Saaty, the author of the AHP method in 1996. ANP represent the relationships of hierarchy, but it does not strict about a hierarchical structure as AHP (Liu *et al.*, 2005). Öztayşi *et al.* (2011) used ANP to compare the customer relationship management (CRM) performance of e-commerce firms. Atmaca and Basar (2012) determine the suitability of existing power plants in Turkey by ANP method.

The location selection problem is considered many alternative locations with multi-criteria. The multi-criteria decision making is classified into two categories: the multi-attribute decision-making (MADM), and the multi-objective decision-making (MODM) (Zanjirani Farahani and Hekmatfar, 2009; Hwang and Yoon, 1981).

The multi-attribute decision-making technique is considered the limited alternative and each alternative response to each objective in a specified level. The best alternative satisfies to the priority of each objective and the interaction between them. The popular technique to solve this problem are dominant, maximin, maximax, conjunctive method, disjunctive method, lexicographic method, elimination by

aspects, permutation method, linear assignment method, simple additive weighting (SAW), hierarchical additive weighting, ELECTRE, TOPSIS, hierarchical tradeoffs, LINMAP, interactive SAW method and MDS with ideal point.

The multi-objective decision-making technique is considered various components and the best alternative is attained some acceptable levels from a set of some objectives. The used techniques to solve this problem are global criterion method, utility function, metric L-P methods, bounded objective method, exico graphic method, goal programming, goal attainment method, method of Geoffrion, interactive GP, surrogate worth trade off, method of satisfactory goals, method of Zionts-Wallenius, STEM and related method, SEMOPS and SIGMOP method, method of displaced ideal, GPSTEM method, method of Steuer, parametric method, C-constraint method and adaptive search method.

2.3.2 Fuzzy TOPSIS

After collect criteria from literature review and consider potential location, we ask the decision makers to select and weight the appropriate criteria for using in location selection. The decision maker' opinions are the speech that difficult to translate to the number but fuzzy help to change the quality data to quantity data (Bellman and Zadeh, 1970). The definitions of fuzzy sets are expressed as follows (Klir, 1992; Klir, 1995; Zimmermann, 1995).

Definition 1. A universe of discourse, *X*, whose generic elements are indicated by *x*. The value of membership of x in fuzzy set $\tilde{a}$ is defined by $\mu_{\tilde{a}}(x) \rightarrow [0,1]$ where $\mu_{\tilde{a}}(x), \forall x \in \tilde{a}$.

Definition 2. A triangular fuzzy number can be denoted as a triplet $\tilde{a} = (a_1, a_2, a_3)$. The membership function $\mu_{\tilde{a}}(x)$ of fuzzy number defined by

$$\mu_{\tilde{a}} = \begin{cases} 0, & x \leq a_1 \\ \frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \leq x \leq a_3 \\ 0, & x > a_3 \end{cases} \quad (1)$$

where $a_1 < a_2 < a_3$ and a_1, a_2, a_3 are real numbers. The x in a_2 gives the maximal grade of $\mu_{\tilde{a}}(x)$ i.e., $\mu_{\tilde{a}}(x) = 1$; it is the most probably value of the evaluation data. The x in a_1 gives the minimal grade of $\mu_{\tilde{a}}(x)$ i.e., $\mu_{\tilde{a}}(x) = 0$; it is the least probably value of the evaluation data. Constants $a_1$and a_3 are the lower and upper bounds of the available area for the evaluation data. These constants reflect the fuzziness of the evaluation data. Figure 2.5 shows a triangular fuzzy number.

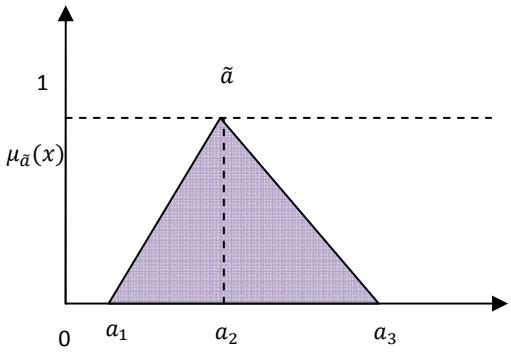


Figure 2.5 A triangular fuzzy number $\tilde{a}$

Definition 3. Let $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$ be two triangular fuzzy numbers in Figure 2.6 Then the distance between them is defined using the vertex method as

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2]} \quad (2)$$

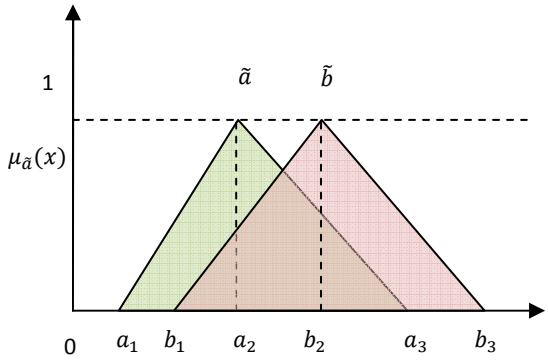


Figure 2.6 Two triangular fuzzy numbers

The linguistic variable is defined as a variable of word or sentence in language (Dursun and Karsak, 2010). The decision's opinion is vagueness usually expressed by linguistic term and set into fuzzy number. This research uses the

judgment values of linguistic with triangular fuzzy numbers. The reason for using a triangular fuzzy number is that is easy to use and calculate (Kannan *et al.*, 2009; Liang and Wang, 1994). The rating of criteria and alternative are linguistic variables and apply a scale of 1-9**.** Table 2.1 presents the linguistic variables and rating of alternatives and Table 2.2 lists the linguistic variables and rating of criteria (Wang and Lee, 2007; Kayikci, 2010; Awasthi *et al.*, 2011; Mokhtarian and Hadi-Vencheh, 2012).

Table 2.1 Linguistic variables for alternatives

Linguistic terms	Membership function
Very poor (VP)	(1, 1, 3)
Poor (P)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Good (G)	(5, 7, 9)
Very good (VG)	(7, 9, 9)

Table 2.2 Linguistic variables for criteria

Linguistic terms	Membership function
Very low (VL)	(1, 1, 3)
Low (L)	(1, 3, 5)
Medium (M)	(3, 5, 7)
High (H)	(5, 7, 9)
Very high (VH)	(7, 9, 9)

Fuzzy is a mathematical way to represent and manipulate linguistic, vagueness information and other fuzzy data (Chen, 2001; Anagnostopoulos, Doukas *et al.*, 2008). This research uses technique called TOPSIS (Technique for Order Preference by Similarity to Ideal Situation). Hwang and Yoon (1981) that developed first stated TOPSIS is a new multi-criteria decision making tool. That based on positive and negative idea. The solution which has been as chosen alternative are shortest distance from positive solution and farthest distance from the negative ideal solution (Jahanshahloo *et al.*, 2006) as shown in Figure 2.7. The major ingredients of

decision process are 1) a group of alternatives 2) a group constrains of choice and 3) a performance function of each alternative that resulting from selecting (Bellmanand and Zadeh, 1970).

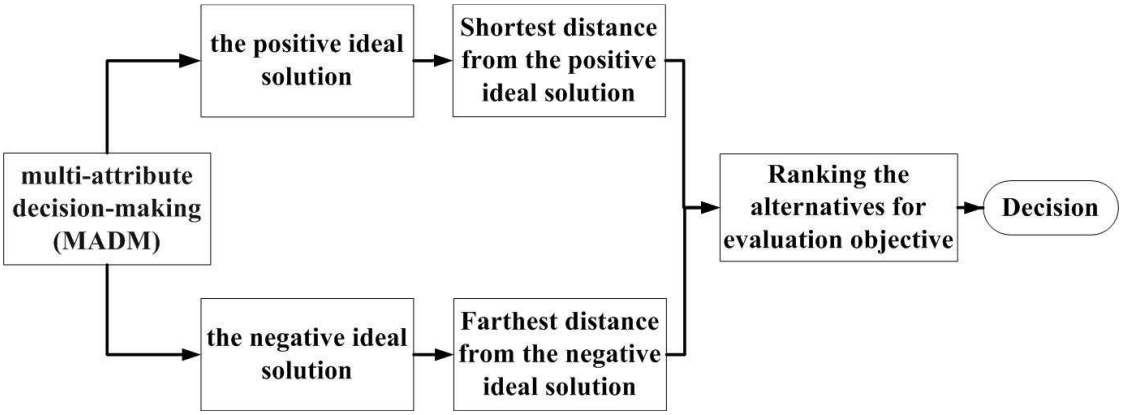


Figure 2.7 The basic flow chart of fuzzy TOPSIS. (Bu *et al.*, 2012)

This technique is presented many benefits. Selçuk (2008) gives TOPSIS method is systematic more than the other fuzzy multi-criteria decision-making (FMCDM) methods and able to understand a human's vagueness when considered this problem. Jiang *et al.* (2011) used the TOPSIS method with Fuzzy Belief Structure model to solve Group Belief multiple criteria decision making problems. Kannan *et al.* (2009) used Interpretive Structural Modeling (ISM) and TOPSIS technique for selection process of best third-party reverse logistics providers. The step of TOPSIS can be expressed into 9 steps (Hwang and Yoon, 1981; Jahanshahloo *et al.*, 2006; Wang and Lee, 2007):

2.3.2.1 Evaluated the performance ratings and weights with linguistic terms.

Assume $A_1, A_2, \dots, A_j$ are j possible alternatives that decision makers have to select, $C_1, C_2, \dots, C_m$ are m criteria which measured the alternative performance. These criteria are two type–best criteria and cost criteria. Both the best criteria that the highest value and the cost criteria that the least value use for the best location selection. The criteria weights are given by $w_i\,(i = 1,2, \dots, m)$. The

performance ratings of each decision makers $D_k(k = 1,2,..,K)$ for each alternative $A_j(j = 1,2,\dots,n)$ with respect to criteria $C_i(i = 1,2,\dots,m)$ are denoted by $\tilde{R}_k = \tilde{x}_{ijk}(i = 1,2,\dots,m; j = 1,2,\dots,n; k = 1,2,\dots,K)$ with membership function $\mu_{\tilde{R}_k}(x)$.

2.3.2.2 Calculate aggregate fuzzy ratings for the criteria and the alternatives.

If the fuzzy ratings of all decision makers are denoted as triangular fuzzy numbers $\tilde{R}_k = (a_k, b_k, c_k), k = 1,2,\dots,K)$, then the aggregated fuzzy rating is given by $\tilde{R} = (a, b, c), k = 1,2,\dots,K$, where

$$a = \min_k\{a_k\},$$

$$b = \frac{1}{K}\sum_{k=1}^{K} b_k,$$

$$c = max_k\{c_k\}. \quad (2.1)$$

If the fuzzy rating and important weight of the *k*th decision maker are $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ and $\widetilde{w}_{ijk} = (w_{jk1}, w_{jk2}, w_{jk3}),\ i = 1,2,\dots,m, j = 1,2,\dots,n,$ respectively, then the aggregated fuzzy ratings $(\tilde{x}_{ij})$ of alternatives with respect to each criterion are given by $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ where

$$a_{ij} = \min_k\{a_{ijk}\},$$

$$b_{ij} = \frac{1}{K}\sum_{k=1}^{K} b_{ijk},$$

$$c_{ij} = max_k\{c_{ijk}\}. \quad (2.2)$$

The aggregated fuzzy weights $\widetilde{w}_{ij}$ of each criterion are calculated as $\widetilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$ where

$$w_{j1} = \min_k\{w_{jk1}\},$$

$$w_{j2} = \frac{1}{K}\sum_{k=1}^{K} w_{jk2},$$

$$w_{j3} = max_k\{c_{jk3}\}. \quad (2.3)$$

2.3.2.3 Calculate the fuzzy decision matrix.

The fuzzy decision matrix for the alternatives $(\widetilde{D})$ and the criteria $(\widetilde{W})$ is formed as follows:

$$\widetilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{array}{cccc} c_1 & c_2 & & c_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \end{array} \quad i = 1, 2, \dots, m \qquad j = 1, 2, \dots, n \tag{2.4}$$

$$\widetilde{W} = (\widetilde{w}_1, \widetilde{w}_2, \dots, \widetilde{w}_n) \tag{2.5}$$

2.3.2.4 Standardize the fuzzy decision matrix.

The raw data are standardized using a linear scale transformation to bring the various criteria scales onto a comparable scale. The normalized fuzzy decision matrix $\tilde{R}$ is given by

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{mxn}, i = 1, 2, \dots., m; j = 1, 2, \dots., n \tag{2.6}$$

where best criteria : $\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right)$ and $c_j^* = max_i\, c_{ij}$ (2.7)

cost criteria : $\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right)$ and $a_j^- = min_i\, a_{ij}$ (2.8)

2.3.2.5 Calculate the weighted normalized matrix.

The normalized matrix $\tilde{V}$ for criteria is calculated by multiplying the weights $(\widetilde{w}_j)$ of evaluation criteria with the normalized fuzzy decision matrix $\tilde{r}_{ij}$:

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{mxn}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad \text{where} \quad \tilde{v}_{ij} = \tilde{r}_{ij}(.)\widetilde{w}_j \tag{2.9}$$

2.3.2.6 Calculate the fuzzy ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS).

The FPIS and FNIS of the alternatives are calculated as follows:

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*) \qquad \text{where} \quad \tilde{v}_j^* = max_i\{v_{ij3}\} \tag{2.10}$$

$$A^- = (\tilde{v}_1, \tilde{v}_2, \dots, \tilde{v}_n) \qquad \text{where} \quad \tilde{v}_j^- = min_i\{v_{ij1}\} \tag{2.11}$$

$$i = 1, 2, \dots, m; \qquad j = 1, 2, \dots, n.$$

2.3.2.7 Calculate the distance of each alternative from FPIS and FNIS.

The distance (d_i^*, d_i^-) of each weighted alternative i = 1, 2, . . ., m from the FPIS and the FNIS is computed as follows:

$$d_i^* = \sum_{j=1}^{n} d_v\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), \ i = 1, 2, \ldots, m \quad (2.12)$$

$$d_i^- = \sum_{j=1}^{n} d_v\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), \ i = 1, 2, \ldots, m \quad (2.13)$$

Where $d_v\left(\tilde{a}, \tilde{b}\right)$ is the distance measurement between two fuzzy numbers ã and b̃.

2.3.2.8 Calculate the closeness coefficient (CC_i) of each alternative.

The closeness coefficient CC_i represents the distances to the fuzzy positive ideal solution *(A^*)* and the fuzzy negative ideal solution (A^-) simultaneously. The closeness coefficient of each alternative is calculated as

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*}, \ i = 1, 2, \ldots, m \quad (2.14)$$

2.3.2.9 Rank the alternatives.

Ranking order the alternatives are according to the closeness coefficient (CC_i) in decreasing order and choose the alternative from the highest closeness coefficient. The chosen alternative has the shortest distance from the FPIS and the farthest distance from the FNIS.

2.3.3 Why use Fuzzy TOPSIS technique

Hosseini *et al.* (2012) and Wang (2008) present the main advantages of TOPSIS compare with other basic MCDM methods are easy to use, can consider into all types of benefit criteria and cost criteria, the practitioners are intelligible and reasonable in logic of TOPSIS, the calculation of process is straightforward, the concept allows a simple mathematical manner to find the best alternatives, and the importance weights can be combine in methodology conveniently. Table 2.3 is shown the comparison of multi-criteria decision making methodologies as TOPSIS, AHP, and ELECRE.

Table 2.3 Comparative analysis of multi-criteria decision making methodologies.
(Özcan *et al.*, 2011; Sipahi and Esen, 2010; Saaty, 2008)

Characteristics	TOPSIS	AHP	ELECTRE
1. Core process	Calculating distance to positive and negative ideal point	Creating hierarchical structure and pair wise comparison matrices	Determining concordance and discordance indexes
2. Necessity to quantify the relative importance of criteria	Yes	Yes	Yes
3. Determining of weights	No specific method. Linear or vector Normalization.	Pairwise comparison matrices 1–9 scale.	No specific method. Based on decision maker.
4. Consistency Check	None	Provided	None
5. Problem Structure	Large number of alternative and criteria, objective and quantitative data	Little number of alternative and criteria, quantitative or qualitative data	Large number of alternative and criteria, objective and quantitative data
6. Final results	Global, net ordering	Global, net ordering	A kernel

2.4 The Criteria for Location Selection

The pharmaceutical supply chain are not similar other supply chain Thus, the criteria collected from literature review are divided into two major areas: general criteria and healthcare criteria.

2.4.1 General Criteria

Previous studies related to the opinion of decision making in selecting criteria for location planning have been studied. Farahani *et al.* (2010) started that reviewed about multi-criteria location problems in three categories of bi-objective, multi-objective and multi-attribute problems. The major criteria from this research are ‘cost’, ‘environmental risk’, ‘service level’, ‘coverage’ and ‘other criteria’: ‘resource accessibility’, ‘economical criteria’, ‘distances including closeness to markets’ or ‘customers, suppliers and resources’, ‘political matters and regulations’ and ‘competition’. Awasthi *et al.* (2011) proposed a multi-criteria decision making approach for location planning. These criteria for urban distribution centers are ‘accessibility’, ‘security’, ‘connectivity to multimodal transport’, ‘costs’, ‘environmental impact’, ‘proximity to customers’, ‘proximity to suppliers’, ‘resource availability’, ‘conformance to sustainable freight regulations’, ‘possibility of expansion’, and ‘quality of service’. Another work was done by Chou *et al.* (2008) who presented a fuzzy multi-criteria decision making model for international tourist hotel location selection. ‘Access’, ‘rest resources’, ‘surrounding environment’, ‘convenience’, ‘internal development’, ‘external development’, ‘human resource’ and ‘operating conditions’ are criteria in their research. Farahani and Asgari (2007) investigated the location distribution centers for military logistics system. The list of attributes is ‘natural environment’, ‘military’, ‘economical’ and ‘infra-structures’. Demirel *et al.* (2010) studied five main criteria and 16 sub-criteria. These main criteria are ‘costs’, ‘labor characteristics’, ‘infrastructure’, ‘market’ and ‘macro environment’. The sub-criteria of cost are ‘labor costs’, ‘transportation cost’, ‘tax incentives and tax structures’, ‘financial Incentives’, and ‘handling costs’. The sub-criteria of labor characteristics are ‘skilled labor’ and ‘availability of labor force’. The sub-criteria of infrastructure are ‘the existence of modes of transportation’, ‘telecommunication’, and ‘quality and reliability of modes of transportation’. The sub-criteria of market are ‘proximity to customers’, ‘proximity to suppliers’, ‘lead times’ and ‘responsiveness’. The sub-criteria of macro environment are ‘policies of government’, ‘industrial regulations laws’, and ‘zoning and construction plan’. The descriptions of each criteria are followed:

2.4.1.1 Cost

Farahani *et al.* (2010) divided ‘cost’ into two types including fixed costs and variable costs. The fixed costs are start up cost including investment cost and the variable costs are transportation, operations, production, services, distribution, logistics, waste disposal, maintenance, and environmental cost. The transportation cost is adjust to the economic structure of the alternative regions, transportation facilities and alternative transportation types such as air, land, railroad, and marine (Demirel *et al.*, 2010).

2.4.1.2 Natural environment

That is the condition of climate, weather, geological, hydrological and topography. The climate contains the statistics of temperature, rain, humidity, atmospheric pressure and wind. The weather is a set of atmospheric in area. The geological is the condition earthquake intensity, flood history and interruption of earth.

2.4.1.3 Accessibility

This criterion is the ease to reach the distribution center by public and private transportation.

2.4.1.4 Labor

The labor criteria is defined as the personnel for a work, who has qualities to work and the number of labor (Demirel *et al.*, 2010).

2.4.1.5 Quality of service

Quality service means timely delivery, delivery to the right place, the right customers, and delivery of the undamaged goods (Demirel *et al.*, 2010).

2.4.1.6 Connectivity to multimodal transport

The transport is performed in a reliable and qualified way between at least two different modes such as highways, railways, seaport, and airport. The different transport modes affected to the reliability of customer and quality of service (Demirel *et al.*, 2010).

2.4.1.7 Conformance to sustainable freight regulations

Ability to conform to sustainable freight regulations imposed by municipal administrations e.g. restricted delivery hours, special delivery zones.

2.4.1.8 Competition

The condition of organizations contests at least one other firm over the same group of customers to be leadership.

2.4.1.9 Demand

The customers require amount of products that willing to buy. The basic demand relationship is between prices of a good and the quantities that increase price influences to decrease quantity.

2.4.1.10 Proximity to customers

This criterion is defined as the distance of the distribution center location to the customer (Demirel *et al.,* 2010; Awasthi *et al.,* 2011).

2.4.1.11 Economic

The condition of economy influences to the distribution center e.g. currency value, exchange rate, market demand etc.

2.4.1.12 Resource availability

Availability of raw materials and packaging are able to respond the requirement of distribution center's order.

2.4.1.13 Infrastructure

The structure of organization is required to operate the services that provide to support the structure of development. Infrastructure refers to the water and electricity supply infrastructure.

2.4.1.14 Possibility of expansion

Distributor is able to manage the growing demand by expand the size, productivity, amount of workers.

2.4.1.15 Density of traffic

The number of vehicles in the area of the roadway from suppliers to distribution center or distribution center to customers.

2.4.1.16 Environmental impact

The distribution center affected positive or negative on the environment such as air pollution, noise.

2.4.1.17 Political regulations

The political regulation is difference from a region to another region (Demirel *et al.*, 2010). It is included tax exemptions, investment facilities and various incentives.

2.4.1.18 Proximity to suppliers

This criterion is defined as the distance of the distribution center location to the suppliers or producers (Demirel *et al.*, 2010; Awasthi *et al.*, 2011).

2.4.1.19 Security

The security is the degree of protection of drug distribution center from damage, loss, crime, theft, vandalism, and accident.

2.4.1.20 Lead time

This criterion is defined the ability and the period of time to fulfill the order (Demirel *et al.*, 2010).

2.4.1.21 Product feature

The characteristics and qualities of product – its size, material, shape, and functionalities are required by customers and benefit to the owner. The usefulness of product is targeted the customer for buying and used for a product marketing strategy.

2.4.1.22 Cultural issues

The international firm's distribution center able adapts to the different culture.

2.4.1.23 Information technology

Using computer-base information system support or manage to store, transmit and operate database.

2.4.1.24 Profit

The amount of income is obtained from the distributor's service that exceeds the expenses, costs and taxes.

2.4.1.25 Coordination

Ability of the distributor to manages the different thing, activity or people to work together for achievement.

2.4.2 Healthcare specific Criteria

Healthcare business has an important role for the society. Since people were born until death, all have to involve with hospital services. Fail to get healthcare services at the time they need will have a severe impact to their safety (Liangrokapart, 2012). Therefore the continuous service of the hospitals, especially during the crisis is extremely important. The hospitals should have sufficient supply of drugs, medical devices, medicinal gas and other products to serve the patients at all time. The suppliers must put all effort to distribute their products to the hospitals in order to ensure that the end customers, the patients, will get the right products at the right quantity, at the right quality, at the right place and at the right time. A good location for continuous products distribution to the hospital should be determined and the criteria to be considered should be identified.

Previous studies have been done in the healthcare research related to location selection. Wu *et al.(*2007) studied the optimal selection of location for Taiwanese hospitals using six evaluation criteria which are ‘factor conditions’, ‘demand conditions’, ‘firm strategy, structure and rivalry’, ‘related and supporting industries’, ‘government’ and ‘chance’ and 18 sub-criteria including ‘capital’, ‘labor’, ‘land’, ‘population number’, ‘population density’, ‘population age distribution’, ‘management objective’, ‘rank of competing hospitals’, ‘policymaker’s attitude’, ‘the medicine practice and the pharmaceutical sector’, ‘hospital administration sector’, ‘the healthcare sector’, ‘qualifications of the hospital’s establishment and the regulations of the established standard’, ‘efforts to promote a medical network’, ‘promulgating tasks that require a hospital assessment’, ‘violent change in market demand’, ‘dramatic fluctuations in production costs’ and ‘significant changes in the financial market and exchange rate’. Simango (1993) presented strategic factors which ‘low corporate tax’, ‘base for EC entry’ and ‘skilled manpower’ that attracts US and European pharmaceutical multinational enterprises to locate in Ireland. While Dunlap and Golub (2011) recommended that the focus should include ‘focus outreach efforts near drug markets’, ‘overlook drug possession’, ‘provide access to private areas near shelters’, ‘continue rescue efforts’ and ‘provide drug maintenance and counseling services’ for disaster management. Dong *et al.* (1999) described the drug policy reform in China that advantage to reduces the cost, reduce the length of the chain between producer and user, and improve their production in China has been used to reform government

production plan to market demand. Especially during disaster, ‘the focus outreach efforts near drug markets criteria’ is important to reach poor drugs users that related to reduce drug users risk (Dunlap and Golub, 2011). The healthcare-specific criteria are summarized in Table 2.5. From the table, Some criteria for location selection for healthcare criteria are also in general criteria consist of ‘Demand’, ‘Labor’, ‘Quality of service’, ‘Infrastructure’, ‘Accessibility’, ‘Resource availability’, ‘Political regulations’, ‘Possibility of expansion’, ‘Economic criteria’, ‘Information technology’, and ‘Environmental impact’. The remaining healthcare criteria are explained as followed:

2.4.2.1 Focus outreach efforts near drug markets

The numbers of potential drugs are likelihood reaching to the requirement of poor drugs users that they can be safely provided during crisis.

2.4.2.2 Population

Population is the numbers of people live in the local area that is the local demand (Wu *et al.*, 2007).

2.4.2.3 Firm strategy, structure and rivalry

The conditions of firm influence to establish, continue practice the management and organize efficiency.

2.4.2.4 Government

Governmental policy controls drug distribution center for establishing and qualifications of the drug distribution center that strengthens the competitiveness includes the standard regulations of the established, efforts to promote a medical network and promulgating tasks (Wu *et al.*, 2007).

2.4.2.5 Chance

The situation which has no negative influence to the drug distribution center such as the decreasing market demand, and fluctuations in production costs.

2.4.2.6 Distance to nearest hospital

The criterion is the distance from the drug distribution center to the nearest hospital. That hospitals are distribution center’s customers. So, it is affect to transport time to service customers.

2.4.2.7 Overlook drug possession

The ability of drug distributor will be more compliant with disaster management directives.

2.4.2.8 Provide access to private areas near shelters

During the crisis, drug distributor able to distribute drug to users that able to consume drugs sufficiently in unmonitored area.

2.4.2.9 Continue rescue efforts

It is important to convenient services to the hospitals that supported for as long as safely patients.

2.4.2.10 Provide drug maintenance and counseling services

Drug distribution center can help relieve drug shortage by support sufficient drug because during the crisis, the drug requirement is increasing.

2.4.2.11 New registration regulations

The distributors who cannot inept to follow the regulation continue to run the drug business.

2.4.2.12 Drug distribution channels

The various distribution technology channels of drugs are procurement of technologies, know-how for innovative drugs affect to increasing market demand.

2.4.2.13 Adoption of international standards

The distribution center should pass good distribution practice (GDP), good storage practice (GSP) certification for good manufacturing practices, and management systems.

2.4.2.14 Goal of site selection process

The distribution center able to serve drug to the rural hospital that increase drugs distribution efficiency.

2.4.2.15 Emergency preparedness concerns

The ability of distribution center responses the rapid increasing demand for emergency time.

2.4.2.16 Competitive prices

The price is one important factor for the customers to decide the service. So, the lower price effects to the high competitive.

2.4.2.17 Reduce costs by way of less linkage and competition

The short linkage of drug supply chain by the drug factories can sell drug to the retailer directly.

2.4.2.18 International tax differentials

For the foreign firm, the tax is one factor to consider operating in that country. The low rate of tax is more responsive from the investors.

2.4.2.19 Material shelf-lives

Material shelf-lives is the length of time that drugs can be stored, continue effective and safe. The benefit of shelf-life is used to establish the expiry date of each batch.

2.5 The flooding situation in 2011

The severe flooding triggered by the land fall of Tropical Storm Nok-ten and spread through the northern provinces, the northeastern province, and central of Thailand. The floodwaters entered to the 31 districts of Bangkok in October 2011. The causes of flooded in Bangkok are the heavy rainfall, the overflow from river, the effect of high tides from the sea, the land subsidence and the low efficiency of drainage system (Phamornpol, 2012). During flooded, the Royal Irrigation Department drain flooded water base on the drainage capacity via eastern Bangkok, western Bangkok and the Chao Phraya River to solve the problem. The capacity by pump is 26.18 million cubic meters per day via western Bangkok and 37.78 million cubic meters per day via eastern Bangkok. While the Chao Phraya River empties about 300 million cubic meters per day by pumps and natural water flow (The Nation, 2011).

Associate Professor Dr. Seree Supratid, director of the Climate Change and Disaster Centre of Rangsit University, said the increase of urban area, the volume of rainfall, the land subsidence and the increase of sea level are the major cause of flood. He proposed the government to construct the dyke to protect the high tides, increase water retention areas and dredge canals for problem-solving. Dr. Pichit Rattakul, the consultant of Asian Disaster Preparedness Center, said the natural

disasters of Bangkok are the flood water from the sea and the Chao Phraya River. Thus, the elevation above mean sea level is one indicator of the subsidence area that the cause of flood. The essence of His Majesty's flood relief initiatives by prevent an overflow from outside areas, release the excess water from inside areas and allocate the areas to store excess water for subsequent release after the floods have subsided (Bangkok Metropolitan Administration, 2011). Thus, the dykes are initiated from the King's ideas.

Mr. Apirak Kosayodhin, former governor of Bangkok Metropolitan Administration (BMA), propose the long-term solutions to manage the flood water are manage the water system, strict the country planning regulation especially drainage area, and expand "Kaem Ling" – water retention areas project. Land use change is an important factor increasing flood severity (Emde, 2012). Associate Professor Dr. Seree Supratid said the vital cause of flood in the future is the change of environmental that the reduction of green zone and empty area. Professor Dr. Thanawat Jarupongsakul state to adjust the city planning and land use to relieve flooding (MCOT, 2013). He said the problem of country planning is not to solve from the government. Thus, good country planning manage is help to flow the floodwater to the river and the sea.

To summarize, the critical review of the concepts and frameworks in the fields of drug distribution center and hospital supply chain suggests the following key points that would be a helpful guide in the improvement of a conceptual framework on the location selecting drug distribution center. A method to evaluate the location in this study is Fuzzy TOPSIS. It is easy to calculate and consider into all types of criteria. The criteria, general criteria and healthcare criteria, from literature review use to evaluate the location. Each criteria will be selected by expert if it is related to the location of drug distribution center as described in Chapter III.

CHAPTER III
METHODOLOGY

This chapter described the research methodology used identify the location selection criteria, select the potential location, evaluate criteria by experts' opinion, collect the data of each location, evaluate the location using fuzzy TOPSIS sensitivity analysis and construct the drug distribution center location selection program.

3.1 Research Methodology

From Figure 3.1, the criteria and multi-criteria location decision making methods from related literature were reviewed and the detailed step-by-step of the methodology are as follows.

3.1.1 Identify the Location Selection Criteria

All location selection criteria collected from literature reviews and the opinion of decision makers were divided into two categories-general criteria and healthcare criteria. The outcome of first step was a set of location selection criteria for drug distribution center.

3.1.1.1 Identify the general criteria

This step started from 25 general location criteria were listed down in Table 3.1. Four criteria – cost, competition, density of traffic, environmental impact are classified into the cost criteria while the remaining criteria are the best criteria. Those criteria were ranked by the frequency of citations. In this research, only the criteria cited by 4 literatures or more were used.

3.1.1.2 Identify the healthcare criteria

The 30 healthcare-specific criteria were also collected from literature review. The list of healthcare-specific criteria was shown in Table 3.2. Both environmental impact and international tax differentials are the cost criteria but the

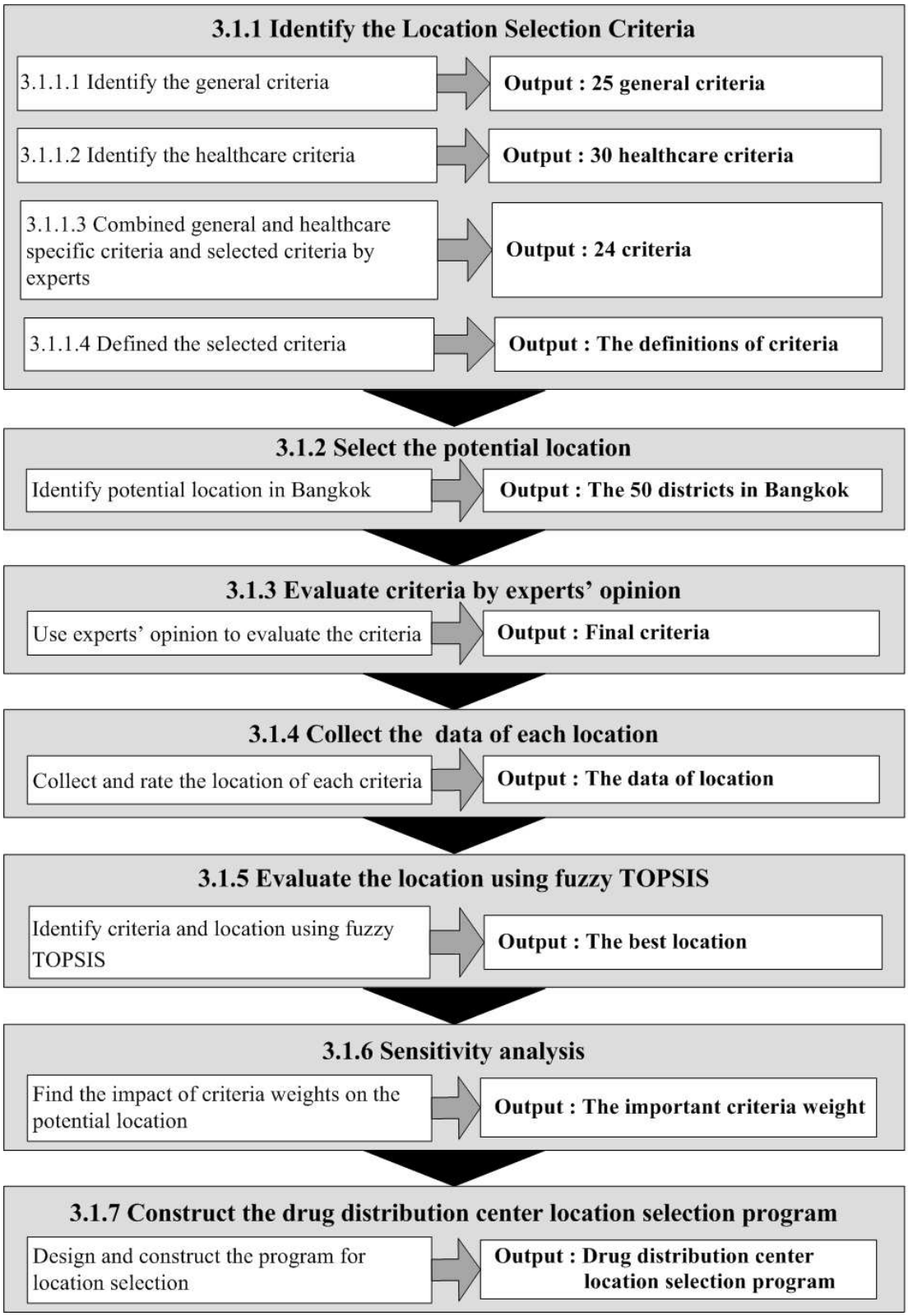


Figure 3.1 Steps of methodology

excess of criteria are the best criteria. Due to the limit of number of literatures, only the criteria cited by two literature or more were used.

3.1.1.3 Combined general and healthcare specific criteria and select criteria by expert.

The criteria from 3.2.3.1 and 3.2.3.2 were combined to 24 criteria and used as location criteria selection. Three experts were asked to confirm if the selected criteria seems to be reasonable to be used in the further study. The questionnaire was shown in Appendix C.

Table 3.1 General criteria for Location selection from literature review

Criteria	Reference
1. Cost	[1], [2], [3], [4], [5], [8], [9], [10], [13], [15], [16], [17], [20], [21], [22], [24]
2. Natural environment	[1], [6],[7], [10], [11], [12], [14], [15], [19], [20], [21], [23]
3. Accessibility	[1], [4], [5], [6], [10], [11], [14], [15], [16], [17], [18], [19]
4. Labor	[2], [5], [6], [8], [9], [10], [13], [15], [19], [21], [23]
5. Quality of service	[1], [2], [4], [6], [7], [12], [15], [16], [23], [24]
6. Connectivity to multimodal transport	[4], [5], [7], [8], [13], [16], [17], [19], [22]
7. Conformance to sustainable freight regulations	[1], [2], [4], [7], [8], [9], [11], [12], [16]
8. Competition	[1], [2], [5], [6], [8], [12], [14], [15], [23]
9. Demand	[4], [6], [7],[9], [11], [12], [15], [18]
10. Proximity to customers	[1], [5], [6], [8], [13], [14], [16], [22]
11. Economic criteria	[1], [3], [12], [15], [17], [19], [25]
12. Resource availability	[1], [4], [5], [6], [11], [16], [23]

Table 3.1 General criteria for Location selection from literature review (cont.)

Criteria	Reference
13. Infrastructure	[13], [15], [17], [18], [19], [20], [23]
14. Possibility of expansion	[1], [2], [9], [12], [16], [22]
15. Density of traffic	[5], [7], [8], [13], [20], [23]
16. Environmental impact	[1], [2], [4], [15], [16], [18]
17. Political regulations	[1], [4], [5], [13], [14], [17]
18. Proximity to suppliers	[5], [13], [14], [16], [21]
19. Security	[1], [5], [16], [18]
20. Information technology	[1], [4], [7], [12]
21. Product feature	[2], [15], [23]
22. Cultural issues	[4], [5], [18]
23. Lead time	[7], [12], [13]
24. Profit	[1], [5]
25. Coordination	[4]

[1] Farahani and Asgari (2007)
[2] Liu, Chan et al. (2011)
[3] Yang, Ji et al. (2007)
[4] Kayikci. (2010)
[5] Chou, Hsu et al.(2008)
[6] Boufounou. (1995)
[7] Kuo. (2011)
[8] Kahraman, Ruan et al. (2003)
[9] Chen. (2001)
[10] Chou, Chang et al. (2008)
[11] Ocalir, Ercoskun et al. (2010)
[12] Lee and Lin (2008)
[13] Demirel, Demirel et al. (2010)
[14] Mokhtarian and Hadi-Vencheh (2012)
[15] Ren, Xing et al. (2011)
[16] Awasthi, Chauhan et al. (2011)
[17] Cheng and Tsai (2009)
[18] Ou and Chou (2009)
[19] Farahani and Asgari (2007)
[20] Li, Liu et al. (2011)
[21] Azadeh, Ghaderi et al. (2011)
[22] Schwartz (1999)
[23] Huang, Yu et al. (2012)
[24] Bu, Van Duin et al. (2012)
[25] Suárez-Vega, Santos-Peñate et al. (2012)

Table 3.2 Specific healthcare criteria for location selection from literature review

Criteria	Reference
1. Demand*	[1], [4], [9]
2. Labor*	[1], [2], [8]
3. Quality of service*	[2], [5], [8]
4. Infrastructure*	[2], [5], [9]
5. Focus outreach efforts near drug markets	[3], [4], [10]
6. Accessibility*	[1], [6]
7. Resource availability*	[1], [9]
8. Political regulations*	[8], [10]
9. Population	[1], [2]
10. Firm strategy, structure and rivalry	[1], [5]
11. Government	[1], [8]
12. Possibility of expansion*	[1]
13. Economic criteria*	[1]
14. Information technology*	[1]
15. Environmental impact*	[1]
16. Chance	[1]
17. Distance to nearest hospital	[2]
18. Overlook drug possession	[3]
19. Provide access to private areas near shelters	[3]

Table 3.2 Specific healthcare criteria for location selection from literature review (cont.)

Criteria	Reference
20. Continue rescue efforts	[3]
21. Provide drug maintenance and counseling services	[3]
22. New registration regulations	[4]
23. Drug distribution channels	[4]
24. Adoption of international standards	[4]
25. Goal of site selection process	[5]
26. Emergency preparedness concerns	[6]
27. Competitive prices	[7]
28. Reduce costs by way of less linkage and competition	[7]
29. International tax differentials	[11]
30. Material shelf-lives	[11]

* These healthcare criteria are the same as general criteria.

[1] Wu, Lin et al.(2007)
[2] Sinuany-Stern , Mehrez et al.(1995)
[3] Dunlap and Golub (2011)
[4] Chan and Daim (2011)
[5] Bennett, Eaton et al.(1982)
[6] Shah (2004)
[7] Dong, Bogg et al. (1999)
[8] Simango. (1993)
[9] Elke A. Pioch and Schmidt (2001)
[10] Craig and Malek (1995)
[11] Susarla and Karimi (2011)

3.1.1.4 Define Each Criterion

The selected criteria from Step 3.1.1.3 were defined and shown in Table 3.3.

Table 3.3 The location selection criteria and definition

Criteria	Definition
1. Cost	Costs in acquiring land, capital, vehicle resources, drivers, resource, logistics, services and taxes etc. for the location.
2. Natural environment	The condition of weather, geological, hydrological, topography (e.g. rain, sunshine, humidity etc.).
3. Accessibility	Access by public and private transport modes to the location.
4. Labor	Sufficient the number of labors and skills.
5. Quality of service	Capability to appropriate and response time service.
6. Connectivity to multimodal transport	Connectivity of the location with multiple modes of transport, e.g. highways, railways, seaport, airport etc.
7. Conformance to sustainable freight regulations	Ability to conform to sustainable freight regulations imposed by municipal administrations for e.g. restricted delivery hours, special delivery zones.
8. Competition	Capability to compete against others or the number of competitor.
9. Demand	The number of customers purchases the products, and whether the needs of the market can be adequately fulfilled.

Table 3.3 The location selection criteria and definition (cont.)

Criteria	Definition
10. Proximity to customers	The distance and time from location to customers.
11. Economic	The condition of economy (e.g. currency value, exchange rate, market demand etc.).
12. Resource availability	Availability of raw materials and labor resources in the location.
13. Infrastructure	The extent and nature of physical distribution center infrastructure and communication system and the availability and convenience to access the water and electricity supply infrastructure.
14. Possibility of expansion	Capability to manage the growing demand.
15. Density of traffic	The frequency of use is from the location to the suppliers or customers.
16. Environmental impact	Impact of location on the environment, for example, air pollution, noise.
17. Political regulations	Good legal rules and regulations to support business.
18. Proximity to suppliers	The distance and time from location to suppliers.

Table 3.3 The location selection criteria and definition (cont.)

Criteria	Definition
19. Security	Drug distribution center is safe from damage, loss, crime, theft, vandalism, and accident.
20. Information technology	The ability of technology sends or receives information for logistics, commerce and financing activities.
21. Focus outreach efforts near drug markets *	Drugs will be maximize the likelihood of reaching poor drugs users, a particularly recalcitrant and poorly informed population.
22. Population *	The medical market demand includes population number, population density and population age distribution.
23. Firm strategy, structure and rivalry *	Drug distribution center establishment, organization, management practices and competitors all influence management objective, rank of competition and policymaker's attitudes.
24. Government *	Governmental policy towards establishing drug distribution center in order to strengthen their competitiveness includes qualifications of the drug distribution center's establishment and the regulations of the established standard, efforts to promote a medical network and promulgating tasks.

Note * healthcare-specific criteria

3.1.2 Select the potential location

Bangkok is the province which has highest number of hospital in Thailand (123 hospitals) (see Appendix A) and has convenient transportation. So, this research chose Bangkok as a case study to locate the drug distribution center. The 50 districts in Bangkok are Bangbon, Bangkapi, Bangkhae, Bangkhen, Bangkholaem, Bangkhunthian, Bangna, Bangphlat, Bangrak, Bangsue, Bangkoknoi, Bangkokyai, Buengkum, Chatuchak, Chomthong, Dindaeng, Donmueang, Dusit, Huaykhwang, Khannayao, Khlongsamwa, Khlongsan, Khlongtoei, Laksi, Latkrabang, Latphrao, Minburi, Nongchok, Nongkhaem, Pathumwan, Phasicharoen, Phayathai, Phrakhanong, Phranakhon, Pomprap, Prawet, Rajburana, Ratchathewi, Saimai, Samphanthawong, Saphansung, Sathon, Suanluang, Talingchan, Thawiwatthana, Thonburi, Thungkhru, Wangthonglang, Watthana, and Yannawa districts (Administrative strategy division, 2012). The map of Bangkok is shown in Figure 3.2. The districts were considered as possible location for drug distribution center.

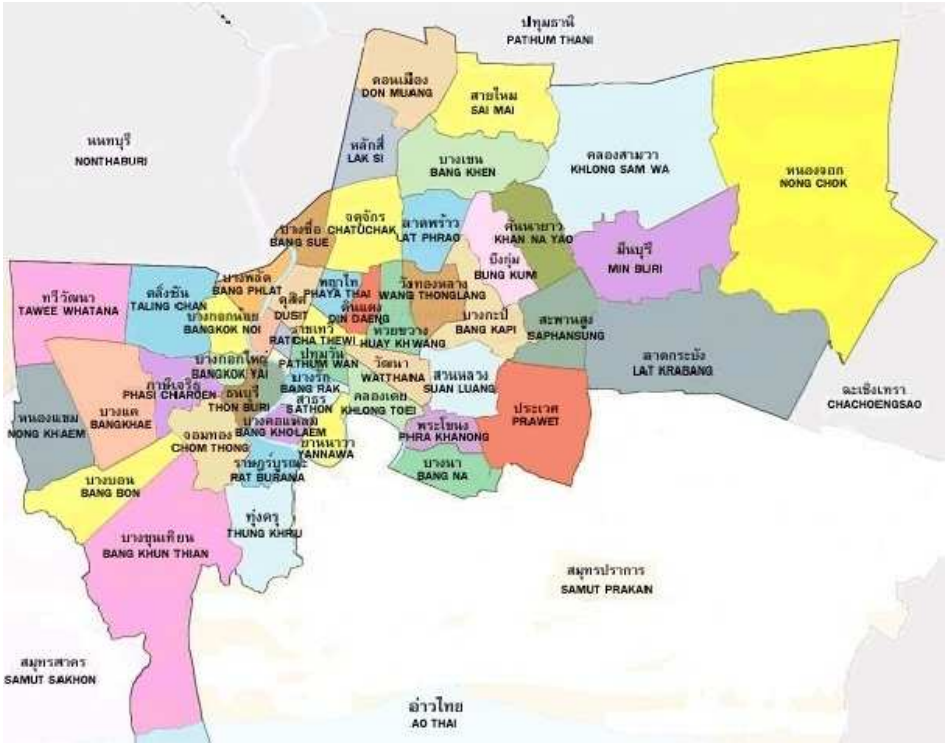


Figure 3.2 The map of Bangkok.

3.1.3 Evaluate criteria by experts' opinion

The nine experts were be asked to ratings for the criteria. These experts worked in general distribution center, drug distribution center, hospital, Bangkok Metropolitan Administration, Thai Logistics and Production Society, and Thai Pharmaceutical Manufacturers Association. The questionnaires were shown in Appendices D. Five ratings of criteria in questionnaire are very low to very high. The two experts from Bangkok Metropolitan Administration were asked to review the criteria from literature review and the criteria for flood protection were added. After that, the other experts were be asked to evaluate these criteria.

3.1.4 Collect the data of each location

The data of location in each criteria was collected to weight location where the 50 districts in Bangkok. The data of locations were presented in Appendix B.

3.1.5 Evaluate the location using fuzzy TOPSIS

The tool for evaluating the location in this study was called fuzzy TOPSIS. The concept was the selected alternative should have the shortest distance from the positive ideal and the farthest distance from the negative ideal solution (Jahanshahloo, 2006; Wang, 2007; Anagnostopoulos, 2008)**.** From the concept theory of fuzzy TOPSIS in chapter 2 was applied to identify criteria and location in this step. The result of this step was the best location for drug distribution center.

3.1.6 Sensitivity analysis

Sensitivity analyses were used to find the impact of criteria weights on the potential location. This step was necessary for the unstable situation to identify the important from other criteria. For this research, the 20 experiments are used to sensitivity analysis. The weights of all criteria are equal for five experiments. The other experiments are set one criteria weight as highest weight and the remaining criteria weights as lowest weight.

3.1.7 Construct the drug distribution center location selection program

Drug distribution center location selection program was constructed to find the new drug distribution center location. It will help to select the location where is able to operate during a flood crisis. The program flowchart illustrating the sequence of operations to solve a location problem is shown in Figure 3.3. The display of program and how to use the program are presented in the next chapter.

Therefore, these steps of methodology are used to find the real location of drug distribution center in Bangkok. The result and discussion of best district is presented in Chapter IV.

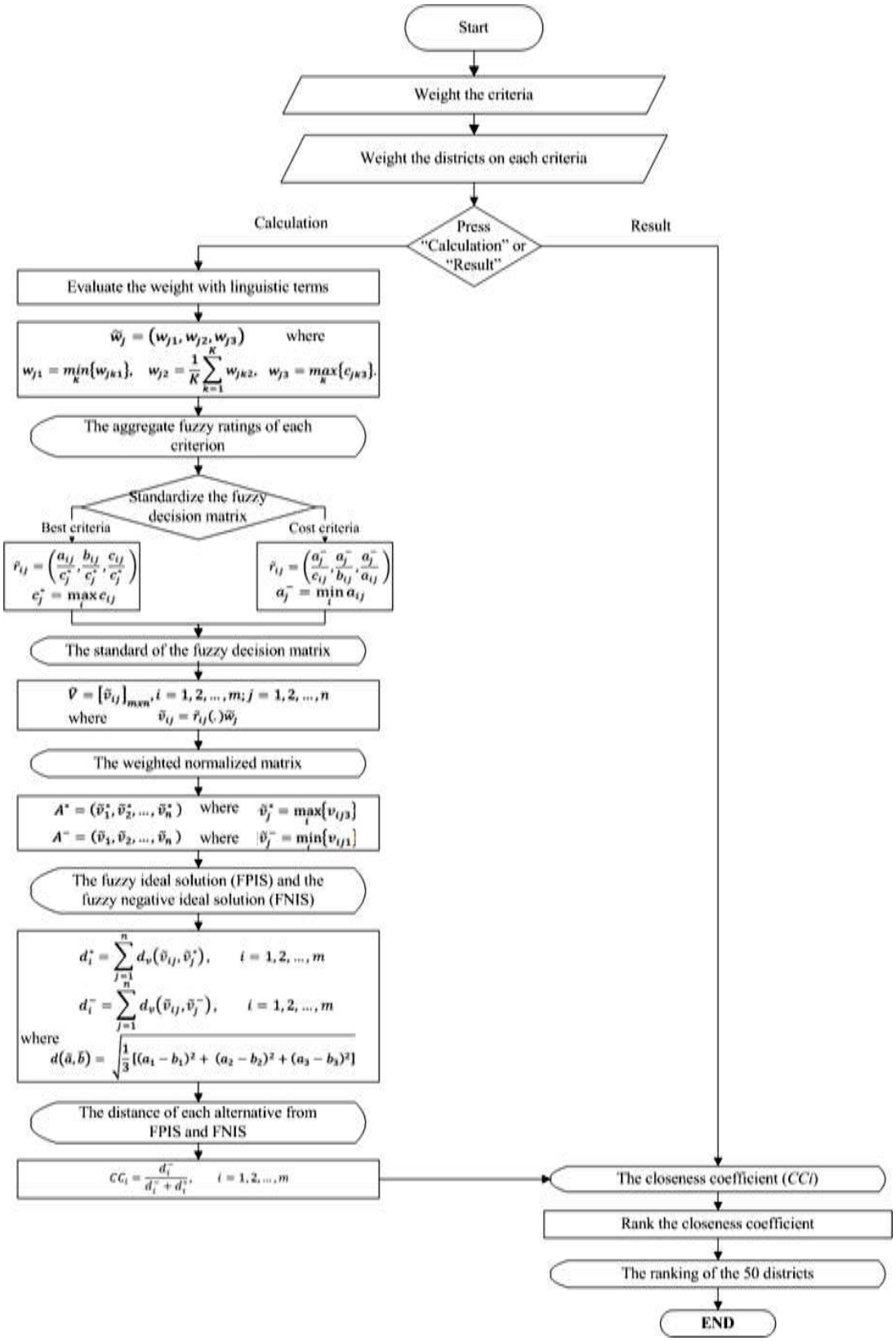


Figure 3.3 The drug distribution center location selection program flowchart

CHAPTER IV
RESULTS AND DISCUSSION

This chapter is the research results from the methodology in Chapter III. This chapter presents the evaluated criteria by experts' opinion, the data of location, the evaluated location using fuzzy TOPSIS, sensitivity analysis and drug distribution center location selection program.

4.1 The evaluated criteria by experts' opinion

The 9 experts worked in relative field were asked for ratings criteria (Appendix E). Three experts work in private drug distribution center with at least 5 years experience. One expert works in local distribution center and has 18 years experience. Two experts have at least 3 years experience in Bangkok Metropolitan Administration. One expert has more than 10 years of hospital working experience. One expert has worked in some logistics society. The other expert has been working in some pharmaceutical association for 5 years.

The 24 criteria as started in Chapter 3 were included in the questionnaires to ask the experts. Whether or not they are sufficient for selecting a drug distribution center. Three additional criteria were suggested by the experts including country planning, flooded management and topography. Then the experts helped to combine the criteria that have similar meaning and omit non-significant criteria. The final criteria suggested by experts and would be used for further calculation are cost, natural environment and its impact, accessibility, labor, connectivity to multimodal transport, government and regulations, competition, demand, infrastructure, density of traffic, security, information technology, flooded management, topography and country planning. The examples of the combination include natural environment and environmental impact and the new criterion is the national environment and its impact. The demand, focus outreach efforts near drug markets and population were also

combined to “Demand” criterion. The political regulations, conformance to sustainable freight regulations and government were combined into “government and regulations”. The criteria, proximity to customers, proximity to suppliers, resource availability and lead time, are not significant for drug distribution center because the location of the customers and suppliers are spread out over Bangkok and resources are available. The “quality of service” and “possibility of expansion” do not involve much with location selection. “Economic criteria” is the same for all location. Finally, the “possibility of expansion” and “firm strategy and structure” are internal factors which are not included in this study. Therefore, the final criteria used in this study are shown in Table 4.1.

Table 4.1 The final criteria.

Criteria	
1. Cost	2. National environment and its impact
3. Accessibility	4. Labor
5. Connectivity to multimodal transport	6. Government and regulations
7. Competition	8. Demand
9. Infrastructure	10. Density of traffic
11. Security	12. Information technology
13. Country planning*	14. Flooded management*
15. Topography Regulation*	

*Additional criteria from the experts’ opinion

However, three additional criteria - flooded management, topography, and country planning criteria are additional criteria from experts’ opinion. The flooded management criterion is the flood prevention systems in district to use the drainage tunnel or the Royally-Initiated Bangkok Flood Dyke. The drainage tunnels drain floodwater from flooded areas to the Chao Phraya River directly while the dyke slowed down the overflow of floodwater from the northern region or river. The

topography criterion is the average height of land from the above mean sea level in the area. If the area is high from mean sea level, the probability of safety from flooding is increased. The country planning criterion is the laws of land usage that refer to diagrams and special operation to improve the land for benefit.

Figure 4.1 reports the experts' opinion on each criterion on average. From the experts' opinion, the important criteria was 'accessibility', 'cost', 'connectivity to multimodal transport', and 'flooded management'.

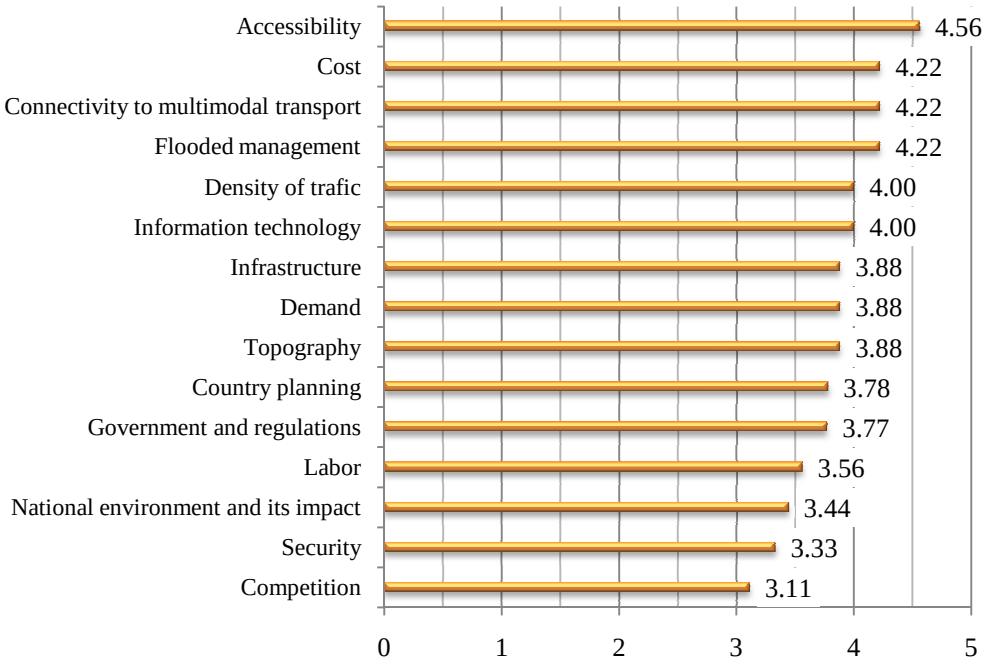


Figure 4.1 The experts' opinion on each criteria on average

4.2 The data of location

The data were collect to support the criteria from the experts' opinion (shown in Appendix B). In term of cost criterion, the fixed cost that able calculates is the land cost. Because of the different customer location, the transportation cost is difficult to calculate. Bang Rak, Pathum Wan, Samphanthawong, Sathon and Yan Nawa districts are the top five of maximum land cost.

In the same province, the climate are similar all districts. So, the environment condition is waste, air and voice, while the geological is flood history for measurement. The least waste of district is Samphanthawong district, the least dust is Din Daeng district, and the least voice is Phra Khanong district. From the history of flooding area, 12 districts were not flooding in 2011 and 1995 but 11 districts were flooded two times.

The connectivity to multimodal transport criteria is collected data of the number of train station, entranced and exited expressway. Six districts have all type of multimodal transports. There are 17 districts have the train station, 17 districts have the entranced expressway and 17 districts have the exited expressway.

In case of accessibility criterion, the public transport modes are underground electric train, skytrain, bus and ferryboat. There are six districts have all types of transportation. Moreover, there are not all type of transportation in 25 districts.

For the regulation criterion, the GMP strict for the condition of drug distribution center, whereas that not limited the location. The regular of transportation is shown in Table B.8. The truck can reach into 13 districts all time, while the other districts, the truck can reach sometime.

Almost districts are supplied water and electrified. The Memorandum of Understanding of Pipeline Water Supply Emergency (MOU) is the project to supply the tap water to the non water area in Bangkok. So, 90% of the Bangkok area is water supply in MOU4. But electrified is supplied all area in Bangkok (Alternative Energy and Efficiency Information Center, 2011).

The number of hospitals in Bangkok are 28 government hospitals and 95 private hospitals. The hospitals are in all districts except Bangkok Yai, Khlong Sam Wa, PhraKhanong, PhraNakhon, Taling Chan, ThungKhru and Yan Nawa.

While, all districts have the signal of 3G internet for receiving information. The internet data was collected before 19 July, 2013. The 19 districts is in the 46.4% of all occurrence crime in Bangkok but 31 districts is in the area that less than 30% of all occurrence crime. Half of all districts are located over three drug distribution center but drug distribution center is not in 24 districts.

For flooded management criterion, the Royally-Initiated Bangkok Flood Dyke is in 24 districts-the Eastern Bangkok Flood Dyke is in 18 districts and the Western Bangkok Flood Dyke is in 6 districts. The seven completed drainage tunnels are Drainage tunnel from Makkasan Pond to the Chao Phraya River, Rama IX-Ramkhamhaeng drainage tunnel, Drainage tunnel at Soi Sukhumvit 26, Drainage tunnel at Soi Sukhumvit 36, Drainage tunnel at Soi Sukhumvit 42, Drainage tunnel at Prem Prachakon Canal, and Drainage system at Phaya Thai District and three drainage tunnels in the future projects are Drainage tunnel beneath Bang Sue Canal, Drainage tunnel from Nong Bon Pond to the Chao Phraya River, and Drainage tunnel at Bang Khen Canal. The future projects are in ten districts and eight districts have these completed drainage tunnels. The height of 31 districts area less than one meter, nine districts are 1-2 meter, and the others are over 2 meter from the mean sea level.

The country planning laws classify the usage of land into eight categories - housing land, commercial land (red zone), Industrial land (purple zone), Warehouse land (violet zone), rural preservation and agriculture land (White with frame and green bias zone), Rural and agricultural land (green zone), conservation and promotion of Thai Culture land (Light brown zone), and government institutions, public assistance and infrastructures land (blue zone) (see in Appendix B). The housing land divided into three levels – low (yellow zone), medium (orange zone), and high residential density (brown zone). The distribution center forbidden construct into low residential density land, rural preservation and agriculture land, and conservation and promotion of Thai Culture land. All area of low residential density land is in 21 districts and all area of conservation and promotion of Thai Culture land is in 12 districts. While, all area of rural preservation and agriculture land is in Bang Khae, Bang Khun Tian, Khlong Sam Wa, Lat Krabang, Min Buri, Nong Chok, Taling Chan and Thawi Watthana. These data use for the next step of methodology.

4.3 The evaluated location using fuzzy TOPSIS

In case using fuzzy TOPSIS, the 15 criteria are classified into cost criteria and best criteria. The cost criteria are cost, competition, and density of traffic while the

remaining criteria are the best criteria. However, the 15 criteria are classified to benefit criteria and cost criteria for using TOPSIS method. The benefit criteria are accessibility, connectivity to multimodal transport, regulations, labor, natural environment, infrastructure, demand, security, information technology, flooded management, topography, and country planning criteria. The cost criteria are cost, competition, and density of traffic.

The data for using fuzzy TOPSIS is the rating of criteria from experts' opinion and the rating of location. The linguistic definition of location used for rating the location is shown in Table 4.2.

Table 4.2 The linguistic definition of criteria.

Criteria	Linguistics	Meaning
1.Cost	Very poor	The maximum of land cost is 0-170,000 Bath/wah^2.
	Poor	The maximum of land cost is 170,001-340,000 Bath/ wah^2.
	Fair	The maximum of land cost is 340,001-510,000 Bath/ wah^2.
	Good	The maximum of land cost is 510,001-680,000 Bath/ wah^2.
	Very good	The maximum of land cost is >680,000 Bath/ wah^2.
2. National environment and its impact	Very poor	There are more than two conditions of dust 221-275 microgram/m^3, waste 281-350 ton/day, voice 81.1-83.5 decibel and 2 times flood history.
	Poor	There are more than two conditions of dust 166-220 microgram/m^3, waste 211-280 ton/day, voice 78.6-81.0 decibel and 2 times flood history.
	Fair	There are more than two conditions of dust 111 - 165 microgram/m^3, waste 151-210 ton/day, voice 76.1-78.5 decibel and one times flood history.

Table 4.2 The linguistic definition of criteria (cont.)

Criteria	Linguistics	Meaning
2. National environment and its impact (cont.)	Good	There are more than two conditions of dust 56 - 110 microgram/m^3, waste 75-150 ton/day, voice 73.6-76.0 decibel and one times flood history.
	Very good	There are more than two conditions of dust 0-55 microgram/m^3, waste <75 ton/day, voice 71.0-73.5 decibel and not flood history.
3.Accessibility	Very poor	There is the bus only.
	Poor	There are the bus and one types of accessibility - the underground electric train, skytrain, or piers.
	Fair	There are the bus and two types of accessibility - the underground electric train, skytrain, piers or bus.
	Good	There are four types of accessibility - the underground electric train, skytrain, piers and bus.
	Very good	There are four types of accessibility and all types are more one - the underground electric train, skytrain, piers or bus.
4. Labor	Very poor	The numbers of labor are <26,000 persons.
	Poor	The numbers of labor are 26,001-54,000 persons.
	Fair	The numbers of labor are 54,001-82,000 persons.
	Good	The numbers of labor are 82,001-110,000 persons.
	Very good	The numbers of labor are >110,001persons.
5.Connectivity to multimodal transport	Very poor	There is no train, the expressway entrance or the expressway exit.
	Poor	There is one type of multimodal transport - train, the expressway entrance or the expressway exit.
	Fair	There are two type of multimodal transport - train, the expressway entrance or the expressway exit.
	Good	There are three type of multimodal transport - train, the expressway entrance or the expressway exit.

Table 4.2 The linguistic definition of criteria (cont.)

Criteria	Linguistics	Meaning
5.Connectivity to multimodal transport	Very good	There are three type of multimodal transport and all types are more one - train, the expressway entrance or the expressway exit.
6. Government and regulations	Very poor	The truck cannot reach into the district all time.
	Poor	The 10-wheel truck cannot reach into all district at 6.21 a.m. to 9.00 p.m.
	Fair	The 10-wheel truck cannot reach into part of district at 6.21 a.m. to 9.00 p.m.
	Good	The 6-wheel truck or more cannot reach into district at 6.00 a.m. to 9.00 a.m. and 4.00 p.m. to 8.00 p.m.
	Very good	The truck can reach into the district all time.
7.Competition	Very poor	The number of drug distribution center is 0.
	Poor	The number of drug distribution center is 1.
	Fair	The number of drug distribution center is 2.
	Good	The number of drug distribution center is 3.
	Very good	The number of drug distribution center is >3.
8.Demand	Very poor	The number of hospital is 0-1.
	Poor	The number of hospital is 2-3.
	Fair	The number of hospital is 4-5.
	Good	The number of hospital is 6-7.
	Very good	The number of hospital is >8.
9.Infrastructure	Very poor	There are no water and electricity supply in district.
	Poor	There are no water or electricity supply in district.
	Fair	The area is in the 3rd and 4th Memorandum of Understanding of Pipeline water supply emergency.

Table 4.2 The linguistic definition of criteria (cont.)

Criteria	Linguistics	Meaning
9.Infrastructure (cont.)	Good	The area is in the 1st and 2nd Memorandum of Understanding of Pipeline water supply emergency.
	Very good	There are >95% of water and electricity supply in district.
10.Density of traffic	Very poor	The average traffic volume is >21,260 vehicles/day
	Poor	The average traffic volume is 21,261-42,520 vehicles/day
	Fair	The average traffic volume is 42,521-63,780 vehicles/day
	Good	The average traffic volume is 63,781-85,040 vehicles/day
	Very good	The average traffic volume is 85,041-106,300 vehicles/day
11.Security	Very poor	The district occurred crime >56.0%.
	Poor	The district occurred crime during 42.1-56.0%.
	Fair	The district occurred crime during 28.1-42.0%.
	Good	The district occurred crime during 14.1-28.0%.
	Very good	The district occurred crime during 0-14.0%.
12.Information technology	Very poor	No signal of 3G internet in district.
	Poor	The signal strength of 3G internet is poor.
	Fair	The signal strength of 3G internet is fair.
	Good	The signal strength of 3G internet is good.
	Very good	The signal strength of 3G internet is good all area.
13.Flooded management	Very poor	No a drainage tunnel or a Royally-Initiated Bangkok Flood Dyke in district.
	Poor	There is a drainage tunnel or a Royally-Initiated Bangkok Flood Dyke in district.

Table 4.2 The linguistic definition of criteria (cont.)

Criteria	Linguistics	Meaning
13.Flooded management (cont.)	Fair	There are two drainage tunnels or Royally-Initiated Bangkok Flood Dyke in district.
	Good	There are three drainage tunnels or the Royally-Initiated Bangkok Flood Dyke in district.
	Very good	There are four drainage tunnels or the Royally-Initiated Bangkok Flood Dyke in district.
14.Topography	Very poor	The elevation is less than 0.5 meter above mean sea level.
	Poor	The elevation is 0.5-1 meter above mean sea level.
	Fair	The elevation is 1-1.5 meter above mean sea level.
	Good	The elevation is 1.5-2 meter above mean sea level.
	Very good	The elevation is over 2 meter above mean sea level.
15.Country planning	Very poor	The forbidden DC area in country planning is 81-100%.
	Poor	The forbidden DC area in country planning is 61-80%.
	Fair	The forbidden DC area in country planning is 41-60%.
	Good	The forbidden DC area in country planning is 21-40%.
	Very good	The forbidden DC area in country planning is 0-20%.

The number of districts from rating location of each criterion is shown in Figure 4.2. The ratings of mostly districts are fair for the natural environment, labor, and information technology criteria. But all districts rating in accessibility, connectivity to multimodal transport, flood management, cost, competition criteria are very poor. Many districts are rated poor in demand, security and topography criteria.

Only regulation criterion, many districts rating are good. Three criteria-infrastructure, country planning and density of traffic are very good for mostly rating of all districts.

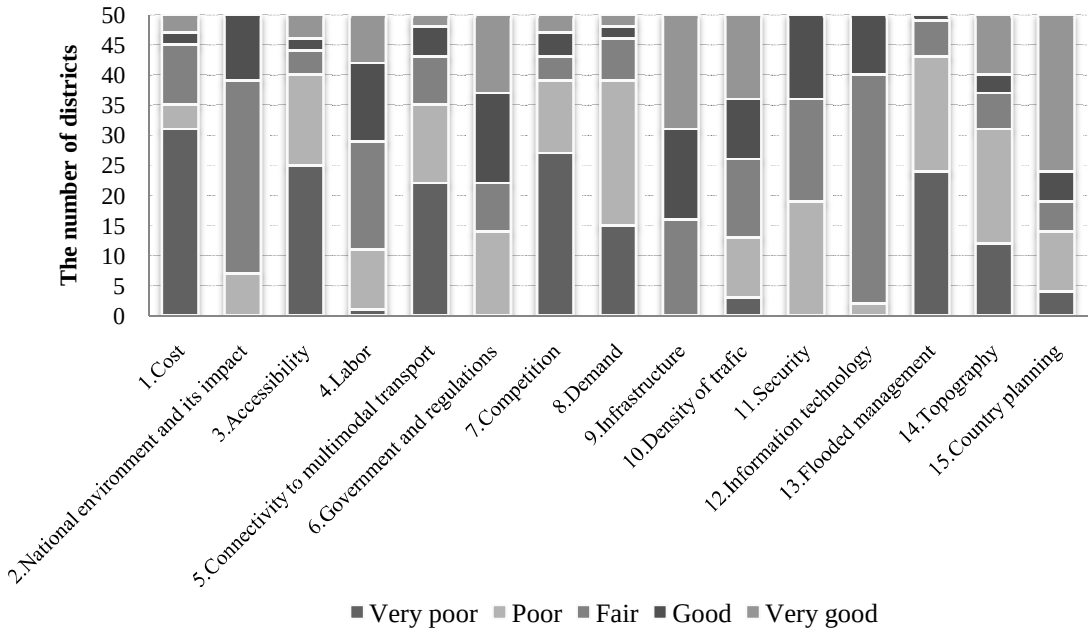


Figure 4.2 The number of districts to each criteria

The closeness coefficients are present in Appendix F. The ranking order of 50 districts from the experts' opinion is shown in Table 4.3. The top five ranking orders are Phasi Charoen, Chom Thong, Bang Sue, Lak Si and Bangkok Noi. However, the closeness coefficients of Phasi Charoen, Chom Thong and Bang Sue are not significantly difference. The selected location could be any district always the three districts. From the real situation happened in 2011, Phasi Charoen was flooded in all sub-district. The reason was that the major causes of the flooding problem during that time were the very heavy rainfall combined with government management on the flood way to these areas. The human managed situation is not predictable, therefore, Phasi Charoen, Chom Thong and Bang Sue was away the flood area in 2011.

Table 4.3 The ranking of districts for location drug distribution center

Ranking	Districts	Ranking	Districts
1	Phasi Charoen	26	Min Buri
2	Chom Thong	27	Chatuchak
3	Bang Sue	28	Nong Chok
4	Lak Si	29	Saphan Sung
5	Bangkok Noi	30	Bang KhoLaem
6	Bang Bon	31	Suan Luang
7	Bang Khun Thian	32	Taling Chan
8	Pathum Wan	33	Dusit
9	Phaya Thai	34	Don Mueang
10	Rat Burana	35	Thon Buri
11	Bang Na	36	BuengKum
12	Bangkok Yai	37	LatKrabang
13	Bang Rak	38	Khan Na Yao
14	Huai Khwang	39	LatPhrao
15	Khlong Toei	40	Phra Khanong
16	Nong Khaem	41	Pom Prap Sattru Phai
17	Bang Khae	42	Wang Thonglang
18	Thawi Watthana	43	Yan Nawa
19	Sathon	44	Prawet
20	Ratchathewi	45	Bang Phlat
21	Sai Mai	46	Samphanthawong
22	Bang Khen	47	Bang Kapi
23	Thung Khru	48	Din Daeng
24	Khlong Sam Wa	49	Khlong San
25	Watthana	50	Phra Nakhon

4.4 Sensitivity analysis

The impact of criteria weight is testing by sensitivity analysis. For this research, the 20 experiments are used to sensitivity analysis. The weights of all criteria are equal for five experiments. These experiments use to find the location where the

importances of all criteria are equal. The other experiments are set one criterion as the highest weight and the remaining criteria as the lowest weight. The criterion which the highest weight is more than important to the other criteria. The ranking of all districts are present in Appendix G.

Table 4.4 reports the top five ranking from sensitivity analysis. Phasi Charoen district is the best location in the equal weight of all criteria, highest weight of national environment and its impact criterion, highest weight of government and regulations criterion, highest weight of security criterion, highest weight of information technology criterion, highest weight of country planning criterion, highest weight of cost criterion and highest weight of competition criterion. Thus, if these criteria are important, Phasi Charoen district is chosen for drug distribution center location. However, the top five ranking orders from experts' opinion are the same of location in high and very high weight of all criteria.

In 2008, the maximum number of drug distribution centers from 50 districts is six in Huai Khwang district (Infopharma Media Services, 2008). That's similar location in the highest weight of demand criterion. Thus, the important criterion for decision location in the past is demand criterion.

Table 4.4 The top five ranking of districts for location drug distribution center

Experiment	Ranking				
	1	**2**	**3**	**4**	**5**
All criteria are very low	Phasi Charoen	Bang Sue	Chom Thong	Lak Si	Bang Bon
All criteria are low	Phasi Charoen	Chom Thong	Bang Sue	Lak Si	Bang Bon
All criteria are medium	Phasi Charoen	Chom Thong	Bang Sue	Lak Si	Bang Bon
All criteria are high	Phasi Charoen	Chom Thong	Bang Sue	Lak Si	Bangkok Noi
All criteria are very high	Phasi Charoen	Chom Thong	Bang Sue	Lak Si	Bangkok Noi

Table 4.4 The top five ranking of districts for location drug distribution center (cont.)

Experiment	Ranking				
	1	2	3	4	5
The highest weight of national environment and its impact	Phasi Charoen	Bangkok Yai	Bang Rak	Bang Sue	Chom Thong
The highest weight of accessibility	Pathum Wan	Bang Rak	Ratchathewi	Watthana	Bang Sue
The highest weight of labor	Bang Khun Thian	Phasi Charoen	Bang Khae	Bang Sue	Chom Thong
The highest weight of connectivity to multimodal transport	Pathum Wan	Chatuchak	Phaya Thai	Suan Luang	Huai Khwang
The highest weight of government and regulations	Phasi Charoen	Chom Thong	Lak Si	Rat Burana	Nong Khaem
The highest weight of demand	Huai Khwang	Ratchathewi	Phaya Thai	Watthana	Bangkok Noi
The highest weight of infrastructure	Bang Sue	Bangkok Noi	Phasi Charoen	Pathum Wan	Phaya Thai
The highest weight of security	Phasi Charoen	Bang Bon	Bangkok Noi	Bang Khun Thian	Nong Khaem
The highest weight of flooded management	Khlong Toei	Bang Na	Phaya Thai	Huai Khwang	Chom Thong
The highest weight of topography	Bang Sue	Lak Si	Phaya Thai	Bang Rak	Sathon

Table 4.4 The top five ranking of districts for location drug distribution center (cont.)

Experiment	Ranking				
	1	2	3	4	5
The highest weight of country planning	Phasi Charoen	Bang Sue	Chom Thong	Bang Bon	Bangkok Noi
The highest weight of cost	Phasi Charoen	Chom Thong	Lak Si	Bang Bon	Bangkok Noi
The highest weight of competition	Phasi Charoen	Chom Thong	Lak Si	Bang Bon	Bang Khun Thian
The highest weight of density of traffic	Bangkok Yai	Thawi Watthana	Phasi Charoen	Khlong Sam Wa	Bang Sue

Pathum Wan district is selected the best location for accessibility and highest weight of connectivity to multimodal transport criterion as significant criterion. If the labor criterion is important, Bang Khun Thian district is proper to located. In addition, this district is the fifth ranking of the highest weight of security and competition criterion cases. Bang Sue district is the best of location in case of the highest weight of infrastructure and topography, the third ranking in case of the experts' opinion and highest weight of country planning criterion, the third ranking in case of equal weight criteria, the fourth ranking in case of the highest weight of national environment and its impact, labor and information technology criteria, and the fifth ranking in case of highest weight of accessibility and density of traffic criterion. Not only Huai Khwang district is the best location for the highest weight of demand criterion, but also the fourth ranking for the highest weight of flooded management criterion and the fifth ranking for the highest weight of connectivity to multimodal transport criterion. Khlong Toei district is proper to selected the best location for the highest weight of flooded management criterion only. Besides, Bangkok Yai district is the best location for the highest weight of density of traffic criterion and the second ranking for the highest weight of national environment and its impact criterion. However, the results of sensitivity base the weight of each criterion on the best district location.

4.5 Drug distribution center location selection program

The step for using this program are as follows:

Step 1: Weight the criteria

The user weights the criteria into the first tab of program “Criteria weight” (Figure 4.3). The program used the abbreviations of weight which very high is VH, high is H, medium is M, low is L and very low is VL for calculation fuzzy TOPSIS. Then, click “NEXT” to weight the location.

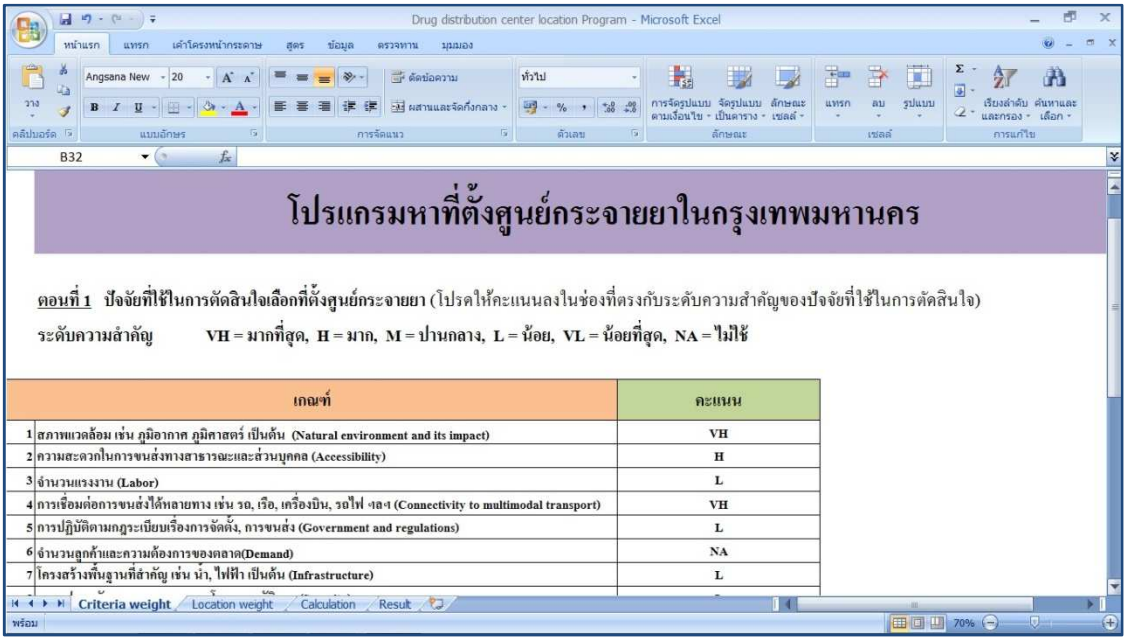
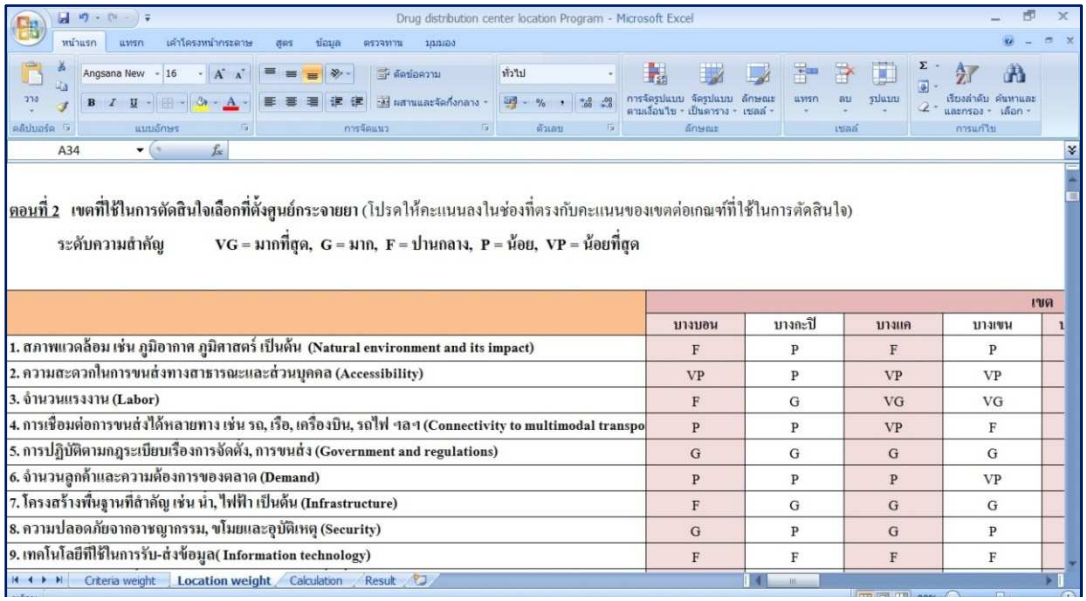


Figure 4.3 Weight the criteria

Step 2: Weight the districts on each criteria

The 50 districts were weight into 15 criteria in this step. The user weights the location into the second tab of program “Location weight” (Figure 4.4). The abbreviations of weight which very good is VG, good is G, fair is F, poor is P and very poor is VP was used for weight location. When the step of weight the location is finish, press “CALCULATION” for the result step-by-step of fuzzy TOPSIS or press “RESULT” for the ranking of the best location (Figure 4.5).



ตอนที่ 2 เขตที่ใช้ในการตัดสินใจเลือกที่ตั้งศูนย์กระจายยา (โปรดให้คะแนนลงในช่องที่ตรงกับคะแนนของเขตต่อเกณฑ์ที่ใช้ในการตัดสินใจ)

ระดับความสำคัญ VG = มากที่สุด, G = มาก, F = ปานกลาง, P = น้อย, VP = น้อยที่สุด

	เขต				
	บางบอน	บางกะปิ	บางแค	บางเขน	1
1. สภาพแวดล้อม เช่น ภูมิอากาศ ภูมิศาสตร์ เป็นต้น (Natural environment and its impact)	F	P	F	P	
2. ความสะดวกในการขนส่งทางสาธารณะและส่วนบุคคล (Accessibility)	VP	P	VP	VP	
3. จำนวนแรงงาน (Labor)	F	G	VG	VG	
4. การเชื่อมต่อการขนส่งได้หลายทาง เช่น รถ, เรือ, เครื่องบิน, รถไฟ ฯลฯ (Connectivity to multimodal transpo	P	P	VP	F	
5. การปฏิบัติตามกฎระเบียบเรื่องการจัดตั้ง, การขนส่ง (Government and regulations)	G	G	G	G	
6. จำนวนลูกค้าและความต้องการของตลาด (Demand)	P	P	P	VP	
7. โครงสร้างพื้นฐานที่สำคัญ เช่น น้ำ, ไฟฟ้า เป็นต้น (Infrastructure)	F	G	G	G	
8. ความปลอดภัยจากอาชญากรรม, ขโมยและอุบัติเหตุ (Security)	G	P	G	P	
9. เทคโนโลยีที่ใช้ในการรับ-ส่งข้อมูล(Information technology)	F	F	F	F	

Criteria weight | Location weight | Calculation | Result

Figure 4.4 Weight the districts on each criteria 1

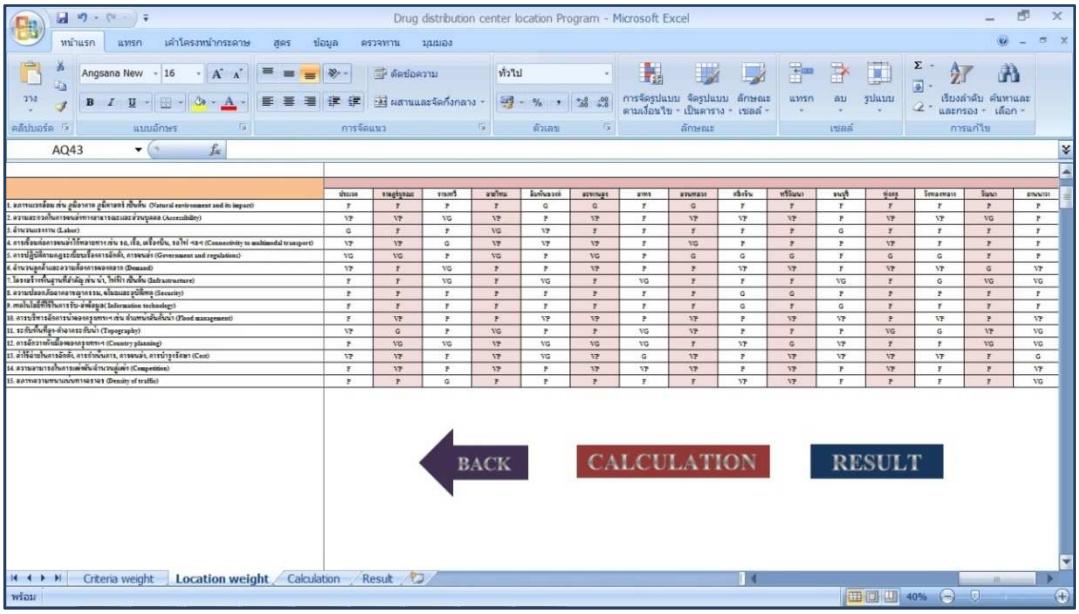


Figure 4.5 Weight the districts on each criteria 2

Step 3: Calculation by fuzzy TOPSIS

When the weights of criteria and locations have been filled, the program will automatically calculate and illustrate the results. The result of fuzzy TOPSIS step-

by-step is shown on the page of “Calculation” (Figure 4.6). On the end of page, press “RESULT” for the ranking of the best location (Figure 4.7).

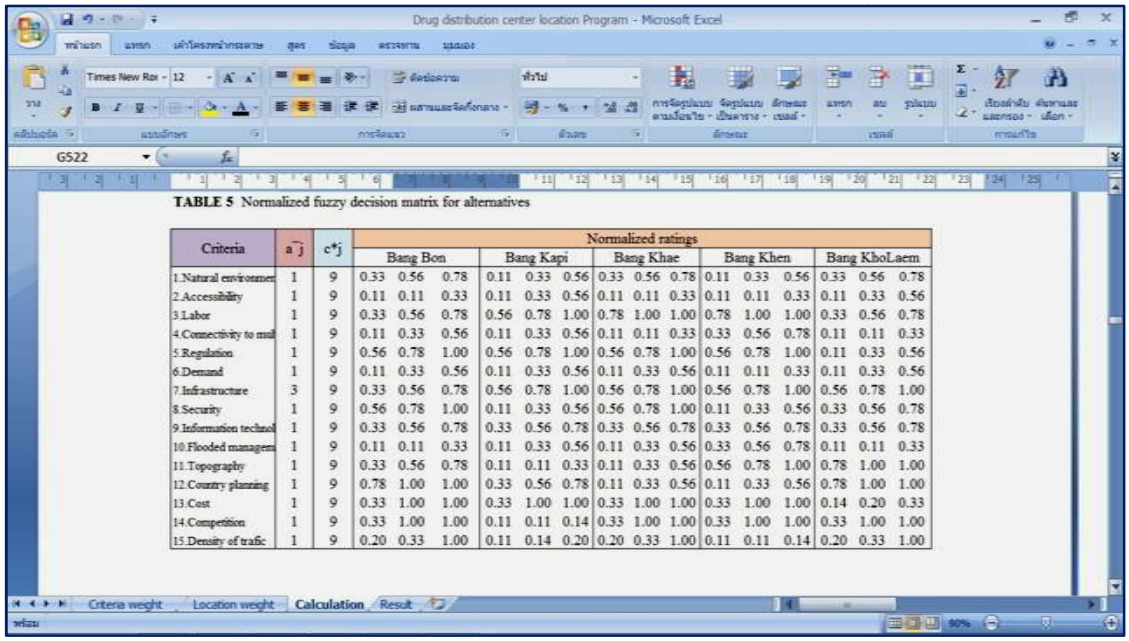


Figure 4.6 Calculation by fuzzy TOPSIS 1

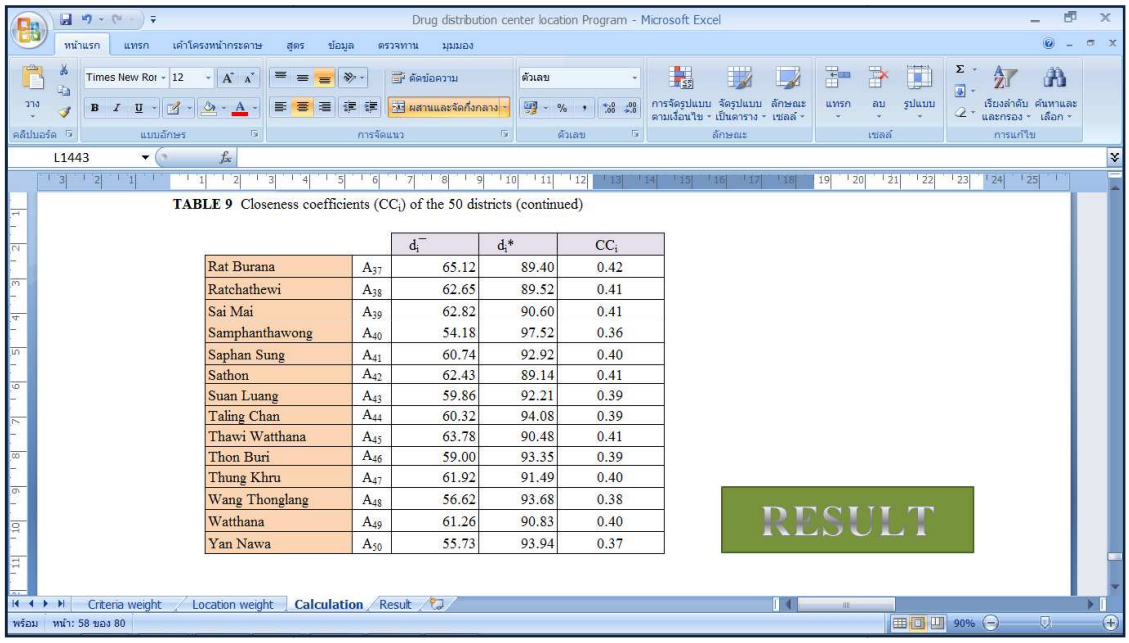


Figure 4.7 Calculation by fuzzy TOPSIS 2

Step 4: The result of location

The page is shown the closeness coefficient (CC_i) and the ranking of 50 districts for establishing a drug distribution center (Figure 4.8).

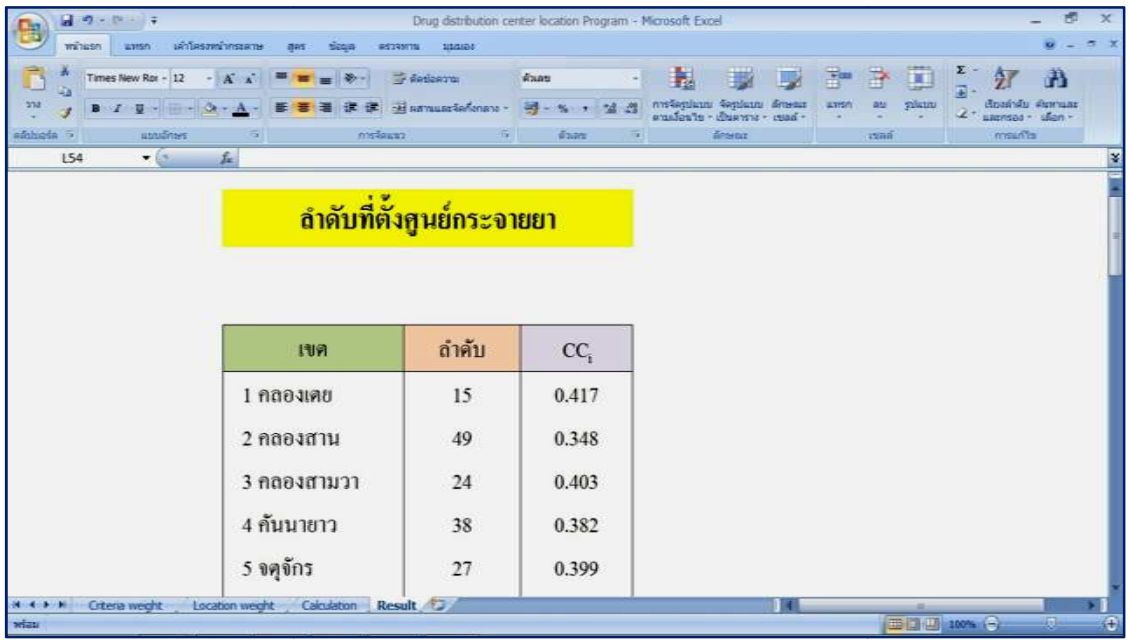


Figure 4.8 The result of location

Therefore, Phasi Charoen district is the best to establish a drug distribution center by using fuzzy TOPSIS. The best location is chosen from the value of closeness coefficient which is the highest. In the real situation in the flooding 2011, the propose location is Chom Thong and Bang Sue.

CHAPTER V
CONCLUSION

This research studied the possible location drug distribution centers which are still able to operate during flood crisis. The possible location for 50 districts was selected among Bangkok. The objectives of this study are to identify the essential criteria for selecting a drug distribution center location and to propose the best district in Bangkok for establishing a drug distribution center which can still operate during flood crisis. The 25 general criteria and 29 healthcare criteria were combined from literature review. These criteria are grouped into 12 criteria and 3 criteria are added from the experts. The final essential criteria for selecting a drug distribution center location include cost, natural environment and its impact, accessibility, labor, connectivity to multimodal transport, government and regulations, competition, demand, infrastructure, density of traffic, security, information technology, flooded management, topography and country planning. Then the experts were asked to rate each criteria ranging from 1(very low) to 5(very high). Data of each district location were identified and collected. Then, these districts were evaluated by fuzzy TOPSIS. The possible location was the highest closeness coefficient (CC_i).

The important criteria are accessibility, cost, connectivity to multimodal transport, and flooded management. The best location from the experts' opinion calculated by fuzzy TOPSIS is Phasi Charoen district. However, the closeness coefficients of Phasi Charoen, Chom Thong and Bang Sue are not significantly difference. The selected location could be any district always the three districts.

However, when sensitivity analysis was conducted, the results of best location from each criterion are varied. Based on natural environment and its impact, government and regulations, security, information technology, cost and competition, the best is Phasi Charoen district. Based on accessibility and connectivity to multimodal transport, the best is Pathum Wan district. Based on labor, the best is Bang

Khun Thian district. Based on demand, the best is Huai Khwang. Based on infrastructure and topography, the best is Bang Sue district. Based on density of traffic, the best is Bangkok Yai district. Based on flooded management, the best is Khlong Toei.

The third, the criteria weights impact to the best location are investigated by sensitivity analysis. Then, the criteria weights change, the best location is also different district.

In summarize, the research methodology applied in this study can be used further to find the most suitable location for other businesses. The criteria should be identified both in general and specifically for the business and its products. The Fuzzy-TOPSIS can also be applied to search for the best location. Finally, sensitivity analysis helps to suggest the best location for different condition.

Suggestion for future research includes the application of this research methodology in other business. The study of smaller areas under district and their comparisons should be connected in order to get specific area for establishing drug distribution center in the real situation. The application of other decision-making methodology can also be conducted to compare the results.

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APPENDICES

APPENDIX A

NUMBER OF HOSPITALS BY TYPE AND PROVINCE

Table A.1 The number of hospitals by type and province

Source : Bureau of Health Policy and Planning (2010)

Province	Number of hospitals			
	Ministry of Public Health hospital	Other government hospital	Private hospital	Total
Bangkok	5	23	95	123
Amnat Charoen	7	-	-	7
Ang Thong	7	1	1	9
Buriram	22	1	2	25
Chachoengsao	10	-	2	12
Chainat	6	-	1	7
Chaiyaphum	15	-	2	17
Chanthaburi	12	-	2	14
Chiang Mai	33	9	13	55
Chiang Rai	17	1	2	20
Chonburi	13	7	11	31
Chumphon	11	3	3	17
Kalasin	14	-	1	15
Kamphaeng Phet	11	-	2	13
Kanchanaburi	15	1	4	20
Khon Kaen	26	6	3	35
Krabi	8	-	1	9
Lampang	14	2	2	18
Lamphun	7	1	2	10
Loei	17	1	2	20
Lopburi	12	2	2	16
Mae Hong Son	8	-	-	8
Maha Sarakham	11	1	1	13
Mukdahan	7	1	1	9
Nakhon Nayok	4	4	-	8

Table A.1 The number of hospitals by type and province (cont.)

Province	Number of hospitals			
	Ministry of Public Health hospital	Other government hospital	Private hospital	Total
Nakhon Pathom	10	3	4	17
Nakhon Phanom	12	2	-	14
Nakhon Ratchasima	31	4	8	43
Nakhon Sawan	16	2	7	25
Nakhon Si Thammarat	20	4	4	28
Nan	14	2	-	16
Narathiwat	13	-	-	13
Nong Bua Lamphu	6	1	1	8
Nong Khai	14	-	3	17
Nonthaburi	10	2	6	18
Pathum Thani	10	1	7	18
Pattani	13	2	-	15
Phang Nga	10	2	-	12
Phatthalung	10	-	2	12
Phayao	7	1	1	9
Phetchabun	11	2	3	16
Phetchaburi	8	1	3	12
Phichit	9	-	4	13
Phitsanulok	9	3	6	18
Phrae	8	-	2	10
Phra Nakhon Si Ayuttaya	16	-	4	20
Phuket	3	-	3	6
Prachinburi	7	2	1	10
Prachuap Khiri Khan	8	2	2	12
Ranong	5	-	1	6
Ratchaburi	9	1	4	14
Rayong	9	3	3	15
Roi Et	17	1	2	20
Sa Kaeo	6	3	-	9
Sakhon Nakhon	18	1	1	20
Samut Prakan	7	2	18	27
Samut Sakhon	2	2	7	11
Samut Songkhram	3	-	1	4

Table A.1 The Number of hospitals by type and province (cont.)

Province	Number of hospitals			
	Ministry of Public Health hospital	Other government hospital	Private hospital	Total
Saraburi	13	1	4	18
Satun	6	-	-	6
Si Saket	19	-	1	20
Singburi	6	-	1	7
Songkhla	18	6	5	29
Sukhothai	9	1	3	13
Suphan Buri	10	-	5	15
Surat Thani	22	3	7	32
Surin	14	1	2	17
Tak	9	2	-	11
Trang	10	1	3	14
Trat	7	-	1	8
Ubon Ratchathani	24	3	3	30
Udon Thani	20	3	3	26
Uthai Thani	8	-	-	8
Uttaradit	9	1	-	10
Yala	8	-	1	9
Yasothon	9	1	2	12
Total	**881**	**136**	**304**	**1,321**

APPENDIX B
THE CRITERIA DATA OF 50 DISTRICTS

Table B.1 The hospitals in 50 districts

Source : Bureau of Health Policy and Strategy (2010)

District	Government hospital	Private hospital
1. Bang Bon	-	- Bangpakok 2 Hospital - Bangpakok 8 Hospital
2. Bang Kapi	-	- Navasri Nursing Home Hospital - Ramkhamhaeng Hospital - Vejthani Hospital
3. Bang Khae	- Ratchaphiphat Hospital	- Kasemrad Hospital Bangkae
4. Bang Khen	-	- Central General Hospital
5. Bang KhoLaem	- Charoenkrung Pracharak Hospital	-Thai Eye Center
6. Bang KhunThian	-	- Bangmod 2 Hospital - Bangmod 3 Hospital - Nakornthon Hospital - Praram 2 Hospital
7. Bang Na	-	- Bangna General Hospital - Kluaynamthai 2 Nursing Home - Manarom Hospital - Sikarin Hospital
8. Bang Phlat	-	- Eye Ear Nose Throat Hospital - Sang Hee Hospital - Yanhee Hospital

Table B.1 The hospitals in 50 districts (cont.)

District	Government hospital	Private hospital
9. Bang Rak	- Lerdsin Hospital	- Bangkok Christian Hospital - BNH Hospital - Mahesak Hospital
10. Bang Sue	-	- Bangpo General Hospital - Kasemrad Hospital Prachachuen
11. Bangkok Noi	- Siriraj Hospital	- Chaophya Hospital - Srivichai 1 Hospital - Thonburi Hospital
12. Bangkok Yai	-	-
13. Bueng Kum	-	- Paolo Memorial Hospital Nawamin - Srisiam Hospital
14. Chatuchak	-	- Mayo Hospital (Thailand) - The Senior Health Care - Vibhavadi Hospital
15. Chom Thong	-	- Bangkhunthian Health Center - Bangmod Hospital - Bangpakok 9 International Hospital
16. Din Daeng	-	- Sutthisan Hospital
17. Don Mueang	- Bhumibol Adulyadej Hospital	-
18. Dusit	- Vajira Hospital	- Bangkok Adventist Hospital
19. Huai Khwang	-	- Asoke Skin Hospital - Bangkok Hospital - Bangkok International Hospital - Golden Years Hospital

Table B.1 The hospitals in 50 districts (cont.)

District	Government hospital	Private hospital
19. Huai Khwang (cont.)	-	- Klongtun Medical Center - Petcharavej Hospital - Piyavate Hospital - Praram 9 Hospital - Wattanosoth Cancer hospital
20. Khan Na Yao	- Nopparat Rajathanee Hospital	- Synphaet Hospital
21. Khlong Sam Wa	-	-
22. Khlong San	- Somdet Chaopraya Institute of Psychiatry - Taksin Hospital	-
23. Khlong Toei	- Thailand Tobacco Monopoly Hospital	- Kluaynamthai Hospital - Theptarin Hospital
24. Lak Si	- Chulabhorn Hospital	- Mongkutwattana General Hospital
25. Lat Krabang	- Bangkok Metropolitan Administration - Lat Krabang Hospital	-
26. LatPhrao	-	- Paolo Memorial Hospital Chokchai 4 - Sena Vetchakarn Hospital
27. Min Buri	-	- Navaminthra 9 Hospital - Navaminthra Hospital - Seriruk Hospital
28. Nong Chok	- Wetchakarunrasm	-
29. Nong Khaem	- Luang Pho Taweesak Hospital	- Srivichai 2 Hospital
30. Pathum Wan	- King Chulalongkorn Memorial Hospital	- Jetanin Institute for Assisted Reproduction

Table B.1 The hospitals in 50 districts (cont.)

District	Government hospital	Private hospital
30. Pathum Wan (cont.)	- Police General Hospital - Thai Red Cross Relief and Public Health Bureau	
31. Phasi Charoen	-	- Bang Phai Hospital - Petkasem 2 Hospital - Phyathai 3 Hospital
32. Phaya Thai	- Prasarnmit Hospital - Veterans General Hospital	- Bangkok Cancer Center Hospital - Decha Hospital - Paolo Memorial Hospital Phaholyothin - Vichaiyut Hospital
33. Phra Khanong	-	-
34. Phra Nakhon	-	-
35. Pom Prap Sattru Phai	- Klang Hospital	- Hua Chiew Hospital - Angkhatha Wanit Hospital
36. Prawet	- Sirindhorn Hospital	-
37. Rat Burana	-	- Bangpakok 1 Hospital - Krungdhon 2 Hospital - Nawamin 2 Hospital - RajBurana Hospital
38. Ratchathewi	- Hospital for Tropical Diseases - Phramongkutklao Hospital - Rajavithi Hospital - Ramathibodi Hospital	- Phyathai 1 Hospital - Phyathai 2 Hospital - Deja General Hospital
39. Sai Mai	-	- B.Care Medical Center - Saimai Hospital

Table B.1 The hospitals in 50 districts (cont.)

District	Government hospital	Private hospital
40. Samphanthawong	-	- Kwongsiew Foundation Hospital - Thian Fah Foundation Hospital
41. Saphan Sung	-	- Kasemrad Hospital Sukhapibal 3
42. Sathon	- Manchakiri hospital	- Saint Louis Hospital
43. Suan Luang	-	- Dr. Panya General Hospital - Samitivej Srinakarin Hospital - Vibharam Hospital
44. Taling Chan	-	-
45. Thawi Watthana	-	- Thonburi 2 Hospital
46. Thon Buri	- Somdejprapinklao Hospital	- Krungdhon 1 Hospital - Ratchada-Tha Phra Health Centre - Yaowarak Hospital
47. Thung Khru	-	-
48. Wang Thonglang	-	- Ladprao General Hospital
49. Watthana	-	- Bumrungrad International Hospital - Camillian Hospital - Rutnin Eye Hospital - Samitivej Sukhumvit Hospital - Sukhumvit Hospital
50. Yan Nawa	-	-

Table B.2 The land cost, dust, waste, voice and labor in 50 districts

Source : Bureau of Property Valuation (2012), Strategy and Evaluation Department (2012)

District	Maximum of land cost (Bath/wah^2)	Dust (PM_{10})	Waste (Ton/day)	Voice (decibel)	Labor (persons)
1. Bang Bon	70,000	103	186.04	76.5	71,861
2. Bang Kapi	160,000	171	284.14	74.2	101,956
3. Bang Khae	150,000	89	256.16	77.2	131,883
4. Bang Khen	150,000	172	237.12	78.8	129,123
5. Bang Kho Laem	450,000	123	124.86	77.6	66,136
6. Bang Khun Thian	90,000	119	255.11	77.0	110,871
7. Bang Na	170,000	112	190.62	80.2	66,559
8. Bang Phlat	170,000	145	142.62	74.4	68,809
9. Bang Rak	850,000	107	151.23	75.3	31,611
10. Bang Sue	220,000	274	157.48	74.3	92,598
11. Bangkok Noi	170,000	87	183.68	77.2	82,330
12. Bangkok Yai	150,000	105	87.87	78.0	50,664
13. Bueng Kum	95,000	144	152.75	76.4	100,277
14. Chatuchak	200,000	119	334.80	77.3	110,711
15. Chom Thong	130,000	142	191.96	78.0	108,816
16. Din Daeng	350,000	84	230.80	76.0	90,434
17. Don Mueang	100,000	94	160.80	79.0	114,004
18. Dusit	400,000	87	175.63	73.8	74,637
19. Huai Khwang	350,000	112	150.60	75.0	53,308
20. Khan Na Yao	95,000	147	95.04	79.0	59,790
21. Khlong Sam Wa	38,000	189	130.31	77.0	113,416
22. Khlong San	215,000	180	121.71	78.0	53,138
23. Khlong Toei	400,000	115	280.04	78.7	75,779
24. Lak Si	140,000	112	146.53	73.6	76,218
25. Lat Krabang	35,000	170	199.78	77.0	110,328
26. Lat Phrao	80,000	149	156.21	75.5	83,804
27. Min Buri	75,000	194	169.32	75.0	93,445
28. Nong Chok	24,000	156	88.22	72.0	105,884

Table B.2 The land cost, dust, waste, voice and labor in 50 districts (cont.)

District	Maximum of land cost (Bath/wah^2)	dust (PM_{10})	Waste (Ton/day)	Voice (decibel)	Labor (persons)
29. Nong Khaem	150,000	101	163.78	77.6	101,718
30. Pathum Wan	800,000	92	216.93	79.0	37,722
31. Phasi Charoen	150,000	132	147.81	73.0	89,506
32. Phaya Thai	350,000	128	147.43	75.0	50,437
33. Phra Khanong	100,000	141	133.23	71.0	64,806
34. Phra Nakhon	400,000	136	190.80	72.9	40,311
35. Pom Prap Sattru Phai	500,000	101	86.74	78.1	35,731
36. Prawet	120,000	140	214.32	75.7	108,686
37. Rat Burana	110,000	124	119.09	78.3	60,251
38. Ratchathewi	400,000	250	171.97	76.3	50,002
39. Sai Mai	150,000	140	169.33	78.3	127,569
40. Samphanthawong	700,000	120	58.27	77.0	19,206
41. Saphan Sung	70,000	144	90.41	75.0	60,989
42. Sathon	600,000	123	158.04	76.2	59,135
43. Suan Luang	140,000	91	186.06	72.0	79,166
44. Taling Chan	185,000	113	114.35	77.5	73,245
45. Thawi Watthana	60,000	175	91.16	76.0	51,758
46. Thon Buri	165,000	86	162.61	77.7	83,364
47. Thung Khru	90,000	139	116.73	78.0	79,444
48. Wang Thonglang	130,000	164	195.85	77.6	78,936
49. Watthana	400,000	148	232.91	80.0	55,453
50. Yan Nawa	550,000	166	157.63	81.3	56,574

Table B.3 The station of sky electric train and the underground electric train in 50 districts

Source : Strategy and Evaluation Department (2012)

District	The station of sky electric train	The station of underground electric train
1. Bang Bon	-	-
2. Bang Kapi	-	-

Table B.3 The station of sky electric train and the underground electric train in 50 districts (cont.)

District	The station of sky electric train	The station of underground electric train
3. Bang Khae	-	-
4. Bang Khen	-	-
5. Bang KhoLaem	-	-
6. Bang Khun Thian	-	-
7. Bang Na	-	-
8. Bang Phlat	-	-
9. Bang Rak	- Sala Daeng Station - Chong Nonsi Station - Surasak Station - Saphan Taksin Station	- Sam Yan Station - Silom Station
10. Bang Sue	-	- Bang Sue station
11. Bangkok Noi	-	-
12. Bangkok Yai	-	-
13. BuengKum	-	-
14. Chatuchak	- Mo Chit Station	- Kamphaeng Phet Station - Lat Phrao Station - Phahon Yothin Station
15. Chom Thong	-	-
16. Din Daeng	-	- Ratchadaphisek Station - Sutthisan Station
17. Don Mueang	-	-
18. Dusit	-	-
19. Huai Khwang	-	- Phra Ram 9 Station - Thailand Cultural Centre Station
20. Khan Na Yao	-	-
21. Khlong Sam Wa	-	-

Table B.3 The station of sky electric train and the underground electric train in 50 districts (cont.)

District	The station of sky electric train	The station of underground electric train
22. Khlong San	- Krung Thon Buri Station - Wongwian Yai Station	-
23. Khlong Toei	- Nana Station - Asok Station - Phra Khanong Station - Phrom Phong Station - Thong Lo Station - On Nut Station - Ekkamai Station	- Khlong Toei Station - Queen Sirikit National Convention Centre Station
24. Lak Si	-	-
25. Lat Krabang	-	-
26. Lat Phrao	-	-
27. Min Buri	-	-
28. Nong Chok	-	-
29. Nong Khaem	-	-
30. Pathum Wan	- Siam Station - Chit Lom Station - Phloen Chit Station - National Stadium Station - Ratchadamri Station	- Hua Lamphong Station - Sam Yan Station - Silom Station
31. Phasi Charoen	-	-
32. Phaya Thai	- Saphan Khwai Station - Sanam Pao Station	-
33. Phra Nakhon	-	-
34. Phra Khanong	-	-
35. Pom Prap Sattru Phai	-	-
36. Prawet	-	-
37. Rat Burana	-	-

Table B.3 The station of sky electric train and the underground electric train in 50 districts (cont.)

District	The station of sky electric train	The station of underground electric train
38. Ratchathewi	- Ratchathewi Station - Victory Monument Station - Phaya Thai Station	- Petchaburi Station
39. Sai Mai	-	-
40. Samphanthawong	-	-
41. Saphan Sung	-	-
42. Sathon	- Surasak Station - Saphan Taksin Station	-
43. Suan Luang	-	-
44. Taling Chan	-	-
45. Thawi Watthana	-	-
46. Thon Buri	-	-
47. Thung Khru	-	-
48. Wang Thonglang	-	-
49. Watthana	- Nana Station - Asok Station - Phra Khanong Station - Phrom Phong Station - Thong Lo Station - On Nut Station - Ekkamai Station	- Sukhumvit Station
50. Yan Nawa	-	-

Table B.4 The number of piers and the bus number in 50 districts

Source : Strategy and Evaluation Department (2012), Traffic and Transportation Department (2012)

District	Piers	The bus number
1. Bang Bon	-	43, 120, 147, 167, 171

Table B.4 The number of piers and the bus number in 50 districts (cont.)

District	Piers	The bus number
2. Bang Kapi	9	8, 22, 36ก, 37ก, 40, ต43, 44, 48, 49, 80, 92, 94, 95, 95ก, 97, 98, 99, 100, 115, 117, 123, 143, 145, 150, 152, 172, 174, 178, 206, 501, 517, 520, 530, 550
3. Bang Khae	-	ต5, 7, 7ก, ต77, 79, 80ก, 91, 101, 123, 146, 147, 157, 165, 169, 171, 183, 509,
4. Bang Khen	-	ต13, 26, 34, 39, 42, ต55, 59, 81, 82, 95, 95ก, 107, 114, 116, 126, 129, 150, 154, 185, 188, 206, 503, 520, 522, 543, 554,
5. Bang Kho Laem	2	138, 140, 141, 142
6. Bang Khun Thian	-	ต7, ปอ.7, 68, 71, 73, 76, 105, 140, 141, 142, 147, 171, 172, 529, 558
7. Bang Na	-	2, 45, 45ก, 46, ต63, 102, 116, 129, 142, 507, 511, 536, 545
8. Bang Phlat	15	ปอ.พ.4, 18, 19, 28, 30, 56, 57, 66, 68, 79, 80, 108, 110, 123, 124, 127, 146, 157, 170, 174, 175, 177, 183, 203, 507, 511, 516, 542, 556
9. Bang Rak	7	1, 15, 16, 35, 36, 45, 45ก, 75, 76, 77, 93, 115,162, 163, 164, 177, 504, 514, 547
10. Bang Sue	4	5, 16, 30, 32, 33, 49, 50, 51, 52, 64, 65, 66, 67, 70, 90, 97, 117, 505, 511, 516
11. Bangkok Noi	15	7, 7ก, 19, 40, 42, 56, 57, 68, 80, 80ก, 81, 84, 80ก, 84ก, 89, 91, 91ก, 101, 108, 146, 147, 149, 157, 163, 164, 165, 169, 171, 175, 177, 509, 542, 547

Table B.4 The number of piers and the bus number in 50 districts (cont.)

District	Piers	The bus number
12. Bangkok Yai	11	26, 36ก, 60, 71, 73ก, 95, 95ก, 96, 115, 150, 156, 178, 501, 520,
13. BuengKum	2	ต10, ต12, ต14, 15, 24, 26, 30, 34, 39, 40, 44, 46, 47, 58, 59, 60, 61, 62, 67, 95, 101, 107, 111, 114, ต118, 119, 120, 126, 129, 185, 188, 206, 503, 522, 543, ต5 50
14. Chatuchak	-	7, 7ก, 19, 40, 42, 56, 57, 68, 80, 80ก, 81, 84, 80 ก, 84ก, 89, 91, 91ก, 101, 108, 146, 147, 149, 157, 163, 164, 165, 169, 171, 175, 177, 509, 542, 547
15. Chom Thong	1	43, 68, 76, 105, 120, 140, 141, 142, 147, 167, 172, 193, 529, 530, 558
16. Din Daeng	-	3, ปอ.พ.4, 8, 12, 13, 24, 69, 92, 27, 28, 29, 34,
17. Don Mueang	-	ต13, 29, 34, 39, 59, 81, 82, 95, ต98, 114, 116, 188, 503, 504, 510, 513, 520, 522, 538
18. Dusit	-	3, ปอ.พ.4, 5, 9, 10, 12, 14, 16, 18, 19, 28, 30, 32, 33, 49, 53, 56, 64, 65, 66, 70, 72, 99, 108, 110, 125, 157, 171, 183, 201, 503, 505, 509, 515, 524, 542, 539
19. Huai Khwang	3	ปอ.พ.4, 12, 13, 24, 36, 36ก, 54, 69, 73, 73ก, 74, 92, 98, 107, 117, 129, 136, 137, 138, 157, 168, 171, 172, 185, 204, 206, 504, 514, 517, 529, 537, 538, 555
20. Khan Na Yao	-	ต14, 54, 71, 115, 168

Table B.4 The number of piers and the bus number in 50 districts (cont.)

District	Piers	The bus number
21. Khlong Sam Wa	-	559
22. Khlong San	3	3, 4, 6, 7, 7ก, 9, 10, 19, 20, 21, 37, 40, 42, 43, 56, 57, 76, 82, 84, 85, 88, 89, 105, 106, 111, 120, 149, 164, 167, 172, 173, 177, 506, 529
23. Khlong Toei	1	4, 13, 22, 45, 46, 47, 71, 72, 74, 98, 102, 107, 109, 115, 116, 136, 141, 149, 154, 173, 180, 185, 205, 507, 519, 544
24. Lak Si	-	13, 29, 38, 51, 52, 59, 62, 65, 89, 95, 114, 356, 504, 510, 513, 538, 555
25. LatKrabang	-	ต25, 26, 92, ต111, 143, 144, 151, 152, 517, 519, 549, 551, 554, 559, 1013
26. LatPhrao	-	26, 154, 156
27. Min Buri	6	8, ต15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 39, 58, 60, 91, 92, 93, 96, 108, 113, 131, 151, 152, 168, 173, 501, 502, 514, 519, ต549
28. Nong Chok	7	ต17, 18, 21, ต55, 57, 131, 526
29. Nong Khaem	3	7, 80, 80ก
30. Pathum Wan	2	2, 4, 7, 13, 14, 15, 16, 17, 21, 25, 29, 40, 45, 45ก, 46, 47, 48, 49, 50, 53, 62, 67, 73, 73ก, 74, 75, 76, 77, 79, 85, 93, 109, 113, 141, 159, 162, 163, 164, 170, 172, 174, 177, 183, 204, 501, 504, 505, 507, 508, 511, 514, 529, 547
31. Phasi Charoen	-	7, 7ก, 80, 80ก, 81, 84, 84ก, 89, 91ก, 101, 146, 147, 157, 163, 164, 165, 171, 509, 547
32. Phaya Thai	-	3, 8, 24, 26, 27, 28, 29, 34, 38, 39, 44, 52, 54, 59, 63, 69, 74, 77, 90, 92, 97, 104, 107, 108,117,

Table B.4 The number of piers and the bus number in 50 districts (cont.)

District	Piers	The bus number
32. Phaya Thai (cont.)	-	129, 138, 157, 204, 502, 503, 504, 509, 510, 524, 555
33. Phra Khanong	-	2, 45, 45ก, 46, 102, 129, 142, 511, 536
34. Phra Nakhon	15	1, 2, 3, 6, 8, 9, 10, 12, 15, 19, 25, 30, 32, 33, 35, 42, 43, 44, 47, 48, 56, 59, 60, 64, 65, 68, 70, 73, 79, 82, 91, 123, 124, 157, 169, 171, 174, 177, 183, 201, 203, 503, 507, 508, 509, 511, 516, 524, 542
35. Pom Prap Sattru Phai	6	1, 2, 4, 7, 8, 10, 15, 21, 25, 35, 37, 43, 44, 47, 48, 49, 53, 56, 59, 60, 70, 73, 73ก, 79, 85, 157, 159, 171, 201, 204, 503, 507, 508, 509, 511, 529, 542
36. Prawet	-	11ก, 36, 46, 48, ต48, ต49, 50, 51, 92, ต109, 110, 139, 145, 180, 182, 206, 207, 517, 551, 1013
37. Rat Burana	-	6, 17, 20, 21, 35, 37, 75, 82, 85, 138, 140, 141, 142, 504, 558
38. Ratchathewi	2	ปอ.พ.4, 8, 12, 13, 14, 17, 24, 26, 29, 34, 36, 36ก, 38, 44, 50, 54, 58, 59, 60, 62, 63, 67, 69, 72, 73, 73ก, 74, 77, 79, 92, 93, 98, 99, 113, 136, 139, 140, 150, 157, 159, 163, 164, 168, 170, 171, 172, 174, 177, 183, 185, 187, 201, 204, 206, 502, 503, 504, 505, 509, 511, 513, 514, 519, 522, 529, 536, 537, 538, 539, 542, 547, 551
39. Sai Mai	-	ต13, 42, ต42, 34, 39, 81, 82, 114, 116, 188, 503, 520, 522, 559
40. Samphanthawong	8	1, 4, 7, 10, 21, 25, 29, 35, 37, 40, 46, 47, 48, 49,

Table B.4 The number of piers and the bus number in 50 districts (cont.)

District	Piers	The bus number
40. Samphanthawong (cont.)	8	53, 56, 73, 73ก, 75, 85, 109, 113, 159, 204, 501, 507, 529
41. Saphan Sung	-	93, 171, 172, 554, 551, 559,
42. Sathon	1	1, 4, 13, 15, 17, 22, 45, 46, 47, 62, 67, 74, 75, 77, 89, 109, 115, 116, 141, 149, 162, 163, 173, 504, 507, 544, 547
43. Suan Luang	-	11ก, 40, 92, 99, 145, 206, 517, 551, 1013
44. Taling Chan	-	ปอ.พ.4, 19, 28, 40, 66, 89, 123, 146, 149, 165, 177, 388, 507, 511, 515, 516, 539, 542,
45. Thawi Watthana	-	7ก, ต33, 79, 84ก, 91ก, 123, 124, 125, 146, 157, 163, 164, 165, 170, 183, 388, 515, 539, 547
46. Thon Buri	1	3, 4, 7, 7ก, 9, 10, 15, 20, 21, 37, 42, 43, 76, 80ก, 82, 84, 84ก, 85, 89, 91ก, 101, 105, 108, 111, 120, 147, 163, 164, 165, 167, 172, 173, 175, 193, 205, 529, 542, 547
47. Thung Khru	-	ต36, 75, 88
48. Wang Thonglang	-	8, 26ก, 27, 36ก, 44, 73ก, 92, 96, 122, 126, 137, 145, 154, 172, 178, 182, 502, 514, 545
49. Watthana	3	2, 22, 23, 25, 26ก, 38, 40, 48, 71, 72, 98, 109, 115, 136, 154, 173, 185, 501, 508, 511, 514, 519, 545
50. Yan Nawa	1	138, 140, 141, 142

Table B.5 The number of Train station, entrance to expressway and exit to expressway in 50 districts

Source : Strategy and Evaluation Department (2012), Traffic and Transportation Department (2012).

District	Train station	Expressway			
		Entrance	N.	Exit	N.
1. Bang Bon	3	-	-	-	-
2. Bang Kapi	-	- Chalong Rat expressway	1	-	-
3. Bang Khae	-	-	-	-	-
4. Bang Khen	-	- Chalong Rat expressway	1	- Chalong Rat expressway	1
5. Bang KhoLaem	-	- Si Rat expressway		- Si Rat expressway	
6. Bang Khun Thian	1	-	-	-	-
7. Bang Na	-	- Burapha Withi expressway	1	- Burapha Withi expressway	1
8. Bang Phlat	-	-	-	-	-
9. Bang Rak	-	- Si Rat expressway	3	- Si Rat expressway	3
10. Bang Sue	-	-	-	-	-
11. Bangkok Noi	2	-	-	-	-
12. Bangkok Yai	-	-	-	-	-
13. BuengKum	-	-	-	-	-
14. Chatuchak	4	-Si Rat expressway	2	- Si Rat expressway	2
15. Chom Thong	4	-	-	-	-
16. Din Daeng	-	-	-	-	-
17. Don Mueang	3	- Si Rat expressway	1	- Si Rat expressway	1
18. Dusit	3	-	-	-	-
19. Huai Khwang	1	- Si Rat expressway - Chalong Rat expressway	2	- Si Rat expressway - Chalong Rat expressway	2
20. Khan Na Yao	-	-	-	-	-
21. Khlong Sam Wa	-	-	-	-	-
22. Khlong San	-	-	-	-	-
23. Khlong Toei	-	- Chalong Rat expressway	1	- Chalong Rat expressway	1
24. Lak Si	2	-	-	-	-
25. LatKrabang	4	-	-	-	-
26. LatPhrao	-	-	-	- Chalong Rat expressway	1
27. Min Buri	-	-	-	-	-
28. Nong Chok	-	-	-	-	-

Table B.5 The number of Train station, entrance to expressway and exit to expressway in 50 districts (cont.)

District	Train station	Expressway			
		Entrance	N.	Exit	N.
29. Nong Khaem	-	-	-	-	-
30. Pathum Wan	1	- Si Rat expressway	1	- Si Rat expressway	1
31. Phasi Charoen	-	-	-	-	-
32. Phaya Thai	2	- Si Rat expressway	1	- Si Rat expressway	1
33. Phra Khanong	-	- Chalong Rat expressway	1	- Chalong Rat expressway	-
34. Phra Nakhon	-	-	-	-	-
35. Pom Prap Sattru Phai	-	-	-	-	-
36. Prawet	-	-	-	-	-
37. Rat Burana	-	-	-	-	-
38. Ratchathewi	4	- Si Rat expressway	1	- Si Rat expressway	1
39. Sai Mai	-	-	-	-	-
40. Samphanthawong	-	-	-	-	-
41. Saphan Sung	-	-	-	-	-
42. Sathon	-	- Si Rat expressway	2	- Si Rat expressway	2
43. Suan Luang	2	- Chalong Rat expressway	2	- Chalong Rat expressway	2
44. Taling Chan	2	-	-	-	-
45. Thawi Watthana	2	-	-	-	-
46. Thon Buri	2	-	-	-	-
47. Thung Khru	-	-	-	-	-
48. Wang Thonglang	-	- Chalong Rat expressway	2	- Chalong Rat expressway	2
49. Watthana	-	- Chalong Rat expressway	1	-	-
50. Yan Nawa	-	- Si Rat expressway	1	- Si Rat expressway	1

Table B.6 The drug distributor in 50 districts

Source : Infopharma Media Services (2008), Traffic and Transportation Department (2011).

District	Drug distributor	Traffic volume (vehicles/day)
1. Bang Bon	-	35,348

Table B.6 The drug distributor in 50 districts (cont.)

District	Drug distributor	Traffic volume (vehicles/day)
2. Bang Kapi	- IDS Marketing (Thailand) Ltd. - Medifive Pharma Co., Ltd. - S.T. Pharma. - US Summit Corporation (Overseas).	81,873
3. Bang Khae	-	29,752
4. Bang Khen	-	86,650
5. Bang KhoLaem	-	39,442
6. Bang KhunThian	-	55,093
7. Bang Na	- Stada Asiatic Co., Ltd.	43,878
8. Bang Phlat	- Far East Pharmaceutical Ltd., Part. - Greater Pharma Ltd., Part. - Oui Heng Import Co., Ltd.	65,508
9. Bang Rak	- Pharma Square Co., Ltd.	92,656
10. Bang Sue	- Masu Co., Ltd.	40,114
11. Bangkok Noi	- Kaspa Pharmaceutical (Thailand) Co., Ltd. - Neopharm Co., Ltd. - Union Medical (Thailand) Co., Ltd.	24,934
12. Bangkok Yai	-	18,727
13. BuengKum	-	69,375
14. Chatuchak	- Siam Medicare Co., Ltd. - Siam Pharmaceutical Co., Ltd. - T.C. Pharma-Chem Co., Ltd.	96,254
15. Chom Thong	-	39,228
16. Din Daeng	- Pharma Square Co., Ltd. - Star Lab Co., Ltd.	69,059
17. Don Mueang	-	67,785
18. Dusit	-	50,508
19. Huai Khwang	- Dabur Pharma (Thailand) Co., Ltd. - Harn Thai Pharma Ltd. - Indochina Healthcare Ltd.	53,896

Table B.6 The drug distributor in 50 districts (cont.)

District	Drug distributor	Traffic volume (vehicles/day)
19. Huai Khwang (cont.)	- Medline Co., Ltd. - Medochemie Ltd. - Tri Medical Co., Ltd.	53,896
20. Khan Na Yao	-	66,789
21. Khlong Sam Wa	-	8,498
22. Khlong San	- B L Hua & Co., Ltd . - SPS Medical Co., Ltd.	46,662
23. Khlong Toei	- BJC Healthcare Co., Ltd. - Bristol-Myers Squibb (Thailand) Ltd. - Cosma Medical Co., Ltd. - Zuellig Pharma Ltd.	57,448
24. Lak Si	-	37,890
25. LatKrabang	- Berlin Pharmaceutical Industry Co., Ltd. - Thai Meji Pharmaceutical Co., Ltd. - Unison Laboratories Co., Ltd.	34,485
26. LatPhrao	-	47,220
27. Min Buri	-	33,399
28. Nong Chok	-	27,500
29. Nong Khaem	-	24,568
30. Pathum Wan	- B L H Trading Co., Ltd.	39,886
31. Phasi Charoen	-	41,940
32. Phaya Thai	- Medicine Supply Co., Ltd.	92,656
33. Phra Khanong	- Biogenetech Co., Ltd. - Olic (Thailand) Ltd. - T P Drug Lab (1969) Co., Ltd. - Vana Corporation Ltd.	63,307
34. Phra Nakhon	- Mayoly Spindler Laboratories. (S. Charoen Bhaesaj Trading Co., Ltd.)	52,071
35. Pom Prap Sattru Phai	- Far East Pharmaceutical Ltd., Part.	34,972

Table B.6 The drug distributor in 50 districts (cont.)

District	Drug distributor	Traffic volume (vehicles/day)
36. Prawet	- Pharmadica Co., Ltd. - Pharmaland (1982) Co., Ltd.	28,866
37. Rat Burana	-	24,898
38. Ratchathewi	- Bangkok Drug Co., Ltd.	80,436
39. Sai Mai	-	22,493
40. Samphanthawong	- DKSH (Thailand) Limited.	21,740
41. Saphan Sung	-	28,866
42. Sathon	-	42,578
43. Suan Luang	-	55,601
44. Taling Chan	- Nupharma & Healthcare Co., Ltd.	12,624
45. Thawi Watthana	-	9,440
46. Thon Buri	- Charoon Bhaesaj Ltd.	55,932
47. Thung Khru	-	31,090
48. Wang Thonglang	- Pro Task Co., Ltd. - Schumit 1967 Co., Ltd.	61,612
49. Watthana	- Biopharm Chemicals Co., Ltd.	54,887
50. Yan Nawa	- Natural Media Co., Ltd. - Pacific Healthcare (Thailand) Co., Ltd. - Wellchem Pharmaceutical Co., Ltd.	89,323

Table B.7 The drainage tunnel and the Royally-Initiated Bangkok Flood Dyke in 50 districts

Source : Bangkok Metropolitan Administration (2011).

District	Drainage tunnel	The Royally-Initiated Bangkok Flood Dyke
1. Bang Bon	-	-
2. Bang Kapi	-	- Eastern Bangkok Flood Dyke
3. Bang Khae	-	- Western Bangkok Flood Dyke

Table B.7 The drainage tunnel and the Royally-Initiated Bangkok Flood Dyke in 50 districts (cont.)

District	Drainage tunnel	The Royally-Initiated Bangkok Flood Dyke
4. Bang Khen	- Drainage tunnel at Bang Khen Canal (future)	- Eastern Bangkok Flood Dyke
5. Bang KhoLaem	-	-
6. Bang KhunThian	-	- Western Bangkok Flood Dyke
7. Bang Na	- Drainage tunnel from Nong Bon Pond to the Chao Phraya River (future)	- Eastern Bangkok Flood Dyke
8. Bang Phlat	-	-
9. Bang Rak	-	-
10. Bang Sue	- Drainage tunnel at Bang Khen Canal (future)	-
11. Bangkok Noi	-	-
12. Bangkok Yai	-	-
13. BuengKum	-	- Eastern Bangkok Flood Dyke
14. Chatuchak	- Drainage tunnel at Bang Khen Canal (future)	-
15. Chom Thong		- Western Bangkok Flood Dyke
16. Din Daeng	- Drainage tunnel beneath Bang Sue Canal (future)	-
17. Don Mueang	-	-
18. Dusit	- Drainage tunnel at Prem Prachakon Canal - Drainage tunnel beneath Bang Sue Canal (future)	-
19. Huai Khwang	- Rama IX-Ramkhamhaeng drainage tunnel	-

Table B.7 The drainage tunnel and the Royally-Initiated Bangkok Flood Dyke in 50 districts (cont.)

District	Drainage tunnel	The Royally-Initiated Bangkok Flood Dyke
19. Huai Khwang (cont.)	- Drainage tunnel beneath Bang Sue Canal (future)	-
20. Khan Na Yao	-	- Eastern Bangkok Flood Dyke
21. Khlong Sam Wa	-	- Eastern Bangkok Flood Dyke
22. Khlong San	-	-
23. Khlong Toei	- Drainage tunnel at Soi Sukhumvit 26 - Drainage tunnel at Soi Sukhumvit 36 - Drainage tunnel at Soi Sukhumvit 42	-
24. Lak Si	-	-
25. LatKrabang	-	-
26. LatPhrao	-	-
27. Min Buri	-	-
28. Nong Chok	-	-
29. Nong Khaem	-	-
30. Pathum Wan	-	-
31. Phasi Charoen	- Drainage tunnel from Makkasan Pond to the Chao Phraya River	-
32. Phaya Thai	- Drainage system at Phaya Thai District - Drainage tunnel beneath Bang Sue Canal (future)	-

Table B.7 The drainage tunnel and the Royally-Initiated Bangkok Flood Dyke in 50 districts (cont.)

District	Drainage tunnel	The Royally-Initiated Bangkok Flood Dyke
33. Phra Khanong	- Drainage tunnel from Nong Bon Pond to the Chao Phraya River (future)	-
34. Phra Nakhon	-	-
35. Pom Prap Sattru Phai	-	-
36. Prawet	- Drainage tunnel from Nong Bon Pond to the Chao Phraya River (future)	- Eastern Bangkok Flood Dyke
37. Rat Burana	-	-
38. Ratchathewi	- Drainage tunnel from Makkasan Pond to the Chao Phraya River	-
39. Sai Mai	-	- Eastern Bangkok Flood Dyke
40. Samphanthawong	-	-
41. Saphan Sung	-	-
42. Sathon	- Drainage tunnel from Makkasan Pond to the Chao Phraya River	
43. Suan Luang	-	-
44. Taling Chan	-	- Western Bangkok Flood Dyke
45. Thawi Watthana	-	-
46. Thon Buri	-	-
47. Thung Khru	-	- Western Bangkok Flood Dyke

Table B.7 The drainage tunnel and the Royally-Initiated Bangkok Flood Dyke in 50 districts (cont.)

District	Drainage tunnel	The Royally-Initiated Bangkok Flood Dyke
48. Wang Thonglang	-	-
49. Watthana	- Rama IX-Ramkhamhaeng drainage tunnel	-
50. Yan Nawa	-	-

Table B.8 The elevation above mean sea level and flood history in 50 districts

Source : Government Savings Bank (2012), TEAM Group of Companies Co., Ltd (2011)

District	Elevation above mean sea level (m.)	Flood	
		2011	1995
1. Bang Bon	1 – 1.5	x	-
2. Bang Kapi	0 – 0.5	-	-
3. Bang Khae	0.5 - 1	x	-
4. Bang Khen	1.5 - 2	x	-
5. Bang KhoLaem	2.5 – 3	x	x
6. Bang KhunThian	1 – 1.5	-	-
7. Bang Na	0 – 0.5	-	-
8. Bang Phlat	0 – 0.5	x	x
9. Bang Rak	2.5 – 3	-	x
10. Bang Sue	2.5 – 3	x	-
11. Bangkok Noi	0.5 – 1	x	x
12. Bangkok Yai	0.5 – 1	-	-
13. BuengKum	0.5 – 1	-	-
14. Chatuchak	0.5 – 1	x	x
15. Chom Thong	0.5 – 1	-	-
16. Din Daeng	1 – 1.5	-	x
17. Don Mueang	0.5 – 1	x	-

Table B.8 The elevation above mean sea level and flood history in 50 districts (cont.)

District	Elevation above mean sea level (m.)	Flood	
		2011	1995
18. Dusit	0.5 – 1	x	x
19. HuaiKhwang	0 – 0.5	-	-
20. Khan Na Yao	1 – 1.5	x	-
21. Khlong Sam Wa	less than 0	x	-
22. Khlong San	0.5 – 1	x	x
23. Khlong Toei	2.5 – 3	x	x
24. Lak Si	2.5 – 3	x	-
25. LatKrabang	0 – 0.5	x	-
26. LatPhrao	1 – 1.5	x	-
27. Min Buri	0.5 – 1	x	-
28. NongChok	0.5 – 1	x	-
29. NongKhaem	0 – 0.5	x	-
30. Pathum Wan	0.5 – 1	-	-
31. Phasi Charoen	0.5 – 1	x	-
32. Phaya Thai	2.5 – 3	-	x
33. PhraKhanong	0 – 0.5	-	x
34. PhraNakhon	0 – 0.5	x	x
35. PomPrapSattruPhai	0.5 – 1	-	x
36. Prawet	0 – 0.5	-	-
37. Rat Burana	1.5 – 2	x	x
38. Ratchathewi	0.5 – 1	-	-
39. Sai Mai	2 – 2.5	x	-
40. Samphanthawong	0.5 – 1	x	x
41. Saphan Sung	0.5 – 1	-	-
42. Sathon	2.5 – 3	x	x
43. SuanLuang	0 – 0.5	-	x
44. Taling Chan	0.5 – 1	x	-

Table B.8 The elevation above mean sea level and flood history in 50 districts (cont.)

District	Elevation above mean sea level (m.)	Flood	
		2011	1995
45. ThawiWatthana	1 – 1.5	x	-
46. Thon Buri	0.5 – 1	x	-
47. ThungKhru	2 – 2.5	-	-
48. Wang Thonglang	1.5 - 2	x	-
49. Watthana	0 – 0.5	-	x
50. Yan Nawa	2.5 - 3	x	-

Note: [x] = That district had been flood.

Table B.9 The measures to prohibit truck traffic

Source : Tonglim (2012).

Route/Area	Measurement
Inner Bangkok (radius 113 Square kilometers)	All trucks with 10 wheels or more are prohibited at 06.00 to 21.00. Except contained concrete, cranes or allowed have permission at 10.00-15.00.
The expressway	The 6 wheels trucks are banned at 06.00-09.00 and 16.00 to 20.00. All trucks with 10 wheels or more are banned at 05.00-09.00 and 15.00 to 21.00.
the west Ring Road	All trucks with 6 wheels or more are prohibited at 06.00 to 21.00.
Suksawat-Rama 2 Road	All trucks with 6 wheels or more are prohibited at 06.00 to 21.00.

Table B.10 The crime in 50 districts

Source : Katikan and Ua-Amnoey (2007).

Districts	%Crime
Bang Kapi, Bang Khen, Bang Sue, BuengKum, Chatuchak, Chom Thong, Don Mueang, Khan Na Yao, Khlong San, Lak Si, LatPhrao, Prawet, Rat Burana, Sai Mai, Saphan Sung, Suan Luang, Thon Buri, Thung Khru, Wang Thonglang	46.4
Bang KhoLaem, Bang Na, Bang Rak, Din Daeng, Dusit, Huai Khwang, Khlong Toei, Pathum Wan, Phaya Thai, Phra Khanong, Phra Nakhon, Pom Prap Sattru Phai, Ratchathewi, Samphanthawong, Sathon, Watthana, Yan Nawa	29.3
Bang Bon, Bang Khae, Bang Khun Thian, Bang Phlat, Bangkok Noi, Bangkok Yai, Khlong Sam Wa, LatKrabang, Min Buri, Nong Chok, Nong Khaem, Phasi Charoen, Taling Chan, Thawi Watthana	21.1

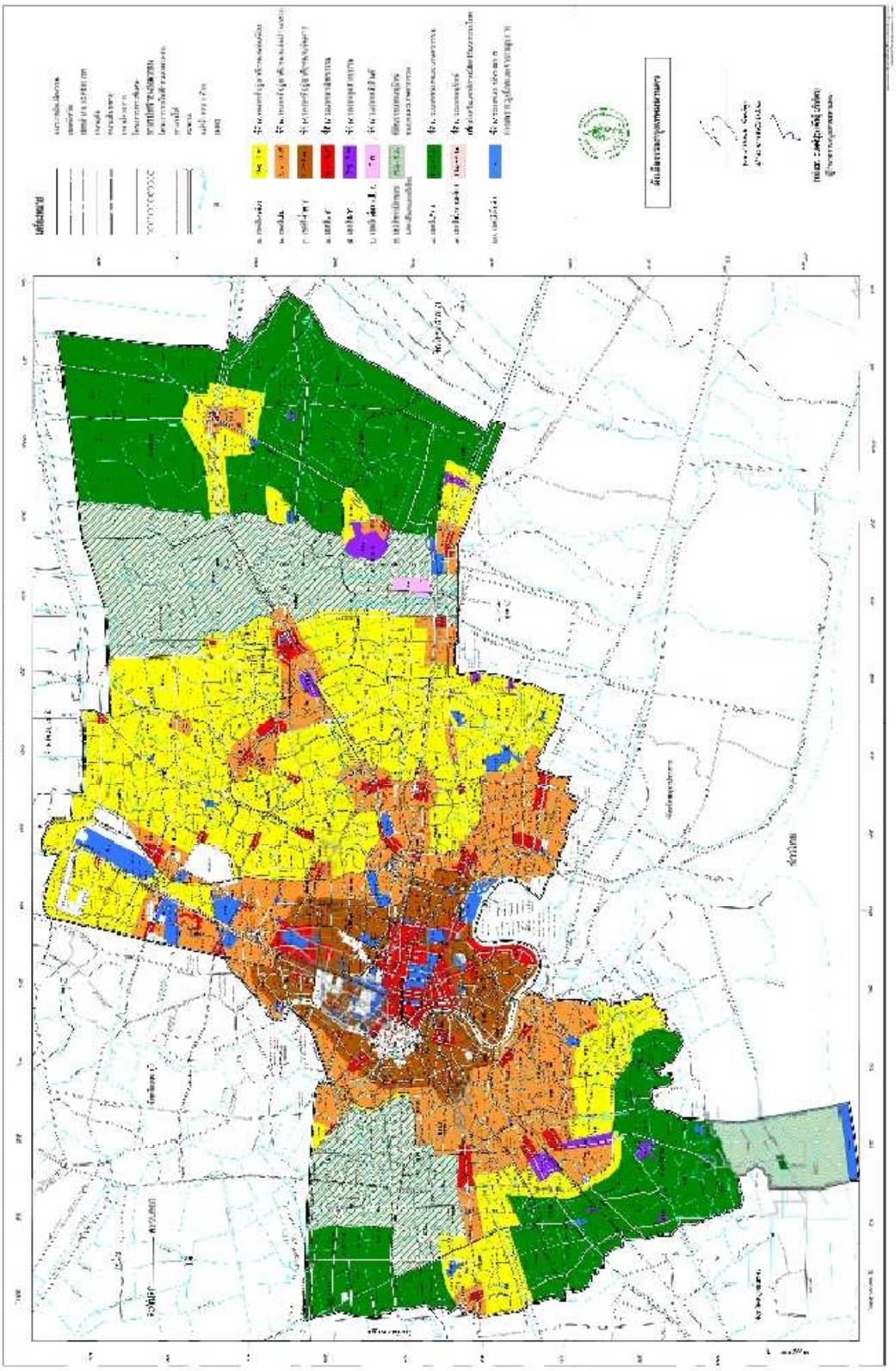

Figure B.1 The country planning of Bangkok

APPENDIX C
THE QUESTIONNAIRE OF LOCATION FOR ESTABLISHING DRUG DISTRIBUTION CENTER (ENGLISH).

The questionnaire of criteria analysis for establishing drug distribution center

All respondents respectfully**,**

This questionnaire is a part of selection location for a drug distribution center research that can be carried out during the flood. The researcher is Miss Thummamateta Treevirotmongkol, Graduate student of Mahidol University Salaya Campus. Please, answer the questionnaire. The information will be use for study.

Objective: The questionnaire is conducted to analysis the factors to select an appropriate location distribution center. Able to meet the needs of customers and safety patient during the flood.

Explanation : There are two section.

section 1 ask the appropriate criteria to consider for establishing drug distribution center.

section 2 for more suggestions.

Thank you for your participant answering my questionnaire.

General information

Name: .....

Organization: ..... Position: .....

Experience in healthcare industry......

Section 1 The criteria is considered the location drug distribution center (please √ into the level of each criteria)

The level of importance 5 = Very high, 4 = high, 3 = Medium, 2 = Low, 1 = very low and 0 = not available

Criteria	5	4	3	2	1	0
1. Costs in acquiring land, capital, vehicle resources, drivers, resource, logistics, services and taxes etc. for the location.						
2. The condition of weather, geological, hydrological, topography (e.g. rain, sunshine, humidity etc.).						
3. Access by public and private transport modes to the location.						
4. Sufficient the number of labors.						
5. Capability to appropriate and response time service.						
6. Connectivity of the location with multiple modes of transport, e.g. highways, seaport, railways etc.						
7. Ability to conform to sustainable freight regulations imposed by municipal administrations for e.g. restricted delivery hours, special delivery zones.						
8. Capability to compete against others or the number of competitor.						
9. The number of customers purchases the products, and whether the needs of the market can be adequately fulfilled.						
10. The distance and time from location to customers.						
11. The condition of economy (e.g. currency value, exchange rate, market demand etc.).						
12. Availability of raw materials resources in the location.						
13. The availability and convenience to access the water and electricity supply infrastructure.						

Criteria	5	4	3	2	1	0
14. Capability to manage continues the growing demand.						
15. The frequency of use traffic is from the location to the suppliers or customers.						
16. Impact of location on the environment, for example, air pollution, noise.						
17. Good legal rules and regulations to support business.						
18. The distance and time from location to suppliers.						
19. The security from crime, accident etc.						
20. The period of time from purchase order until the customers receive drug.						
21. The feature of product (e.g. size, type, preservation temperature etc.).						
22. The technology for sending and receiving information)						
23. Firm strategy and structure						
24. Governmental policy towards establishing drug distribution center includes the regulations of the established standard.						
25. Focus outreach efforts near drug markets						
26. The density and structure of the population.						
27. The flood management in Bangkok						
28. The mean sea level of area						
29. The permit DC area in country planning						
30. Others (please identify).....						
31. Others (please identify).....						
32. Others (please identify).....						
33. Others (please identify).....						
34. Others (please identify).....						
35. Others (please identify).....						

Section 2 Recommend and suggestion

.....

.....

.....

.....

Thank you for taking the time to answer the question.

APPENDIX D
THE QUESTIONNAIRE OF LOCATION FOR ESTABLISHING DRUG DISTRIBUTION CENTER (THAI).

แบบสอบถามสำรวจปัจจัยที่ใช้ตั้งศูนย์กระจายยา

กราบเรียน ผู้ตอบแบบสอบถามทุกท่าน

แบบสอบถามฉบับนี้เป็นส่วนหนึ่งในงานวิจัยการเลือกที่ตั้งศูนย์กระจายยาที่สามารถดำเนินการได้ในระหว่างเกิดอุทกภัยของ น.ส.ธัมมาเมตตา ตรีวิโรจน์มงคล นักศึกษาปริญญาโท มหาวิทยาลัยมหิดล จึงใคร่ขอความกรุณาในการตอบแบบสอบถามค่ะ โดยข้อมูลที่ได้ใช้ในการวิจัยเท่านั้นค่ะ

วัตถุประสงค์ : แบบสอบถามนี้จัดทำเพื่อสำรวจความคิดเห็นถึงปัจจัยในการเลือกที่ตั้งศูนย์กระจายยาที่เหมาะสม สามารถตอบสนองต่อความต้องการของลูกค้าและความปลอดภัยของผู้ป่วยระหว่างเกิดอุทกภัยได้ค่ะ

คำชี้แจง : แบบสอบถามนี้มี 2 ตอนค่ะ

ตอนที่ 1 สอบถามปัจจัยที่ใช้ในการพิจารณาจัดตั้งศูนย์กระจายยา

ตอนที่ 2 ข้อเสนอแนะเพิ่มเติม

ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

ชื่อ-นามสกุล ผู้ตอบแบบสอบถาม.....

หน่วยงาน..... ตำแหน่ง.....

ประสบการณ์ในการทำงานด้านนี้.....

<u>ตอนที่ 1</u> ปัจจัยที่ใช้ในการตัดสินใจเลือกที่ตั้งศูนย์กระจายยา (โปรดทำเครื่องหมาย √ ในช่องที่ตรงกับระดับความสำคัญของปัจจัยที่ใช้ในการตัดสินใจ)

ระดับความสำคัญ 5 = มากที่สุด 4 = มาก 3 = ปานกลาง 2 = น้อย 1 = น้อยที่สุด และ 0 = ไม่ใช้

ปัจจัย	5	4	3	2	1	0
1.ค่าใช้จ่ายในการจัดตั้ง, การดำเนินการ, การขนส่ง, การบำรุงรักษา (Cost)						
2.สภาพแวดล้อม เช่น ภูมิอากาศ ภูมิศาสตร์ เป็นต้น (Natural environment)						
3. ความสะดวกในการขนส่งทางสาธารณะและส่วนบุคคล (Accessibility)						
4.จำนวนแรงงาน (Labor)						
5.คุณภาพด้านเวลาและความเหมาะสมในการให้บริการ (Quality of service)						
6.การเชื่อมต่อการขนส่งได้หลายทาง เช่น รถ, เรือ, เครื่องบิน, รถไฟ ฯลฯ (Connectivity to multimodal transport)						
7.การปฏิบัติตามกฎระเบียบเรื่องการขนส่ง (Conformance to sustainable freight regulations)						
8.ความสามารถในการแข่งขัน/จำนวนคู่แข่ง (Competition)						
9.จำนวนลูกค้าและความต้องการของตลาด(Demand)						
10.ระยะทางใกล้กับที่ตั้งของลูกค้า (Proximity to customers)						
11.สภาพเศรษฐกิจ เช่น ความต้องการทางตลาด, อัตราแลกเปลี่ยนฯลฯ (Economic criteria)						
12.ความง่ายในการจัดหาวัตถุดิบ (Resource availability)						
13.โครงสร้างพื้นฐานที่สำคัญ เช่น น้ำ, ไฟฟ้า เป็นต้น (Infrastructure)						
14.การขยายกิจการเพื่อรองรับการเติบโตในอนาคต (Possibility of expansion)						
15.สภาพความหนาแน่นทางจราจร (Density of traffic)						
16. ผลกระทบต่อสิ่งแวดล้อม เช่น กลิ่น, เสียง, ขยะ ฯลฯ (Environmental impact)						

ปัจจัย	5	4	3	2	1	0
17. กฎหมายสนับสนุน (Political regulations)						
18. ระยะทางใกล้กับที่ตั้งของซัพพลายเออร์ (Proximity to suppliers)						
19. ความปลอดภัยจากอาชญากรรม, ขโมยและอุบัติเหตุ (Security)						
20. ระยะเวลาที่ใช้ตั้งแต่ออกใบสั่งซื้อจนกระทั่งลูกค้าได้รับยา (Lead time)						
21. ลักษณะของยา เช่น ขนาด, ชนิด, อุณหภูมิที่ใช้จัดเก็บ (Product feature)						
22. เทคโนโลยีที่ใช้ในการรับ-ส่งข้อมูล(Information technology)						
23.กลยุทธ์หรือนโยบายของบริษัทในการจัดตั้งและการจัดการ (Firm strategy and structure)						
24.กฎระเบียบของรัฐในการจัดตั้งศูนย์กระจายยา เช่น GMP เป็นต้น (Government)						
25.ประสิทธิภาพในการกระจายยาได้ปริมาณใกล้เคียงกับความต้องการของตลาดอย่างต่อเนื่อง(Focus outreach efforts near drug markets)						
26.ความต้องการยาในตลาดรวมถึงจำนวนประชากร, จำนวนโรงพยาบาล, ความหนาแน่นของประชากร และโครงสร้างของประชากร (Population)						
27.การบริหารจัดการน้ำของกรุงเทพฯ เช่น ตำแหน่งคันกั้นน้ำ (Flood management)						
28.ระดับพื้นที่สูง-ต่ำจากระดับน้ำ (Topography)						
29.การจัดวางผังเมืองของกรุงเทพฯ (Country planning)						
30.อื่นๆ (โปรดระบุ).....						
31.อื่นๆ (โปรดระบุ).....						
32.อื่นๆ (โปรดระบุ).....						
33.อื่นๆ (โปรดระบุ).....						
34.อื่นๆ (โปรดระบุ).....						
35.อื่นๆ (โปรดระบุ).....						

ตอนที่ 2ข้อคิดเห็นและข้อเสนอแนะเพิ่มเติม

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ขอกราบขอบพระคุณทุกท่านที่สละเวลาในการตอบแบบสอบถามค่ะ

APPENDIX E
THE INFORMATION OF EXPERTS

Table E.1 The list of experts

No.	Organization	Position	Experience
1.	DKSH (Thailand) Co., Ltd.	Business Process Reengineering Manager	12 years
2.	National Healthcare Systems Co., Ltd.(N Health)	Logistic Manager	Over 5 years
3.	Boonthavorn Ceramics Co., Ltd.	Manager	18 years
4.	Thai Pharmaceutical Manufacturers Association	President	5 years
5.	DKSH (Thailand) Co., Ltd.	Senior Logistics-Medical Device Distribution Center	Over 13 years
6.	Thai Logistics And Production Society	Consultant	Over 20 years
7.	Siriraj Hospital	Head of Drug and Medical Supplies Information Management	10 years
8.	Bangkok Metropolitan Administration	Experienced Level	4 years
9.	Bangkok Metropolitan Administration	Experienced Level	3 years

APPENDIX F

THE EVALUATION OF LOCATION FROM EXPERTS' OPINION

TABLE F.1 Aggregate fuzzy weights for criteria

Criteria	Experts											
	D1			D2			D3			D4		
1.National environment and its impact	M	3	5 7	M	3	5 7	H	5	7 9	M	3	5 7
2.Accessibility	VH	7	9 9	H	5	7 9	VH	7	9 9	VH	7	9 9
3.Labor	M	3	5 7	H	5	7 9	L	1	3 5	VH	7	9 9
4.Connectivity to multimodal transport	VH	7	9 9	M	3	5 7	VH	7	9 9	VH	7	9 9
5.Government and regulations	H	5	7 9	M	3	5 7	H	5	7 9	VH	7	9 9
6.Demand	M	3	5 7	VH	7	9 9	H	5	7 9	H	5	7 9
7.Infrastructure	H	5	7 9	M	3	5 7	H	5	7 9	H	5	7 9
8.Security	M	3	5 7	H	5	7 9	H	5	7 9	H	5	7 9
9.Information technology	L	1	3 5	H	5	7 9	VH	7	9 9	VH	7	9 9
10.Flooded management	H	5	7 9	H	5	7 9	VH	7	9 9	VH	7	9 9
11.Topography	H	5	7 9	M	3	5 7	VH	7	9 9	VH	7	9 9
12.Country planning	H	5	7 9	M	3	5 7	VH	7	9 9	VH	7	9 9
13.Cost	VH	7	9 9	VH	7	9 9	H	5	7 9	VH	7	9 9
14.Competition	M	3	5 7	H	5	7 9	M	3	5 7	H	5	7 9
15.Density of traffic	H	5	7 9	H	5	7 9	M	3	5 7	H	5	7 9

TABLE F.1 Aggregate fuzzy weights for criteria (cont.)

Criteria	Experts											
	D5			D6			D7			D8		
1.National environment and its impact	M	3	5 7	H	5	7 9	VH	7	9 9	L	1	3 5
2.Accessibility	VH	7	9 9	VH	7	9 9	VH	7	9 9	H	5	7 9
3.Labor	VH	7	9 9	H	5	7 9	L	1	3 5	M	3	5 7
4.Connectivity to multimodal transport	H	5	7 9	VH	7	9 9	H	5	7 9	M	3	5 7
5.Government and regulations	H	5	7 9	VH	7	9 9	M	3	5 7	M	3	5 7
6.Demand	H	5	7 9	VH	7	9 9	M	3	5 7	H	5	7 9
7.Infrastructure	M	3	5 7	VH	7	9 9	H	5	7 9	H	5	7 9
8.Security	M	3	5 7	H	5	7 9	M	3	5 7	L	1	3 5
9.Information technology	H	5	7 9	H	5	7 9	H	5	7 9	H	5	7 9
10.Flooded management	H	5	7 9	VH	7	9 9	H	5	7 9	H	5	7 9
11.Topography	M	3	5 7	VH	7	9 9	H	5	7 9	H	5	7 9
12.Country planning	M	3	5 7	VH	7	9 9	L	1	3 5	M	3	5 7
13.Cost	VH	7	9 9	VH	7	9 9	M	3	5 7	M	3	5 7
14.Competition	M	3	5 7	H	5	7 9	L	1	3 5	L	1	3 5
15.Density of traffic	H	5	7 9	VH	7	9 9	M	3	5 7	VH	7	9 9

TABLE F.1 Aggregate fuzzy weights for criteria (cont.)

Criteria	Experts		Aggregate fuzzy weights		
	D9				
1.National environment and its impact	H	5 7 9	1	5.89	9
2.Accessibility	M	3 5 7	3	8.11	9
3.Labor	H	5 7 9	1	6.11	9
4.Connectivity to multimodal transport	H	5 7 9	3	7.44	9
5.Government and regulations	M	3 5 7	3	6.56	9
6.Demand	M	3 5 7	3	6.78	9
7.Infrastructure	H	5 7 9	3	6.78	9
8.Security	M	3 5 7	1	5.67	9
9.Information technology	H	5 7 9	1	7	9
10.Flooded management	H	5 7 9	5	7.67	9
11.Topography	H	5 7 9	3	7.22	9
12.Country planning	H	5 7 9	1	6.56	9
13.Cost	M	3 5 7	3	7.44	9
14.Competition	M	3 5 7	1	5.22	9
15.Density of traffic	H	5 7 9	3	7	9

TABLE F.2 National environment and its impact criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	F	3	5	7	LatPhrao	F	3	5	7
Bang Kapi	P	1	3	5	Min Buri	F	3	5	7
Bang Khae	F	3	5	7	Nong Chok	G	5	7	9
Bang Khen	P	1	3	5	Nong Khaem	F	3	5	7
Bang KhoLaem	F	3	5	7	Pathum Wan	F	3	5	7
Bang Khun Thian	F	3	5	7	Phasi Charoen	G	5	7	9
Bang Na	F	3	5	7	Phaya Thai	F	3	5	7
Bang Phlat	F	3	5	7	Phra Khanong	G	5	7	9
Bang Rak	G	5	7	9	Phra Nakhon	G	5	7	9
Bang Sue	F	3	5	7	Pom Prap Sattru Phai	G	5	7	9
Bangkok Noi	F	3	5	7	Prawet	F	3	5	7
Bangkok Yai	G	5	7	9	Rat Burana	F	3	5	7
BuengKum	F	3	5	7	Ratchathewi	P	1	3	5
Chatuchak	P	1	3	5	Sai Mai	F	3	5	7
Chom Thong	F	3	5	7	Samphanthawong	G	5	7	9
Din Daeng	F	3	5	7	Saphan Sung	G	5	7	9
Don Mueang	F	3	5	7	Sathon	F	3	5	7
Dusit	G	5	7	9	Suan Luang	G	5	7	9
Huai Khwang	F	3	5	7	Taling Chan	F	3	5	7
Khan Na Yao	F	3	5	7	Thawi Watthana	F	3	5	7
Khlong Sam Wa	F	3	5	7	Thon Buri	F	3	5	7
Khlong San	F	3	5	7	Thung Khru	F	3	5	7
Khlong Toei	P	1	3	5	Wang Thonglang	F	3	5	7
Lak Si	F	3	5	7	Watthana	P	1	3	5
LatKrabang	F	3	5	7	Yan Nawa	P	1	3	5

TABLE F.3 Accessibility criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	VP	1	1	3	LatPhrao	VP	1	1	3
Bang Kapi	P	1	3	5	Min Buri	P	1	3	5
Bang Khae	VP	1	1	3	Nong Chok	VP	1	1	3
Bang Khen	VP	1	1	3	Nong Khaem	VP	1	1	3
Bang KhoLaem	P	1	3	5	Pathum Wan	VG	7	9	9
Bang Khun Thian	VP	1	1	3	Phasi Charoen	VP	1	1	3
Bang Na	VP	1	1	3	Phaya Thai	P	1	3	5
Bang Phlat	P	1	3	5	Phra Khanong	VP	1	1	3
Bang Rak	VG	7	9	9	Phra Nakhon	P	1	3	5
Bang Sue	F	3	5	7	Pom Prap Sattru Phai	P	1	3	5
Bangkok Noi	P	1	3	5	Prawet	VP	1	1	3
Bangkok Yai	P	1	3	5	Rat Burana	VP	1	1	3
BuengKum	P	1	3	5	Ratchathewi	VG	7	9	9
Chatuchak	F	3	5	7	Sai Mai	VP	1	1	3
Chom Thong	P	1	3	5	Samphanthawong	P	1	3	5
Din Daeng	P	1	3	5	Saphan Sung	VP	1	1	3
Don Mueang	VP	1	1	3	Sathon	F	3	5	7
Dusit	VP	1	1	3	Suan Luang	VP	1	1	3
Huai Khwang	F	3	5	7	Taling Chan	VP	1	1	3
Khan Na Yao	VP	1	1	3	Thawi Watthana	VP	1	1	3
Khlong Sam Wa	VP	1	1	3	Thon Buri	P	1	3	5
Khlong San	F	3	5	7	Thung Khru	VP	1	1	3
Khlong Toei	G	5	7	9	Wang Thonglang	VP	1	1	3
Lak Si	VP	1	1	3	Watthana	VG	7	9	9
LatKrabang	VP	1	1	3	Yan Nawa	P	1	3	5

TABLE F.4 Labor criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	F	3	5	7	LatPhrao	G	5	7	9
Bang Kapi	G	5	7	9	Min Buri	G	5	7	9
Bang Khae	VG	7	9	9	Nong Chok	G	5	7	9
Bang Khen	VG	7	9	9	Nong Khaem	G	5	7	9
Bang KhoLaem	F	3	5	7	Pathum Wan	P	1	3	5
Bang Khun Thian	VG	7	9	9	Phasi Charoen	G	5	7	9
Bang Na	F	3	5	7	Phaya Thai	P	1	3	5
Bang Phlat	F	3	5	7	Phra Khanong	F	3	5	7
Bang Rak	P	1	3	5	Phra Nakhon	P	1	3	5
Bang Sue	G	5	7	9	Pom Prap Sattru Phai	P	1	3	5
Bangkok Noi	G	5	7	9	Prawet	G	5	7	9
Bangkok Yai	P	1	3	5	Rat Burana	F	3	5	7
BuengKum	G	5	7	9	Ratchathewi	P	1	3	5
Chatuchak	VG	7	9	9	Sai Mai	VG	7	9	9
Chom Thong	G	5	7	9	Samphanthawong	VP	1	1	3
Din Daeng	G	5	7	9	Saphan Sung	F	3	5	7
Don Mueang	VG	7	9	9	Sathon	F	3	5	7
Dusit	F	3	5	7	Suan Luang	F	3	5	7
Huai Khwang	P	1	3	5	Taling Chan	F	3	5	7
Khan Na Yao	F	3	5	7	Thawi Watthana	P	1	3	5
Khlong Sam Wa	VG	7	9	9	Thon Buri	G	5	7	9
Khlong San	P	1	3	5	Thung Khru	F	3	5	7
Khlong Toei	F	3	5	7	Wang Thonglang	F	3	5	7
Lak Si	F	3	5	7	Watthana	F	3	5	7
LatKrabang	VG	7	9	9	Yan Nawa	F	3	5	7

TABLE F.5 Connectivity to multimodal transport criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	P	1	3	5	LatPhrao	P	1	3	5
Bang Kapi	P	1	3	5	Min Buri	VP	1	1	3
Bang Khae	VP	1	1	3	Nong Chok	VP	1	1	3
Bang Khen	F	3	5	7	Nong Khaem	VP	1	1	3
Bang KhoLaem	VP	1	1	3	Pathum Wan	G	5	7	9
Bang Khun Thian	P	1	3	5	Phasi Charoen	VP	1	1	3
Bang Na	F	3	5	7	Phaya Thai	G	5	7	9
Bang Phlat	VP	1	1	3	Phra Khanong	F	3	5	7
Bang Rak	F	3	5	7	Phra Nakhon	VP	1	1	3
Bang Sue	VP	1	1	3	Pom Prap Sattru Phai	VP	1	1	3
Bangkok Noi	P	1	3	5	Prawet	VP	1	1	3
Bangkok Yai	VP	1	1	3	Rat Burana	VP	1	1	3
BuengKum	VP	1	1	3	Ratchathewi	G	5	7	9
Chatuchak	VG	7	9	9	Sai Mai	VP	1	1	3
Chom Thong	P	1	3	5	Samphanthawong	VP	1	1	3
Din Daeng	VP	1	1	3	Saphan Sung	VP	1	1	3
Don Mueang	G	5	7	9	Sathon	F	3	5	7
Dusit	P	1	3	5	Suan Luang	VG	7	9	9
Huai Khwang	G	5	7	9	Taling Chan	P	1	3	5
Khan Na Yao	VP	1	1	3	Thawi Watthana	P	1	3	5
Khlong Sam Wa	VP	1	1	3	Thon Buri	P	1	3	5
Khlong San	VP	1	1	3	Thung Khru	VP	1	1	3
Khlong Toei	F	3	5	7	Wang Thonglang	F	3	5	7
Lak Si	P	1	3	5	Watthana	P	1	3	5
LatKrabang	P	1	3	5	Yan Nawa	F	3	5	7

TABLE F.6 Government and regulations criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	G	5	7	9	LatPhrao	G	5	7	9
Bang Kapi	G	5	7	9	Min Buri	VG	7	9	9
Bang Khae	G	5	7	9	Nong Chok	VG	7	9	9
Bang Khen	G	5	7	9	Nong Khaem	VG	7	9	9
Bang KhoLaem	P	1	3	5	Pathum Wan	P	1	3	5
Bang Khun Thian	G	5	7	9	Phasi Charoen	VG	7	9	9
Bang Na	G	5	7	9	Phaya Thai	P	1	3	5
Bang Phlat	F	3	5	7	Phra Khanong	G	5	7	9
Bang Rak	P	1	3	5	Phra Nakhon	P	1	3	5
Bang Sue	F	3	5	7	Pom Prap Sattru Phai	P	1	3	5
Bangkok Noi	F	3	5	7	Prawet	VG	7	9	9
Bangkok Yai	F	3	5	7	Rat Burana	VG	7	9	9
BuengKum	G	5	7	9	Ratchathewi	P	1	3	5
Chatuchak	F	3	5	7	Sai Mai	VG	7	9	9
Chom Thong	VG	7	9	9	Samphanthawong	P	1	3	5
Din Daeng	P	1	3	5	Saphan Sung	VG	7	9	9
Don Mueang	G	5	7	9	Sathon	P	1	3	5
Dusit	P	1	3	5	Suan Luang	G	5	7	9
Huai Khwang	P	1	3	5	Taling Chan	G	5	7	9
Khan Na Yao	VG	7	9	9	Thawi Watthana	G	5	7	9
Khlong Sam Wa	VG	7	9	9	Thon Buri	F	3	5	7
Khlong San	P	1	3	5	Thung Khru	G	5	7	9
Khlong Toei	F	3	5	7	Wang Thonglang	G	5	7	9
Lak Si	VG	7	9	9	Watthana	F	3	5	7
LatKrabang	VG	7	9	9	Yan Nawa	P	1	3	5

TABLE F.7 Demand criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	P	1	3	5	LatPhrao	P	1	3	5
Bang Kapi	P	1	3	5	Min Buri	VP	1	1	3
Bang Khae	P	1	3	5	Nong Chok	P	1	3	5
Bang Khen	VP	1	1	3	Nong Khaem	F	3	5	7
Bang KhoLaem	P	1	3	5	Pathum Wan	P	1	3	5
Bang Khun Thian	F	3	5	7	Phasi Charoen	G	5	7	9
Bang Na	F	3	5	7	Phaya Thai	G	5	7	9
Bang Phlat	P	1	3	5	Phra Khanong	VP	1	1	3
Bang Rak	F	3	5	7	Phra Nakhon	P	1	3	5
Bang Sue	P	1	3	5	Pom Prap Sattru Phai	VP	1	1	3
Bangkok Noi	F	3	5	7	Prawet	F	3	5	7
Bangkok Yai	VP	1	1	3	Rat Burana	F	3	5	7
BuengKum	P	1	3	5	Ratchathewi	G	5	7	9
Chatuchak	P	1	3	5	Sai Mai	P	1	3	5
Chom Thong	P	1	3	5	Samphanthawong	P	1	3	5
Din Daeng	VP	1	1	3	Saphan Sung	VP	1	1	3
Don Mueang	VP	1	1	3	Sathon	P	1	3	5
Dusit	P	1	3	5	Suan Luang	P	1	3	5
Huai Khwang	VG	7	9	9	Taling Chan	VP	1	1	3
Khan Na Yao	P	1	3	5	Thawi Watthana	VP	1	1	3
Khlong Sam Wa	VP	1	1	3	Thon Buri	F	3	5	7
Khlong San	P	1	3	5	Thung Khru	VP	1	1	3
Khlong Toei	P	1	3	5	Wang Thonglang	VP	1	1	3
Lak Si	P	1	3	5	Watthana	G	5	7	9
LatKrabang	P	1	3	5	Yan Nawa	VP	1	1	3

TABLE F.8 Infrastructure criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	F	3	5	7	LatPhrao	G	5	7	9
Bang Kapi	G	5	7	9	Min Buri	F	3	5	7
Bang Khae	G	5	7	9	Nong Chok	F	3	5	7
Bang Khen	G	5	7	9	Nong Khaem	F	3	5	7
Bang KhoLaem	G	5	7	9	Pathum Wan	VG	7	9	9
Bang Khun Thian	F	3	5	7	Phasi Charoen	G	5	7	9
Bang Na	G	5	7	9	Phaya Thai	VG	7	9	9
Bang Phlat	G	5	7	9	Phra Khanong	G	5	7	9
Bang Rak	VG	7	9	9	Phra Nakhon	VG	7	9	9
Bang Sue	VG	7	9	9	Pom Prap Sattru Phai	VG	7	9	9
Bangkok Noi	VG	7	9	9	Prawet	F	3	5	7
Bangkok Yai	VG	7	9	9	Rat Burana	F	3	5	7
BuengKum	G	5	7	9	Ratchathewi	VG	7	9	9
Chatuchak	G	5	7	9	Sai Mai	F	3	5	7
Chom Thong	G	5	7	9	Samphanthawong	VG	7	9	9
Din Daeng	VG	7	9	9	Saphan Sung	F	3	5	7
Don Mueang	G	5	7	9	Sathon	VG	7	9	9
Dusit	VG	7	9	9	Suan Luang	F	3	5	7
Huai Khwang	VG	7	9	9	Taling Chan	F	3	5	7
Khan Na Yao	F	3	5	7	Thawi Watthana	F	3	5	7
Khlong Sam Wa	F	3	5	7	Thon Buri	VG	7	9	9
Khlong San	F	3	5	7	Thung Khru	F	3	5	7
Khlong Toei	VG	7	9	9	Wang Thonglang	G	5	7	9
Lak Si	VG	7	9	9	Watthana	VG	7	9	9
LatKrabang	G	5	7	9	Yan Nawa	VG	7	9	9

TABLE F.9 Security criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	G	5	7	9	LatPhrao	P	1	3	5
Bang Kapi	P	1	3	5	Min Buri	G	5	7	9
Bang Khae	G	5	7	9	Nong Chok	G	5	7	9
Bang Khen	P	1	3	5	Nong Khaem	G	5	7	9
Bang KhoLaem	F	3	5	7	Pathum Wan	F	3	5	7
Bang Khun Thian	G	5	7	9	Phasi Charoen	G	5	7	9
Bang Na	F	3	5	7	Phaya Thai	F	3	5	7
Bang Phlat	G	5	7	9	Phra Khanong	F	3	5	7
Bang Rak	F	3	5	7	Phra Nakhon	F	3	5	7
Bang Sue	P	1	3	5	Pom Prap Sattru Phai	F	3	5	7
Bangkok Noi	G	5	7	9	Prawet	P	1	3	5
Bangkok Yai	G	5	7	9	Rat Burana	P	1	3	5
BuengKum	P	1	3	5	Ratchathewi	F	3	5	7
Chatuchak	P	1	3	5	Sai Mai	P	1	3	5
Chom Thong	P	1	3	5	Samphanthawong	F	3	5	7
Din Daeng	F	3	5	7	Saphan Sung	P	1	3	5
Don Mueang	P	1	3	5	Sathon	F	3	5	7
Dusit	F	3	5	7	Suan Luang	P	1	3	5
Huai Khwang	F	3	5	7	Taling Chan	G	5	7	9
Khan Na Yao	P	1	3	5	Thawi Watthana	G	5	7	9
Khlong Sam Wa	G	5	7	9	Thon Buri	P	1	3	5
Khlong San	P	1	3	5	Thung Khru	P	1	3	5
Khlong Toei	F	3	5	7	Wang Thonglang	P	1	3	5
Lak Si	P	1	3	5	Watthana	F	3	5	7
LatKrabang	G	5	7	9	Yan Nawa	F	3	5	7

TABLE F.10 Information technology criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	F	3	5	7	LatPhrao	F	3	5	7
Bang Kapi	F	3	5	7	Min Buri	P	1	3	5
Bang Khae	F	3	5	7	Nong Chok	F	3	5	7
Bang Khen	F	3	5	7	Nong Khaem	F	3	5	7
Bang KhoLaem	F	3	5	7	Pathum Wan	F	3	5	7
Bang Khun Thian	P	1	3	5	Phasi Charoen	G	5	7	9
Bang Na	F	3	5	7	Phaya Thai	F	3	5	7
Bang Phlat	F	3	5	7	Phra Khanong	F	3	5	7
Bang Rak	G	5	7	9	Phra Nakhon	G	5	7	9
Bang Sue	F	3	5	7	Pom Prap Sattru Phai	G	5	7	9
Bangkok Noi	G	5	7	9	Prawet	F	3	5	7
Bangkok Yai	F	3	5	7	Rat Burana	F	3	5	7
BuengKum	F	3	5	7	Ratchathewi	F	3	5	7
Chatuchak	G	5	7	9	Sai Mai	F	3	5	7
Chom Thong	F	3	5	7	Samphanthawong	F	3	5	7
Din Daeng	F	3	5	7	Saphan Sung	F	3	5	7
Don Mueang	F	3	5	7	Sathon	F	3	5	7
Dusit	G	5	7	9	Suan Luang	F	3	5	7
Huai Khwang	F	3	5	7	Taling Chan	G	5	7	9
Khan Na Yao	F	3	5	7	Thawi Watthana	F	3	5	7
Khlong Sam Wa	F	3	5	7	Thon Buri	G	5	7	9
Khlong San	F	3	5	7	Thung Khru	F	3	5	7
Khlong Toei	F	3	5	7	Wang Thonglang	F	3	5	7
Lak Si	F	3	5	7	Watthana	F	3	5	7
LatKrabang	G	5	7	9	Yan Nawa	F	3	5	7

TABLE F.11 Flooded management criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	VP	1	1	3	LatPhrao	VP	1	1	3
Bang Kapi	P	1	3	5	Min Buri	VP	1	1	3
Bang Khae	P	1	3	5	Nong Chok	VP	1	1	3
Bang Khen	F	3	5	7	Nong Khaem	P	1	3	5
Bang KhoLaem	VP	1	1	3	Pathum Wan	P	1	3	5
Bang Khun Thian	P	1	3	5	Phasi Charoen	VP	1	1	3
Bang Na	F	3	5	7	Phaya Thai	F	3	5	7
Bang Phlat	VP	1	1	3	Phra Khanong	P	1	3	5
Bang Rak	VP	1	1	3	Phra Nakhon	VP	1	1	3
Bang Sue	P	1	3	5	Pom Prap Sattru Phai	VP	1	1	3
Bangkok Noi	VP	1	1	3	Prawet	F	3	5	7
Bangkok Yai	VP	1	1	3	Rat Burana	VP	1	1	3
BuengKum	P	1	3	5	Ratchathewi	P	1	3	5
Chatuchak	P	1	3	5	Sai Mai	P	1	3	5
Chom Thong	P	1	3	5	Samphanthawong	VP	1	1	3
Din Daeng	P	1	3	5	Saphan Sung	VP	1	1	3
Don Mueang	VP	1	1	3	Sathon	P	1	3	5
Dusit	F	3	5	7	Suan Luang	VP	1	1	3
Huai Khwang	F	3	5	7	Taling Chan	P	1	3	5
Khan Na Yao	P	1	3	5	Thawi Watthana	VP	1	1	3
Khlong Sam Wa	P	1	3	5	Thon Buri	VP	1	1	3
Khlong San	VP	1	1	3	Thung Khru	P	1	3	5
Khlong Toei	G	5	7	9	Wang Thonglang	VP	1	1	3
Lak Si	VP	1	1	3	Watthana	P	1	3	5
LatKrabang	VP	1	1	3	Yan Nawa	VP	1	1	3

TABLE F.12 Topography criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	F	3	5	7	LatPhrao	F	3	5	7
Bang Kapi	VP	1	1	3	Min Buri	P	1	3	5
Bang Khae	P	1	3	5	Nong Chok	P	1	3	5
Bang Khen	G	5	7	9	Nong Khaem	VP	1	1	3
Bang KhoLaem	VG	7	9	9	Pathum Wan	P	1	3	5
Bang Khun Thian	F	3	5	7	Phasi Charoen	P	1	3	5
Bang Na	VP	1	1	3	Phaya Thai	VG	7	9	9
Bang Phlat	VP	1	1	3	Phra Khanong	VP	1	1	3
Bang Rak	VG	7	9	9	Phra Nakhon	VP	1	1	3
Bang Sue	VG	7	9	9	Pom Prap Sattru Phai	P	1	3	5
Bangkok Noi	P	1	3	5	Prawet	VP	1	1	3
Bangkok Yai	P	1	3	5	Rat Burana	G	5	7	9
BuengKum	P	1	3	5	Ratchathewi	P	1	3	5
Chatuchak	P	1	3	5	Sai Mai	VG	7	9	9
Chom Thong	P	1	3	5	Samphanthawong	P	1	3	5
Din Daeng	F	3	5	7	Saphan Sung	P	1	3	5
Don Mueang	P	1	3	5	Sathon	VG	7	9	9
Dusit	P	1	3	5	Suan Luang	VP	1	1	3
Huai Khwang	VP	1	1	3	Taling Chan	P	1	3	5
Khan Na Yao	F	3	5	7	Thawi Watthana	F	3	5	7
Khlong Sam Wa	VP	1	1	3	Thon Buri	P	1	3	5
Khlong San	P	1	3	5	Thung Khru	VG	7	9	9
Khlong Toei	VG	7	9	9	Wang Thonglang	G	5	7	9
Lak Si	VG	7	9	9	Watthana	VP	1	1	3
LatKrabang	VP	1	1	3	Yan Nawa	VG	7	9	9

TABLE F.13 Country planning criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	VG	7	9	9	LatPhrao	VP	1	1	3
Bang Kapi	F	3	5	7	Min Buri	P	1	3	5
Bang Khae	P	1	3	5	Nong Chok	P	1	3	5
Bang Khen	P	1	3	5	Nong Khaem	G	5	7	9
Bang KhoLaem	VG	7	9	9	Pathum Wan	VG	7	9	9
Bang Khun Thian	G	5	7	9	Phasi Charoen	VG	7	9	9
Bang Na	VG	7	9	9	Phaya Thai	VG	7	9	9
Bang Phlat	VG	7	9	9	Phra Khanong	VG	7	9	9
Bang Rak	VG	7	9	9	Phra Nakhon	P	1	3	5
Bang Sue	VG	7	9	9	Pom Prap Sattru Phai	VG	7	9	9
Bangkok Noi	VG	7	9	9	Prawet	P	1	3	5
Bangkok Yai	VG	7	9	9	Rat Burana	VG	7	9	9
BuengKum	P	1	3	5	Ratchathewi	VG	7	9	9
Chatuchak	VG	7	9	9	Sai Mai	VP	1	1	3
Chom Thong	VG	7	9	9	Samphanthawong	VG	7	9	9
Din Daeng	VG	7	9	9	Saphan Sung	VG	7	9	9
Don Mueang	P	1	3	5	Sathon	VG	7	9	9
Dusit	G	5	7	9	Suan Luang	F	3	5	7
Huai Khwang	VG	7	9	9	Taling Chan	VP	1	1	3
Khan Na Yao	F	3	5	7	Thawi Watthana	G	5	7	9
Khlong Sam Wa	P	1	3	5	Thon Buri	VP	1	1	3
Khlong San	VG	7	9	9	Thung Khru	F	3	5	7
Khlong Toei	VG	7	9	9	Wang Thonglang	F	3	5	7
Lak Si	G	5	7	9	Watthana	VG	7	9	9
LatKrabang	P	1	3	5	Yan Nawa	VG	7	9	9

TABLE F.14 Cost criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	VP	1	1	3	LatPhrao	VP	1	1	3
Bang Kapi	VP	1	1	3	Min Buri	VP	1	1	3
Bang Khae	VP	1	1	3	Nong Chok	VP	1	1	3
Bang Khen	VP	1	1	3	Nong Khaem	VP	1	1	3
Bang KhoLaem	F	3	5	7	Pathum Wan	VG	7	9	9
Bang Khun Thian	VP	1	1	3	Phasi Charoen	VP	1	1	3
Bang Na	VP	1	1	3	Phaya Thai	F	3	5	7
Bang Phlat	VP	1	1	3	Phra Khanong	VP	1	1	3
Bang Rak	VG	7	9	9	Phra Nakhon	F	3	5	7
Bang Sue	P	1	3	5	Pom Prap Sattru Phai	F	3	5	7
Bangkok Noi	VP	1	1	3	Prawet	VP	1	1	3
Bangkok Yai	VP	1	1	3	Rat Burana	VP	1	1	3
BuengKum	VP	1	1	3	Ratchathewi	F	3	5	7
Chatuchak	P	1	3	5	Sai Mai	VP	1	1	3
Chom Thong	VP	1	1	3	Samphanthawong	VG	7	9	9
Din Daeng	F	3	5	7	Saphan Sung	VP	1	1	3
Don Mueang	VP	1	1	3	Sathon	G	5	7	9
Dusit	F	3	5	7	Suan Luang	VP	1	1	3
Huai Khwang	F	3	5	7	Taling Chan	P	1	3	5
Khan Na Yao	VP	1	1	3	Thawi Watthana	VP	1	1	3
Khlong Sam Wa	VP	1	1	3	Thon Buri	VP	1	1	3
Khlong San	P	1	3	5	Thung Khru	VP	1	1	3
Khlong Toei	F	3	5	7	Wang Thonglang	VP	1	1	3
Lak Si	VP	1	1	3	Watthana	F	3	5	7
LatKrabang	VP	1	1	3	Yan Nawa	G	5	7	9

TABLE F.15 Competition criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	VP	1	1	3	LatPhrao	VP	1	1	3
Bang Kapi	VG	7	9	9	Min Buri	VP	1	1	3
Bang Khae	VP	1	1	3	Nong Chok	VP	1	1	3
Bang Khen	VP	1	1	3	Nong Khaem	VP	1	1	3
Bang KhoLaem	VP	1	1	3	Pathum Wan	P	1	3	5
Bang Khun Thian	VP	1	1	3	Phasi Charoen	VP	1	1	3
Bang Na	P	1	3	5	Phaya Thai	P	1	3	5
Bang Phlat	G	5	7	9	Phra Khanong	VG	7	9	9
Bang Rak	P	1	3	5	Phra Nakhon	P	1	3	5
Bang Sue	P	1	3	5	Pom Prap Sattru Phai	P	1	3	5
Bangkok Noi	G	5	7	9	Prawet	F	3	5	7
Bangkok Yai	VP	1	1	3	Rat Burana	VP	1	1	3
BuengKum	VP	1	1	3	Ratchathewi	P	1	3	5
Chatuchak	G	5	7	9	Sai Mai	VP	1	1	3
Chom Thong	VP	1	1	3	Samphanthawong	P	1	3	5
Din Daeng	F	3	5	7	Saphan Sung	VP	1	1	3
Don Mueang	VP	1	1	3	Sathon	VP	1	1	3
Dusit	VP	1	1	3	Suan Luang	VP	1	1	3
Huai Khwang	VP	1	1	3	Taling Chan	P	1	3	5
Khan Na Yao	VP	1	1	3	Thawi Watthana	VP	1	1	3
Khlong Sam Wa	VP	1	1	3	Thon Buri	P	1	3	5
Khlong San	F	3	5	7	Thung Khru	VP	1	1	3
Khlong Toei	VG	7	9	9	Wang Thonglang	F	3	5	7
Lak Si	VP	1	1	3	Watthana	P	1	3	5
LatKrabang	G	5	7	9	Yan Nawa	VP	1	1	3

TABLE F.16 Density of trafic criteria weights for alternatives

Alternatives	Weight				Alternatives	Weight			
Bang Bon	P	1	3	5	LatPhrao	F	3	5	7
Bang Kapi	G	5	7	9	Min Buri	P	1	3	5
Bang Khae	P	1	3	5	Nong Chok	P	1	3	5
Bang Khen	VG	7	9	9	Nong Khaem	P	1	3	5
Bang KhoLaem	P	1	3	5	Pathum Wan	P	1	3	5
Bang Khun Thian	F	3	5	7	Phasi Charoen	P	1	3	5
Bang Na	F	3	5	7	Phaya Thai	VG	7	9	9
Bang Phlat	G	5	7	9	Phra Khanong	F	3	5	7
Bang Rak	VG	7	9	9	Phra Nakhon	F	3	5	7
Bang Sue	P	1	3	5	Pom Prap Sattru Phai	P	1	3	5
Bangkok Noi	P	1	3	5	Prawet	P	1	3	5
Bangkok Yai	VP	1	1	3	Rat Burana	P	1	3	5
BuengKum	G	5	7	9	Ratchathewi	G	5	7	9
Chatuchak	VG	7	9	9	Sai Mai	P	1	3	5
Chom Thong	P	1	3	5	Samphanthawong	P	1	3	5
Din Daeng	G	5	7	9	Saphan Sung	P	1	3	5
Don Mueang	G	5	7	9	Sathon	F	3	5	7
Dusit	F	3	5	7	Suan Luang	F	3	5	7
Huai Khwang	F	3	5	7	Taling Chan	VP	1	1	3
Khan Na Yao	G	5	7	9	Thawi Watthana	VP	1	1	3
Khlong Sam Wa	VP	1	1	3	Thon Buri	F	3	5	7
Khlong San	F	3	5	7	Thung Khru	P	1	3	5
Khlong Toei	F	3	5	7	Wang Thonglang	F	3	5	7
Lak Si	P	1	3	5	Watthana	F	3	5	7
LatKrabang	P	1	3	5	Yan Nawa	VG	7	9	9

TABLE F.17 Normalized fuzzy decision matrix for alternatives

Criteria	$a^{-}j$	c*j	Normalized ratings			
			Bang Bon	Bang Kapi	Bang Khae	Bang Khen
1. National environment and its impact	1	9	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.33 0.56
2.Accessibility	1	9	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.11 0.33
3.Labor	1	9	0.33 0.56 0.78	0.56 0.78 1.00	0.78 1.00 1.00	0.78 1.00 1.00
4.Connectivity to multimodal transport	1	9	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33	0.33 0.56 0.78
5.Government and regulations	1	9	0.56 0.78 1.00	0.56 0.78 1.00	0.56 0.78 1.00	0.56 0.78 1.00
6.Demand	1	9	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33
7.Infrastructure	3	9	0.33 0.56 0.78	0.56 0.78 1.00	0.56 0.78 1.00	0.56 0.78 1.00
8.Security	1	9	0.56 0.78 1.00	0.11 0.33 0.56	0.56 0.78 1.00	0.11 0.33 0.56
9.Information technology	1	9	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	1	9	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.33 0.56	0.33 0.56 0.78
11.Topography	1	9	0.33 0.56 0.78	0.11 0.11 0.33	0.11 0.33 0.56	0.56 0.78 1.00
12.Country planning	1	9	0.78 1.00 1.00	0.33 0.56 0.78	0.11 0.33 0.56	0.11 0.33 0.56
13.Cost	1	9	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00
14.Competition	1	9	0.33 1.00 1.00	0.11 0.11 0.14	0.33 1.00 1.00	0.33 1.00 1.00
15.Density of traffic	1	9	0.20 0.33 1.00	0.11 0.14 0.20	0.20 0.33 1.00	0.11 0.11 0.14

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Bang KhoLaem	Bang Khun Thian	Bang Na	Bang Phlat
1. National environment and its impact	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78
2.Accessibility	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.33 0.56
3.Labor	0.33 0.56 0.78	0.78 1.00 1.00	0.33 0.56 0.78	0.33 0.56 0.78
4.Connectivity to multimodal transport	0.11 0.11 0.33	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.11 0.33
5.Government and regulations	0.11 0.33 0.56	0.56 0.78 1.00	0.56 0.78 1.00	0.33 0.56 0.78
6.Demand	0.11 0.33 0.56	0.33 0.56 0.78	0.33 0.56 0.78	0.11 0.33 0.56
7.Infrastructure	0.56 0.78 1.00	0.33 0.56 0.78	0.56 0.78 1.00	0.56 0.78 1.00
8.Security	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78	0.56 0.78 1.00
9.Information technology	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	0.11 0.11 0.33	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.11 0.33
11.Topography	0.78 1.00 1.00	0.33 0.56 0.78	0.11 0.11 0.33	0.11 0.11 0.33
12.Country planning	0.78 1.00 1.00	0.56 0.78 1.00	0.78 1.00 1.00	0.78 1.00 1.00
13.Cost	0.14 0.20 0.33	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00
14.Competition	0.33 1.00 1.00	0.33 1.00 1.00	0.20 0.33 1.00	0.11 0.14 0.20
15.Density of traffic	0.20 0.33 1.00	0.14 0.20 0.33	0.14 0.20 0.33	0.11 0.14 0.20

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Bang Rak	Bang Sue	Bangkok Noi	Bangkok Yai
1. National environment and its impact	0.56 0.78 1.00	0.33 0.56 0.78	0.33 0.56 0.78	0.56 0.78 1.00
2.Accessibility	0.78 1.00 1.00	0.33 0.56 0.78	0.11 0.33 0.56	0.11 0.33 0.56
3.Labor	0.11 0.33 0.56	0.56 0.78 1.00	0.56 0.78 1.00	0.11 0.33 0.56
4.Connectivity to multimodal transport	0.33 0.56 0.78	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33
5.Government and regulations	0.11 0.33 0.56	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78
6.Demand	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.11 0.33
7.Infrastructure	0.78 1.00 1.00	0.78 1.00 1.00	0.78 1.00 1.00	0.78 1.00 1.00
8.Security	0.33 0.56 0.78	0.11 0.33 0.56	0.56 0.78 1.00	0.56 0.78 1.00
9.Information technology	0.56 0.78 1.00	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78
10.Flooded management	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.11 0.33
11.Topography	0.78 1.00 1.00	0.78 1.00 1.00	0.11 0.33 0.56	0.11 0.33 0.56
12.Country planning	0.78 1.00 1.00	0.78 1.00 1.00	0.78 1.00 1.00	0.78 1.00 1.00
13.Cost	0.11 0.11 0.14	0.20 0.33 1.00	0.33 1.00 1.00	0.33 1.00 1.00
14.Competition	0.20 0.33 1.00	0.20 0.33 1.00	0.11 0.14 0.20	0.33 1.00 1.00
15.Density of traffic	0.11 0.11 0.14	0.20 0.33 1.00	0.20 0.33 1.00	0.33 1.00 1.00

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	BuengKum	Chatuchak	Chom Thong	Din Daeng
1.National environment and its impact	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78	0.33 0.56 0.78
2.Accessibility	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.33 0.56	0.11 0.33 0.56
3.Labor	0.56 0.78 1.00	0.78 1.00 1.00	0.56 0.78 1.00	0.56 0.78 1.00
4.Connectivity to multimodal transport	0.11 0.11 0.33	0.78 1.00 1.00	0.11 0.33 0.56	0.11 0.11 0.33
5.Government and regulations	0.56 0.78 1.00	0.33 0.56 0.78	0.78 1.00 1.00	0.11 0.33 0.56
6.Demand	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33
7.Infrastructure	0.56 0.78 1.00	0.56 0.78 1.00	0.56 0.78 1.00	0.78 1.00 1.00
8.Security	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56	0.33 0.56 0.78
9.Information technology	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56
11.Topography	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56	0.33 0.56 0.78
12.Country planning	0.11 0.33 0.56	0.78 1.00 1.00	0.78 1.00 1.00	0.78 1.00 1.00
13.Cost	0.33 1.00 1.00	0.20 0.33 1.00	0.33 1.00 1.00	0.14 0.20 0.33
14.Competition	0.33 1.00 1.00	0.11 0.14 0.20	0.33 1.00 1.00	0.14 0.20 0.33
15.Density of traffic	0.11 0.14 0.20	0.11 0.11 0.14	0.20 0.33 1.00	0.11 0.14 0.20

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Don Mueang	Dusit	Huai Khwang	Khan Na Yao
1.National environment and its impact	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78	0.33 0.56 0.78
2.Accessibility	0.11 0.11 0.33	0.11 0.11 0.33	0.33 0.56 0.78	0.11 0.11 0.33
3.Labor	0.78 1.00 1.00	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78
4.Connectivity to multimodal transport	0.56 0.78 1.00	0.11 0.33 0.56	0.56 0.78 1.00	0.11 0.11 0.33
5.Government and regulations	0.56 0.78 1.00	0.11 0.33 0.56	0.11 0.33 0.56	0.78 1.00 1.00
6.Demand	0.11 0.11 0.33	0.11 0.33 0.56	0.78 1.00 1.00	0.11 0.33 0.56
7.Infrastructure	0.56 0.78 1.00	0.78 1.00 1.00	0.78 1.00 1.00	0.33 0.56 0.78
8.Security	0.11 0.33 0.56	0.33 0.56 0.78	0.33 0.56 0.78	0.11 0.33 0.56
9.Information technology	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	0.11 0.11 0.33	0.33 0.56 0.78	0.33 0.56 0.78	0.11 0.33 0.56
11.Topography	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33	0.33 0.56 0.78
12.Country planning	0.11 0.33 0.56	0.56 0.78 1.00	0.78 1.00 1.00	0.33 0.56 0.78
13.Cost	0.33 1.00 1.00	0.14 0.20 0.33	0.14 0.20 0.33	0.33 1.00 1.00
14.Competition	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00
15.Density of traffic	0.11 0.14 0.20	0.14 0.20 0.33	0.14 0.20 0.33	0.11 0.14 0.20

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Khlong Sam Wa	Khlong San	Khlong Toei	Lak Si
1.National environment and its impact	0.33 0.56 0.78	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78
2.Accessibility	0.11 0.11 0.33	0.33 0.56 0.78	0.56 0.78 1.00	0.11 0.11 0.33
3.Labor	0.78 1.00 1.00	0.11 0.33 0.56	0.33 0.56 0.78	0.33 0.56 0.78
4.Connectivity to multimodal transport	0.11 0.11 0.33	0.11 0.11 0.33	0.33 0.56 0.78	0.11 0.33 0.56
5.Government and regulations	0.78 1.00 1.00	0.11 0.33 0.56	0.33 0.56 0.78	0.78 1.00 1.00
6.Demand	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56
7.Infrastructure	0.33 0.56 0.78	0.78 1.00 1.00	0.78 1.00 1.00	0.56 0.78 1.00
8.Security	0.56 0.78 1.00	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.33 0.56
9.Information technology	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	0.11 0.33 0.56	0.11 0.11 0.33	0.56 0.78 1.00	0.11 0.11 0.33
11.Topography	0.11 0.11 0.33	0.11 0.33 0.56	0.78 1.00 1.00	0.78 1.00 1.00
12.Country planning	0.11 0.33 0.56	0.78 1.00 1.00	0.78 1.00 1.00	0.56 0.78 1.00
13.Cost	0.33 1.00 1.00	0.20 0.33 1.00	0.14 0.20 0.33	0.33 1.00 1.00
14.Competition	0.33 1.00 1.00	0.14 0.20 0.33	0.11 0.11 0.14	0.33 1.00 1.00
15.Density of traffic	0.33 1.00 1.00	0.14 0.20 0.33	0.14 0.20 0.33	0.20 0.33 1.00

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	LatKrabang	LatPhrao	Min Buri	Nong Chok
1.National environment and its impact	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.56 0.78 1.00
2.Accessibility	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33
3.Labor	0.78 1.00 1.00	0.56 0.78 1.00	0.56 0.78 1.00	0.56 0.78 1.00
4.Connectivity to multimodal transport	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.11 0.33
5.Government and regulations	0.78 1.00 1.00	0.56 0.78 1.00	0.78 1.00 1.00	0.78 1.00 1.00
6.Demand	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33
7.Infrastructure	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78	0.33 0.56 0.78
8.Security	0.56 0.78 1.00	0.11 0.33 0.56	0.56 0.78 1.00	0.56 0.78 1.00
9.Information technology	0.56 0.78 1.00	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78
10.Flooded management	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.11 0.33
11.Topography	0.11 0.11 0.33	0.33 0.56 0.78	0.11 0.33 0.56	0.11 0.33 0.56
12.Country planning	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.33 0.56
13.Cost	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00
14.Competition	0.11 0.14 0.20	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00
15.Density of traffic	0.20 0.33 1.00	0.14 0.20 0.33	0.20 0.33 1.00	0.20 0.33 1.00

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Nong Khaem	Pathum Wan	Phasi Charoen	Phaya Thai
1.National environment and its impact	0.33 0.56 0.78	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78
2.Accessibility	0.11 0.11 0.33	0.78 1.00 1.00	0.11 0.11 0.33	0.11 0.33 0.56
3.Labor	0.56 0.78 1.00	0.11 0.33 0.56	0.56 0.78 1.00	0.11 0.33 0.56
4.Connectivity to multimodal transport	0.11 0.11 0.33	0.56 0.78 1.00	0.11 0.11 0.33	0.56 0.78 1.00
5.Government and regulations	0.78 1.00 1.00	0.11 0.33 0.56	0.78 1.00 1.00	0.11 0.33 0.56
6.Demand	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.33 0.56	0.56 0.78 1.00
7.Infrastructure	0.33 0.56 0.78	0.78 1.00 1.00	0.56 0.78 1.00	0.78 1.00 1.00
8.Security	0.56 0.78 1.00	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78
9.Information technology	0.33 0.56 0.78	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78
10.Flooded management	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33	0.33 0.56 0.78
11.Topography	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.33 0.56	0.78 1.00 1.00
12.Country planning	0.56 0.78 1.00	0.78 1.00 1.00	0.78 1.00 1.00	0.78 1.00 1.00
13.Cost	0.33 1.00 1.00	0.11 0.11 0.14	0.33 1.00 1.00	0.14 0.20 0.33
14.Competition	0.33 1.00 1.00	0.20 0.33 1.00	0.33 1.00 1.00	0.20 0.33 1.00
15.Density of traffic	0.20 0.33 1.00	0.20 0.33 1.00	0.20 0.33 1.00	0.11 0.11 0.14

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Phra Khanong	Phra Nakhon	Pom Prap Sattru Phai	Prawet
1.National environment and its impact	0.56 0.78 1.00	0.56 0.78 1.00	0.56 0.78 1.00	0.33 0.56 0.78
2.Accessibility	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33
3.Labor	0.33 0.56 0.78	0.11 0.33 0.56	0.11 0.33 0.56	0.56 0.78 1.00
4.Connectivity to multimodal transport	0.33 0.56 0.78	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.11 0.33
5.Government and regulations	0.56 0.78 1.00	0.11 0.33 0.56	0.11 0.33 0.56	0.78 1.00 1.00
6.Demand	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33
7.Infrastructure	0.56 0.78 1.00	0.78 1.00 1.00	0.78 1.00 1.00	0.33 0.56 0.78
8.Security	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.11 0.33 0.56
9.Information technology	0.33 0.56 0.78	0.56 0.78 1.00	0.56 0.78 1.00	0.33 0.56 0.78
10.Flooded management	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.11 0.33	0.33 0.56 0.78
11.Topography	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33
12.Country planning	0.78 1.00 1.00	0.11 0.33 0.56	0.78 1.00 1.00	0.11 0.33 0.56
13.Cost	0.33 1.00 1.00	0.14 0.20 0.33	0.14 0.20 0.33	0.33 1.00 1.00
14.Competition	0.11 0.11 0.14	0.20 0.33 1.00	0.20 0.33 1.00	0.14 0.20 0.33
15.Density of traffic	0.14 0.20 0.33	0.14 0.20 0.33	0.20 0.33 1.00	0.20 0.33 1.00

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Rat Burana	Ratchathewi	Sai Mai	Samphanthawong
1.National environment and its impact	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78	0.56 0.78 1.00
2.Accessibility	0.11 0.11 0.33	0.78 1.00 1.00	0.11 0.11 0.33	0.11 0.33 0.56
3.Labor	0.33 0.56 0.78	0.11 0.33 0.56	0.78 1.00 1.00	0.11 0.11 0.33
4.Connectivity to multimodal transport	0.11 0.11 0.33	0.56 0.78 1.00	0.11 0.11 0.33	0.11 0.11 0.33
5.Government and regulations	0.78 1.00 1.00	0.11 0.33 0.56	0.78 1.00 1.00	0.11 0.33 0.56
6.Demand	0.33 0.56 0.78	0.78 1.00 1.00	0.11 0.33 0.56	0.11 0.33 0.56
7.Infrastructure	0.33 0.56 0.78	0.78 1.00 1.00	0.33 0.56 0.78	0.78 1.00 1.00
8.Security	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.33 0.56	0.33 0.56 0.78
9.Information technology	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33
11.Topography	0.56 0.78 1.00	0.11 0.33 0.56	0.78 1.00 1.00	0.11 0.33 0.56
12.Country planning	0.78 1.00 1.00	0.78 1.00 1.00	0.11 0.11 0.33	0.78 1.00 1.00
13.Cost	0.33 1.00 1.00	0.14 0.20 0.33	0.33 1.00 1.00	0.11 0.11 0.14
14.Competition	0.33 1.00 1.00	0.20 0.33 1.00	0.33 1.00 1.00	0.20 0.33 1.00
15.Density of traffic	0.20 0.33 1.00	0.11 0.14 0.20	0.20 0.33 1.00	0.20 0.33 1.00

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Saphan Sung	Sathon	Suan Luang	Taling Chan
1.National environment and its impact	0.56 0.78 1.00	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78
2.Accessibility	0.11 0.11 0.33	0.33 0.56 0.78	0.11 0.11 0.33	0.11 0.11 0.33
3.Labor	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78
4.Connectivity to multimodal transport	0.11 0.11 0.33	0.33 0.56 0.78	0.78 1.00 1.00	0.11 0.33 0.56
5.Government and regulations	0.78 1.00 1.00	0.11 0.33 0.56	0.56 0.78 1.00	0.56 0.78 1.00
6.Demand	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33
7.Infrastructure	0.33 0.56 0.78	0.78 1.00 1.00	0.33 0.56 0.78	0.33 0.56 0.78
8.Security	0.11 0.33 0.56	0.33 0.56 0.78	0.11 0.33 0.56	0.56 0.78 1.00
9.Information technology	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.56 0.78 1.00
10.Flooded management	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.33 0.56
11.Topography	0.11 0.33 0.56	0.78 1.00 1.00	0.11 0.11 0.33	0.11 0.33 0.56
12.Country planning	0.78 1.00 1.00	0.78 1.00 1.00	0.33 0.56 0.78	0.11 0.11 0.33
13.Cost	0.33 1.00 1.00	0.11 0.14 0.20	0.33 1.00 1.00	0.20 0.33 1.00
14.Competition	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00	0.20 0.33 1.00
15.Density of traffic	0.20 0.33 1.00	0.14 0.20 0.33	0.14 0.20 0.33	0.33 1.00 1.00

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings			
	Thawi Watthana	Thon Buri	Thung Khru	Wang Thonglang
1.National environment and its impact	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78	0.33 0.56 0.78
2.Accessibility	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33	0.11 0.11 0.33
3.Labor	0.11 0.33 0.56	0.56 0.78 1.00	0.33 0.56 0.78	0.33 0.56 0.78
4.Connectivity to multimodal transport	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.11 0.33	0.33 0.56 0.78
5.Government and regulations	0.56 0.78 1.00	0.33 0.56 0.78	0.56 0.78 1.00	0.56 0.78 1.00
6.Demand	0.11 0.11 0.33	0.33 0.56 0.78	0.11 0.11 0.33	0.11 0.11 0.33
7.Infrastructure	0.33 0.56 0.78	0.78 1.00 1.00	0.33 0.56 0.78	0.56 0.78 1.00
8.Security	0.56 0.78 1.00	0.11 0.33 0.56	0.11 0.33 0.56	0.11 0.33 0.56
9.Information technology	0.33 0.56 0.78	0.56 0.78 1.00	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	0.11 0.11 0.33	0.11 0.11 0.33	0.11 0.33 0.56	0.11 0.11 0.33
11.Topography	0.33 0.56 0.78	0.11 0.33 0.56	0.78 1.00 1.00	0.56 0.78 1.00
12.Country planning	0.56 0.78 1.00	0.11 0.11 0.33	0.33 0.56 0.78	0.33 0.56 0.78
13.Cost	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00	0.33 1.00 1.00
14.Competition	0.33 1.00 1.00	0.20 0.33 1.00	0.33 1.00 1.00	0.14 0.20 0.33
15.Density of traffic	0.33 1.00 1.00	0.14 0.20 0.33	0.20 0.33 1.00	0.14 0.20 0.33

TABLE F.17 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Normalized ratings	
	Watthana	Yan Nawa
1.National environment and its impact	0.11 0.33 0.56	0.11 0.33 0.56
2.Accessibility	0.78 1.00 1.00	0.11 0.33 0.56
3.Labor	0.33 0.56 0.78	0.33 0.56 0.78
4.Connectivity to multimodal transport	0.11 0.33 0.56	0.33 0.56 0.78
5.Government and regulations	0.33 0.56 0.78	0.11 0.33 0.56
6.Demand	0.56 0.78 1.00	0.11 0.11 0.33
7.Infrastructure	0.78 1.00 1.00	0.78 1.00 1.00
8.Security	0.33 0.56 0.78	0.33 0.56 0.78
9.Information technology	0.33 0.56 0.78	0.33 0.56 0.78
10.Flooded management	0.11 0.33 0.56	0.11 0.11 0.33
11.Topography	0.11 0.11 0.33	0.78 1.00 1.00
12.Country planning	0.78 1.00 1.00	0.78 1.00 1.00
13.Cost	0.14 0.20 0.33	0.11 0.14 0.20
14.Competition	0.20 0.33 1.00	0.33 1.00 1.00
15.Density of traffic	0.14 0.20 0.33	0.11 0.11 0.14

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS

Criteria	Normalized alternatives			
	Bang Bon	Bang Kapi	Bang Khae	Bang Khen
1.National environment and its impact	0.33 3.27 7.00	0.11 1.96 5.00	0.33 3.27 7.00	0.11 1.96 5.00
2.Accessibility	0.33 0.90 3.00	0.33 2.70 5.00	0.33 0.90 3.00	0.33 0.90 3.00
3.Labor	0.33 3.40 7.00	0.56 4.75 9.00	0.78 6.11 9.00	0.78 6.11 9.00
4.Connectivity to multimodal transport	0.33 2.48 5.00	0.33 2.48 5.00	0.33 0.83 3.00	1.00 4.14 7.00
5.Government and regulations	1.67 5.10 9.00	1.67 5.10 9.00	1.67 5.10 9.00	1.67 5.10 9.00
6.Demand	0.33 2.26 5.00	0.33 2.26 5.00	0.33 2.26 5.00	0.33 0.75 3.00
7.Infrastructure	1.00 3.77 7.00	1.67 5.27 9.00	1.67 5.27 9.00	1.67 5.27 9.00
8.Security	0.56 4.41 9.00	0.11 1.89 5.00	0.56 4.41 9.00	0.11 1.89 5.00
9.Information technology	0.33 3.89 7.00	0.33 3.89 7.00	0.33 3.89 7.00	0.33 3.89 7.00
10.Flooded management	0.56 0.85 3.00	0.56 2.56 5.00	0.56 2.56 5.00	1.67 4.26 7.00
11.Topography	1.00 4.01 7.00	0.33 0.80 3.00	0.33 2.41 5.00	1.67 5.62 9.00
12.Country planning	0.78 6.56 9.00	0.33 3.64 7.00	0.11 2.19 5.00	0.11 2.19 5.00
13.Cost	1.00 7.44 9.00	1.00 7.44 9.00	1.00 7.44 9.00	1.00 7.44 9.00
14.Competition	0.33 5.22 9.00	0.11 0.58 1.29	0.33 5.22 9.00	0.33 5.22 9.00
15.Density of traffic	0.60 2.33 9.00	0.33 1.00 1.80	0.60 2.33 9.00	0.33 0.78 1.29

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Bang KhoLaem	Bang Khun Thian	Bang Na	Bang Phlat
1.National environment and its impact	0.33 3.27 7.00	0.33 3.27 7.00	0.33 3.27 7.00	0.33 3.27 7.00
2.Accessibility	0.33 2.70 5.00	0.33 0.90 3.00	0.33 0.90 3.00	0.33 2.70 5.00
3.Labor	0.33 3.40 7.00	0.78 6.11 9.00	0.33 3.40 7.00	0.33 3.40 7.00
4.Connectivity to multimodal transport	0.33 0.83 3.00	0.33 2.48 5.00	1.00 4.14 7.00	0.33 0.83 3.00
5.Government and regulations	0.33 2.19 5.00	1.67 5.10 9.00	1.67 5.10 9.00	1.00 3.64 7.00
6.Demand	0.33 2.26 5.00	1.00 3.77 7.00	1.00 3.77 7.00	0.33 2.26 5.00
7.Infrastructure	1.67 5.27 9.00	1.00 3.77 7.00	1.67 5.27 9.00	1.67 5.27 9.00
8.Security	0.33 3.15 7.00	0.56 4.41 9.00	0.33 3.15 7.00	0.56 4.41 9.00
9.Information technology	0.33 3.89 7.00	0.11 2.33 5.00	0.33 3.89 7.00	0.33 3.89 7.00
10.Flooded management	0.56 0.85 3.00	0.56 2.56 5.00	1.67 4.26 7.00	0.56 0.85 3.00
11.Topography	2.33 7.22 9.00	1.00 4.01 7.00	0.33 0.80 3.00	0.33 0.80 3.00
12.Country planning	0.78 6.56 9.00	0.56 5.10 9.00	0.78 6.56 9.00	0.78 6.56 9.00
13.Cost	0.43 1.49 3.00	1.00 7.44 9.00	1.00 7.44 9.00	1.00 7.44 9.00
14.Competition	0.33 5.22 9.00	0.33 5.22 9.00	0.20 1.74 9.00	0.11 0.75 1.80
15.Density of traffic	0.60 2.33 9.00	0.43 1.40 3.00	0.43 1.40 3.00	0.33 1.00 1.80

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Bang Rak	Bang Sue	Bangkok Noi	Bangkok Yai
1.National environment and its impact	0.56 4.58 9.00	0.33 3.27 7.00	0.33 3.27 7.00	0.56 4.58 9.00
2.Accessibility	2.33 8.11 9.00	1.00 4.51 7.00	0.33 2.70 5.00	0.33 2.70 5.00
3.Labor	0.11 2.04 5.00	0.56 4.75 9.00	0.56 4.75 9.00	0.11 2.04 5.00
4.Connectivity to multimodal transport	1.00 4.14 7.00	0.33 0.83 3.00	0.33 2.48 5.00	0.33 0.83 3.00
5.Government and regulations	0.33 2.19 5.00	1.00 3.64 7.00	1.00 3.64 7.00	1.00 3.64 7.00
6.Demand	1.00 3.77 7.00	0.33 2.26 5.00	1.00 3.77 7.00	0.33 0.75 3.00
7.Infrastructure	2.33 6.78 9.00	2.33 6.78 9.00	2.33 6.78 9.00	2.33 6.78 9.00
8.Security	0.33 3.15 7.00	0.11 1.89 5.00	0.56 4.41 9.00	0.56 4.41 9.00
9.Information technology	0.56 5.44 9.00	0.33 3.89 7.00	0.56 5.44 9.00	0.33 3.89 7.00
10.Flooded management	0.56 0.85 3.00	0.56 2.56 5.00	0.56 0.85 3.00	0.56 0.85 3.00
11.Topography	2.33 7.22 9.00	2.33 7.22 9.00	0.33 2.41 5.00	0.33 2.41 5.00
12.Country planning	0.78 6.56 9.00	0.78 6.56 9.00	0.78 6.56 9.00	0.78 6.56 9.00
13.Cost	0.33 0.83 1.29	0.60 2.48 9.00	1.00 7.44 9.00	1.00 7.44 9.00
14.Competition	0.20 1.74 9.00	0.20 1.74 9.00	0.11 0.75 1.80	0.33 5.22 9.00
15.Density of traffic	0.33 0.78 1.29	0.60 2.33 9.00	0.60 2.33 9.00	1.00 7.00 9.00

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	BuengKum	Chatuchak	Chom Thong	Din Daeng
1.National environment and its impact	0.33 3.27 7.00	0.11 1.96 5.00	0.33 3.27 7.00	0.33 3.27 7.00
2.Accessibility	0.33 2.70 5.00	1.00 4.51 7.00	0.33 2.70 5.00	0.33 2.70 5.00
3.Labor	0.56 4.75 9.00	0.78 6.11 9.00	0.56 4.75 9.00	0.56 4.75 9.00
4.Connectivity to multimodal transport	0.33 0.83 3.00	2.33 7.44 9.00	0.33 2.48 5.00	0.33 0.83 3.00
5.Government and regulations	1.67 5.10 9.00	1.00 3.64 7.00	2.33 6.56 9.00	0.33 2.19 5.00
6.Demand	0.33 2.26 5.00	0.33 2.26 5.00	0.33 2.26 5.00	0.33 0.75 3.00
7.Infrastructure	1.67 5.27 9.00	1.67 5.27 9.00	1.67 5.27 9.00	2.33 6.78 9.00
8.Security	0.11 1.89 5.00	0.11 1.89 5.00	0.11 1.89 5.00	0.33 3.15 7.00
9.Information technology	0.33 3.89 7.00	0.56 5.44 9.00	0.33 3.89 7.00	0.33 3.89 7.00
10.Flooded management	0.56 2.56 5.00	0.56 2.56 5.00	0.56 2.56 5.00	0.56 2.56 5.00
11.Topography	0.33 2.41 5.00	0.33 2.41 5.00	0.33 2.41 5.00	1.00 4.01 7.00
12.Country planning	0.11 2.19 5.00	0.78 6.56 9.00	0.78 6.56 9.00	0.78 6.56 9.00
13.Cost	1.00 7.44 9.00	0.60 2.48 9.00	1.00 7.44 9.00	0.43 1.49 3.00
14.Competition	0.33 5.22 9.00	0.11 0.75 1.80	0.33 5.22 9.00	0.14 1.04 3.00
15.Density of traffic	0.33 1.00 1.80	0.33 0.78 1.29	0.60 2.33 9.00	0.33 1.00 1.80

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Don Mueang	Dusit	Huai Khwang	Khan Na Yao
1.National environment and its impact	0.33 3.27 7.00	0.56 4.58 9.00	0.33 3.27 7.00	0.33 3.27 7.00
2.Accessibility	0.33 0.90 3.00	0.33 0.90 3.00	1.00 4.51 7.00	0.33 0.90 3.00
3.Labor	0.78 6.11 9.00	0.33 3.40 7.00	0.11 2.04 5.00	0.33 3.40 7.00
4.Connectivity to multimodal transport	1.67 5.79 9.00	0.33 2.48 5.00	1.67 5.79 9.00	0.33 0.83 3.00
5.Government and regulations	1.67 5.10 9.00	0.33 2.19 5.00	0.33 2.19 5.00	2.33 6.56 9.00
6.Demand	0.33 0.75 3.00	0.33 2.26 5.00	2.33 6.78 9.00	0.33 2.26 5.00
7.Infrastructure	1.67 5.27 9.00	2.33 6.78 9.00	2.33 6.78 9.00	1.00 3.77 7.00
8.Security	0.11 1.89 5.00	0.33 3.15 7.00	0.33 3.15 7.00	0.11 1.89 5.00
9.Information technology	0.33 3.89 7.00	0.56 5.44 9.00	0.33 3.89 7.00	0.33 3.89 7.00
10.Flooded management	0.56 0.85 3.00	1.67 4.26 7.00	1.67 4.26 7.00	0.56 2.56 5.00
11.Topography	0.33 2.41 5.00	0.33 2.41 5.00	0.33 0.80 3.00	1.00 4.01 7.00
12.Country planning	0.11 2.19 5.00	0.56 5.10 9.00	0.78 6.56 9.00	0.33 3.64 7.00
13.Cost	1.00 7.44 9.00	0.43 1.49 3.00	0.43 1.49 3.00	1.00 7.44 9.00
14.Competition	0.33 5.22 9.00	0.33 5.22 9.00	0.33 5.22 9.00	0.33 5.22 9.00
15.Density of traffic	0.33 1.00 1.80	0.43 1.40 3.00	0.43 1.40 3.00	0.33 1.00 1.80

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Khlong Sam Wa	Khlong San	Khlong Toei	Lak Si
1.National environment and its impact	0.33 3.27 7.00	0.33 3.27 7.00	0.11 1.96 5.00	0.33 3.27 7.00
2.Accessibility	0.33 0.90 3.00	1.00 4.51 7.00	1.67 6.31 9.00	0.33 0.90 3.00
3.Labor	0.78 6.11 9.00	0.11 2.04 5.00	0.33 3.40 7.00	0.33 3.40 7.00
4.Connectivity to multimodal transport	0.33 0.83 3.00	0.33 0.83 3.00	1.00 4.14 7.00	0.33 2.48 5.00
5.Government and regulations	2.33 6.56 9.00	0.33 2.19 5.00	1.00 3.64 7.00	2.33 6.56 9.00
6.Demand	0.33 0.75 3.00	0.33 2.26 5.00	0.33 2.26 5.00	0.33 2.26 5.00
7.Infrastructure	1.00 3.77 7.00	2.33 6.78 9.00	2.33 6.78 9.00	1.67 5.27 9.00
8.Security	0.56 4.41 9.00	0.11 1.89 5.00	0.33 3.15 7.00	0.11 1.89 5.00
9.Information technology	0.33 3.89 7.00	0.33 3.89 7.00	0.33 3.89 7.00	0.33 3.89 7.00
10.Flooded management	0.56 2.56 5.00	0.56 0.85 3.00	2.78 5.96 9.00	0.56 0.85 3.00
11.Topography	0.33 0.80 3.00	0.33 2.41 5.00	2.33 7.22 9.00	2.33 7.22 9.00
12.Country planning	0.11 2.19 5.00	0.78 6.56 9.00	0.78 6.56 9.00	0.56 5.10 9.00
13.Cost	1.00 7.44 9.00	0.60 2.48 9.00	0.43 1.49 3.00	1.00 7.44 9.00
14.Competition	0.33 5.22 9.00	0.14 1.04 3.00	0.11 0.58 1.29	0.33 5.22 9.00
15.Density of traffic	1.00 7.00 9.00	0.43 1.40 3.00	0.43 1.40 3.00	0.60 2.33 9.00

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	LatKrabang	LatPhrao	Min Buri	Nong Chok
1.National environment and its impact	0.33 3.27 7.00	0.33 3.27 7.00	0.33 3.27 7.00	0.56 4.58 9.00
2.Accessibility	0.33 0.90 3.00	0.33 0.90 3.00	0.33 2.70 5.00	0.33 0.90 3.00
3.Labor	0.78 6.11 9.00	0.56 4.75 9.00	0.56 4.75 9.00	0.56 4.75 9.00
4.Connectivity to multimodal transport	0.33 2.48 5.00	0.33 2.48 5.00	0.33 0.83 3.00	0.33 0.83 3.00
5.Government and regulations	2.33 6.56 9.00	1.67 5.10 9.00	2.33 6.56 9.00	2.33 6.56 9.00
6.Demand	0.33 2.26 5.00	0.33 2.26 5.00	0.33 2.26 5.00	0.33 0.75 3.00
7.Infrastructure	1.00 3.77 7.00	1.67 5.27 9.00	1.00 3.77 7.00	1.00 3.77 7.00
8.Security	0.56 4.41 9.00	0.11 1.89 5.00	0.56 4.41 9.00	0.56 4.41 9.00
9.Information technology	0.56 5.44 9.00	0.33 3.89 7.00	0.11 2.33 5.00	0.33 3.89 7.00
10.Flooded management	0.56 0.85 3.00	0.56 0.85 3.00	0.56 0.85 3.00	0.56 0.85 3.00
11.Topography	0.33 0.80 3.00	1.00 4.01 7.00	0.33 2.41 5.00	0.33 2.41 5.00
12.Country planning	0.11 2.19 5.00	0.11 0.73 3.00	0.11 2.19 5.00	0.11 2.19 5.00
13.Cost	1.00 7.44 9.00	1.00 7.44 9.00	1.00 7.44 9.00	1.00 7.44 9.00
14.Competition	0.11 0.75 1.80	0.33 5.22 9.00	0.33 5.22 9.00	0.33 5.22 9.00
15.Density of traffic	0.60 2.33 9.00	0.43 1.40 3.00	0.60 2.33 9.00	0.60 2.33 9.00

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Nong Khaem	Pathum Wan	Phasi Charoen	Phaya Thai
1.National environment and its impact	0.33 3.27 7.00	0.33 3.27 7.00	0.56 4.58 9.00	0.33 3.27 7.00
2.Accessibility	0.33 0.90 3.00	2.33 8.11 9.00	0.33 0.90 3.00	0.33 2.70 5.00
3.Labor	0.56 4.75 9.00	0.11 2.04 5.00	0.56 4.75 9.00	0.11 2.04 5.00
4.Connectivity to multimodal transport	0.33 0.83 3.00	1.67 5.79 9.00	0.33 0.83 3.00	1.67 5.79 9.00
5.Government and regulations	2.33 6.56 9.00	0.33 2.19 5.00	2.33 6.56 9.00	0.33 2.19 5.00
6.Demand	0.33 2.26 5.00	1.00 3.77 7.00	0.33 2.26 5.00	1.67 5.27 9.00
7.Infrastructure	1.00 3.77 7.00	2.33 6.78 9.00	1.67 5.27 9.00	2.33 6.78 9.00
8.Security	0.56 4.41 9.00	0.33 3.15 7.00	0.56 4.41 9.00	0.33 3.15 7.00
9.Information technology	0.33 3.89 7.00	0.33 3.89 7.00	0.56 5.44 9.00	0.33 3.89 7.00
10.Flooded management	0.56 2.56 5.00	0.56 2.56 5.00	0.56 0.85 3.00	1.67 4.26 7.00
11.Topography	0.33 0.80 3.00	0.33 2.41 5.00	0.33 2.41 5.00	2.33 7.22 9.00
12.Country planning	0.56 5.10 9.00	0.78 6.56 9.00	0.78 6.56 9.00	0.78 6.56 9.00
13.Cost	1.00 7.44 9.00	0.33 0.83 1.29	1.00 7.44 9.00	0.43 1.49 3.00
14.Competition	0.33 5.22 9.00	0.20 1.74 9.00	0.33 5.22 9.00	0.20 1.74 9.00
15.Density of traffic	0.60 2.33 9.00	0.60 2.33 9.00	0.60 2.33 9.00	0.33 0.78 1.29

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Phra Khanong	Phra Nakhon	Pom Prap Sattru Phai	Prawet
1.National environment and its impact	0.56 4.58 9.00	0.56 4.58 9.00	0.56 4.58 9.00	0.33 3.27 7.00
2.Accessibility	0.33 0.90 3.00	0.33 2.70 5.00	0.33 2.70 5.00	0.33 0.90 3.00
3.Labor	0.33 3.40 7.00	0.11 2.04 5.00	0.11 2.04 5.00	0.56 4.75 9.00
4.Connectivity to multimodal transport	1.00 4.14 7.00	0.33 0.83 3.00	0.33 0.83 3.00	0.33 0.83 3.00
5.Government and regulations	1.67 5.10 9.00	0.33 2.19 5.00	0.33 2.19 5.00	2.33 6.56 9.00
6.Demand	0.33 0.75 3.00	0.33 0.75 3.00	0.33 2.26 5.00	0.33 0.75 3.00
7.Infrastructure	1.67 5.27 9.00	2.33 6.78 9.00	2.33 6.78 9.00	1.00 3.77 7.00
8.Security	0.33 3.15 7.00	0.33 3.15 7.00	0.33 3.15 7.00	0.11 1.89 5.00
9.Information technology	0.33 3.89 7.00	0.56 5.44 9.00	0.56 5.44 9.00	0.33 3.89 7.00
10.Flooded management	0.56 2.56 5.00	0.56 0.85 3.00	0.56 0.85 3.00	1.67 4.26 7.00
11.Topography	0.33 0.80 3.00	0.33 0.80 3.00	0.33 2.41 5.00	0.33 0.80 3.00
12.Country planning	0.78 6.56 9.00	0.11 2.19 5.00	0.78 6.56 9.00	0.11 2.19 5.00
13.Cost	1.00 7.44 9.00	0.43 1.49 3.00	0.43 1.49 3.00	1.00 7.44 9.00
14.Competition	0.11 0.58 1.29	0.20 1.74 9.00	0.20 1.74 9.00	0.14 1.04 3.00
15.Density of traffic	0.43 1.40 3.00	0.43 1.40 3.00	0.60 2.33 9.00	0.60 2.33 9.00

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives											
	Rat Burana			Ratchathewi			Sai Mai			Samphanthawong		
1.National environment and its impact	0.33	3.27	7.00	0.11	1.96	5.00	0.33	3.27	7.00	0.56	4.58	9.00
2.Accessibility	0.33	0.90	3.00	2.33	8.11	9.00	0.33	0.90	3.00	0.33	2.70	5.00
3.Labor	0.33	3.40	7.00	0.11	2.04	5.00	0.78	6.11	9.00	0.11	0.68	3.00
4.Connectivity to multimodal transport	0.33	0.83	3.00	1.67	5.79	9.00	0.33	0.83	3.00	0.33	0.83	3.00
5.Government and regulations	2.33	6.56	9.00	0.33	2.19	5.00	2.33	6.56	9.00	0.33	2.19	5.00
6.Demand	1.00	3.77	7.00	2.33	6.78	9.00	0.33	2.26	5.00	0.33	2.26	5.00
7.Infrastructure	1.00	3.77	7.00	2.33	6.78	9.00	1.00	3.77	7.00	2.33	6.78	9.00
8.Security	0.11	1.89	5.00	0.33	3.15	7.00	0.11	1.89	5.00	0.33	3.15	7.00
9.Information technology	0.33	3.89	7.00	0.33	3.89	7.00	0.33	3.89	7.00	0.33	3.89	7.00
10.Flooded management	0.56	0.85	3.00	0.56	2.56	5.00	0.56	2.56	5.00	0.56	0.85	3.00
11.Topography	1.67	5.62	9.00	0.33	2.41	5.00	2.33	7.22	9.00	0.33	2.41	5.00
12.Country planning	0.78	6.56	9.00	0.78	6.56	9.00	0.11	0.73	3.00	0.78	6.56	9.00
13.Cost	1.00	7.44	9.00	0.43	1.49	3.00	1.00	7.44	9.00	0.33	0.83	1.29
14.Competition	0.33	5.22	9.00	0.20	1.74	9.00	0.33	5.22	9.00	0.20	1.74	9.00
15.Density of traffic	0.60	2.33	9.00	0.33	1.00	1.80	0.60	2.33	9.00	0.60	2.33	9.00

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Saphan Sung	Sathon	Suan Luang	Taling Chan
1.National environment and its impact	0.56 4.58 9.00	0.33 3.27 7.00	0.56 4.58 9.00	0.33 3.27 7.00
2.Accessibility	0.33 0.90 3.00	1.00 4.51 7.00	0.33 0.90 3.00	0.33 0.90 3.00
3.Labor	0.33 3.40 7.00	0.33 3.40 7.00	0.33 3.40 7.00	0.33 3.40 7.00
4.Connectivity to multimodal transport	0.33 0.83 3.00	1.00 4.14 7.00	2.33 7.44 9.00	0.33 2.48 5.00
5.Government and regulations	2.33 6.56 9.00	0.33 2.19 5.00	1.67 5.10 9.00	1.67 5.10 9.00
6.Demand	0.33 0.75 3.00	0.33 2.26 5.00	0.33 2.26 5.00	0.33 0.75 3.00
7.Infrastructure	1.00 3.77 7.00	2.33 6.78 9.00	1.00 3.77 7.00	1.00 3.77 7.00
8.Security	0.11 1.89 5.00	0.33 3.15 7.00	0.11 1.89 5.00	0.56 4.41 9.00
9.Information technology	0.33 3.89 7.00	0.33 3.89 7.00	0.33 3.89 7.00	0.56 5.44 9.00
10.Flooded management	0.56 0.85 3.00	0.56 2.56 5.00	0.56 0.85 3.00	0.56 2.56 5.00
11.Topography	0.33 2.41 5.00	2.33 7.22 9.00	0.33 0.80 3.00	0.33 2.41 5.00
12.Country planning	0.78 6.56 9.00	0.78 6.56 9.00	0.33 3.64 7.00	0.11 0.73 3.00
13.Cost	1.00 7.44 9.00	0.33 1.06 1.80	1.00 7.44 9.00	0.60 2.48 9.00
14.Competition	0.33 5.22 9.00	0.33 5.22 9.00	0.33 5.22 9.00	0.20 1.74 9.00
15.Density of traffic	0.60 2.33 9.00	0.43 1.40 3.00	0.43 1.40 3.00	1.00 7.00 9.00

TABLE F.18 Weighted normalized alternatives, FPIS and FNIS (cont.)

Criteria	Normalized alternatives			
	Thawi Watthana	Thon Buri	Thung Khru	Wang Thonglang
1.National environment and its impact	0.33 3.27 7.00	0.33 3.27 7.00	0.33 3.27 7.00	0.33 3.27 7.00
2.Accessibility	0.33 0.90 3.00	0.33 2.70 5.00	0.33 0.90 3.00	0.33 0.90 3.00
3.Labor	0.11 2.04 5.00	0.56 4.75 9.00	0.33 3.40 7.00	0.33 3.40 7.00
4.Connectivity to multimodal transport	0.33 2.48 5.00	0.33 2.48 5.00	0.33 0.83 3.00	1.00 4.14 7.00
5.Government and regulations	1.67 5.10 9.00	1.00 3.64 7.00	1.67 5.10 9.00	1.67 5.10 9.00
6.Demand	0.33 0.75 3.00	1.00 3.77 7.00	0.33 0.75 3.00	0.33 0.75 3.00
7.Infrastructure	1.00 3.77 7.00	2.33 6.78 9.00	1.00 3.77 7.00	1.67 5.27 9.00
8.Security	0.56 4.41 9.00	0.11 1.89 5.00	0.11 1.89 5.00	0.11 1.89 5.00
9.Information technology	0.33 3.89 7.00	0.56 5.44 9.00	0.33 3.89 7.00	0.33 3.89 7.00
10.Flooded management	0.56 0.85 3.00	0.56 0.85 3.00	0.56 2.56 5.00	0.56 0.85 3.00
11.Topography	1.00 4.01 7.00	0.33 2.41 5.00	2.33 7.22 9.00	1.67 5.62 9.00
12.Country planning	0.56 5.10 9.00	0.11 0.73 3.00	0.33 3.64 7.00	0.33 3.64 7.00
13.Cost	1.00 7.44 9.00	1.00 7.44 9.00	1.00 7.44 9.00	1.00 7.44 9.00
14.Competition	0.33 5.22 9.00	0.20 1.74 9.00	0.33 5.22 9.00	0.14 1.04 3.00
15.Density of traffic	1.00 7.00 9.00	0.43 1.40 3.00	0.60 2.33 9.00	0.43 1.40 3.00

TABLE F.18 Normalized fuzzy decision matrix for alternatives (cont.)

Criteria	Alternatives		FPIS (A^*)	FPNS (A^-)
	Watthana	Yan Nawa		
1.National environment and its impact	0.11 1.96 5.00	0.11 1.96 5.00	9 9 9	0.11 0.11 0.11
2.Accessibility	2.33 8.11 9.00	0.33 2.70 5.00	9 9 9	0.33 0.33 0.33
3.Labor	0.33 3.40 7.00	0.33 3.40 7.00	9 9 9	0.11 0.11 0.11
4.Connectivity to multimodal transport	0.33 2.48 5.00	1.00 4.14 7.00	9 9 9	0.33 0.33 0.33
5.Government and regulations	1.00 3.64 7.00	0.33 2.19 5.00	9 9 9	0.33 0.33 0.33
6.Demand	1.67 5.27 9.00	0.33 0.75 3.00	9 9 9	0.33 0.33 0.33
7.Infrastructure	2.33 6.78 9.00	2.33 6.78 9.00	9 9 9	1.00 1.00 1.00
8.Security	0.33 3.15 7.00	0.33 3.15 7.00	9 9 9	0.11 0.11 0.11
9.Information technology	0.33 3.89 7.00	0.33 3.89 7.00	9 9 9	0.11 0.11 0.11
10.Flooded management	0.56 2.56 5.00	0.56 0.85 3.00	9 9 9	0.56 0.56 0.56
11.Topography	0.33 0.80 3.00	2.33 7.22 9.00	9 9 9	0.33 0.33 0.33
12.Country planning	0.78 6.56 9.00	0.78 6.56 9.00	9 9 9	0.11 0.11 0.11
13.Cost	0.43 1.49 3.00	0.33 1.06 1.80	9 9 9	0.33 0.33 0.33
14.Competition	0.20 1.74 9.00	0.33 5.22 9.00	9 9 9	0.11 0.11 0.11
15.Density of traffic	0.43 1.40 3.00	0.33 0.78 1.29	9 9 9	0.33 0.33 0.33

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives

Criteria	Bang Bon $d_v(A_1, A^-)$	Bang Kapi $d_v(A_2, A^-)$	Bang Khae $d_v(A_3, A^-)$	Bang Khen $d_v(A_4, A^-)$	Bang KhoLaem $d_v(A_5, A^-)$
1.National environment and its impact	4.38	3.02	4.38	3.02	4.38
2.Accessibility	1.57	3.02	1.57	1.57	3.02
3.Labor	4.41	5.80	6.20	6.20	4.41
4.Connectivity to multimodal transport	2.97	2.97	1.57	4.45	1.57
5.Government and regulations	5.76	5.76	5.76	5.76	2.90
6.Demand	2.91	2.91	2.91	1.56	2.91
7.Infrastructure	3.81	5.25	5.25	5.25	5.25
8.Security	5.71	3.00	5.71	3.00	4.35
9.Information technology	4.54	4.54	4.54	4.54	4.54
10.Flooded management	1.42	2.81	2.81	4.34	1.42
11.Topography	4.41	1.56	2.95	5.91	6.50
12.Country planning	6.35	4.47	3.07	3.07	6.35
13.Cost	6.48	6.48	6.48	6.48	1.68
14.Competition	5.92	0.73	5.92	5.92	5.92
15.Density of traffic	5.14	0.93	5.14	0.61	5.14

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Bang Khun Thian $d_v(A_6, A^-)$	Bang Na $d_v(A_7, A^-)$	Bang Phlat $d_v(A_8, A^-)$	Bang Rak $d_v(A_9, A^-)$	Bang Sue $d_v(A_{10}, A^-)$
1.National environment and its impact	4.38	4.38	4.38	5.75	4.38
2.Accessibility	1.57	1.57	3.02	6.82	4.56
3.Labor	6.20	4.41	4.41	3.03	5.80
4.Connectivity to multimodal transport	2.97	4.45	1.57	4.45	1.57
5.Government and regulations	5.76	5.76	4.31	2.90	4.31
6.Demand	4.35	4.35	2.91	4.35	2.91
7.Infrastructure	3.81	5.25	5.25	5.75	5.75
8.Security	5.71	4.35	5.71	4.35	3.00
9.Information technology	3.10	4.54	4.54	5.99	4.54
10.Flooded management	2.81	4.34	1.42	1.42	2.81
11.Topography	4.41	1.56	1.56	6.50	6.50
12.Country planning	5.89	6.35	6.35	6.35	6.35
13.Cost	6.48	6.48	6.48	0.62	5.16
14.Competition	5.92	5.22	1.04	5.22	5.22
15.Density of traffic	1.66	1.66	0.93	0.61	5.14

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Bangkok Noi $d_v(A_{11}, A^-)$	Bangkok Yai $d_v(A_{12}, A^-)$	BuengKum $d_v(A_{13}, A^-)$	Chatuchak $d_v(A_{14}, A^-)$	Chom Thong $d_v(A_{15}, A^-)$
1.National environment and its impact	4.38	5.75	4.38	3.02	4.38
2.Accessibility	3.02	3.02	3.02	4.56	3.02
3.Labor	5.80	3.03	5.80	6.20	5.80
4.Connectivity to multimodal transport	2.97	1.57	1.57	6.57	2.97
5.Government and regulations	4.31	4.31	5.76	4.31	6.27
6.Demand	4.35	1.56	2.91	2.91	2.91
7.Infrastructure	5.75	5.75	5.25	5.25	5.25
8.Security	5.71	5.71	3.00	3.00	3.00
9.Information technology	5.99	4.54	4.54	5.99	4.54
10.Flooded management	1.42	1.42	2.81	2.81	2.81
11.Topography	2.95	2.95	2.95	2.95	2.95
12.Country planning	6.35	6.35	3.07	6.35	6.35
13.Cost	6.48	6.48	6.48	5.16	6.48
14.Competition	1.04	5.92	5.92	1.04	5.92
15.Density of traffic	5.14	6.32	0.93	0.61	5.14

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Din Daeng $d_v(A_{16}, A^-)$	Don Mueang $d_v(A_{17}, A^-)$	Dusit $d_v(A_{18}, A^-)$	Huai Khwang $d_v(A_{19}, A^-)$	Khan Na Yao $d_v(A_{20}, A^-)$
1.National environment and its impact	4.38	4.38	5.75	4.38	4.38
2.Accessibility	3.02	1.57	1.57	4.56	1.57
3.Labor	5.80	6.20	4.41	3.03	4.41
4.Connectivity to multimodal transport	1.57	5.96	2.97	5.96	1.57
5.Government and regulations	2.90	5.76	2.90	2.90	6.27
6.Demand	1.56	1.56	2.91	6.34	2.91
7.Infrastructure	5.75	5.25	5.75	5.75	3.81
8.Security	4.35	3.00	4.35	4.35	3.00
9.Information technology	4.54	4.54	5.99	4.54	4.54
10.Flooded management	2.81	1.42	4.34	4.34	2.81
11.Topography	4.41	2.95	2.95	1.56	4.41
12.Country planning	6.35	3.07	5.89	6.35	4.47
13.Cost	1.68	6.48	1.68	1.68	6.48
14.Competition	1.75	5.92	5.92	5.92	5.92
15.Density of traffic	0.93	0.93	1.66	1.66	0.93

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Khlong Sam Wa $d_v(A_{21}, A^-)$	Khlong San $d_v(A_{22}, A^-)$	Khlong Toei $d_v(A_{23}, A^-)$	Lak Si $d_v(A_{24}, A^-)$	LatKrabang $d_v(A_{25}, A^-)$
1.National environment and its impact	4.38	4.38	3.02	4.38	4.38
2.Accessibility	1.57	4.56	6.13	1.57	1.57
3.Labor	6.20	3.03	4.41	4.41	6.20
4.Connectivity to multimodal transport	1.57	1.57	4.45	2.97	2.97
5.Government and regulations	6.27	2.90	4.31	6.27	6.27
6.Demand	1.56	2.91	2.91	2.91	2.91
7.Infrastructure	3.81	5.75	5.75	5.25	3.81
8.Security	5.71	3.00	4.35	3.00	5.71
9.Information technology	4.54	4.54	4.54	4.54	5.99
10.Flooded management	2.81	1.42	5.93	1.42	1.42
11.Topography	1.56	2.95	6.50	6.50	1.56
12.Country planning	3.07	6.35	6.35	5.89	3.07
13.Cost	6.48	5.16	1.68	6.48	6.48
14.Competition	5.92	1.75	0.73	5.92	1.04
15.Density of traffic	6.32	1.66	1.66	5.14	5.14

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	LatPhrao $d_v(A_{26}, A^-)$	Min Buri $d_v(A_{27}, A^-)$	Nong Chok $d_v(A_{28}, A^-)$	Nong Khaem $d_v(A_{29}, A^-)$	Pathum Wan $d_v(A_{30}, A^-)$
1.National environment and its impact	4.38	4.38	5.75	4.38	4.38
2.Accessibility	1.57	3.02	1.57	1.57	6.82
3.Labor	5.80	5.80	5.80	5.80	3.03
4.Connectivity to multimodal transport	2.97	1.57	1.57	1.57	5.96
5.Government and regulations	5.76	6.27	6.27	6.27	2.90
6.Demand	2.91	2.91	1.56	2.91	4.35
7.Infrastructure	5.25	3.81	3.81	3.81	5.75
8.Security	3.00	5.71	5.71	5.71	4.35
9.Information technology	4.54	3.10	4.54	4.54	4.54
10.Flooded management	1.42	1.42	1.42	2.81	2.81
11.Topography	4.41	2.95	2.95	1.56	2.95
12.Country planning	1.71	3.07	3.07	5.89	6.35
13.Cost	6.48	6.48	6.48	6.48	0.62
14.Competition	5.92	5.92	5.92	5.92	5.22
15.Density of traffic	1.66	5.14	5.14	5.14	5.14

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Phasi Charoen $d_v(A_{31}, A^-)$	Phaya Thai $d_v(A_{32}, A^-)$	Phra Khanong $d_v(A_{33}, A^-)$	Phra Nakhon $d_v(A_{34}, A^-)$	PomPrap SattruPhai $d_v(A_{35}, A^-)$
1.National environment and its impact	5.75	4.38	5.75	5.75	5.75
2.Accessibility	1.57	3.02	1.57	3.02	3.02
3.Labor	5.80	3.03	4.41	3.03	3.03
4.Connectivity to multimodal transport	1.57	5.96	4.45	1.57	1.57
5.Government and regulations	6.27	2.90	5.76	2.90	2.90
6.Demand	2.91	5.81	1.56	1.56	2.91
7.Infrastructure	5.25	5.75	5.25	5.75	5.75
8.Security	5.71	4.35	4.35	4.35	4.35
9.Information technology	5.99	4.54	4.54	5.99	5.99
10.Flooded management	1.42	4.34	2.81	1.42	1.42
11.Topography	2.95	6.50	1.56	1.56	2.95
12.Country planning	6.35	6.35	6.35	3.07	6.35
13.Cost	6.48	1.68	6.48	1.68	1.68
14.Competition	5.92	5.22	0.73	5.22	5.22
15.Density of traffic	5.14	0.61	1.66	1.66	5.14

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Prawet $d_v(A_{36}, A^-)$	Rat Burana $d_v(A_{37}, A^-)$	Ratchathewi $d_v(A_{38}, A^-)$	Sai Mai $d_v(A_{39}, A^-)$	Samphan thawong $d_v(A_{40}, A^-)$
1.National environment and its impact	4.38	4.38	3.02	4.38	5.75
2.Accessibility	1.57	1.57	6.82	1.57	3.02
3.Labor	5.80	4.41	3.03	6.20	1.70
4.Connectivity to multimodal transport	1.57	1.57	5.96	1.57	1.57
5.Government and regulations	6.27	6.27	2.90	6.27	2.90
6.Demand	1.56	4.35	6.34	2.91	2.91
7.Infrastructure	3.81	3.81	5.75	3.81	5.75
8.Security	3.00	3.00	4.35	3.00	4.35
9.Information technology	4.54	4.54	4.54	4.54	4.54
10.Flooded management	4.34	1.42	2.81	2.81	1.42
11.Topography	1.56	5.91	2.95	6.50	2.95
12.Country planning	3.07	6.35	6.35	1.71	6.35
13.Cost	6.48	6.48	1.68	6.48	0.62
14.Competition	1.75	5.92	5.22	5.92	5.22
15.Density of traffic	5.14	5.14	0.93	5.14	5.14

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Saphan Sung $d_v(A_{41}, A^-)$	Sathon $d_v(A_{42}, A^-)$	Suan Luang $d_v(A_{43}, A^-)$	Taling Chan $d_v(A_{44}, A^-)$	Thawi Watthana $d_v(A_{45}, A^-)$
1.National environment and its impact	5.75	4.38	5.75	4.38	4.38
2.Accessibility	1.57	4.56	1.57	1.57	1.57
3.Labor	4.41	4.41	4.41	4.41	3.03
4.Connectivity to multimodal transport	1.57	4.45	6.57	2.97	2.97
5.Government and regulations	6.27	2.90	5.76	5.76	5.76
6.Demand	1.56	2.91	2.91	1.56	1.56
7.Infrastructure	3.81	5.75	3.81	3.81	3.81
8.Security	3.00	4.35	3.00	5.71	5.71
9.Information technology	4.54	4.54	4.54	5.99	4.54
10.Flooded management	1.42	2.81	1.42	2.81	1.42
11.Topography	2.95	6.50	1.56	2.95	4.41
12.Country planning	6.35	6.35	4.47	1.71	5.89
13.Cost	6.48	0.95	6.48	5.16	6.48
14.Competition	5.92	5.92	5.92	5.22	5.92
15.Density of traffic	5.14	1.66	1.66	6.32	6.32

TABLE F.19 Distances $d_v(A_i..A^-)$ for alternatives (cont.)

Criteria	Thon Buri $d_v(A_{46}, A^-)$	Thung Khru $d_v(A_{47}, A^-)$	Wang Thonglang $d_v(A_{48}, A^-)$	Watthana $d_v(A_{49}, A^-)$	Yan Nawa $d_v(A_{50}, A^-)$
1.National environment and its impact	4.38	4.38	4.38	3.02	3.02
2.Accessibility	3.02	1.57	1.57	6.82	3.02
3.Labor	5.80	4.41	4.41	4.41	4.41
4.Connectivity to multimodal transport	2.97	1.57	4.45	2.97	4.45
5.Government and regulations	4.31	5.76	5.76	4.31	2.90
6.Demand	4.35	1.56	1.56	5.81	1.56
7.Infrastructure	5.75	3.81	5.25	5.75	5.75
8.Security	3.00	3.00	3.00	4.35	4.35
9.Information technology	5.99	4.54	4.54	4.54	4.54
10.Flooded management	1.42	2.81	1.42	2.81	1.42
11.Topography	2.95	6.50	5.91	1.56	6.50
12.Country planning	1.71	4.47	4.47	6.35	6.35
13.Cost	6.48	6.48	6.48	1.68	0.95
14.Competition	5.22	5.92	1.75	5.22	5.92
15.Density of traffic	1.66	5.14	1.66	1.66	0.61

TABLE F.20 Distances $d_v(A_i . A^*)$ for alternatives

Criteria	**Bang Bon** $d_v(A_1, A^*)$	**Bang Kapi** $d_v(A_2, A^*)$	**Bang Khae** $d_v(A_3, A^*)$	**Bang Khen** $d_v(A_4, A^*)$	**Bang KhoLaem** $d_v(A_5, A^*)$
1.National environment and its impact	6.11	6.94	6.11	6.94	6.11
2.Accessibility	7.67	6.60	7.67	7.67	6.60
3.Labor	6.07	5.46	5.03	5.03	6.07
4.Connectivity to multimodal transport	6.67	6.67	7.70	5.53	7.70
5.Government and regulations	4.80	4.80	4.80	4.80	6.77
6.Demand	6.75	6.75	6.75	7.73	6.75
7.Infrastructure	5.64	4.75	4.75	4.75	4.75
8.Security	5.55	6.97	5.55	6.97	6.15
9.Information technology	5.92	5.92	5.92	5.92	5.92
10.Flooded management	7.61	6.55	6.55	5.17	7.61
11.Topography	5.56	7.71	6.70	4.66	3.98
12.Country planning	4.95	5.99	6.87	6.87	4.95
13.Cost	4.71	4.71	4.71	4.71	7.44
14.Competition	5.46	8.35	5.46	5.46	5.46
15.Density of traffic	6.19	7.98	6.19	8.21	6.19

TABLE F.20 Distances $d_v(A_i \,.\, A^*)$ for alternatives (cont.)

Criteria	Bang Khun Thian $d_v(A_6, A^*)$	Bang Na $d_v(A_7, A^*)$	Bang Phlat $d_v(A_8, A^*)$	Bang Rak $d_v(A_9, A^*)$	Bang Sue $d_v(A_{10}, A^*)$
1.National environment and its impact	6.11	6.11	6.11	5.50	6.11
2.Accessibility	7.67	7.67	6.60	3.88	5.42
3.Labor	5.03	6.07	6.07	6.92	5.46
4.Connectivity to multimodal transport	6.67	5.53	7.70	5.53	7.70
5.Government and regulations	4.80	4.80	5.68	6.77	5.68
6.Demand	5.64	5.64	6.75	5.64	6.75
7.Infrastructure	5.64	4.75	4.75	4.06	4.06
8.Security	5.55	6.15	5.55	6.15	6.97
9.Information technology	6.82	5.92	5.92	5.29	5.92
10.Flooded management	6.55	5.17	7.61	7.61	6.55
11.Topography	5.56	7.71	7.71	3.98	3.98
12.Country planning	5.37	4.95	4.95	4.95	4.95
13.Cost	4.71	4.71	4.71	8.19	6.14
14.Competition	5.46	6.59	8.14	6.59	6.59
15.Density of traffic	7.47	7.47	7.98	8.21	6.19

TABLE F.20 Distances $d_v(A_i . A^*)$ for alternatives (cont.)

Criteria	Bangkok Noi $d_v(A_{11}, A^*)$	Bangkok Yai $d_v(A_{12}, A^*)$	BuengKum $d_v(A_{13}, A^*)$	Chatuchak $d_v(A_{14}, A^*)$	Chom Thong $d_v(A_{15}, A^*)$
1.National environment and its impact	6.11	5.50	6.11	6.94	6.11
2.Accessibility	6.60	6.60	6.60	5.42	6.60
3.Labor	5.46	6.92	5.46	5.03	5.46
4.Connectivity to multimodal transport	6.67	7.70	7.70	3.95	6.67
5.Government and regulations	5.68	5.68	4.80	5.68	4.10
6.Demand	5.64	7.73	6.75	6.75	6.75
7.Infrastructure	4.06	4.06	4.75	4.75	4.75
8.Security	5.55	5.55	6.97	6.97	6.97
9.Information technology	5.29	5.92	5.92	5.29	5.92
10.Flooded management	7.61	7.61	6.55	6.55	6.55
11.Topography	6.70	6.70	6.70	6.70	6.70
12.Country planning	4.95	4.95	6.87	4.95	4.95
13.Cost	4.71	4.71	4.71	6.14	4.71
14.Competition	8.14	5.46	5.46	8.14	5.46
15.Density of traffic	6.19	4.76	7.98	8.21	6.19

TABLE F.20 Distances $d_v(A_i . A^*)$ for alternatives (cont.)

Criteria	Din Daeng $d_v(A_{16}, A^*)$	Don Mueang $d_v(A_{17}, A^*)$	Dusit $d_v(A_{18}, A^*)$	Huai Khwang $d_v(A_{19}, A^*)$	Khan Na Yao $d_v(A_{20}, A^*)$
1.National environment and its impact	6.11	6.11	5.50	6.11	6.11
2.Accessibility	6.60	7.67	7.67	5.42	7.67
3.Labor	5.46	5.03	6.07	6.92	6.07
4.Connectivity to multimodal transport	7.70	4.62	6.67	4.62	7.70
5.Government and regulations	6.77	4.80	6.77	6.77	4.10
6.Demand	7.73	7.73	6.75	4.06	6.75
7.Infrastructure	4.06	4.75	4.06	4.06	5.64
8.Security	6.15	6.97	6.15	6.15	6.97
9.Information technology	5.92	5.92	5.29	5.92	5.92
10.Flooded management	6.55	7.61	5.17	5.17	6.55
11.Topography	5.56	6.70	6.70	7.71	5.56
12.Country planning	4.95	6.87	5.37	4.95	5.99
13.Cost	7.44	4.71	7.44	7.44	4.71
14.Competition	7.70	5.46	5.46	5.46	5.46
15.Density of traffic	7.98	7.98	7.47	7.47	7.98

TABLE F.20 Distances $d_v(A_i . A^*)$ for alternatives (cont.)

Criteria	**Khlong Sam Wa** $d_v(A_{21}, A^*)$	**Khlong San** $d_v(A_{22}, A^*)$	**Khlong Toei** $d_v(A_{23}, A^*)$	**Lak Si** $d_v(A_{24}, A^*)$	**LatKrabang** $d_v(A_{25}, A^*)$
1.National environment and its impact	6.11	6.11	6.94	6.11	6.11
2.Accessibility	7.67	5.42	4.51	7.67	7.67
3.Labor	5.03	6.92	6.07	6.07	5.03
4.Connectivity to multimodal transport	7.70	7.70	5.53	6.67	6.67
5.Government and regulations	4.10	6.77	5.68	4.10	4.10
6.Demand	7.73	6.75	6.75	6.75	6.75
7.Infrastructure	5.64	4.06	4.06	4.75	5.64
8.Security	5.55	6.97	6.15	6.97	5.55
9.Information technology	5.92	5.92	5.92	5.92	5.29
10.Flooded management	6.55	7.61	4.00	7.61	7.61
11.Topography	7.71	6.70	3.98	3.98	7.71
12.Country planning	6.87	4.95	4.95	5.37	6.87
13.Cost	4.71	6.14	7.44	4.71	4.71
14.Competition	5.46	7.70	8.35	5.46	8.14
15.Density of traffic	4.76	7.47	7.47	6.19	6.19

TABLE F.20 Distances $d_v(A_i . A^*)$ for alternatives (cont.)

Criteria	LatPhrao $d_v(A_{26}, A^*)$	Min Buri $d_v(A_{27}, A^*)$	Nong Chok $d_v(A_{28}, A^*)$	Nong Khaem $d_v(A_{29}, A^*)$	Pathum Wan $d_v(A_{30}, A^*)$
1.National environment and its impact	6.11	6.11	5.50	6.11	6.11
2.Accessibility	7.67	6.60	7.67	7.67	3.88
3.Labor	5.46	5.46	5.46	5.46	6.92
4.Connectivity to multimodal transport	6.67	7.70	7.70	7.70	4.62
5.Government and regulations	4.80	4.10	4.10	4.10	6.77
6.Demand	6.75	6.75	7.73	6.75	5.64
7.Infrastructure	4.75	5.64	5.64	5.64	4.06
8.Security	6.97	5.55	5.55	5.55	6.15
9.Information technology	5.92	6.82	5.92	5.92	5.92
10.Flooded management	7.61	7.61	7.61	6.55	6.55
11.Topography	5.56	6.70	6.70	7.71	6.70
12.Country planning	7.82	6.87	6.87	5.37	4.95
13.Cost	4.71	4.71	4.71	4.71	8.19
14.Competition	5.46	5.46	5.46	5.46	6.59
15.Density of traffic	7.47	6.19	6.19	6.19	6.19

TABLE F.20 Distances $d_v(A_i . A^*)$ for alternatives (cont.)

Criteria	Phasi Charoen $d_v(A_{31}, A^*)$	Phaya Thai $d_v(A_{32}, A^*)$	Phra Khanong $d_v(A_{33}, A^*)$	Phra Nakhon $d_v(A_{34}, A^*)$	PomPrap SattruPhai $d_v(A_{35}, A^*)$
1.National environment and its impact	5.50	6.11	5.50	5.50	5.50
2.Accessibility	7.67	6.60	7.67	6.60	6.60
3.Labor	5.46	6.92	6.07	6.92	6.92
4.Connectivity to multimodal transport	7.70	4.62	5.53	7.70	7.70
5.Government and regulations	4.10	6.77	4.80	6.77	6.77
6.Demand	6.75	4.75	7.73	7.73	6.75
7.Infrastructure	4.75	4.06	4.75	4.06	4.06
8.Security	5.55	6.15	6.15	6.15	6.15
9.Information technology	5.29	5.92	5.92	5.29	5.29
10.Flooded management	7.61	5.17	6.55	7.61	7.61
11.Topography	6.70	3.98	7.71	7.71	6.70
12.Country planning	4.95	4.95	4.95	6.87	4.95
13.Cost	4.71	7.44	4.71	7.44	7.44
14.Competition	5.46	6.59	8.35	6.59	6.59
15.Density of traffic	6.19	8.21	7.47	7.47	6.19

TABLE F.20 Distances $d_v(A_i . A^*)$ for alternatives (cont.)

Criteria	Prawet $d_v(A_{36}, A^*)$	Rat Burana $d_v(A_{37}, A^*)$	Ratchathewi $d_v(A_{38}, A^*)$	Sai Mai $d_v(A_{39}, A^*)$	Samphan thawong $d_v(A_{40}, A^*)$
1.National environment and its impact	6.11	6.11	6.94	6.11	5.50
2.Accessibility	7.67	7.67	3.88	7.67	6.60
3.Labor	5.46	6.07	6.92	5.03	7.84
4.Connectivity to multimodal transport	7.70	7.70	4.62	7.70	7.70
5.Government and regulations	4.10	4.10	6.77	4.10	6.77
6.Demand	7.73	5.64	4.06	6.75	6.75
7.Infrastructure	5.64	5.64	4.06	5.64	4.06
8.Security	6.97	6.97	6.15	6.97	6.15
9.Information technology	5.92	5.92	5.92	5.92	5.92
10.Flooded management	5.17	7.61	6.55	6.55	7.61
11.Topography	7.71	4.66	6.70	3.98	6.70
12.Country planning	6.87	4.95	4.95	7.82	4.95
13.Cost	4.71	4.71	7.44	4.71	8.19
14.Competition	7.70	5.46	6.59	5.46	6.59
15.Density of traffic	6.19	6.19	7.98	6.19	6.19

TABLE F.20 Distances $d_v(A_i \,.\, A^*)$ for alternatives (cont.)

Criteria	Saphan Sung $d_v(A_{41}, A^*)$	Sathon $d_v(A_{42}, A^*)$	Suan Luang $d_v(A_{43}, A^*)$	Taling Chan $d_v(A_{44}, A^*)$	Thawi Watthana $d_v(A_{45}, A^*)$
1.National environment and its impact	5.50	6.11	5.50	6.11	6.11
2.Accessibility	7.67	5.42	7.67	7.67	7.67
3.Labor	6.07	6.07	6.07	6.07	6.92
4.Connectivity to multimodal transport	7.70	5.53	3.95	6.67	6.67
5.Government and regulations	4.10	6.77	4.80	4.80	4.80
6.Demand	7.73	6.75	6.75	7.73	7.73
7.Infrastructure	5.64	4.06	5.64	5.64	5.64
8.Security	6.97	6.15	6.97	5.55	5.55
9.Information technology	5.92	5.92	5.92	5.29	5.92
10.Flooded management	7.61	6.55	7.61	6.55	7.61
11.Topography	6.70	3.98	7.71	6.70	5.56
12.Country planning	4.95	4.95	5.99	7.82	5.37
13.Cost	4.71	7.96	4.71	6.14	4.71
14.Competition	5.46	5.46	5.46	6.59	5.46
15.Density of traffic	6.19	7.47	7.47	4.76	4.76

TABLE F.20 Distances $d_v(A_i \,.\, A^*)$ for alternatives (cont.)

Criteria	Thon Buri $d_v(A_{46}, A^*)$	Thung Khru $d_v(A_{47}, A^*)$	Wang Thonglang $d_v(A_{48}, A^*)$	Watthana $d_v(A_{49}, A^*)$	Yan Nawa $d_v(A_{50}, A^*)$
1.National environment and its impact	6.11	6.11	6.11	6.94	6.94
2.Accessibility	6.60	7.67	7.67	3.88	6.60
3.Labor	5.46	6.07	6.07	6.07	6.07
4.Connectivity to multimodal transport	6.67	7.70	5.53	6.67	5.53
5.Government and regulations	5.68	4.80	4.80	5.68	6.77
6.Demand	5.64	7.73	7.73	4.75	7.73
7.Infrastructure	4.06	5.64	4.75	4.06	4.06
8.Security	6.97	6.97	6.97	6.15	6.15
9.Information technology	5.29	5.92	5.92	5.92	5.92
10.Flooded management	7.61	6.55	7.61	6.55	7.61
11.Topography	6.70	3.98	4.66	7.71	3.98
12.Country planning	7.82	5.99	5.99	4.95	4.95
13.Cost	4.71	4.71	4.71	7.44	7.96
14.Competition	6.59	5.46	7.70	6.59	5.46
15.Density of traffic	7.47	6.19	7.47	7.47	8.21

TABLE F.21 Closeness coefficients (CC_i) of the 50 districts

Alternatives		d_i^-	d_i^*	CC_i	Order
Bang Bon	A_1	65.79	89.7	0.42	**6**
Bang Kapi	A_2	53.26	96.2	0.36	**47**
Bang Khae	A_3	64.26	90.8	0.41	**17**
Bang Khen	A_4	61.68	90.4	0.41	**22**
Bang KhoLaem	A_5	60.33	92.4	0.39	**30**
Bang Khun Thian	A_6	65.03	89.0	0.42	**7**
Bang Na	A_7	64.67	89.2	0.42	**11**
Bang Phlat	A_8	53.89	96.2	0.36	**45**
Bang Rak	A_9	64.10	89.3	0.42	**13**
Bang Sue	A_{10}	67.99	88.5	0.43	**3**
Bangkok Noi	A_{11}	65.65	89.4	0.42	**5**
Bangkok Yai	A_{12}	64.69	89.8	0.42	**12**
BuengKum	A_{13}	58.39	93.3	0.38	**36**
Chatuchak	A_{14}	60.75	91.5	0.4	**27**
Chom Thong	A_{15}	67.79	87.9	0.44	**2**
Din Daeng	A_{16}	51.79	96.7	0.35	**48**
Don Mueang	A_{17}	59.00	92.9	0.39	**34**
Dusit	A_{18}	59.04	92.5	0.39	**33**
Huai Khwang	A_{19}	63.32	88.22	0.42	**14**
Khan Na Yao	A_{20}	57.50	93.18	0.38	**38**
Khlong Sam Wa	A_{21}	61.78	91.51	0.40	**24**
Khlong San	A_{22}	51.93	97.17	0.35	**49**
Khlong Toei	A_{23}	62.71	87.79	0.42	**15**
Lak Si	A_{24}	66.65	88.33	0.43	**4**
LatKrabang	A_{25}	58.53	94.04	0.38	**37**

TABLE F.21 Closeness coefficients (CC_i) of the 50 districts (cont.)

Alternatives		d_i^-	d_i^*	CC_i	Order
LatPhrao	A_{26}	57.8	93.7	0.38	**39**
Min Buri	A_{27}	61.5	92.2	0.4	**26**
Nong Chok	A_{28}	61.5	92.8	0.4	**28**
Nong Khaem	A_{29}	64.4	90.9	0.41	**16**
Pathum Wan	A_{30}	65.2	89.2	0.42	**8**
Phasi Charoen	A_{31}	69.1	88.4	0.44	**1**
Phaya Thai	A_{32}	64.4	88.2	0.42	**9**
Phra Khanong	A_{33}	57.2	93.9	0.38	**40**
Phra Nakhon	A_{34}	48.5	100	0.33	**50**
Pom Prap Sattru Phai	A_{35}	58	95.2	0.38	**41**
Prawet	A_{36}	54.8	95.6	0.36	**44**
Rat Burana	A_{37}	65.1	89.4	0.42	**10**
Ratchathewi	A_{38}	62.7	89.5	0.41	**20**
Sai Mai	A_{39}	62.8	90.6	0.41	**21**
Saphan Sung	A_{40}	54.2	97.5	0.36	**46**
Saphan Sung	A_{41}	60.7	92.9	0.4	**29**
Sathon	A_{42}	62.4	89.1	0.41	**19**
Suan Luang	A_{43}	59.9	92.2	0.39	**31**
Taling Chan	A_{44}	60.3	94.1	0.39	**32**
Thawi Watthana	A_{45}	63.8	90.5	0.41	**18**
Thon Buri	A_{46}	59	93.4	0.39	**35**
Thung Khru	A_{47}	61.9	91.5	0.4	**23**
Wang Thonglang	A_{48}	56.6	93.7	0.38	**42**
Watthana	A_{49}	61.3	90.8	0.4	**25**
Yan Nawa	A_{50}	55.7	93.9	0.37	**43**

APPENDIX G
THE RESULT OF SENSITIVITY ANALYSIS

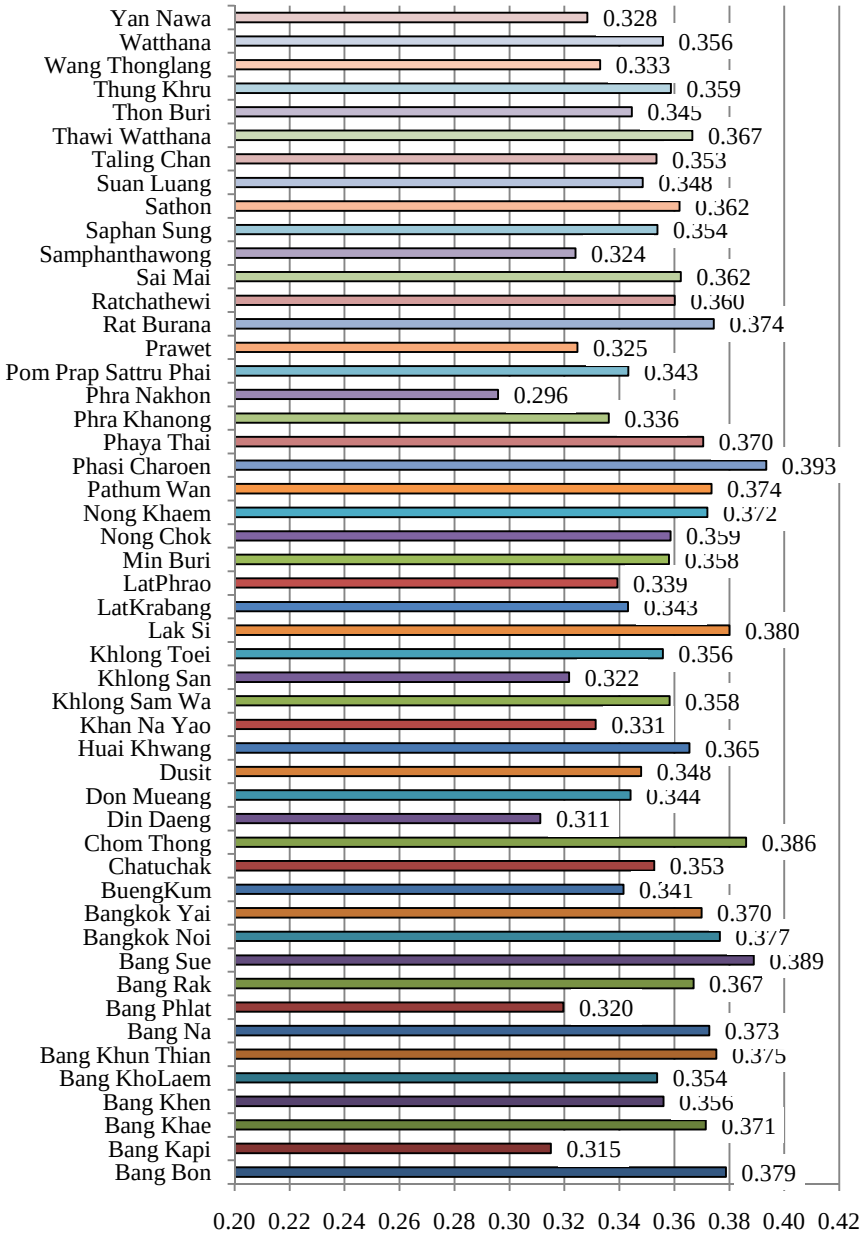


Figure G.1 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (all criteria are very low)

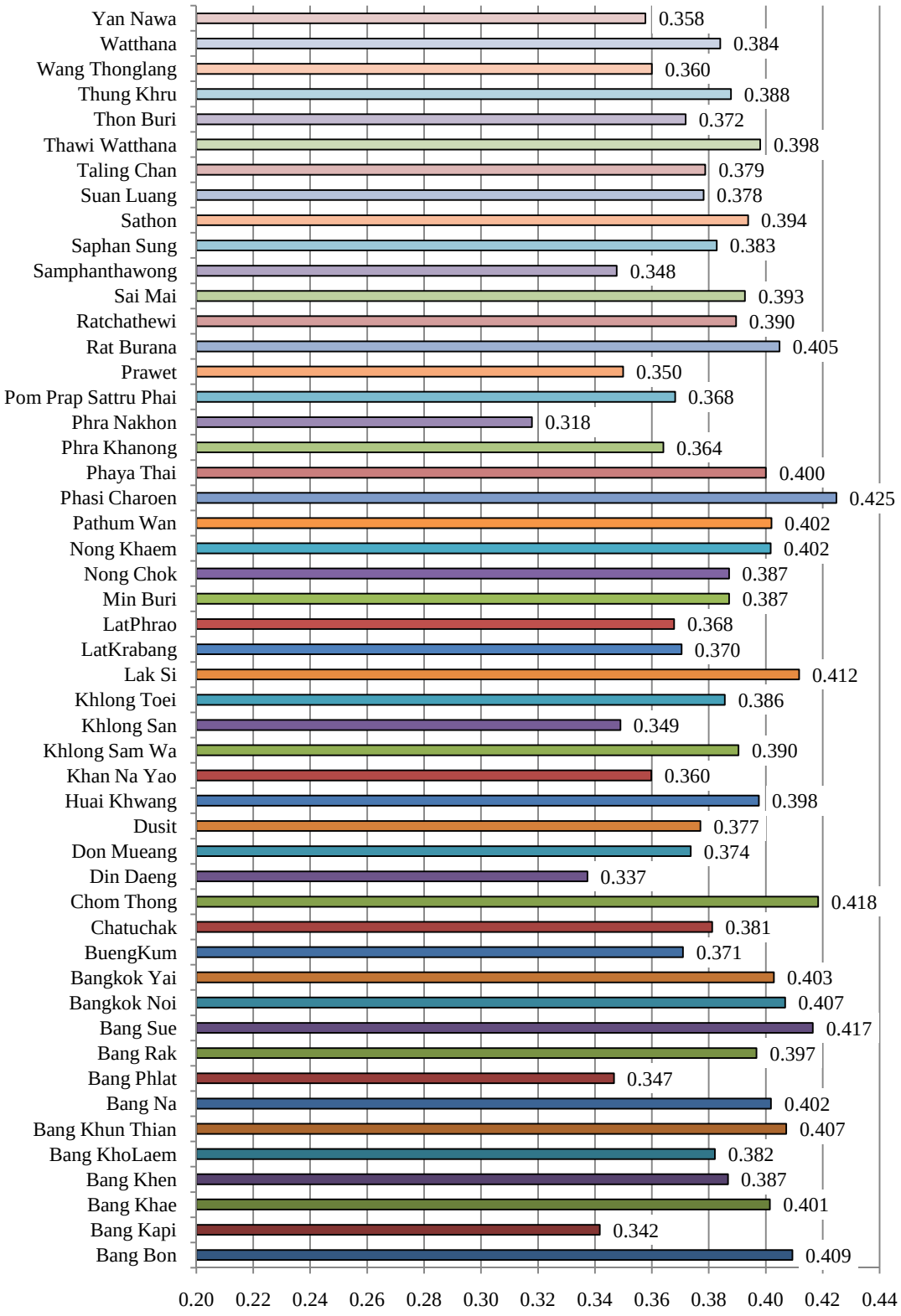


Figure G.2 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (all criteria are low)

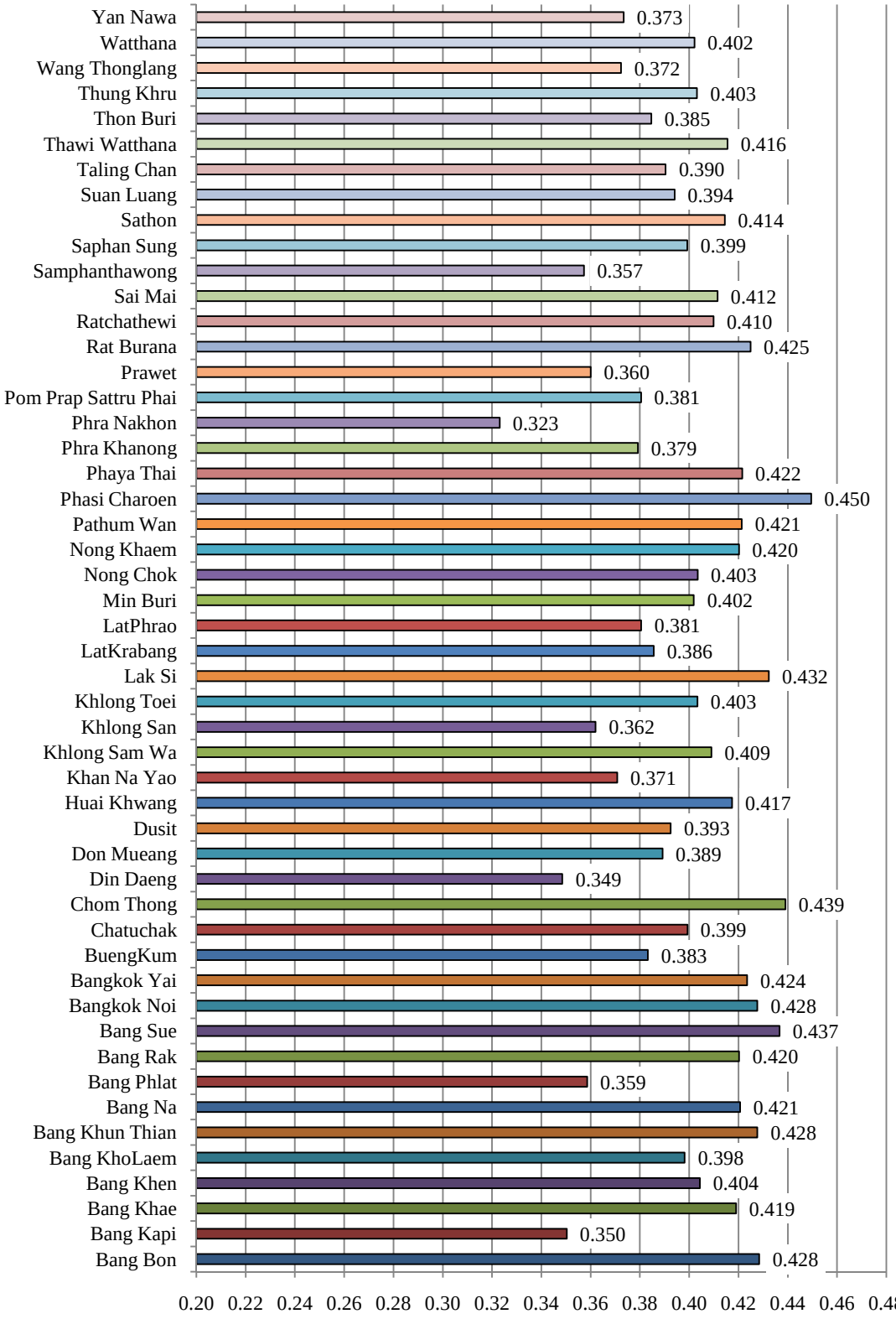


Figure G.3 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (all criteria are medium)

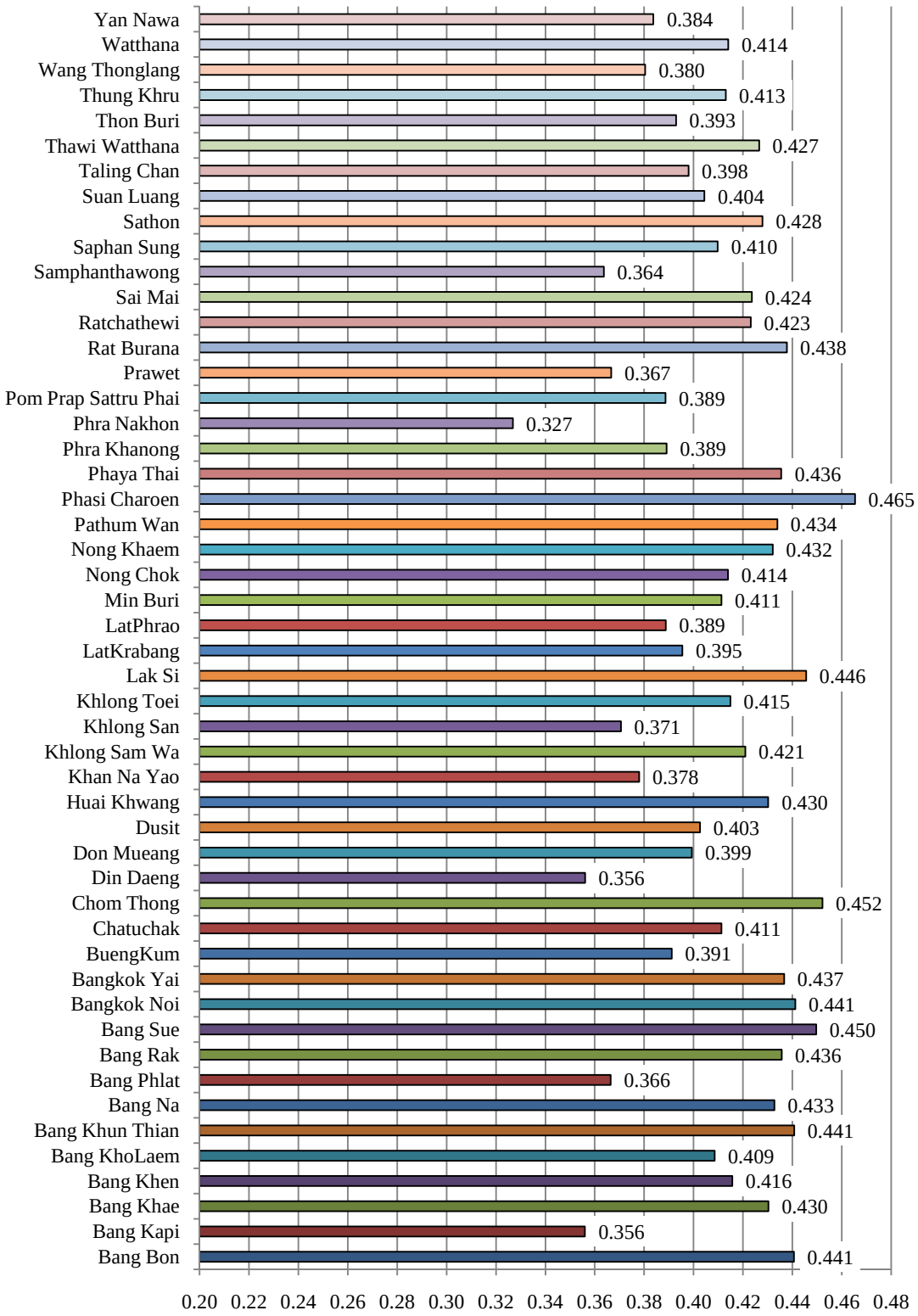


Figure G.4 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (all criteria are high)

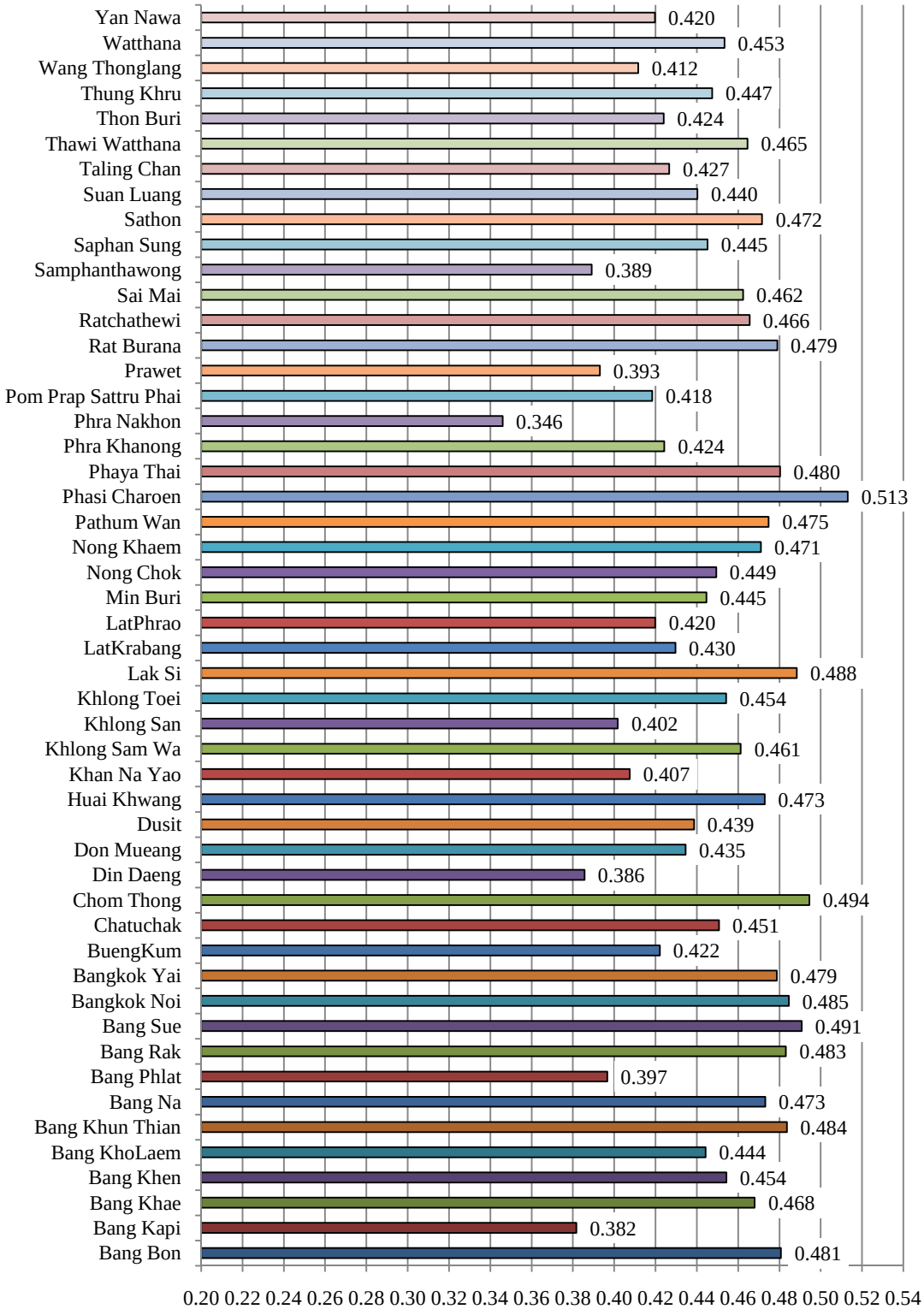


Figure G.5 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (all criteria are very high)

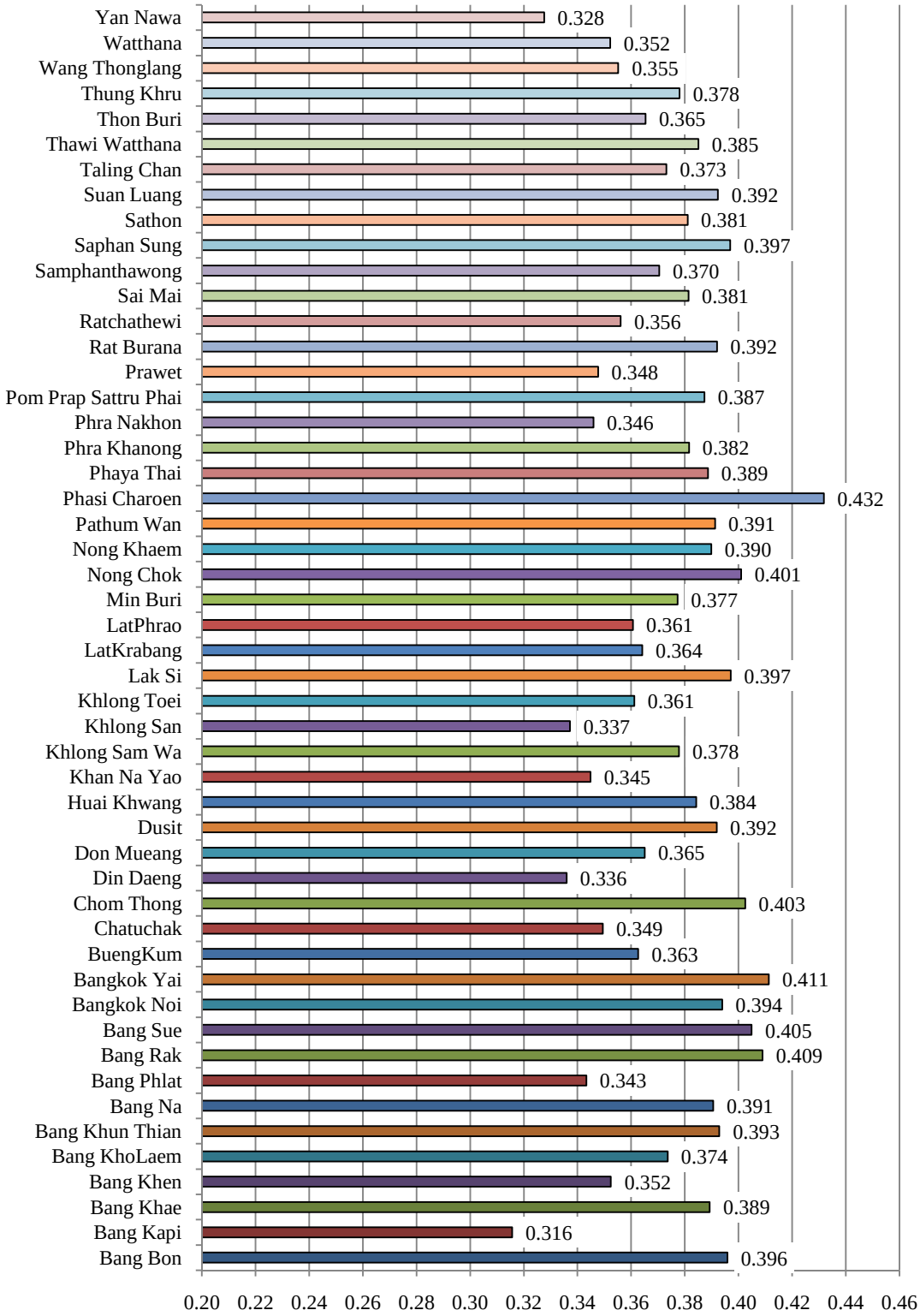


Figure G.6 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of national environment and its impactcriterion)

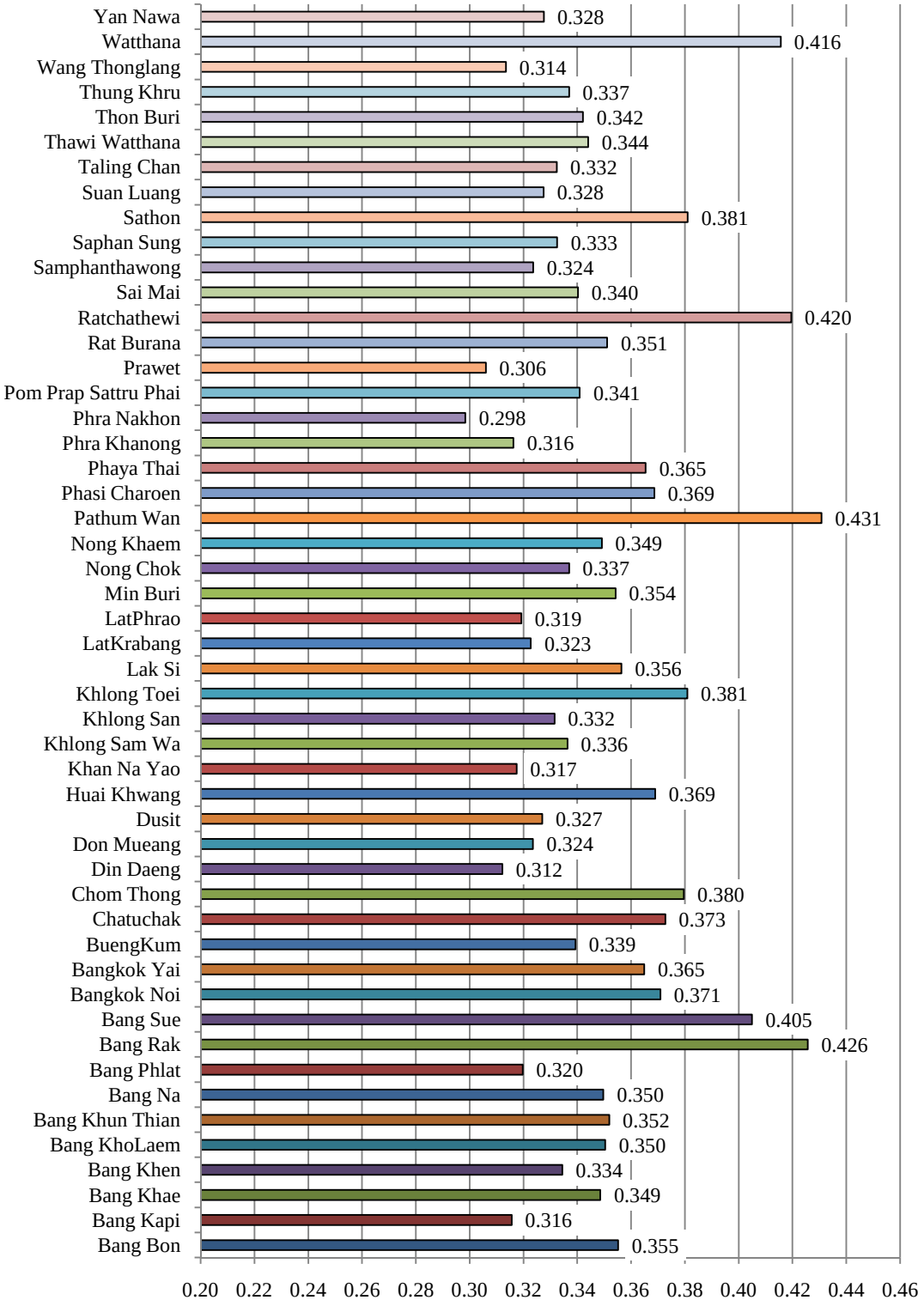


Figure G.7 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of accessibility criterion)

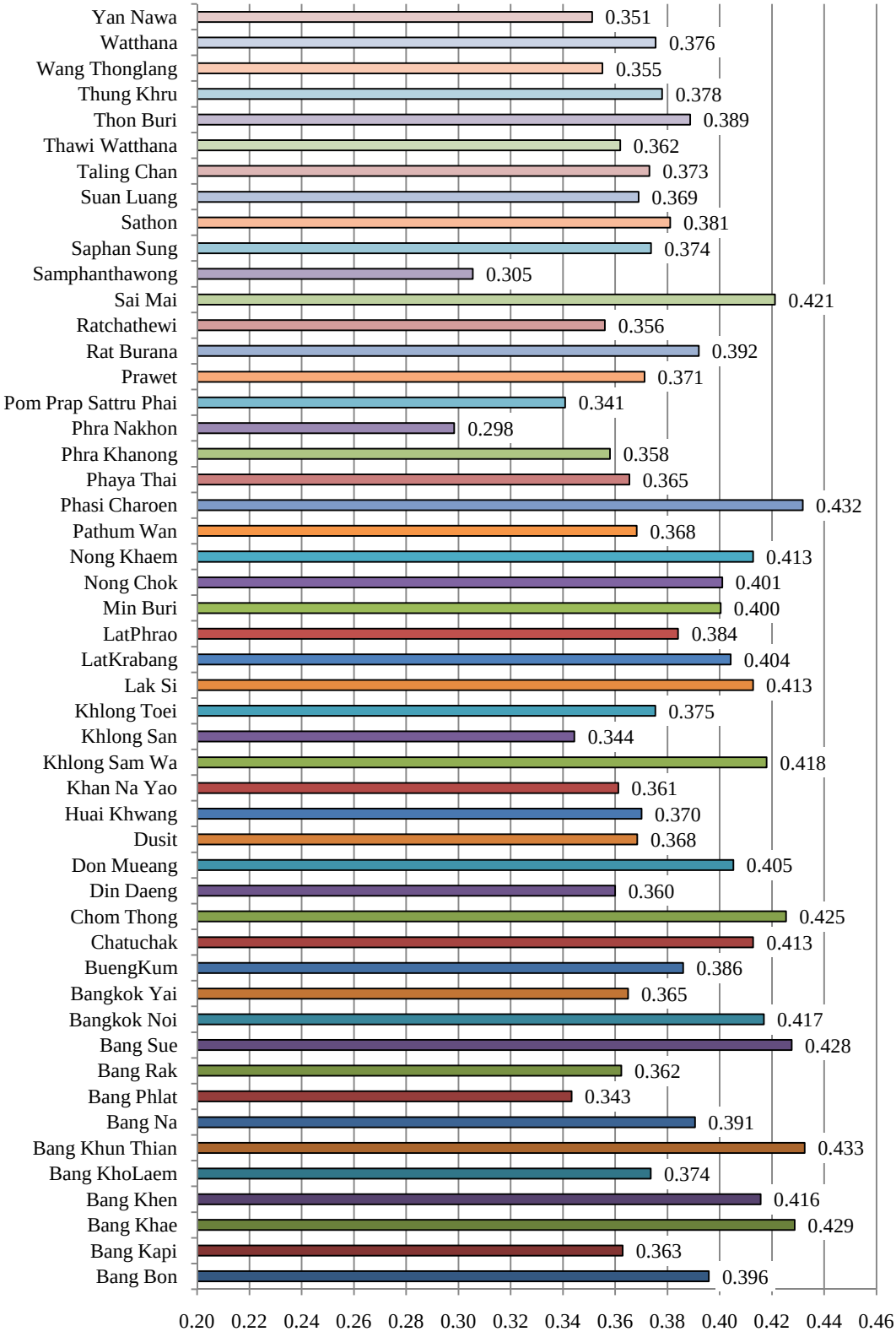


Figure G.8 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of labor criterion)

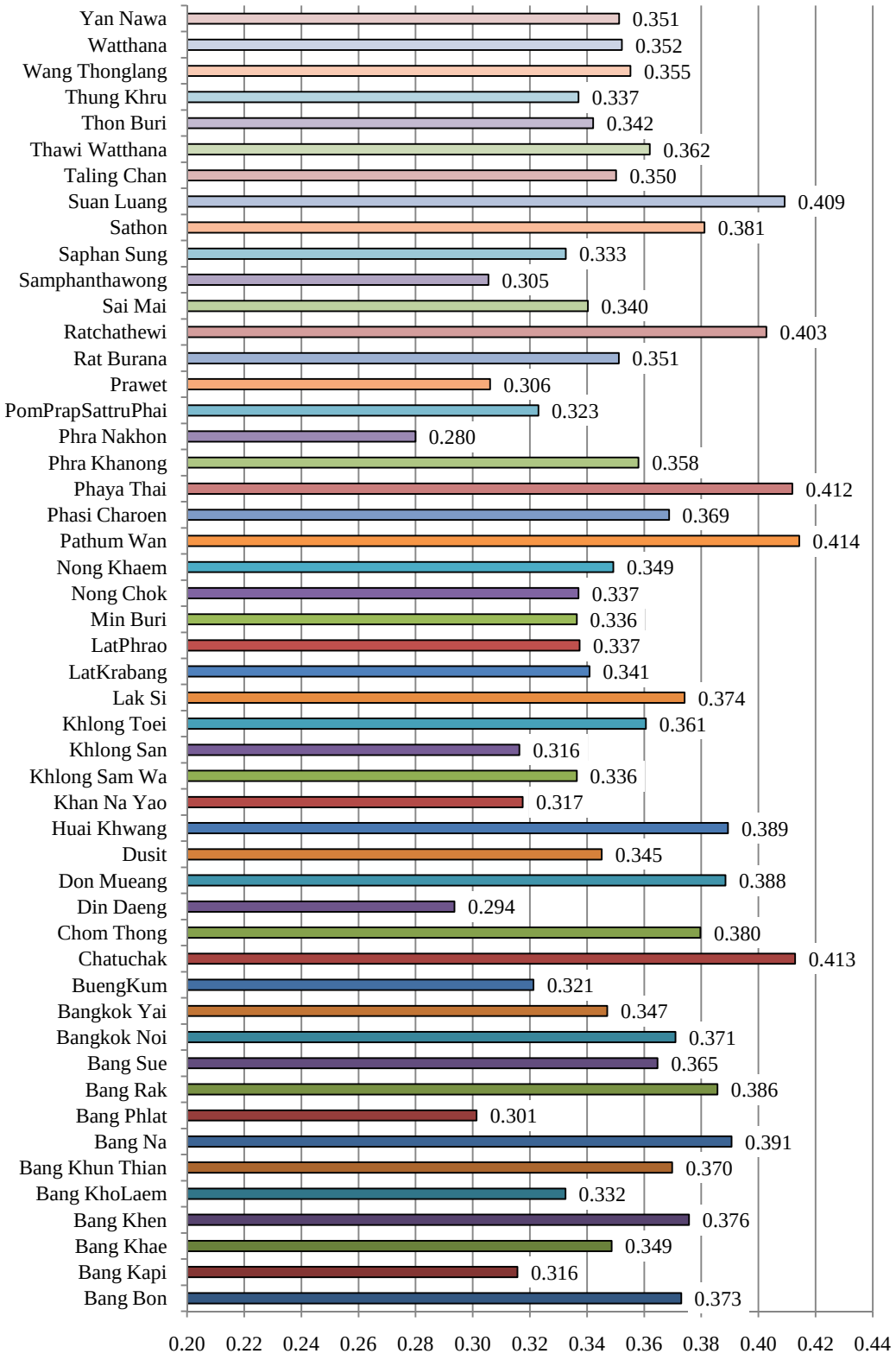


Figure G.9 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of connectivity to multimodal transport criterion)

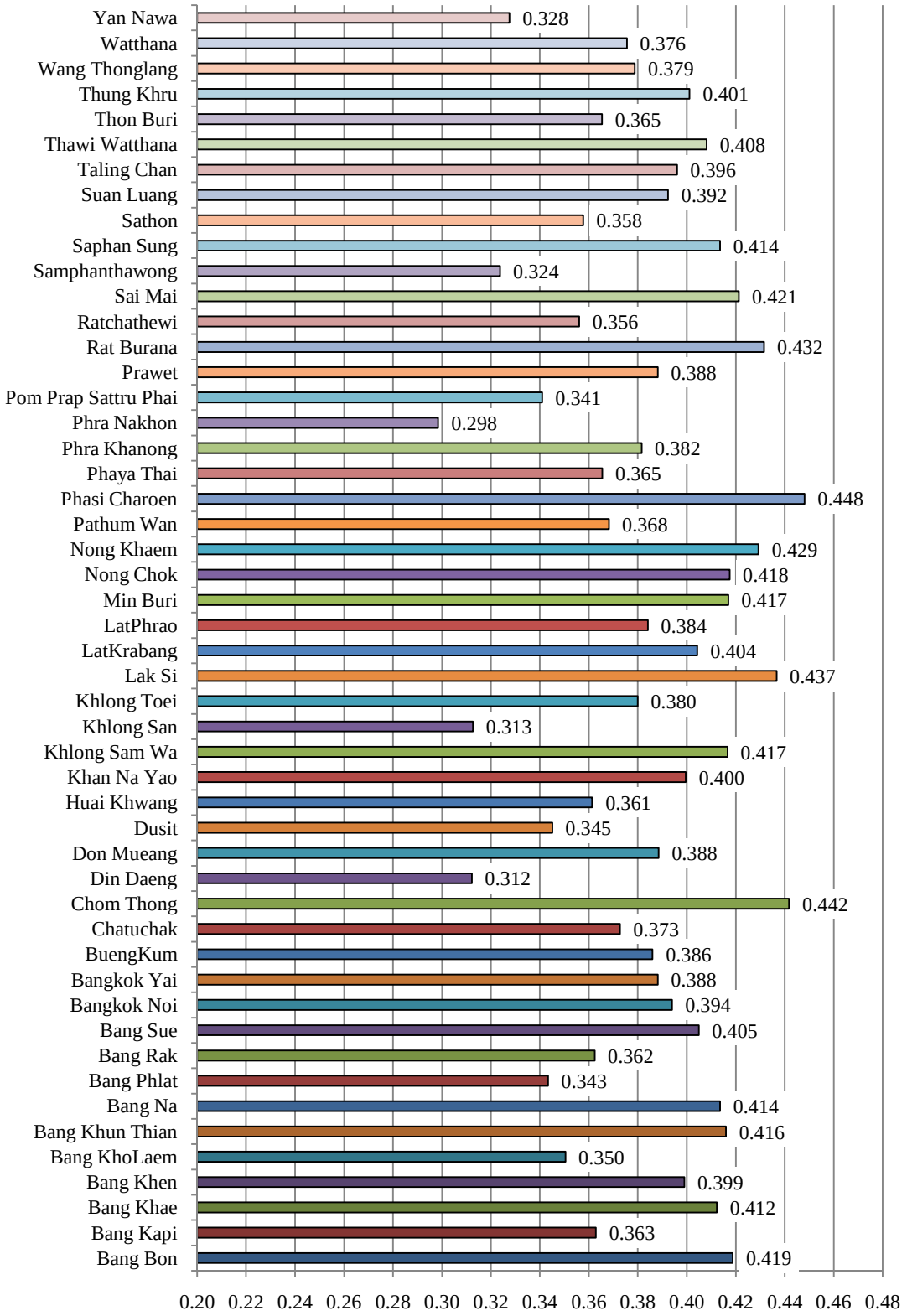


Figure G.10 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight government and regulations criterion)

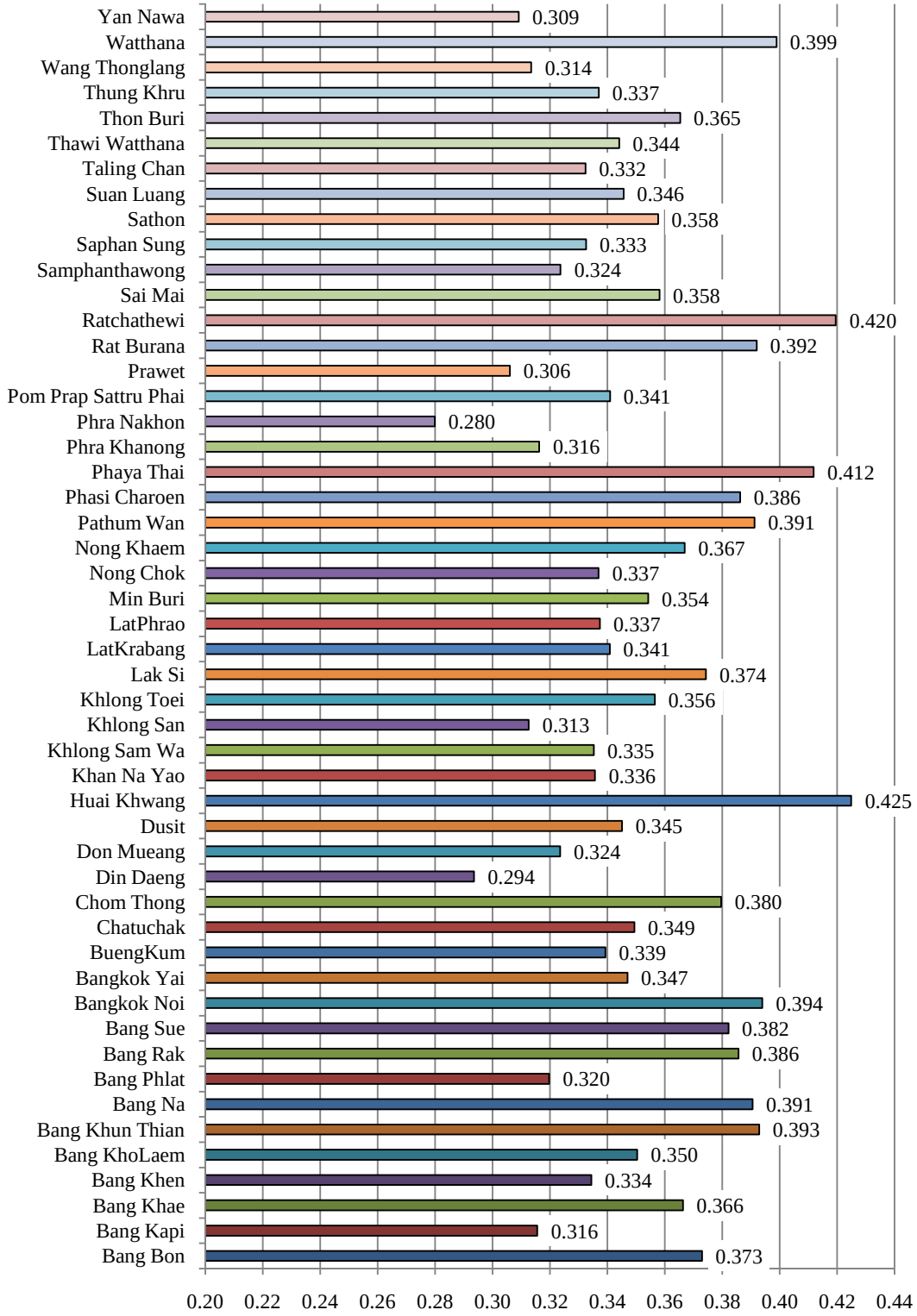


Figure G.11 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of demand criterion)

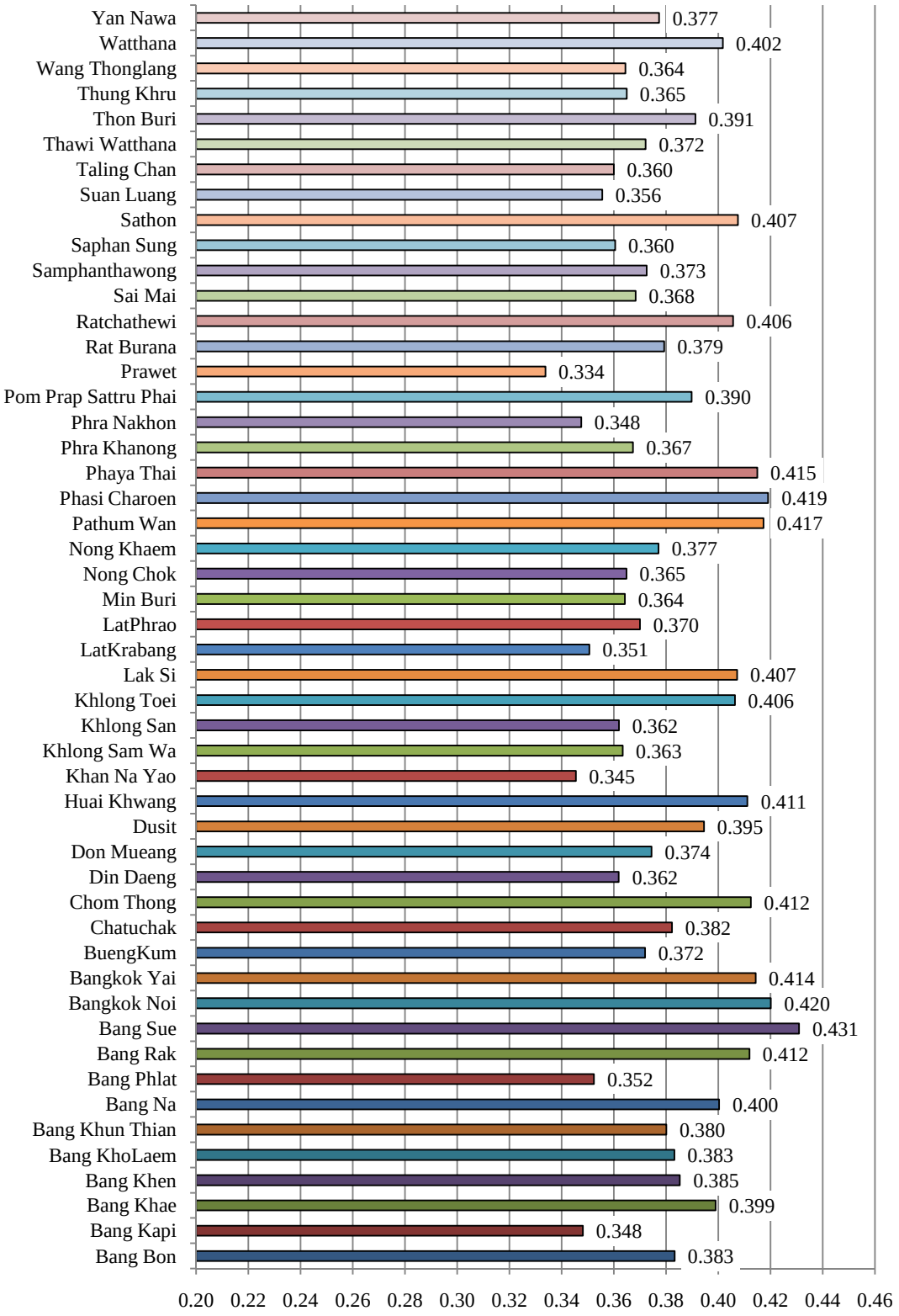


Figure G.12 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of infrastructure criterion)

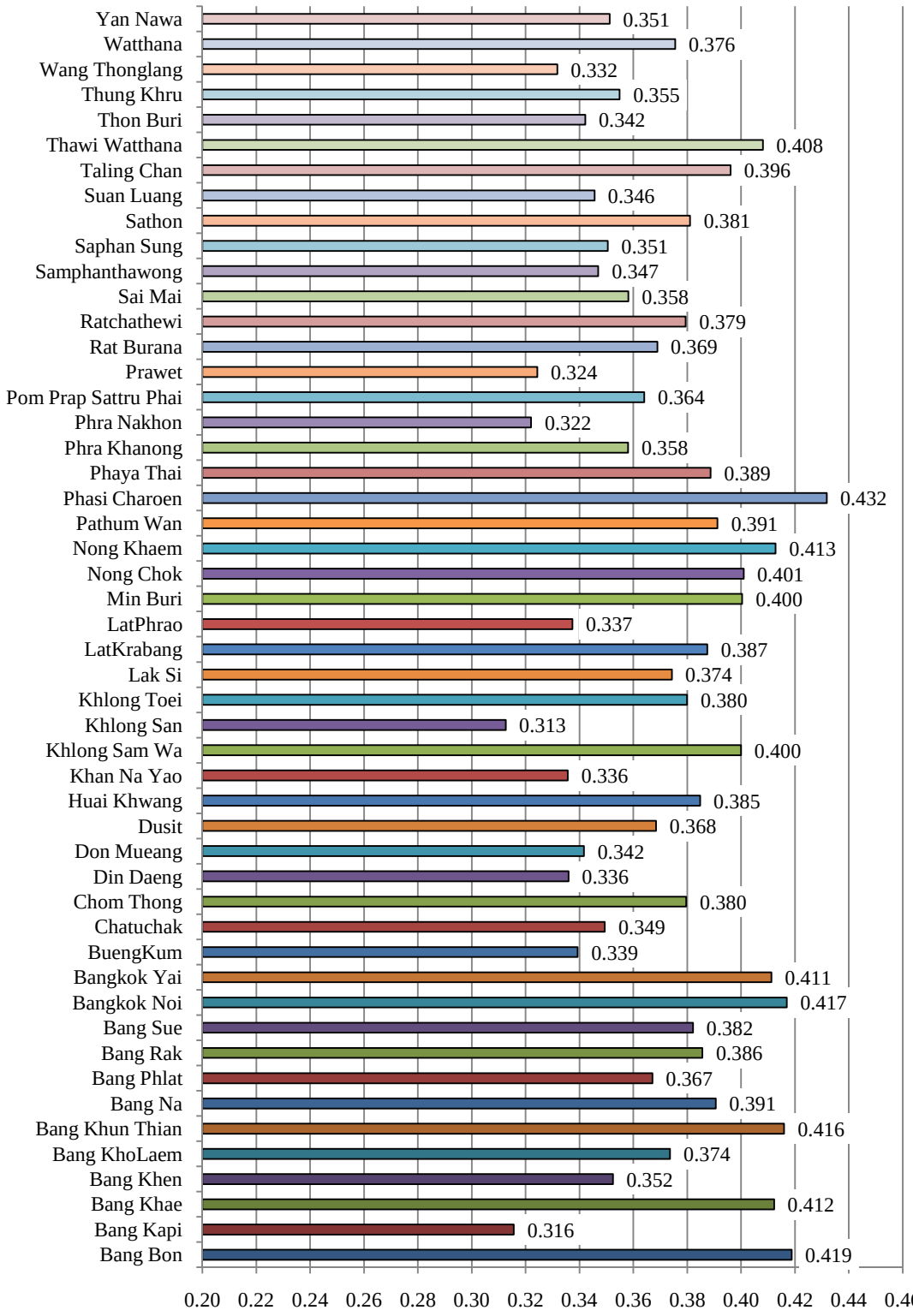


Figure G.13 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of security criterion)

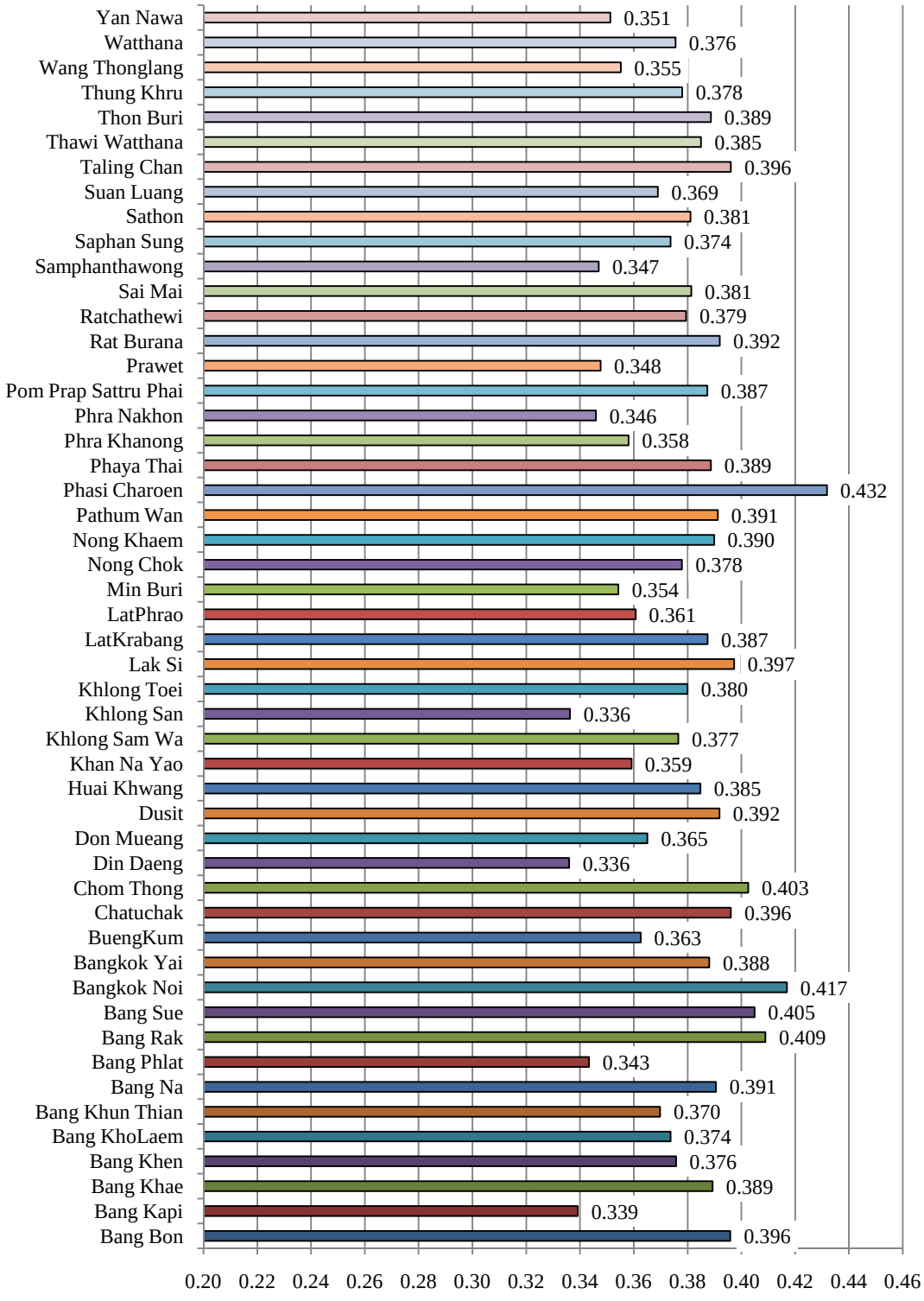


Figure G.14 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of information technology criterion)

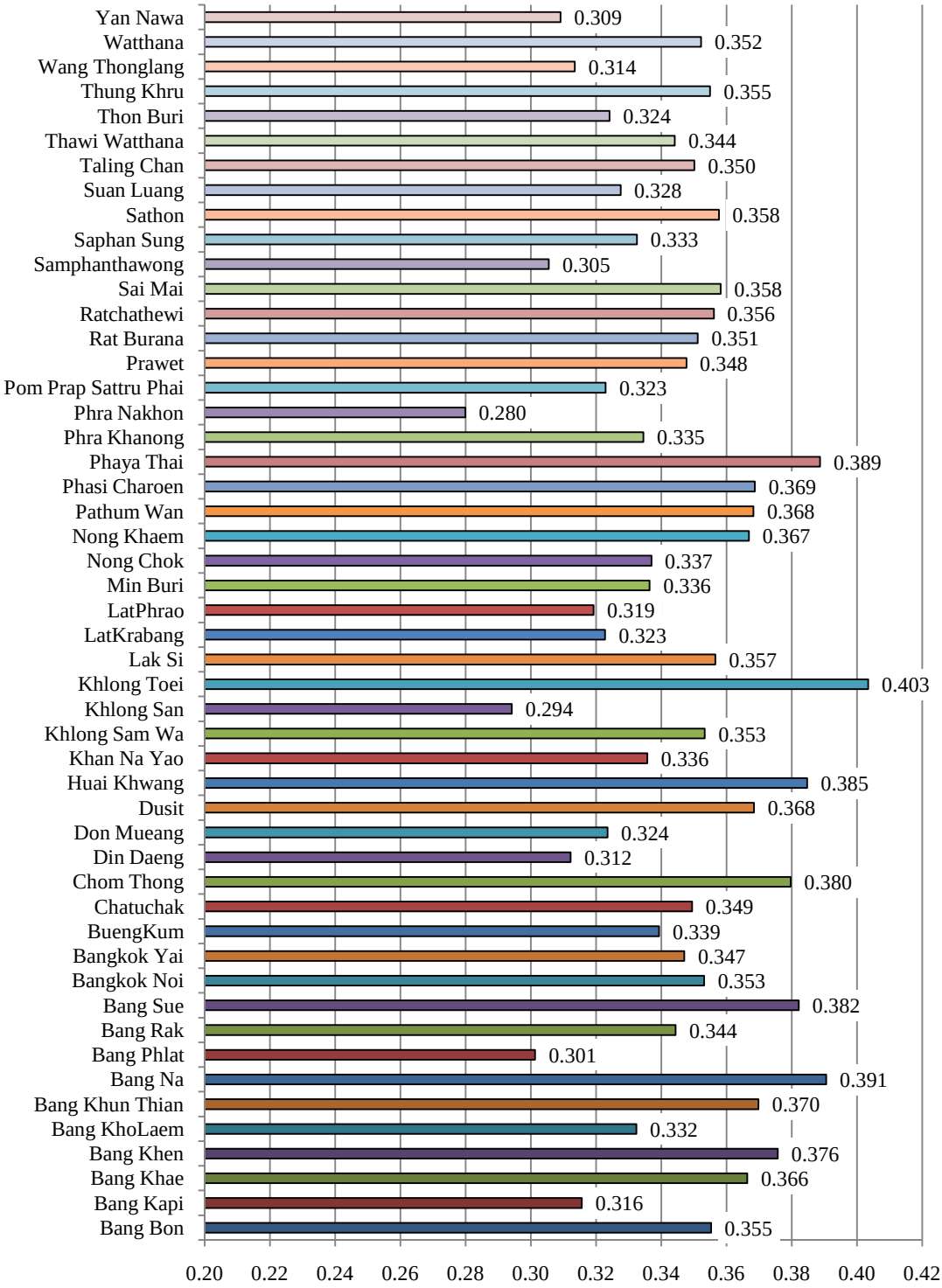


Figure G.15 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of flooded management criterion)

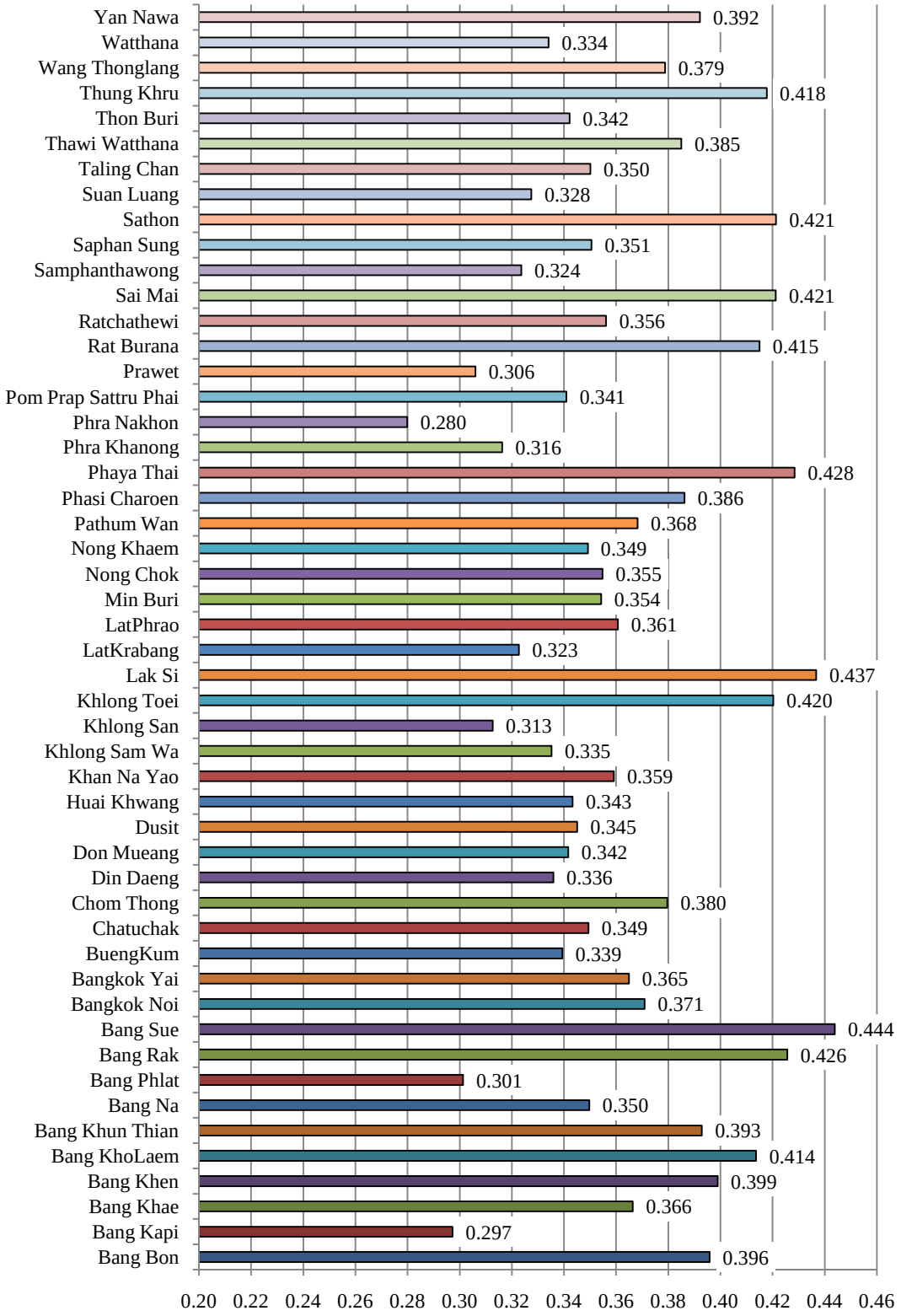


Figure G.16 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of topography criterion)

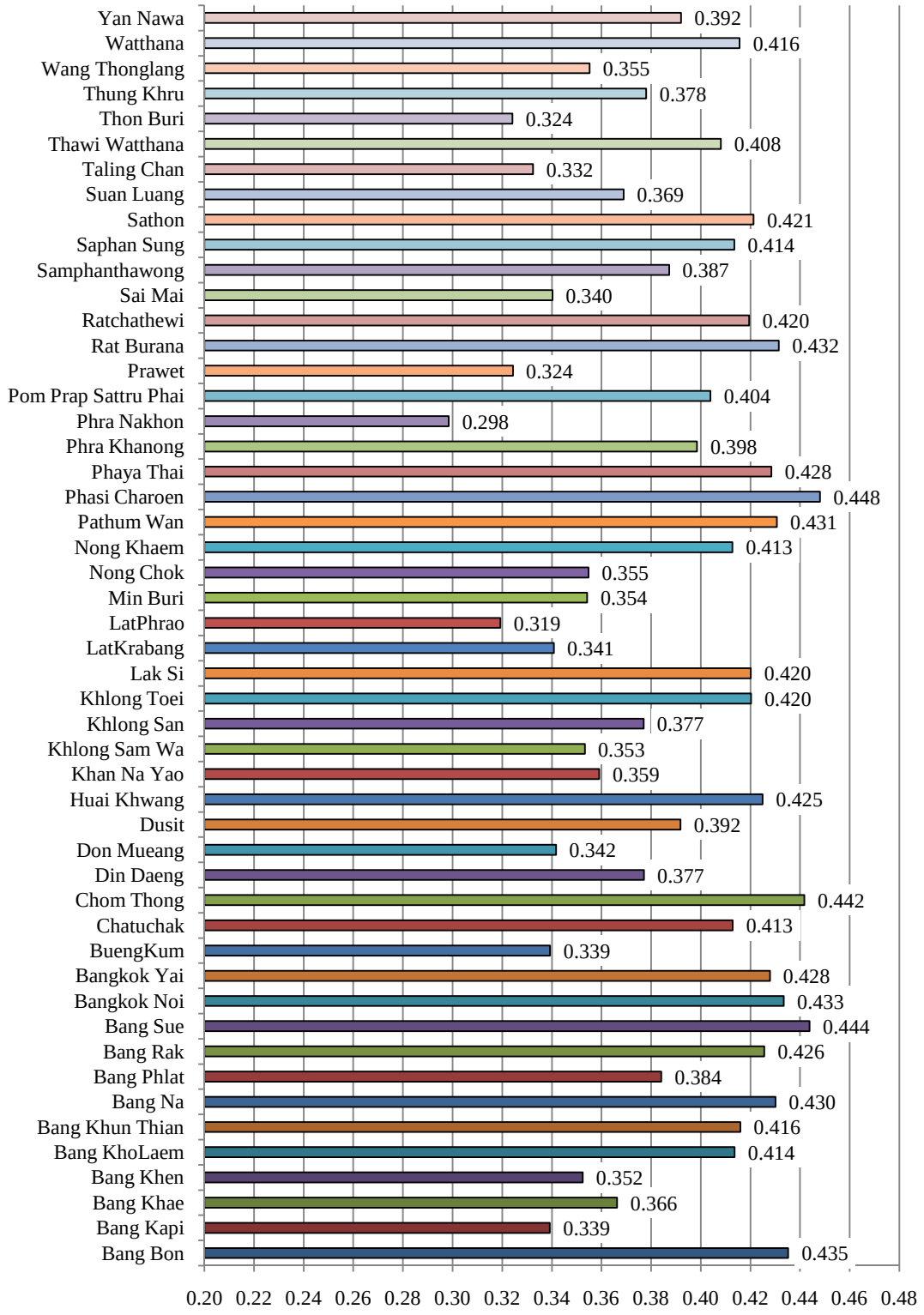


Figure G.17 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of country planning criterion)

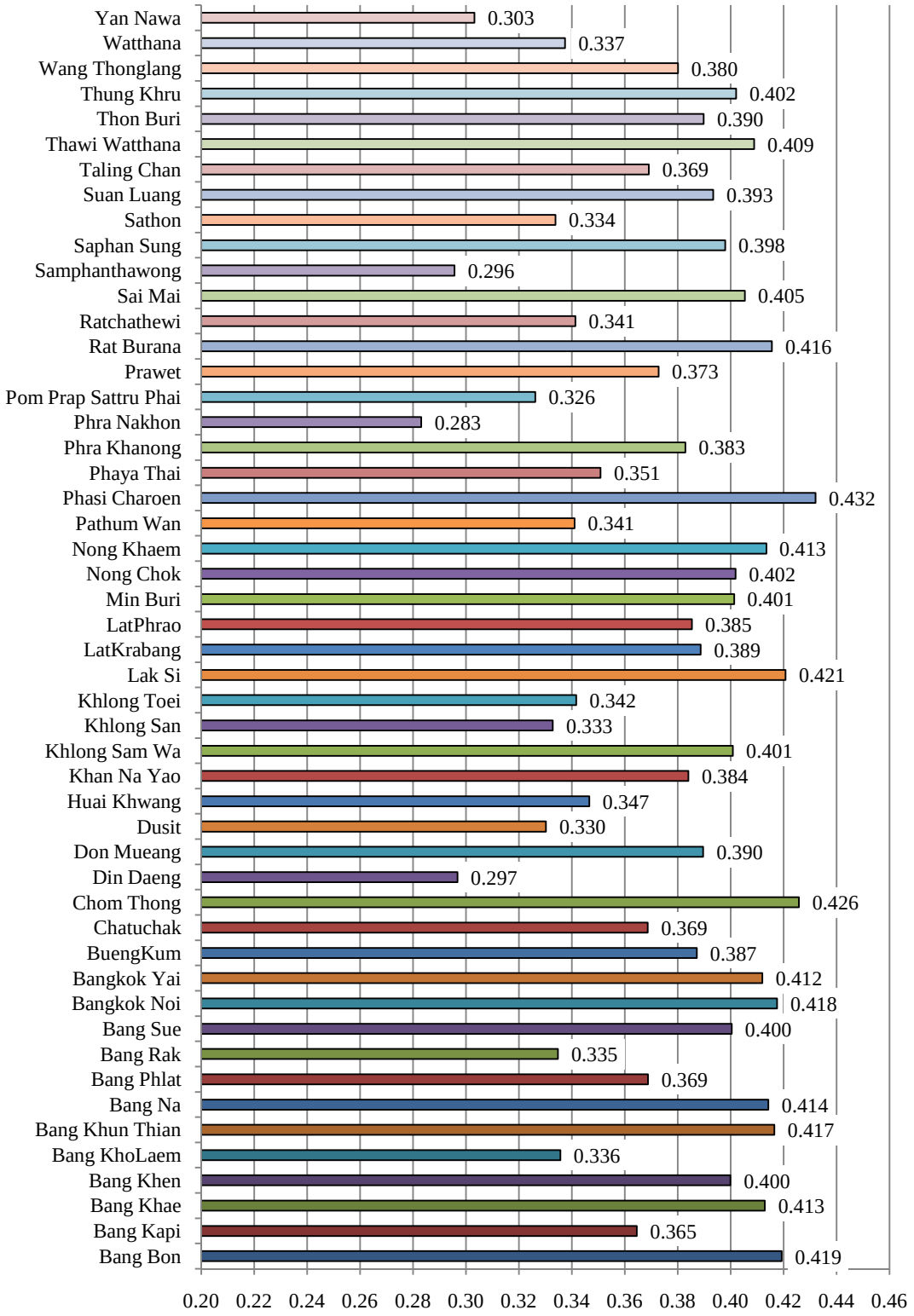


Figure G.18 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of cost criterion)

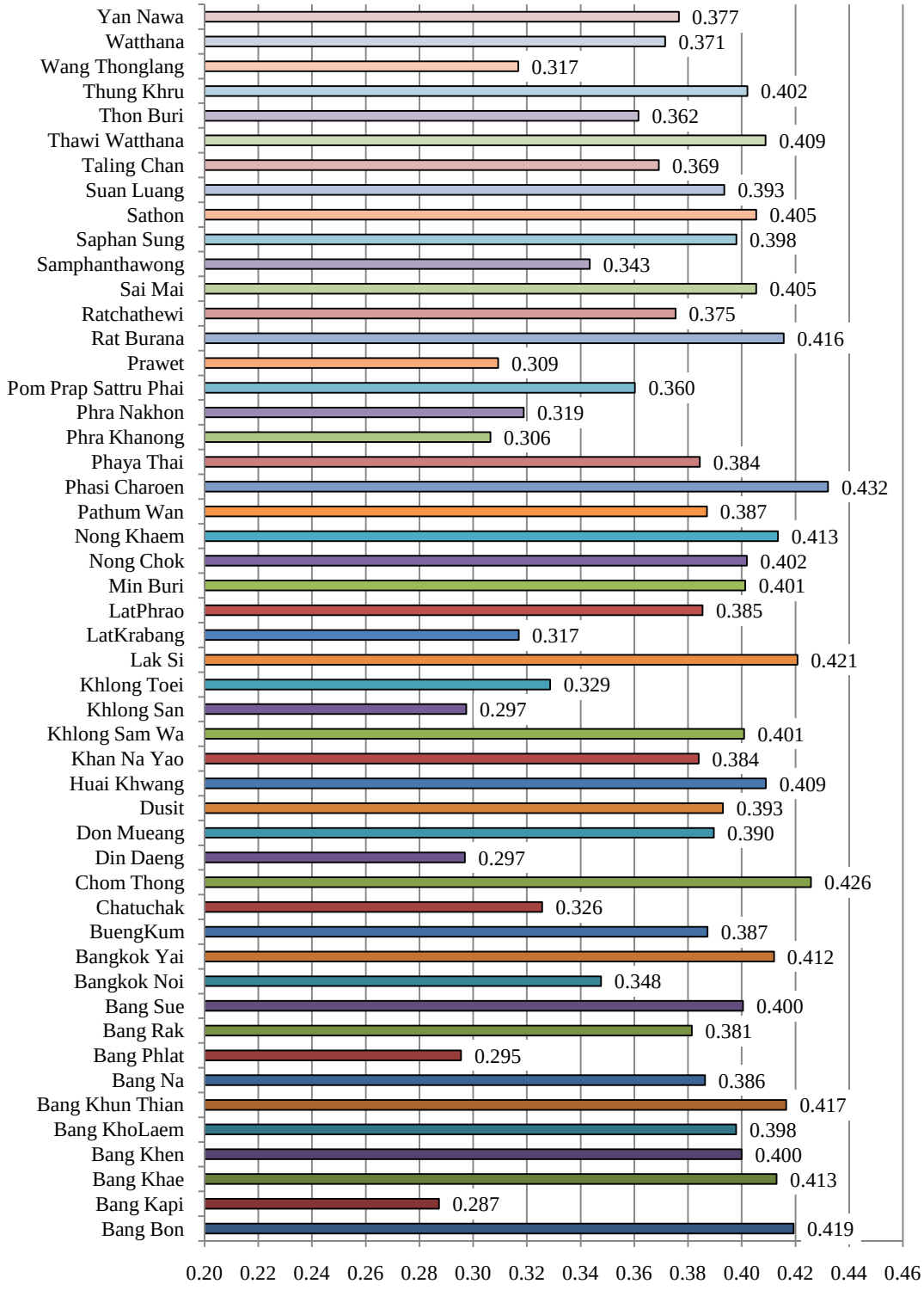


Figure G.19 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of competition criterion)

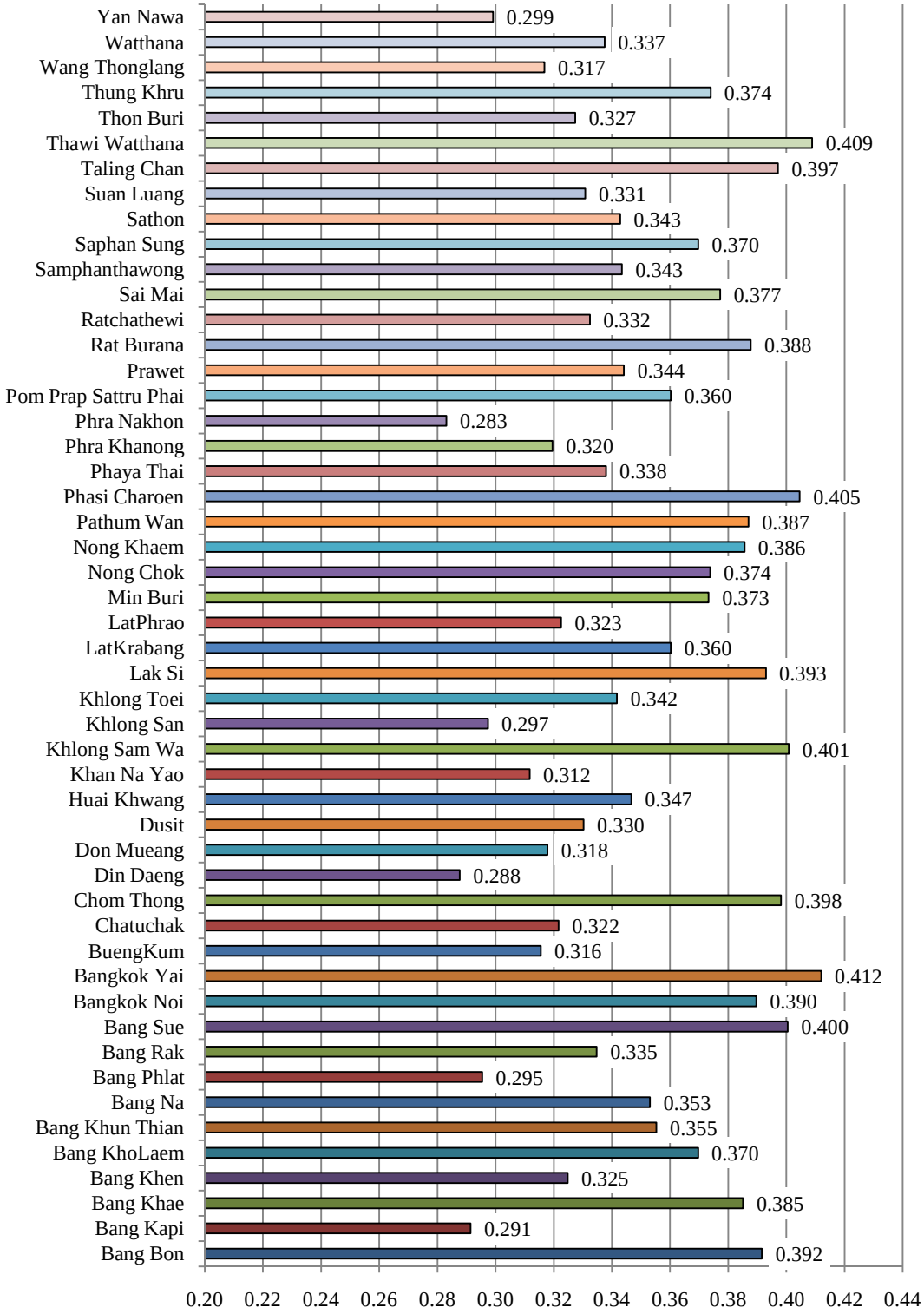


Figure G.20 The closeness coefficient (CC_i) of 50 districts for sensitivity analysis (highest weight of density of traffic criterion)

Table G.1 The result of equal weight all criteria

Order	Sensitivity analysis				
	Very low	**Low**	**Medium**	**High**	**Very high**
1	Phasi Charoen	Phasi Charoen	Phasi Charoen	Phasi Charoen	Phasi Charoen
2	Bang Sue	Chom Thong	Chom Thong	Chom Thong	Chom Thong
3	Chom Thong	Bang Sue	Bang Sue	Bang Sue	Bang Sue
4	Lak Si	Lak Si	Lak Si	Lak Si	Lak Si
5	Bang Bon	Bang Bon	Bang Bon	Bangkok Noi	Bangkok Noi
6	Bangkok Noi	Bang Khun Thian	Bangkok Noi	Bang Khun Thian	Bang Khun Thian
7	Bang Khun Thian	Bangkok Noi	Bang Khun Thian	Bang Bon	Bang Rak
8	Rat Burana	Rat Burana	Rat Burana	Rat Burana	Bang Bon
9	Pathum Wan	Bangkok Yai	Bangkok Yai	Bangkok Yai	Phaya Thai
10	Bang Na	Pathum Wan	Phaya Thai	Bang Rak	Huai Khwang
11	Nong Khaem	Bang Na	Pathum Wan	Phaya Thai	Rat Burana
12	Bang Khae	Nong Khaem	Bang Na	Pathum Wan	Bangkok Yai
13	Phaya Thai	Bang Khae	Bang Rak	Huai Khwang	Pathum Wan
14	Bangkok Yai	Phaya Thai	Nong Khaem	Bang Na	Khlong Toei
15	Bang Rak	Thawi Watthana	Huai Khwang	Nong Khaem	Bang Na
16	Thawi Watthana	Huai Khwang	Bang Khae	Bang Khae	Sathon
17	Huai Khwang	Bang Rak	Thawi Watthana	Sathon	Nong Khaem
18	Sai Mai	Sathon	Sathon	Khlong Toei	Bang Khae
19	Sathon	Sai Mai	Khlong Toei	Thawi Watthana	Ratchathewi
20	Khlong Toei	Khlong Toei	Sai Mai	Sai Mai	Thawi Watthana
21	Ratchathewi	Ratchathewi	Ratchathewi	Ratchathewi	Sai Mai
22	Thung Khru	Khlong Sam Wa	Khlong Sam Wa	Khlong Sam Wa	Khlong Sam Wa
23	Nong Chok	Thung Khru	Bang Khen	Bang Khen	Bang Khen
24	Min Buri	Min Buri	Nong Chok	Watthana	Watthana
25	Khlong Sam Wa	Nong Chok	Thung Khru	Nong Chok	Chatuchak

Table G.1 The result of equal weight all criteria (cont.)

Order	Sensitivity analysis				
	Very low	**Low**	**Medium**	**High**	**Very high**
26	Bang Khen	Bang Khen	Watthana	Thung Khru	Nong Chok
27	Watthana	Watthana	Min Buri	Min Buri	Thung Khru
28	Saphan Sung	Saphan Sung	Chatuchak	Chatuchak	Saphan Sung
29	Bang KhoLaem	Bang KhoLaem	Saphan Sung	Saphan Sung	Min Buri
30	Taling Chan	Chatuchak	Bang KhoLaem	Bang KhoLaem	Bang KhoLaem
31	Chatuchak	Taling Chan	Suan Luang	Suan Luang	Suan Luang
32	Suan Luang	Suan Luang	Dusit	Dusit	Dusit
33	Dusit	Dusit	Taling Chan	Don Mueang	Don Mueang
34	Thon Buri	Don Mueang	Don Mueang	Taling Chan	LatKrabang
35	Don Mueang	Thon Buri	LatKrabang	LatKrabang	Taling Chan
36	Pom Prap Sattru Phai	BuengKum	Thon Buri	Thon Buri	Phra Khanong
37	LatKrabang	LatKrabang	BuengKum	BuengKum	Thon Buri
38	BuengKum	Pom Prap Sattru Phai	LatPhrao	Phra Khanong	BuengKum
39	LatPhrao	LatPhrao	Pom Prap Sattru Phai	Khan Na Yao	Khan Na Yao
40	Khan Na Yao	Khan Na Yao	Khan Na Yao	LatPhrao	LatPhrao
41	Phra Khanong	Phra Khanong	Phra Khanong	Pom Prap Sattru Phai	Yan Nawa
42	Wang Thonglang	Wang Thonglang	Yan Nawa	Yan Nawa	Pom Prap Sattru Phai
43	Yan Nawa	Yan Nawa	Wang Thonglang	Wang Thonglang	Wang Thonglang
44	Prawet	Prawet	Prawet	Prawet	Bang Phlat
45	Samphantha wong	Samphantha wong	Bang Phlat	Bang Phlat	Prawet
46	Bang Phlat	Bang Phlat	Samphantha wong	Samphantha wong	Samphantha wong
47	Bang Kapi	Bang Kapi	Bang Kapi	Din Daeng	Din Daeng
48	Khlong San	Din Daeng	Din Daeng	Bang Kapi	Bang Kapi
49	Din Daeng	Khlong San	Khlong San	Khlong San	Khlong San
50	Phra Nakhon	Phra Nakhon	Phra Nakhon	Phra Nakhon	Phra Nakhon

Table G.2 The result of highest weight national environment and its impact, accessibility, labor and connectivity to multimodal transport criteria

Order	Sensitivity analysis			
	National environment and its impact	**Accessibility**	**Labor**	**Connectivity to multimodal transport**
1	Phasi Charoen	Pathum Wan	Bang Khun Thian	Pathum Wan
2	Bangkok Yai	Bang Rak	Phasi Charoen	Chatuchak
3	Bang Rak	Ratchathewi	Bang Khae	Phaya Thai
4	Bang Sue	Watthana	Bang Sue	Suan Luang
5	Chom Thong	Bang Sue	Chom Thong	Huai Khwang
6	Nong Chok	Khlong Toei	Sai Mai	Ratchathewi
7	Lak Si	Huai Khwang	Bangkok Noi	Bang Na
8	Saphan Sung	Sathon	Khlong Sam Wa	Don Mueang
9	Bang Bon	Chom Thong	Bang Khen	Bang Rak
10	Bangkok Noi	Chatuchak	Chatuchak	Sathon
11	Bang Khun Thian	Bangkok Noi	Nong Khaem	Khlong Toei
12	Suan Luang	Phasi Charoen	Don Mueang	Chom Thong
13	Rat Burana	Phaya Thai	LatKrabang	Bang Khen
14	Dusit	Bangkok Yai	Nong Chok	Lak Si
15	Pathum Wan	Lak Si	Min Buri	Bang Bon
16	Bang Na	Bang Bon	Lak Si	Bangkok Noi
17	Nong Khaem	Min Buri	Bang Bon	Bang Khun Thian
18	Bang Khae	Bang Khun Thian	Rat Burana	Phasi Charoen
19	Phaya Thai	Rat Burana	Bang Na	Bang Sue
20	Pom Prap Sattru Phai	Bang KhoLaem	Thon Buri	Thawi Watthana
21	Thawi Watthana	Bang Na	BuengKum	Phra Khanong
22	Huai Khwang	Nong Khaem	LatPhrao	Wang Thonglang
23	Phra Khanong	Bang Khae	Sathon	Watthana
24	Sai Mai	Thawi Watthana	Khlong Toei	Yan Nawa
25	Sathon	Thon Buri	Thung Khru	Rat Burana
26	Thung Khru	Pom Prap Sattru Phai	Watthana	Taling Chan

Table G.2 The result of highest weight National environment and its impact, accessibility, labor and connectivity to multimodal transport criteria (cont.)

Order	Sensitivity analysis			
	National environment and its impact	**Accessibility**	**Labor**	**Connectivity to multimodal transport**
27	Min Buri	Sai Mai	Saphan Sung	Nong Khaem
28	Khlong Sam Wa	BuengKum	Bang KhoLaem	Bang Khae
29	Bang KhoLaem	Thung Khru	Taling Chan	Bangkok Yai
30	Taling Chan	Nong Chok	Prawet	Dusit
31	Samphantha wong	Khlong San	Suan Luang	Thon Buri
32	Thon Buri	Khlong Sam Wa	Dusit	LatKrabang
33	Don Mueang	Bang Khen	Pathum Wan	Sai Mai
34	LatKrabang	Saphan Sung	Phaya Thai	LatPhrao
35	BuengKum	Taling Chan	Bangkok Yai	Thung Khru
36	LatPhrao	Yan Nawa	Bang Kapi	Nong Chok
37	Khan Na Yao	Suan Luang	Bang Rak	Min Buri
38	Khlong Toei	Dusit	Thawi Watthana	Khlong Sam Wa
39	Ratchathewi	Samphantha wong	Huai Khwang	Saphan Sung
40	Wang Thonglang	Don Mueang	Din Daeng	Bang KhoLaem
41	Bang Khen	LatKrabang	Khan Na Yao	Pom Prap Sattru Phai
42	Watthana	Bang Phlat	Phra Khanong	BuengKum
43	Chatuchak	LatPhrao	Ratchathewi	Khan Na Yao
44	Prawet	Khan Na Yao	Wang Thonglang	Bang Kapi
45	Phra Nakhon	Phra Khanong	Yan Nawa	Prawet
46	Bang Phlat	Bang Kapi	Bang Phlat	Samphantha wong
47	Khlong San	Wang Thonglang	Pom Prap Sattru Phai	Bang Phlat
48	Din Daeng	Din Daeng	Khlong San	Khlong San
49	Yan Nawa	Prawet	Samphantha wong	Din Daeng
50	Bang Kapi	Phra Nakhon	Phra Nakhon	Phra Nakhon

Table G.3 The result of highest weight government and regulations, demand, infrastructure and security criteria

Order	Sensitivity analysis			
	Government and regulations	**Demand**	**Infrastructure**	**Security**
1	Phasi Charoen	Huai Khwang	Bang Sue	Phasi Charoen
2	Chom Thong	Ratchathewi	Bangkok Noi	Bang Bon
3	Lak Si	Phaya Thai	Phasi Charoen	Bangkok Noi
4	Rat Burana	Watthana	Pathum Wan	Bang Khun Thian
5	Nong Khaem	Bangkok Noi	Phaya Thai	Nong Khaem
6	Sai Mai	Bang Khun Thian	Bangkok Yai	Bang Khae
7	Bang Bon	Rat Burana	Chom Thong	Bangkok Yai
8	Nong Chok	Pathum Wan	Bang Rak	Thawi Watthana
9	Min Buri	Bang Na	Huai Khwang	Nong Chok
10	Khlong Sam Wa	Phasi Charoen	Sathon	Min Buri
11	Bang Khun Thian	Bang Rak	Lak Si	Khlong Sam Wa
12	Saphan Sung	Bang Sue	Khlong Toei	Taling Chan
13	Bang Na	Chom Thong	Ratchathewi	Pathum Wan
14	Bang Khae	Lak Si	Watthana	Bang Na
15	Thawi Watthana	Bang Bon	Bang Na	Phaya Thai
16	Bang Sue	Nong Khaem	Bang Khae	LatKrabang
17	LatKrabang	Bang Khae	Dusit	Bang Rak
18	Thung Khru	Thon Buri	Thon Buri	Huai Khwang
19	Khan Na Yao	Sai Mai	Pom Prap Sattru Phai	Bang Sue
20	Bang Khen	Sathon	Bang Khen	Sathon
21	Taling Chan	Khlong Toei	Bang Bon	Khlong Toei
22	Bangkok Noi	Min Buri	Bang KhoLaem	Chom Thong
23	Suan Luang	Bang KhoLaem	Chatuchak	Ratchathewi
24	Don Mueang	Chatuchak	Bang Khun Thian	Watthana
25	Prawet	Bangkok Yai	Rat Burana	Lak Si

Table G.3 The result of highest weight government and regulations, demand, infrastructure and security criteria (cont.)

Order	Sensitivity analysis			
	Government and regulations	**Demand**	**Infrastructure**	**Security**
26	Bangkok Yai	Suan Luang	Yan Nawa	Bang KhoLaem
27	BuengKum	Dusit	Nong Khaem	Rat Burana
28	LatPhrao	Thawi Watthana	Don Mueang	Dusit
29	Phra Khanong	Pom Prap Sattru Phai	Samphantha wong	Bang Phlat
30	Khlong Toei	LatKrabang	Thawi Watthana	Pom Prap Sattru Phai
31	Wang Thonglang	BuengKum	BuengKum	Sai Mai
32	Watthana	LatPhrao	LatPhrao	Phra Khanong
33	Chatuchak	Thung Khru	Sai Mai	Thung Khru
34	Pathum Wan	Nong Chok	Phra Khanong	Bang Khen
35	Phaya Thai	Khan Na Yao	Thung Khru	Yan Nawa
36	Thon Buri	Khlong Sam Wa	Nong Chok	Saphan Sung
37	Bang Kapi	Bang Khen	Wang Thonglang	Chatuchak
38	Bang Rak	Saphan Sung	Min Buri	Samphantha wong
39	Huai Khwang	Taling Chan	Khlong Sam Wa	Suan Luang
40	Sathon	Samphantha wong	Khlong San	Thon Buri
41	Ratchathewi	Don Mueang	Din Daeng	Don Mueang
42	Bang KhoLaem	Bang Phlat	Saphan Sung	BuengKum
43	Dusit	Phra Khanong	Taling Chan	LatPhrao
44	Bang Phlat	Bang Kapi	Suan Luang	Din Daeng
45	Pom Prap Sattru Phai	Wang Thonglang	Bang Phlat	Khan Na Yao
46	Yan Nawa	Khlong San	LatKrabang	Wang Thonglang
47	Samphantha wong	Yan Nawa	Bang Kapi	Prawet
48	Khlong San	Prawet	Phra Nakhon	Phra Nakhon
49	Din Daeng	Din Daeng	Khan Na Yao	Bang Kapi
50	Phra Nakhon	Phra Nakhon	Prawet	Khlong San

Table G.4 The result of highest weight information technology, flooded management, topography and country planning criteria

Order	Sensitivity analysis			
	Information technology	**Flooded management**	**Topography**	**Country planning**
1	Phasi Charoen	Khlong Toei	Bang Sue	Phasi Charoen
2	Bangkok Noi	Bang Na	Lak Si	Bang Sue
3	Bang Rak	Phaya Thai	Phaya Thai	Chom Thong
4	Bang Sue	Huai Khwang	Bang Rak	Bang Bon
5	Chom Thong	Bang Sue	Sathon	Bangkok Noi
6	Lak Si	Chom Thong	Sai Mai	Rat Burana
7	Chatuchak	Bang Khen	Khlong Toei	Pathum Wan
8	Taling Chan	Bang Khun Thian	Thung Khru	Bang Na
9	Bang Bon	Phasi Charoen	Rat Burana	Phaya Thai
10	Rat Burana	Dusit	Bang KhoLaem	Bangkok Yai
11	Dusit	Pathum Wan	Bang Khen	Bang Rak
12	Pathum Wan	Nong Khaem	Bang Bon	Huai Khwang
13	Bang Na	Bang Khae	Bang Khun Thian	Sathon
14	Nong Khaem	Sai Mai	Yan Nawa	Khlong Toei
15	Bang Khae	Sathon	Phasi Charoen	Lak Si
16	Thon Buri	Lak Si	Thawi Watthana	Ratchathewi
17	Phaya Thai	Ratchathewi	Chom Thong	Bang Khun Thian
18	Bangkok Yai	Bang Bon	Wang Thonglang	Watthana
19	LatKrabang	Thung Khru	Bangkok Noi	Bang KhoLaem
20	Pom Prap Sattru Phai	Khlong Sam Wa	Pathum Wan	Saphan Sung
21	Thawi Watthana	Bangkok Noi	Bang Khae	Chatuchak
22	Huai Khwang	Watthana	Bangkok Yai	Nong Khaem
23	Sai Mai	Rat Burana	LatPhrao	Thawi Watthana
24	Sathon	Taling Chan	Khan Na Yao	Pom Prap Sattru Phai
25	Khlong Toei	Chatuchak	Ratchathewi	Phra Khanong
26	Ratchathewi	Prawet	Nong Chok	Yan Nawa

Table G.4 The result of highest weight information technology, flooded management, topography and country planning criteria (cont.)

Order	Sensitivity analysis			
	Information technology	**Flooded management**	**Topography**	**Country planning**
27	Thung Khru	Bangkok Yai	Min Buri	Dusit
28	Nong Chok	Bang Rak	Saphan Sung	Samphantha wong
29	Khlong Sam Wa	Thawi Watthana	Taling Chan	Bang Phlat
30	Bang Khen	BuengKum	Bang Na	Thung Khru
31	Watthana	Nong Chok	Chatuchak	Din Daeng
32	Saphan Sung	Min Buri	Nong Khaem	Khlong San
33	Bang KhoLaem	Khan Na Yao	Dusit	Suan Luang
34	Bang Khun Thian	Phra Khanong	Huai Khwang	Bang Khae
35	Suan Luang	Saphan Sung	Thon Buri	Khan Na Yao
36	Don Mueang	Bang KhoLaem	Don Mueang	Wang Thonglang
37	BuengKum	Suan Luang	Pom Prap Sattru Phai	Nong Chok
38	LatPhrao	Thon Buri	BuengKum	Min Buri
39	Khan Na Yao	Don Mueang	Din Daeng	Khlong Sam Wa
40	Phra Khanong	Pom Prap Sattru Phai	Khlong Sam Wa	Bang Khen
41	Wang Thonglang	LatKrabang	Watthana	Don Mueang
42	Min Buri	LatPhrao	Suan Luang	LatKrabang
43	Yan Nawa	Bang Kapi	Samphantha wong	Sai Mai
44	Prawet	Wang Thonglang	LatKrabang	BuengKum
45	Samphantha wong	Din Daeng	Phra Khanong	Bang Kapi
46	Phra Nakhon	Yan Nawa	Khlong San	Taling Chan
47	Bang Phlat	Samphantha wong	Prawet	Prawet
48	Bang Kapi	Bang Phlat	Bang Phlat	Thon Buri
49	Khlong San	Khlong San	Bang Kapi	LatPhrao
50	Din Daeng	Phra Nakhon	Phra Nakhon	Phra Nakhon

Table G.5 The result of highest weight cost, competition and density of traffic criteria

Order	Sensitivity analysis		
	Cost	**Competition**	**Density of traffic**
1	Phasi Charoen	Phasi Charoen	Bangkok Yai
2	Chom Thong	Chom Thong	Thawi Watthana
3	Lak Si	Lak Si	Phasi Charoen
4	Bang Bon	Bang Bon	Khlong Sam Wa
5	Bangkok Noi	Bang Khun Thian	Bang Sue
6	Bang Khun Thian	Rat Burana	Chom Thong
7	Rat Burana	Nong Khaem	Taling Chan
8	Bang Na	Bang Khae	Lak Si
9	Nong Khaem	Bangkok Yai	Bang Bon
10	Bang Khae	Huai Khwang	Bangkok Noi
11	Bangkok Yai	Thawi Watthana	Rat Burana
12	Thawi Watthana	Sai Mai	Pathum Wan
13	Sai Mai	Sathon	Nong Khaem
14	Thung Khru	Thung Khru	Bang Khae
15	Nong Chok	Nong Chok	Sai Mai
16	Min Buri	Min Buri	Thung Khru
17	Khlong Sam Wa	Khlong Sam Wa	Nong Chok
18	Bang Sue	Bang Sue	Min Buri
19	Bang Khen	Bang Khen	Saphan Sung
20	Saphan Sung	Saphan Sung	Bang KhoLaem
21	Suan Luang	Bang KhoLaem	LatKrabang
22	Thon Buri	Suan Luang	Pom Prap Sattru Phai
23	Don Mueang	Dusit	Bang Khun Thian
24	LatKrabang	Don Mueang	Bang Na
25	BuengKum	BuengKum	Huai Khwang

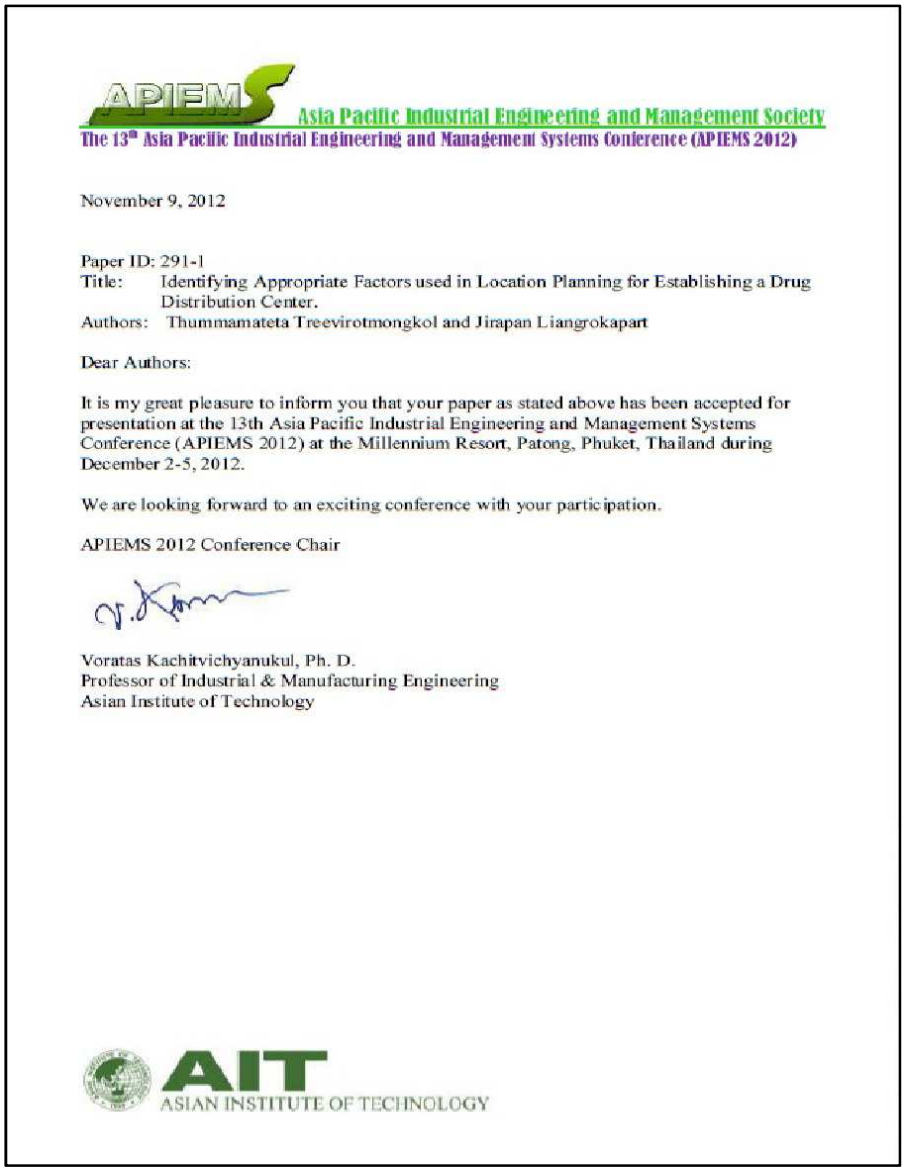
Table G.5 The result of highest weight cost, competition and density of traffic criteria (cont.)

Order	Sensitivity analysis		
	Cost	**Competition**	**Density of traffic**
26	LatPhrao	Pathum Wan	Prawet
27	Khan Na Yao	Bang Na	Samphanthawong
28	Phra Khanong	LatPhrao	Sathon
29	Wang Thonglang	Phaya Thai	Khlong Toei
30	Prawet	Khan Na Yao	Phaya Thai
31	Taling Chan	Bang Rak	Watthana
32	Bang Phlat	Yan Nawa	Bang Rak
33	Chatuchak	Ratchathewi	Ratchathewi
34	Bang Kapi	Watthana	Suan Luang
35	Phaya Thai	Taling Chan	Dusit
36	Huai Khwang	Thon Buri	Thon Buri
37	Khlong Toei	Pom Prap Sattru Phai	Bang Khen
38	Ratchathewi	Bangkok Noi	LatPhrao
39	Pathum Wan	Samphantha wong	Chatuchak
40	Watthana	Khlong Toei	Phra Khanong
41	Bang KhoLaem	Chatuchak	Don Mueang
42	Bang Rak	Phra Nakhon	Wang Thonglang
43	Sathon	LatKrabang	BuengKum
44	Khlong San	Wang Thonglang	Khan Na Yao
45	Dusit	Prawet	Yan Nawa
46	Pom Prap Sattru Phai	Phra Khanong	Khlong San
47	Yan Nawa	Khlong San	Bang Phlat
48	Din Daeng	Din Daeng	Bang Kapi
49	Samphanthawong	Bang Phlat	Din Daeng
50	Phra Nakhon	Bang Kapi	Phra Nakhon

APPENDIX H

2012 INTERNATIONAL CONFERENCE ON INDUSTRIAL ENGINEERING AND MANAGEMENT SYSTEMS SUBMITTED PAPER

H.1 ACCEPTANCE LETTER



APIEMS Asia Pacific Industrial Engineering and Management Society

The 13th Asia Pacific Industrial Engineering and Management Systems Conference (APIEMS 2012)

November 9, 2012

Paper ID: 291-1
Title: Identifying Appropriate Factors used in Location Planning for Establishing a Drug Distribution Center.
Authors: Thummamateta Treevirotmongkol and Jirapan Liangrokapart

Dear Authors:

It is my great pleasure to inform you that your paper as stated above has been accepted for presentation at the 13th Asia Pacific Industrial Engineering and Management Systems Conference (APIEMS 2012) at the Millennium Resort, Patong, Phuket, Thailand during December 2-5, 2012.

We are looking forward to an exciting conference with your participation.

APIEMS 2012 Conference Chair

Voratas Kachitvichyanukul, Ph. D.
Professor of Industrial & Manufacturing Engineering
Asian Institute of Technology

AIT ASIAN INSTITUTE OF TECHNOLOGY

H.2 FULL PAPER

Proceedings of the Asia Pacific Industrial Engineering & Management Systems Conference 2012
V. Kachitvichyanukul, H.T. Luong, and R. Pitakaso Eds.

Identifying Appropriate Factors used in Location Planning for Establishing a Drug Distribution Center

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Abstract Due to 2011 flood crisis in Thailand, a number of drug manufacturers had been under the flood water for a few months. Some drug manufacturers did not get the direct impact from the flooding, but they could not distribute drugs to their customers due to transport disruption. These had resulted in shortage of drugs in many hospitals especially in the remote areas. Therefore, the objective of this research is to identify appropriate factors used in location planning for establishing a drug distribution center. It is expected that the proposed location selection will help the distribution center to continuously distribute drugs to its customers during crisis and hence save the patients. Finally, the appropriate factors will be identified and recommended for decision makers.

Keywords: Drug distribution center, Location Planning, Disruption.

1. INTRODUCTION

The World Bank (2011) stated that the manufacturing sector suffered the biggest damages and loses of 1,007 billion Baht due to 2011 flooding in Thailand. Like other organizations and industries, many of drug manufacturers had closed down during crisis due to the plants had been under the flood water or their employees could not go to work. Some drug manufacturers did not get the direct impact from the flooding, but they could not operate and distribute drugs to their customers due to transport disruption. These had a big impact on the entire hospital supply chain including manufacturers, distributors, hospitals, and the end customers-the patients (Liangrokapart, 2012). As a result, the stock shortage of drugs and medical supplies in some hospitals had been problems due to the transport disruption and the end customers had got all the shortage risks.

As the transport disruption was the major problem on the drug shortage in many hospitals, it was challenging to find some solutions for solving the problem. One possible solution is to build a new drug distribution center located on the flood-free zone with full accessibility during the crisis so that the distribution center could continue transfer drugs to the customer without any disruption. In order to find the best new location for the distribution center, a number of factors should be identified and considered.

This paper presents the methodology to identify appropriate factors used in location selection for establishing a drug distribution center.

The drug distribution center is one of players in healthcare supply chain which distributes drugs to the hospitals before the drugs were prescribed to the patients. The objective of this study is to select an appropriate location for establishing a drug distribution center which will be able to distribute drug to its customers during the crisis and hence, save the patients. The proper location helps to continuously supply sufficient drugs to the customers during the crisis.

The research methodology begins with the literature review. From literature reviews, a number of criteria used in decision making for finding the best location have been identified. Experts' opinion strategies were conducted in order to confirm the importance of each selected criteria.

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Interestingly, some healthcare-related criteria have been identified in addition to the general criteria for location selection.

In this paper is divided as follows. Section 2 presents literature review. In section 3, presents the research methodology. In section 4, presents result and discussion. Finally, the conclusion is presented.

2. LITERATURE REVIEW

2.1 Definition of Distribution Center

A distribution center (DC) is a building which stores the products under the suitable temperature and humidity. The processing of distribution center is to receive various products, store until customers need and distribute to the retailers, wholesalers, or consumers (Sorat, 2009). The good practices of distribution centers help to reduce inventory level, inventory carrying cost, the final price of the product delivered to the end consumers and processing time of order processing.

2.2 Location Selection Criteria in General.

Previous studies related to the opinion of decision makers in selecting criteria for location planning have been studied. Farahani *et al.* (2010) started that reviewed about multi-criteria location problems in three categories of bi-objective, multi-objective and multi-attribute problems. The major criteria from this research are 'cost', 'environmental risk', 'service level', 'coverage' and 'other criteria'- 'resource accessibility', 'economical criteria', 'distances including closeness to markets' or 'customers, suppliers and resources', 'political matters and regulations' and 'competition'. The authors divided 'cost' into two types including fixed costs and variable costs. The fixed costs are start up cost until investment and the variable costs are transportation, operations, production, services, distribution, logistics, waste disposal, maintenance, and environmental cost. Awasthi *et al.* (2011) proposed a multi-criteria decision making approach for location planning. These criteria for urban distribution centers are 'accessibility', 'security', 'connectivity to multimodal transport', 'costs', 'environmental impact', 'proximity to customers', 'proximity to suppliers', 'resource availability', 'conformance to sustainable freight regulations', 'possibility of expansion', and 'quality of service'. Another work was done by Chou *et al.* (2008) who presented a fuzzy multi-criteria decision making model for international tourist hotel location selection. 'Access', 'rest resources', 'surrounding environment', 'convenience', 'internal development', 'external development', 'human resource', 'operating conditions' are criteria in their research. Farahani *et al.*(2007) investigated the location distribution centers for military logistics system. The list of attributes is 'natural environment', 'military', 'economical', 'infra-structures'. They summarized that the land cost is the most important reason for business expansion. It is also confirmed by the research of Yang *et al.* (2007) that in business problem, cost is very important for decision making role because of the limited investment. Demirel *et al.* (2010) added that 'costs', 'labor characteristics', 'infrastructure', and 'markets' are the factors to evaluate a real warehouse location selection problem of a big Turkish logistic firm. Azadeh *et al.* (2011) presented an integrated approach for location of wind plants in Iran by using 4 categories of 'population and human labor', 'distance of power distribution networks', 'land cost' and 'geographical area'. Other authors including Kayikci. (2010), Ren *et al.* (2011), Ou *et al.* (2009), Li *et al.* (2011), Kuo. (2011), Kahraman *et al.* (2003), Chen. (2001), Kayikci. (2010), Boufounou. (1995), Ocalir *et al.* (2010), Mokhtarian *et al.* (2012), Cheng *et al.* (2009), Lee *et al.* (2008) and Liu *et al.* (2011) also studied the criteria for location selection in different industries. The summary of general criteria for location selection is shown in Table 1.

2.3 Healthcare-specific Criteria.

Healthcare business is an important role for the society. Since people were born until death, all have to involve with hospital services. Fail to get healthcare services at the time they need will have a severe impact to their safety (Liangrokapart, 2012). Therefore the continued service of the hospitals, especially during the crisis is extremely important. The hospitals should have sufficient supply of drugs, medical devices, medicinal gas and other products to serve the patients at all time. The suppliers must put all effort to distribute their products to the hospitals by all means in order to ensure that the end customers-the patients will get the right products at the right quantity, at the right quality, at the right place and at the right time. A good location for continued distributing products to the hospital should be determined and the criteria to be considered should be identified.

Previous studies have been done in the healthcare research related to location selection. Wu (2007) studied the optimal selection of location for Taiwanese hospitals using six evaluation criteria which are 'factor conditions', 'demand conditions', 'firm strategy, structure and rivalry', 'related and supporting industries', 'government' and 'chance' and 18 sub-criteria including 'capital', 'labor', 'land', 'population number', 'population density', 'population age distribution', 'management objective',

Table 1: General criteria for Location selection from literature review

Authors	Political regulations	Profit	Accessibility	Security	Product feature	Connectivity to multimodal transport	Cost	Infrastructure	Environmental impact	Coordination	Density of traffic	Lead time	Proximity to suppliers	Proximity to customers	Resource availability	Conformance to sustainable freight regulations	Quality of service	Possibility of expansion	Economic criteria	Competition	Labor	Information technology	Demand	Cultural issues	Natural environment
Farahani *et al.* (2007)	x	x	x	x			x		x					x	x	x	x	x	x	x					x
Liu *et al.* (2011)					x		x		x							x	x	x		x	x				
Yang *et al.* (2007)							x																		
Kayikci (2010)	x		x			x	x		x	x					x	x	x	x	x			x	x	x	
Chou *et al.* (2008)	x	x	x	x		x	x				x		x	x	x					x	x			x	
Boufounou. (1995)			x											x	x		x			x	x		x		x
Kuo. (2011)						x					x	x				x	x	x				x	x		x
Kahraman *et al.* (2003)						x	x				x			x		x		x		x	x				
Chen. (2001)							x									x		x			x		x		
Chou. (2008)			x				x														x				x
Ocalir *et al.* (2010)			x												x	x							x		x
Lee *et al.* (2008);											x	x				x	x	x	x	x		x	x		x
Demirel *et al.* (2010);	x					x	x	x				x	x	x							x				
Mokhtarian *et al.* (2012)	x		x										x	x						x					x
Awasthi *et al.* (2011);			x	x		x	x		x				x	x	x	x	x	x							
Ren *et al.* (2011);			x		x		x	x	x								x		x	x	x		x		x
Cheng *et al.* (2009);	x		x			x	x	x											x						
Ou *et al.* (2009);			x	x				x	x														x	x	
Farahani *et al.* (2007)			x			x		x											x		x				x
Li *et al.* (2011)							x	x			x														x
Azadeh *et al.* (2011)							x						x								x				x
Total	6	2	12	4	2	8	14	6	6	1	5	3	5	7	6	9	8	8	6	8	10	3	8	3	13

Table 2: Healthcare-specific criteria from literature review.

Authors	Accessibility	Environmental impact	Resource availability	Possibility of expansion	Economic criteria	Information abilities	Demand	Labor	Service availability	Infrastructure	Population	Firm strategy, structure and rivalry	Government	Chance	Total distance to nearest hospital	Focus outreach efforts near drug markets	Overlook drug possession	Provide access to private areas near shelters	Continue rescue efforts	Provide drug maintenance, detox and counseling services	New registration regulations	Drug distribution channels	Intellectual property issues	Adoption of international standards	Goal of site selection process	Emergency preparedness concerns	Competitive prices	Reduce costs by way of less linkage and competition	Political regulations
Wu *et al.* (2007)	x	x	x	x	x	x	x	x			x	x	x	x															
Sinuany-Stern *et al.* (1995)								x	x	x	x				x														
Dunlap *et al.* (2011)																x	x	x	x	x									
Chan *et al.* (2011)							x									x					x	x	x	x					
Bennett *et al.* (1982)									x	x		x													x				
Shah *et al.* (2004)	x																									x			
Dong *et al.* (1999)																											x	x	
Simango. (1993)								x	x				x																x
Elke *et al.* (2001)			x				x			x																			
Craig *et al.* (1995)																x													x
Total	2	1	2	1	1	1	3	3	3	3	2	2	2	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	2

rank of competing hospitals', 'policy maker's attitude', 'the medicine practice and the pharmaceutical sector', 'hospital administration sector', 'the healthcare sector', 'qualifications of the hospital's establishment and the regulations of the established standard', 'efforts to promote a medical network', 'promulgating tasks that require a hospital assessment', 'violent change in market demand', 'dramatic fluctuations in production costs' and 'significant changes in the financial market and exchange rate'. Simango (1993) presented strategic factors which 'low corporate tax', 'base for EC entry' and 'skilled manpower' that attract US and European pharmaceutical multinational enterprises to locate in Ireland. While Dunlap *et al.* (2011) recommended that the focus should include 'focus outreach efforts near drug markets', 'overlook drug possession', 'provide access to private areas near shelters', 'continue rescue efforts' and 'provide drug maintenance, detox and counseling services' for disaster management. Dong *et al.* (1999) described the drug policy reform in China that advantage to reduces the cost, reduce the length of the chain between producer and user, and improve their production in China has been used to reform government production plan to market demand. Especially during disaster, 'the focus outreach efforts near drug markets criteria' is important to reach poor drugs users that related to reduce drug users risk (Dunlop, 2011). The healthcare-specific criteria are summarized in Table 2.

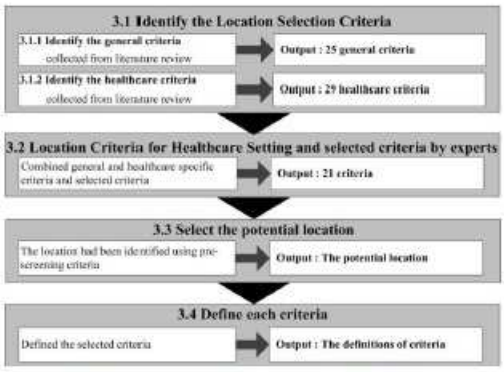

Figure 1: Methodology used for selecting criteria.

3. METHODOLOGY USED FOR SELECTION CRITERIA

The main steps of methodology are identifying location selection criteria and identifying potential location for a distribution center. The methodology is presented in Figure 1.

3.1 Identify the Location Selection Criteria

All criteria collected from literature review and the opinion of decision makers are divided into two major areas-general criteria and healthcare criteria. Finally, the outcome of first step is a group of location selection criteria for drug distribution center.

3.1.1 Identify the General Criteria

This step starts from 25 general location criteria were listed down in Table 2. Those criteria were ranked by the frequency of citations. In this research, only the criteria cited by five literatures or more were used in the study.

3.1.2 Identify the Healthcare Criteria

The 29 healthcare-specific criteria were also collected from literature review as shown in Table 3. In this research, due to the limited number of literatures, only the criteria cited by two literature or more were used in this study.

3.2 Location Criteria for Healthcare Setting and Selected Criteria by Experts

The criteria from 3.1.1 and 3.1.2 are combined and used as selected location criteria. Three experts were asked to confirm if the selected criteria seems to be reasonable to be used in the further study. At this step, the total of 22 criteria were selected including 'accessibility', 'connectivity to multimodal transport', 'costs', 'conformance to sustainable freight regulations', 'quality of service' 'possibility of expansion', 'competition', 'labor', 'natural environment', 'infrastructure', 'environmental impact', 'density of traffic', 'political regulations', 'proximity to suppliers', 'resource availability', 'economical criteria', 'demand', 'proximity to suppliers', 'firm strategy, structure and rivalry', 'government', 'focus outreach efforts near drug markets' and 'population'.

3.3 Select the Potential Location

The 50 districts in Bangkok are Bangbon, Bangkapi, Bangkhae, Bangkhen, Bangkholaem, Bangkhunthian, Bangna, Bangphlat, Bangrak, Bangsue, Bangkoknoi, Bangkokyai, Buengkum, Chatuchak, Chomthong, Dindaeng, Donmueang, Dusit, Huaykhwang, Khannayao, Khlongsamwa, Khlongsan, Khlongtoei, Laksi, Latkrabang, Latphrao, Minburi, Nongchok, Nongkhaem, Pathumwan, Phasicharoen, Phayathai, Phrakhanong, Phranakhon, Pomprap, Prawet, Rajburana, Ratchathewi, Saimai, Samphanthawong, Saphansung, Sathon, Suanluang, Talingchan, Thawiwatthana, Thonburi, Thungkhru,

Wangthonglang, Watthana, and Yannawa districts. Those districts are considered as possible areas for drug distribution center location. However, for efficient identification, potential locations were identified using pre-screening criteria. The pre-screening criteria include (see Figure 2).

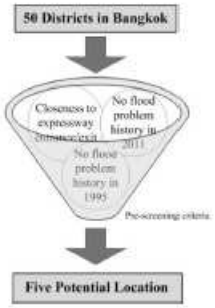

Figure 2: The pre-screening criteria for location selection.

1) No flood problem history in 1995.

2) No flood problem history in 2011.

3) Closeness to expressway entrance/exit.

After application of the pre-screening criteria, the output of this step is 5 potential location areas for establishing drug distribution center.

3.4 Define Each Criterion

The selected criteria from Step 3.2 are defined and shown in Appendix A.

4. RESULT AND DISCUSSION

The result and framework of this research is presented in Figure 3. From the above methodology, the outputs of each step were identified and summarized into the final step. Totally, 22 criteria were selected as the criteria to be considered for location selection of drug distribution center. The selected criteria are the combination of 18 general criteria and 4 healthcare specific criteria from literature review. Then three experts were asked to reconfirm that the selected criteria seem to be relevant to the research. The 18 general criteria include 'accessibility', 'connectivity to multimodal transport', 'cost', 'conformance to sustainable freight regulations', 'quality of service', 'possibility of expansion', 'competition', 'labor', 'natural environment', 'infrastructure', 'environment impact', 'density of traffic', 'political regulations', 'proximity to suppliers', 'resource availability', 'economic criteria', 'demand' and 'proximity to suppliers'. The four healthcare specific criteria were considered to be applied further in this study including 'firm strategy, structure and rivalry', 'government', 'focus outreach efforts near drug markets' and 'population'.

For the stage of identifying potential location areas for establishing a drug distribution center to be able to continue its operations during the diaster, the output of pre-screening location are five districts including Ratchathewi, Pathumwan, Chomthong, Banna, and Bangkapi districts. The map of five potential locations in Bangkok is illustrated in Figure 4. In future, the five districts will be evaluated using fuzzy TOPSIS to select the best location for drug distribution center.

5. CONCLUSION

In order to select the best location for establishing a drug distribution center where it can continue operations during the crisis, a set of appropriate criteria were identified using previous lit review and experts'opion. In this study, not only the criteria used in location selection for distribution center in general were considered, but also the healthcare specific criteria were added in the consideration. Finally, the 22 criteria were summarized as important criteria to be used in further study. It is expected that the selected criteria will be applied to justify the pre-selection location and recommended the best location for drug distribution center in the further study.

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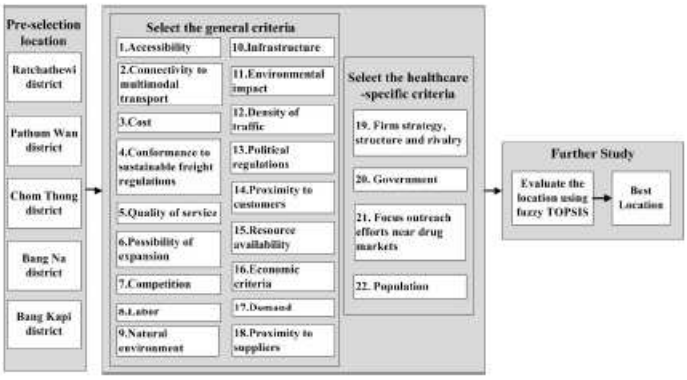

Figure 3: The result and future work of this research

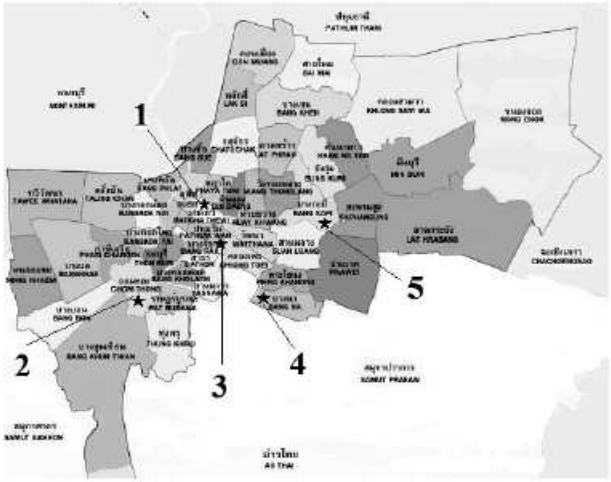

Figure 4: The potential location in Bangkok

APPENDIX A : The selected location criteria and definition

Criteria	Definition
1. Accessibility	Access by public and private transport modes to the location.
2. Connectivity to multimodal transport	Connectivity of the location with multiple modes of transport, e.g. highways, railways, seaport, airport etc.
3. Cost	Costs in acquiring land, capital, vehicle resources, drivers, resource, logistics, services and taxes etc. for the location.
4. Conformance to sustainable freight regulations	Ability to conform to sustainable freight regulations imposed by municipal administrations for e.g. restricted delivery hours, special delivery zones.
5. Quality of service	Capability to appropriate and response time service.
6. Possibility of expansion	Capability to manage the growing demand.
7. Competition	Capability to compete against others or the number of competitor.
8. Labor	Sufficient the number of labors and skills.
9. Natural environment	The condition of weather, geological, hydrological, topography (e.g. rain, sunshine, humidity etc.).
10. Infrastructure	The extent and nature of physical distribution center infrastructure and communication system and the availability and convenience to access the water and electricity supply infrastructure.
11. Environmental impact	Impact of location on the environment, for example, air pollution, noise.
12. Density of traffic	The frequency of use is from the location to the suppliers or customers.
13. Political regulations	Good legal rules and regulations to support business.
14. Proximity to customers	The distance and time from location to customers.
15. Resource availability	Availability of raw materials and labor resources in the location.
16. Economic criteria	The condition of economy (e.g. currency value, exchange rate, market demand etc.).
17. Demand	The number of customers purchases the products, and whether the needs of the market can be adequately fulfilled.
18. Proximity to suppliers	The distance and time from location to suppliers.
19. Firm strategy, structure and rivalry *	Drug distribution center establishment, organization, management practices and competitors all influence management objective, rank of competition and policymaker's attitudes.
20. Government *	Governmental policy towards establishing drug distribution center in order to strengthen their competitiveness includes qualifications of the drug distribution center's establishment and the regulations of the established standard, efforts to promote a medical network and promulgating tasks.
21. Focus outreach efforts near drug markets *	Drugs will be maximize the likelihood of reaching poor drugs users, a particularly recalcitrant and poorly informed population.
22. Population *	The medical market demand includes population number, population density and population age distribution.

Note * healthcare-specific criteria

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