Social Network Analysis by Fuzzy Relations: Implementation Based on Members of the Thai Parliament Society

by

Mr. Kitikorn Dowpiset

A Doctoral Dissertation

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy
in Computer and Engineering Management
Assumption University

December 1999

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ABSTRACT

Due to the strategic impact of a facility location decision, a location search requires thorough analysis of numerous location factors. The difficulties in multi-factor analysis of location decisions have been challenged by many location researchers. This dissertation investigates the design and implementation of a geographic information system-based decision support system (GISDSS) in the facility location domain. The GISDSS for locating a manufacturing facility is intended to assist facilities planners in improving the quality of strategic decision-making in facility location.

A review of past location studies was conducted to identify the major considerations for locating a facility and to develop a taxonomy of location factors for Thailand. The GISDSS incorporates a chromatic representation location model and vastly accepted location factors. A geographic information system (GIS) is used with the location model to manipulate data, and identify suitable sites. The recommendation on the best location is furnished to a user through a Visual Basic-based interactive graphical user interface. The GISDSS for facility location provides users with location recommendations in both a graphical format, illustrated by the color displays; and a numerical format, quantitatively stated by the color equation. The

system also makes transparent its recommendations via explanation reports.

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I. INTRODUCTION

A. RESEARCH SIGNIFICANCE

The selection of a new facility location ranks among the most important decisions made by company management. A facility location decision is strategic in nature and implies commitment of a large sum of money to cover high initial investment costs. The impact of facility location decisions can last years into the future. Business expansion or consolidation, for example, imposes a major cause for considering a new plant location.

The problem of locating a new facility is a critical concern as it affects the future profitability and productivity of a firm. Company management therefore encounters an important task in finding the most suitable site for a new facility.

The existence of several intangible factors as well as tangible ones pose a major concern for obtaining the solution to the location problem. Providing management with the best possible approach for developing a quality decision on the selection of a new facility location is thus a prime challenge.

B. THE LOCATION PROBLEM

For effectively solving the facility location problem, the acquisition and analysis of voluminous amounts of information as well as the identification of an appropriate site which best fits the company's needs are required. A variety of factors, such as cost of electricity and water, availability and cost of labor, taxes, availability of industrial parks, and investment promotion zones have influence on making a decision on a new facility location. In general, there are two types of location factors; quantifiable and nonquantifiable factors. The first one is quantifiable in numerical terms and includes such factor as cost of land and magnitude of market. The second one concerns qualitative values, for example, proximity to market and quality of life issues (Harvard Business School, 1989).

Location decisions follow the hierarchical structure as depicted in Figure 1. At the highest level, the planners decide whether to locate the facility in Thailand or overseas. If Thailand is selected, the evaluation then proceeds down the hierarchy to consider the preferred locations.

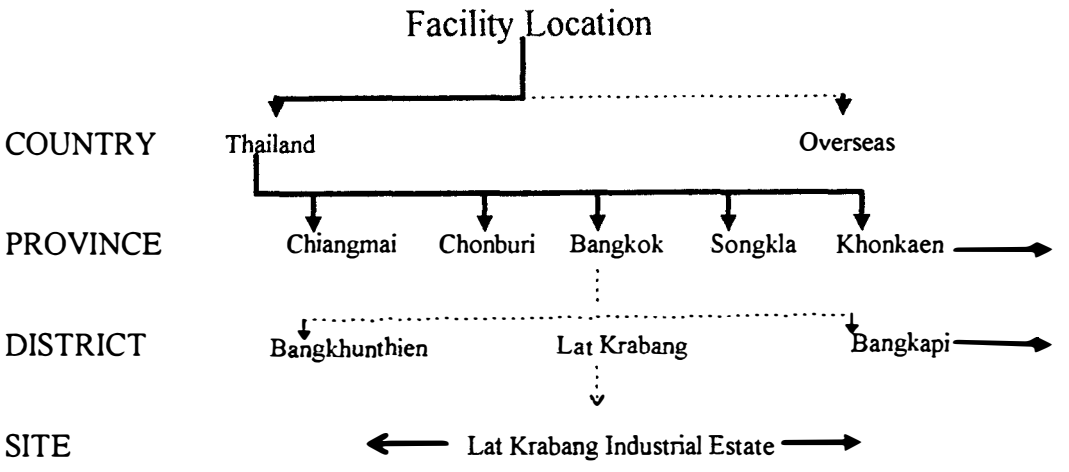

Figure 1. A Facility Location Hierarchy

In analyzing the huge amount of information on location alternatives, facility location models ranging from simple ranking and scoring model to more sophisticated techniques such as mathematical programming and computer programming have been used. Both objective and subjective factors may be taken into consideration.

A geographic information system-based decision support system (GISDSS) can help facilitate the solution to the facility location problem. The GISDSS incorporates a chromatic representation location model and vastly accepted location factors. A geographic information system (GIS) is used with the location model to manipulate data, and identify suitable sites. The ability to support facilities analysts with a reliable, yet time and cost-effective

procedure in arriving at high quality decisions is primary advantage of this approach.

C. RESEARCH OBJECTIVES

This research integrates a decision support system (DSS), a database management system (DBMS), and an interactive graphical user interface (GUI) concepts in the facility location domain. The approach tries to combine the strengths of each component into a unified system.

The objectives of this research are as follows:

-Conduct a review of literature on location research that has been done to date. Advanced concepts, i.e. a decision support system (DSS), a database management system (DBMS), and an interactive graphical user interface (GUI) will be investigated to assess the feasibility of an integrated methodology for obtaining solutions on location problems.

-Propose a conceptual architecture of a GISDSS.

-Develop a prototype GISDSS according to the proposed conceptual architecture.

In the following sections, section II will detail the literature survey. Section III will present the research methodology. System development will be described in section IV and the conclusion will be discussed in section V.

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II. LITERATURE REVIEW

A. OVERVIEW

1. Location Research

"Most human decision-making, whether individual or organizational, is concerned with the discovery and selection of satisfactory alternatives..." (March and Simon, 1958). Locational decision-making is no difference. A location problem is a spatial resources allocation problem, i.e. a spatially distributed set of demands (customers) is served by one or more facilities (servers). In spatial analysis, many siting models seek to optimize (e.g. finding the shortest travel distance) proximity (distance or time) which is a fundamental metric. However, rather than optimizing, decision makers often base decisions on the satisfactory rather than the best possible. The objective of this research is to locate a facility to optimize an objective function comprising both quantifiable and nonquantifiable location variables. The objective function can be exemplified as minimizing maximum travel costs and minimizing average travel time.

Recorded efforts at solving location problems originated by Fermat early in the 17th century (Love et al., 1988). Fermat wrote,

"Let he who does not approve of my method attempt the solution of the following problem:

"Given three points in the plane find a fourth point such that the sum of its distances to the three given points is a minimum."

The introduction of the location theory was first formally proposed in 1909 by Alfred Weber. His work was first published in Germany (Weber, 1909). He considered the problem of locating a single warehouse to minimize the total travel distance between the warehouse and a set of spatially distributed customers.

Another early location problem was formulated by Hotelling (1929), an economist who considered the problem of locating two competing vendors along a straight line. His model is based on the assumption that customers patronize the closest facility. It implies that the facilities concerned are equally attractive. In the 1940's and early 1960's, researchers who investigated location problems include Apple (1963), Armour and Buffa (1963), Moore (1962), Reed (1961), Yaseen (1960), Miehle (1958), Moses (1958), Muther (1955), Losch (1954), Ireson (1952), and Hoover (1948), etc.

Researchers who further studied in facility location problems in the 1970's to 1990's include Houshyar et al. (1997), Dohse et al.

(1996), Hormozi et al. (1996), Jungthirapanich and Benjamin (1995), Randhawa et al. (1995), Carrizosa et al. (1995), Current et al. (1994), Miller (1993), Louveaux et al. (1992), Weaver et al. (1991), Drezner et al. (1989), Muther and Hales (1987), Price and Turcotte (1986), Hochbaum (1982), Granger (1981), Klingman et al. (1976), Francis and White (1974), Smith (1971), ReVelle et al. (1970), and Nutt (1970).

Location problems can be classified into following categories (Brandeau and Chiu, 1989):

-Network Design. A central facility is to be located to minimize the total distance of transportation from sources to the central facility.

-Warehouse Location. Locating an undermined number of warehouses in a region to serve customers is done with the objective of minimizing the total warehouse cost.

-Fire Box Coverage. A fixed number of fire boxes is sited. The objective is to minimize the maximum distance that any citizen must travel to the nearest box.

-Competitive Facility Location. A new facility is introduced in an area already served by competing firms with the objective of locating the new facility to yield maximum profit or market share.

2.Facility Location Procedures

Locating a new facility ranks among the largest and most important decisions that company management will have to face. A commitment made by a company for a new location is generally irreversible. Therefore, every factor influencing the profitability of the company should be evaluate with care. Company management may form a committee and let each functional areas appoint a representative. This method is often laborious and time-consuming. Appointing a small decision-making team is also a way to undertake a site selection study. The team's objective is to collect information and coordinate all affected functions' requirements in the organization. Once the requirements have been developed, the next step is to consider all factors, if possible, exerting any effect on facility location-i.e., labor, tax and financial inducements, utilities, climate, environmental considerations, and transportation, etc. (Harvard Business School, 1989; Granger, 1981; Muther and Hales, 1987; Smith, 1971; Nutt, 1970; Moore, 1962; Yaseen, 1960). Information on these factors can be obtained from sources, such as:

-local chambers of commerce,

-government publications,

-transportation companies,

-utilities service providers,

-etc.

Three input for solving facility location problem are location factors, location models, and users' requirements (Jungthirapanich, 1997). Location factors and users' requirements are the first two parameters needed to be satisfied by each location. The location model is employed if there is a comparative evaluation among locations. Suitable locations resulted from the evaluation are left for further investigation. Detailed evaluation of locations which are not eliminated will then be conducted. Generally, the framework of phases in facility location problem are as follows (Benjamin, 1989):

-Identification of candidate sites,

-Rapid preliminary screening of sites,

-Detailed evaluation of top few sites, and

-Final decision on the best location.

B. SURVEYS OF LOCATION RESEARCH

1. Location Models

As observed, a model of any problem must comprise: an objective (optimizing or nonoptimizing); system parameters; and decision variable(s). A facility location model is a mathematical optimization model that evaluates whether a site should be opened, or

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whether an existing facility should be closed, or where a new facility should be located, based on costs and constraints.

An illustrative list of the most common costs, variables, and constraints included in facility location models (Miller, 1993):

Typical cost components:

-variable production costs at each manufacturing plant,

-variable handling costs at each warehouse,

-the fixed cost per year of operating a facility,

-the fixed cost to build a new facility,

-the transportation costs to ship product and/or materials from one facility to another,

-inbound transportation costs from raw materials sources and from suppliers, and

-inventory carrying costs.

Typical variables and constraints:

-the production rates and capacities of each manufacturing plant,

-the handling rates and capacities at each warehouse,

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-a 0-1 variable associated with each potential new manufacturing facility and/or warehouse. This variable takes a value of 1 if a facility is to be opened, 0 otherwise,

-the demand for each product at each retail outlet, and

-inventory targets and maximum levels.

A recent bibliography on location analysis includes approximately 1,500 titles (Domschke and Drexl, 1985) and at least twelve survey articles (Current et al., 1990; Brandeau and Chiu, 1989; Erkut and Neuman, 1989; Aikens, 1985; Tansel et al., 1983a,b; ReVelle et al., 1983; Francis et al., 1983; Leonardi, 1981; Krarup and Pruzan, 1979, 1983; Scott, 1970) have been published on the topic (Current and Weber, 1994).

Continued interest in location modeling is evident with the publication of six books on the topic (Louveaux et al., 1989; Hurter and Martinich, 1989; Love et al., 1988; Berry and Parr, 1988; Gosh and Rushton, 1987; Ghosh and McLafferty, 1987).

The non-facility related areas can also be formulated within the mathematical constructs of facility location modeling. Applications of facility location models to non-facility problems include: vendor selection (Current and Weber, 1994); flexible manufacturing system tool selection (Daskin et al., 1990); metallurgical grade assignment

(Vasco et al., 1989); production lot sizing (Van Oudhensden and Singh, 1988); ingot size selection (Vasco et al., 1988); positioning of political party platforms (Ginsberg et al., 1987); data base management (Pirkul, 1986); apparel sizing (Tryfos, 1986); archaeological settlement analysis (Bell and Church, 1985); and medical diagnosis (Reggia et al., 1983).

A taxonomy of location models categorized by Jungthirapanich (1997) include:

- Manual Models, Requiring Objective Location Factors,
- Manual Models, Requiring Objective or Subjective Location Factors,
- Computer Models, Requiring Objective Location Factors, and
- Computer Models, Requiring Objective or Subjective Location Factors.

a. Manual Models, Requiring Objective Location Factors

i. Hoover's Cost Analysis (Hoover, 1948).

Hoover stated that the location relation of an industry to its customers is a system of market areas. He considered both demand and cost factors. The assumption is based on the fact that customers are scattered, hence, in order to survive, a producer must sell to

customers at various locations. Hoover's theory recognizes the capitalistic influence on a location. In his consideration, such factors as public services and taxes were included. However, this theory did not consider the locational interdependence. He did mention supply and market areas which fit into the spatial interdependence field, though, he did not discuss it to any conclusion.

ii. Interdependence Theory of Location.

This methodology concluded that price varies with locations and buyers are assumed to be dispersed over an area. The size of the market area which is served by a firm is determined by locational interdependence of the firm. Interest in this theory of location is seen with the research works of authors include Chamberlin (1946), Smithies (1941), Lerner and Singer (1939), Hotelling (1929), and Fetter (1924).

b. Manual Models, Requiring Objective or Subjective location Factors

i. Ranking (Scoring) Models.

The model is widely used mainly because of its simplicity. It has relatively low data requirements and allow the evaluation of both quantifiable and nonquantifiable factors. Authors who interested in this theory include Salvendy (1982), Granger (1981), Monks (1977),

Ireson (1971), Stobaugh (1969), and Reed (1967). The mathematical expression can be stated as:

$$X_j = \sum_{i=1}^{n} w_i x_{ij}$$

where i = location factor number,

j = candidate location number,

n = number of candidate locations,

w_i = weight assigned to factor i,

x_{ij} = rank/score assigned to factor i for location j, and

X_j = suitability index calculated for location j.

The best location is candidate j such that Max $[X_j]$

ii. Dimensional Analysis.

According to Singhvi (1987) and Wild (1971), this model has a likely improvement over the ranking (scoring) procedure in that it considers measurable cost information and complements this data with subjective rankings and scores of the non-measurable factors.

c. Computer Models, Requiring Objective Location Factors

i. Center of Gravity Models.

This technique attempts to locate the optimum site by determining location coordinates which would minimize the material

handling cost (Love, 1988; Francis, McGinnis and White, 1983). The model is formulated as follows:

$$\text{Minimize} \sum_{i=1}^{m} W_i[(x-a_i)^2 + (y-b_i)^2]^{1/2}$$

where m = *number of markets to be served by the facility,*

(x,y) = coordinate location of a new facility,

(a_i,b_i) = coordinate location of the market i, and

W_i = demand for market i.

There are some weaknesses of this model: only one objective, minimizing the transportation and distribution costs of finished goods, is considered; and transportation and distribution costs are assumed to be linear and directly proportional to the distance.

ii. Regression Analysis.

Important determinants of sales are established and used as independent variables in a regression equation (Kimes and Fitzsimmons, 1990). A regression equation is as following:

$$Y_i = (a_1x_1+...+a_nx_n) + b$$

where Y_i = forecast sales of location i,

x_n = independent variables affecting sales,

a_n = coefficient of the variable x_n, and

b = constant.

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d. Computer Models, Requiring Objective or Subjective Location Factors

i. Expert Systems.

Expert systems have gained acceptance and are increasingly applied in industries (Benjamin and Jungthirapanich, 1991; Benjamin et al., 1990; Legati, 1990; Han and Kim, 1989; Engel and Beasley, 1988; and Milacic, 1986). Note that nonquantifiable factors must be assigned numerical values before they can be used in the models. Some methods for determining numerical ratings of nonquantifiable factors include (Jungthirapanich, 1997):

-Find other quantifiable location factors that are equivalent to nonquantifiable ones.

-Consult experts who are familiar with areas under consideration and let them assign numerical ratings to location factors.

ii. Decision Analysis.

A decision analysis model evaluates risks associated with alternative sites (Raiffa, 1968; Kirkwood, 1982). Steps in exploiting the decision analysis include the followings:

-Determine evaluation attributes for measuring the desirability of candidate locations,

-Consider a multi-attribute utility function $u(x_1 \ldots x_n)$ which represents a facilities planner's attitude toward risk-taking and trade-offs among attributes,

-Determine the specific level x_i of each evaluation attribute X_i that would result from selecting each location. Uncertainty about these level can be encoded as a probability distribution $p(x_1,\ldots,x_n \mid a)$ showing the desirability of a candidate location with respect to the evaluation attributes,

-Rank locations in order of their expected utilities U(a) where $U(a)= x_1, x_2, \ldots, x_n u(x_1,\ldots,x_n)p(x_1,\ldots,x_n \mid a)$, and

-Perform the sensitivity analysis and make the final decision.

2. Location Factors

It is clear that selecting the most significant set of various location factors with careful consideration and planning is the key in making the right decision on where to locate a company facility. Location factors, as mentioned earlier, can be classified into quantifiable and nonquantifiable factors. The first can be exemplified as cost of land, utilities, and labor. The examples of the second can be climate, quality of life, and so on. Both factors can be classified according to facility type, product life cycle, and industry type as follows (Harvard Business School, 1989):

Facility Type.

Company management would probably prefer locating a new production facility to locating a distribution center or a warehouse.

Product Life Cycle.

-During the product development stage, facilities are often located in major Research and Development centers. The cost of facilities are usually high and can be justified by prompt introduction of new products.

-At the growth stage, facilities located close to major markets are preferred to minimize transportation costs and time.

-As a product reaches mature stage, a suitable location depends on company's competitive strategies. For example, a facility may be relocated to areas where production costs are cheaper, if the company aims for increased price sensitivity.

Industry Type.

-High-tech industries pay more attention to factors that attract highly skilled labor, such as quality of life issues, and educational institutions.

-Labor-intensive industries emphasize more on labor-related factors, such as labor availability and rates.

After conducting an intensive survey, the location factors in Thailand can be grouped into following categories:

-Market,

-Transportation,

-Utilities,

-Raw Materials,

-Investment Promotion Zones,

-Availability of Industrial Parks,

-Land Cost,

-Environmental Concerns,

-Governmental Considerations, and

-Labor.

The importance on making location decisions of the factors is discussed below:

a. Market.

It is desirable that a facility be located near the market area for the product as costs for timely product distribution correspond to location. The scope of the market that a manufacturer usually takes into account is determined primarily by two factors, proximity to customers in order to deliver products to them more quickly and economically than competitors, and purchasing power of customers in

area. The following lists are used as guidelines for estimating market potential:

-Population: number of people,

-Wealth: per capita income,

-Competition.

b. Transportation.

Transportation poses significant effect on location decisions in almost every countries in the world especially in Thailand. Availability of suitable transportation facilities is required in order to move personnel, equipment, raw materials, and products to and from the facility. Transportation rates have significant impact on production costs. The list shown below are used to describe representative transportation media:

-Highway: for all types of products,

-Railroad: for all types of products,

-Water: for all types of products,

-Air: used when fast delivery is needed,

-Human carriers: in small quantity with careful handling for short distance,

-Pipelines: for gases and liquids.

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The volume and types of raw materials and products will often determine the mode of transportation best suited to the facility.

The following guidelines can be used when making transportation media decision:

-Compare cost of services,

-Check facilities for handling shipments,

-Choose an appropriate medium regarding urgency of the product delivery.

c. Utilities.

The costs and availability of fuel, electricity, and water will exert a major impact on location decisions.

i. Water.

The best source is usually the public utility because its water is certified as being safe for human consumption. Local water supplies must be adequate for process requirements and fire protection. Sources of water are as following:

-municipal water,

-ground water,

-surface water, and rain water.

ii. Electricity and Fuel.

The cost of electricity and fuel is often a significant operating expense for a manufacturing facility. The types of generation influence power expenses. Hydroelectric power is usually cheap, while nuclear power cost is the cheapest, though, establishing a nuclear generator is the most expensive.

d. Raw Materials.

The cost of shipping raw materials to the facility should be considered along with the cost of transporting the products to market so as to minimize the total cost as much as possible. Sule (1994) generalizes effect of raw materials on facility locations as follows:

-When perishable or bulky raw materials are to be used, locate a facility near the source of raw materials,

-When raw materials that are easy to find are used, locate a facility near the market.

e. Investment Promotion Zones.

Investment Promotion Zone offers attractive benefits to investors, including reduction or exemption of import duties on machinery and raw or essential materials, and corporate tax

exemptions. According to the Board of Investment, Thailand is divided into three zones. In an effort to encourage investment in the regional areas away from Bangkok, Zone 3 which comprises provinces located more than 150 km from Bangkok, offers the greatest incentives.

Zone 1 consists of Bangkok and five surrounding provinces namely Patumthani, Samutprakarn, Samutsakorn, Nakornpathom, and Nontaburi.

The benefits for locating a facility in zone 1:

-50 percent import duty reduction for machinery used in projects that export at least 80 percent of their total sales, or that located in industrial parks or promoted industrial zones.

-Three-year corporate income tax holiday for projects that export at least 80 percent of total sales, or that are located in industrial parks or promoted industrial zones.

-One-year exemption from import duties on raw or essential materials used in the manufacture of exports.

Zone 2, which offers more incentives than zone 1, comprises ten provinces, namely Pranakornsriayuthaya, Angthong, Chacherngsao, Chonburi, Kanchanaburi, Nakornnayok, Ratchaburi, Samutsongkram, Saraburi, and Supanburi.

The benefits for locating a facility in zone 2:

-50 percent import duty reduction on machinery.

-A three-year corporate income tax holiday, extendible to seven years, is provided for projects that locate in industrial parks or promoted industrial zones.

-One-year exemption from import duties on raw or essential materials used in the manufacture of exports.

Zone 3 consists of the remaining provinces and Laem Chabang Industrial Park.

The benefits for locating a facility in zone 3:

-Eight-year corporate income tax holiday.

-Exemption from import duty for machinery.

-Five-year exemption from import duties on raw or essential materials used for production for manufacture of exports.

-Five-year, 75 percent reduction of import duties on raw or essential materials used for domestic sales, except for Laem Chabang Industrial Park.

-Double deduction from taxable income of water, electricity and transport costs for 10 years.

-Deduction from net profits of 25 percent of the project's infrastructure installation or construction cost.

List of activities eligible for promotion is provided in Appendix D.

f. Availability of Industrial Parks.

An industrial park resembles an industrial town or industrial city with complete infrastructure needed for industrial operations such as electricity, water supply, environment controls, and other public utilities (Industrial Estate Authority of Thailand Report, 1997). Industrial parks are located strategically accessible to airports, seaports for easy transportation and most of them have commercial banks, other commercial services and government services such as post office, customs houses etc.

Industrial Parks are developed and managed by the Industrial Estate Authority of Thailand (IEAT). IEAT is a state enterprise attached to the Ministry of Industry. Their objective is to support Thailand's industrial development through providing the basic infrastructure and public utilities needed by industry.

Tax incentives from IEAT are as follows:

-Exemption of import duty and value added tax (VAT) on machinery, components etc. and material imported for factory construction,

-Exemption of import duty and value added tax (VAT) on raw materials,

-Exemption of export duty and value added tax (VAT) on exported goods, and

-Exemption or refund of duties and value added tax (VAT) for local goods utilized for production.

Non-tax incentives from IEAT are the followings:

-Permission for foreign investors to own land for carrying out promoted activities,

-Permission to bring in foreign technicians and experts to work under promoted projects,

-Permission for foreign technicians, experts and their spouses or dependents to stay in the country, and

-Permission to take or remit foreign currency.

g. Land Cost.

The cost of land has a big influence for management in making decision on selecting a new site. Land price corresponds to the civilization of each province. Definitely, Bangkok has the most expensive land cost while a province in Northeastern, Mukdaharn, has the least expensive one.

h. Environmental Concerns.

Good living conditions are needed to attract and maintain motivated workers. Cultural facilities, temples, libraries, parks, good

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schools, theaters, and recreational facilities are essential factors for making the conditions. The weather characteristic can greatly affect the cost of the buildings to be constructed as well as the site operating costs. A very hot climate could require the site to have additional air conditioning for workers comfort and additional cooling towers for process equipment. Waste disposal released by some inconsiderate manufacturers causes water pollution. Waste water treatment should be considered in order to abide the environmental regulations. Facilities that do not use the sewage disposal system provided by the public should build their own disposal.

i. Governmental Considerations.

Government has a full responsibility to manage the good living conditions for society. Laws and regulations should support the operation of manufacturing facilities. Cooperation of the government can either enhance or impede the business investment climate in the areas.

The types and rates of taxes charged by government must be considered seriously because taxes are a large part of operating cost. There are three classes of tax imposed on under the Revenue Code:

-Corporate Income Tax. This tax applies to companies, registered ordinary partnerships, registered limited partnerships, joint ventures, foundations, and associations. The standard corporate income tax rate is 35 percent of net profits. Registered companies listed on Securities Exchange of Thailand pay a reduced rate of 30 percent of net profits. The income of Foundations and Associations excluding registration fees, subscription fees from members and donations of cash or property are taxed at a 10 percent rate. Companies engaged in international transport pay tax at the rate of 3 percent of gross ticket receipts collected in Thailand for transporting passengers, and/or 3 percent of gross freight charges collected for transporting goods from Thailand, instead of tax on net profits.

-Personal Income Tax. This tax applies to private taxpayers. Standard deductions of expenses allowed by the law vary from 10-85 percent depending upon the category of income. Income after deductions, allowances, and exemptions will be taxable income at the progressive rates as scheduled in Table I.

Table I. The Progressive Personal Income Tax Rate

Net income not exceeding	
Baht 50,000	5 percent
Baht 50,001-200,000	10 percent
Baht 200,001-500,000	20 percent
Baht 500,001-1,000,000	30 percent
Baht 1,000,001-2,000,000	40 percent
Baht 2,000,001 upwards	50 percent

-Value Added Tax. The tax is levied at each stage of manufacture and distribution. The value added tax rate is 10 percent.

j. Labor.

The adequacy of labor force in both skilled and unskilled employees is necessary in production processes. The availability of skilled technical employees at a selected site will influence the design criteria established for a particular process plant. A site that requires highly skilled employees should be located in area where there are sufficient skilled employees, such as areas where universities are located.

Labor rates have a huge impact on manufacturing costs, especially for labor intensive industries. The rates in Thailand are relatively standard in any provinces.

Labor attitude influences operating cost. In determining the attitude of operating labor, the best approach is to contact personnel directors or labor relations directors of companies in the areas being considered, to obtain first-hand information. Most contacts will result in useful information that can be used to evaluate labor climate.

C. A GEOGRAPHIC INFORMATION SYSTEM (GIS)

1. Overview

A geographic information system (GIS) is a graphic-based computerized database management system for the storage, retrieval, manipulation, analysis, and display both spatial and non-spatial data. A GIS evolved as a means of assembling and analyzing diverse spatial data.

Spatial data are usually described in a GIS by geographic position and other attributes in computer readable form. GIS technologies continue to advance with improvements in computer graphics, database management technologies, and the incorporation of

satellite images. These advances have made more sophisticated, accurate, and cost-effective GIS applications available to support decisions and inform policies in areas such as environmental resource management, land-use planning, and law enforcement, among others (Robey and Sahay, 1996).

GIS applications have become extremely popular, particularly in public sector in the U.S. GIS even was described by Fletcher et al. (1992) as the technology with the biggest impact on the thinking of county managers in local governments in the country.

The use of geographic information system for analysis, modeling, and decision support in a wide range of application areas is growing very rapidly (Karimi and Blais, 1996). Applications such as mapping, monitoring, decision making, and research are benefiting greatly from the GIS technology, systems, tools, and procedures.

The development of geographic information systems has its roots in at least two overlapping areas (Star and Estes, 1990):

-an interest in managing the urban environment (particularly in terms of planning and renewal), and

-a concern for the balancing competing uses of environmental resources.

Three important factors helped lead to the creation of digital geographic information systems in the 1960's (Star and Estes, 1990):

-refinements in cartographic technique,

-rapid developments in digital computer systems, and

-the quantitative revolution in spatial analysis.

Cartography is defined in the Multilingual Dictionary of Technical Terms in Cartography (Meynen, 1973) as "the art, science and technology of making maps together with their study as scientific documents and works of art". It is fundamentally directed at communicating information to a user and is central to an understanding of the strengths and weaknesses of geographic information systems technology.

Most systems in GISs rely on data from existing maps, or an data that can be mapped readily (Shelton and Estes, 1979). Maps are both a very important form of input to a geographic information system, and common means to portray the results of an analysis from a GIS. Following Robinson et al. (1978), maps:

-are typically reductions which are smaller than the areas they portray. Each map must have a defined relationship between what exists in the area being represented, and the mapped representation.

-involve transformations. The transformation of a surface which is not flat into a flat plane is often needed in mapping.

-are abstractions of reality. Maps are the cartographer's representation of an area, and as such, display the data that the cartographer has selected for a specific use.

-contain symbols which represent elements of reality. Few map symbols have universally accepted meanings, but some maps use a standardized set of symbols.

-portray data using a variety of marks, including lines, dots, tones, colors, textures, and patterns.

2.General Applications

The development of geographic information systems, in terms of both the technology and the underlying concepts, has drawn on the talent and experience of many researchers.

The automated geographic information systems began to appear in the 1960's. Ian McHarg (1969) introduced to us the concept of land suitability/capability analysis (SCA). SCA is a technique in which data concerning land use in a locale being studied is entered into an analog or digital GIS. Two systems, exemplified for the spurring of development of spatial data-processing systems in resource management concerns, are STORET and MIADS. STORET was

developed by the U.S. Public Health Service for storage of spatial information about water quality (Green, 1964). MIADS was developed by the U.S. Forest Service for the analysis of recreation alternatives and hydrology (Amidon, 1964). In the university community, the University of Washington at Seattle made contributions in the areas of transportation analysis and urban planning and renewal (Gaits, 1969).

The first system to be generally acknowledged as a GIS was the Canada Geographic Information System or CGIS (Peuquet, 1977). CGIS was developed to help with an environmental problem: rehabilitation and development of Canada's agricultural lands.

Many early systems were developed to solve relatively narrow, specific kinds of problems. The past twenty years have seen an explosion in the technological base for these systems, particularly in the areas of data processing and remote sensing systems (Parent and Church, 1988). One recent trend in the evolution of GIS technology is the inclusion of artificial intelligence into GIS design and operation as stated by Smith (1984). Wagendorp (1995) provided examples of how the development of GIS capabilities in a rural health district in Southwest Michigan provided an essential analysis and management tool. McTigue (1994) described the use of GIS to systematically evaluate sites for disposal or application of treatment residuals,

frequently the most difficult task in developing land based disposal systems.

D. A DECISION SUPPORT SYSTEM (DSS)

Most experts define a DSS as a series of integrated computer software and as any computer-based information system that helps decision makers with semistructured or unstructured tasks (Rector, 1983). The purpose of a decision support system (DSS) is to support managers responsible for making and implementing decisions rather than to replace them (Alter, 1980). There are many ways that the DSS supports managerial activities. Some DSSs contain explicit models that provide managers with solution for particular decisions; others help them by expediting access to information that they would otherwise not obtain.

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The basic conceptual elements of a decision support system are described below (Grauer and Fedra, 1986):

-An interactive user interface that facilitates communications between users and the system.

-A task scheduler or control program that interprets the user requests and organizes the tasks to be performed by the system. This

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element contains the knowledge about individual system modules. The control program can translate a user request into either

-a data/knowledge base query, or

-a request for scenario analysis.

Alter (1980) classified the DSSs into six major categories:

-Retrieving a single item of information,

-Providing a mechanism for ad hoc data analysis,

-Providing prespecified aggregation of data in the form of reports,

-Estimating the consequences of proposed decisions,

-Proposing decisions, and

-Making decisions.

III. RESEARCH METHODOLOGY

A. OVERVIEW

Facility location is a multidisciplinary research area. Industrial engineering, economics, and geography can be exemplified as such area. The objectives in solving location problems, though, are all similar, i.e. to find optimal locations for new or additional facilities.

According to Reed (1967), this research area can be considered to have four phases:

i. The least production cost phase.

Emphasis was primarily placed on location factors that directly influence cost production. The contribution by Von Thunen (1875) and Weber (1909) exemplify the development of location theories during this phase.

ii. The proximity to market phase.

There were additional considerations, i.e. interdependence of firms within a multimarket economy, effect of uneven population, uneven resource distribution, and imperfect competition included in this phase. The work of Hoover (1948) can be represented in the second phase.

iii. The profit maximization phase.

Two primary factors were total revenue and total cost. An optimum facility location can be determined by profit. Greenhut (1956) based his study of facility location on this concept.

iv. The least cost to customer phase.

During this phase, focus was primarily placed on delivered cost to customers. Researchers who contributed to this phase include Isard (1956) and Moses (1958).

B. ANALYZING SYSTEM'S REQUIREMENTS

The success of the development of GISDSS to support quality decision making on locating manufacturing facilities in Thailand depends largely upon identification of structured and quantifiable system's requirements. System's requirements comprise both those required by users and system developers.

1. User's Requirements.

System's performance is a major concern for users. Gaschnig et al. (1983) suggested some aspects of computing systems' performance that are to be achieved as follows:

-the system's efficiency,

-the quality of the human-computer interaction, and

-the quality of the system's recommendations.

2. System Developer's Requirements.

Technical capabilities of the system are primary concern for system developers. Leigh and Doherty (1986) suggested that graphical display capability represents an important consideration in the development of a DSS. In addition, Sprague and Watson (1989) proposed a model to identify developer's requirements on the DSS capabilities. Database management capability, modeling with analytic capability, and dialog handling or the man-machine interface are three aspects pointed out in the model.

The system's requirements can be interpreted as described below:

A Geographic Information System (GIS) and a chromatic representation location model will be employed in an integrated manner. These two components will manipulate the data inputs and provide appropriate recommendations.

A mouse-driven interface will be used to achieve an enhanced quality of the human-computer interface. Its primary advantage is ease of use and speed of human-computer interaction.

The GIS will be used as a database management system to facilitate the storage and retrieval of information in location

databases. It is used as a tool to input, validate, manage, analyze, and visualize geographical information and also enables us to manage a diverse combination of vector, raster, and tabular data. Its primary advantage is ease of use as it has a feature-based design that allows us to interact with data conveniently.

Visual Basic program represents a vital link from the system to the user. User friendly graphical user interface will improve efficiency by providing users with step-by-step instructions on how to successfully proceed through a consultation session.

C. THE SYSTEM'S ARCHITECTURE

The architecture of the GISDSS for facility location as a result of the system's requirement analysis is depicted in Figure 2.

The system's architecture comprises three operating environments, namely the data environment, the system environment, and the user environment.

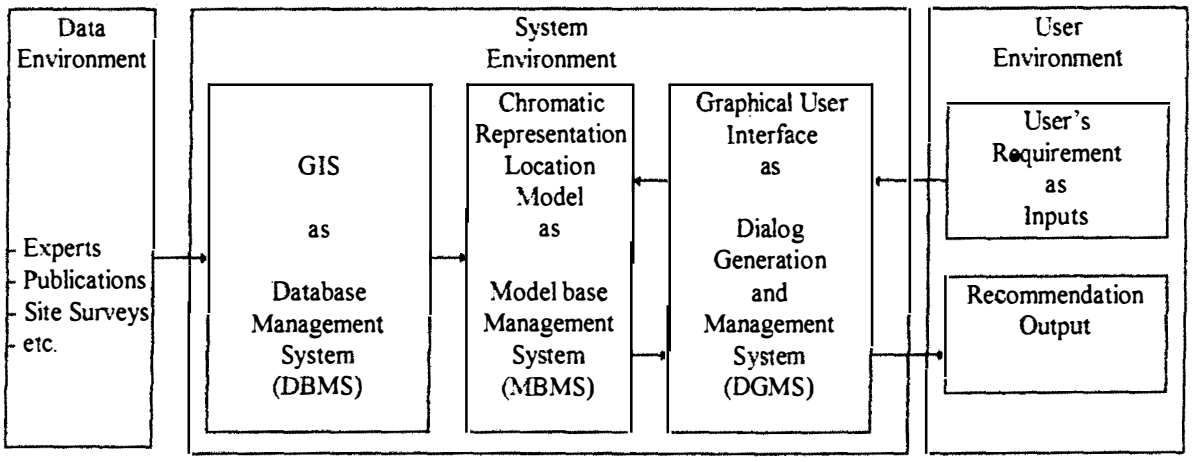

Fig. 2. The architecture of the GISDSS for Facility Location

The three environments are described below:

i. Data Environment.

This component provides domain knowledge necessary for the GISDSS. The fidelity of a GISDSS for facility location depends largely on the adequacy and accuracy of location databases. The system maintains an ample location information for Thailand. Data resided in the location databases were acquired through various data acquisition techniques, including peer interviews, questionnaires, dialogs with business owners or corporate facilities planners, site visits, and compilation of location data from published or computer-based sources.

ii. System Environment.

The system environment comprises three main components, namely the database management system (DBMS), the model base

management system (MBMS), and the dialog generation and management system (DGMS).

iii. User's Environment.

The two main functions performed within the user environment include soliciting users' requirements and providing recommendation outputs.

D. THE LOCATION DATABASE

Due to an huge amount of location information, a database management system (DBMS) is needed to manage effective and efficient storage and retrieval of data. The DBMS is designed for creating and maintaining databases and for linking data with application programs. Creating a location database for all provinces in Thailand requires a significant investment which is due to its size and the difficulty in collecting data.

The amount of data which needs to be acquired for complete system development is voluminous, covering every provinces and districts in Thailand. There are 76 provinces in Thailand, with a number of districts in each provinces. For example, Khonkaen has 20 districts.

Information on location factors can be obtained from many sources as stated below:

i. Governmental Offices.

Information on location factors in Thailand can mostly be gathered from the governmental offices located in Bangkok. Phone calls or personal contacts, which are strongly recommended, can be made to these offices to gather those information. Cost incurred in doing this varies among the method used. Personal contacts are the most expensive means if those offices are located far away from the people who make contacts. However, they are the most useful method for obtaining the accurate data especially when the data is sizable. The list below gives examples of some governmental offices:

-Department of Local Administration.

-Department of Land.

-The Metropolitan Electricity Authority.

-National Statistical Office.

-The Department of Aviation.

-The Provincial Electricity Authority.

-The Provincial Waterworks Authority.

-The Metropolitan Waterworks Authority.

-The Department of Land Transport.

-Port Authority of Thailand and Harbour Department.

-*Office of the National Economic and Social Development* Board.

-Ministry of Science.

-Ministry of Labour and Social Welfare.

-Ministry of Industry.

-The State Railway of Thailand.

-The Communication Authority of Thailand.

-Industrial Estate Authority of Thailand.

-Thai Board of Investment.

ii. Publications.

The best way to gather information on the publications is by searching for it in the libraries. However, in Thailand there are not many publications concerning the location factors.

iii. Industrial Companies.

Methods used to obtain information from industrial companies are similar to those employed for governmental offices.

iv. Human Experts.

People who are involved in a specific location for a long period of time could be referred to as the experts. The experts can also be researchers or educators who have a deep knowledge of particular

areas. Information obtained from this source is normally free of charge.

Appendix A provides a list of location information sources for selected location factors.

IV. SYSTEM DEVELOPMENT

A. OVERVIEW

A DSS was characterized by Sprague (1987) as following:

-It emphasizes an interactive user interface which facilitates its use by noncomputer personnel;

-It integrates the use of solution models or analytical techniques with traditional data access and retrieval;

-It is focused on unstructured, semistructured, and underspecified problems that upper management usually faces; and

-It is adaptable and flexible to changes in the environment and the decision-making approach of the user.

The basic components of a typical DSS include (Sage, 1986):

-a database management system (DBMS),

-a model base management system (MBMS), and

-a dialog generation and management system (DGMS).

A GISDSS integrates a decision support system and a geographic information system. The purpose of the integration is to combine advantages of both the DSS and the GIS to achieve more powerful decision support tool.

B. THE SYSTEM'S CONCEPTUAL FRAMEWORK

Figure 3 illustrates the conceptual framework which shows how information flows among GISDSS components and the task environment.

The system requests inputs from the user on the perceived importance of each group of location factors and begins its evaluation. The system retrieves required information from the location database during the data collection phase. The location data and the user's inputs are sent to the chromatic representation location model to identify and analyze of location alternatives. The chromatic representation location model then interprets the results from this data analysis phase to sort out preferred locations. The model will

forward the suitable locations to the users interface component where recommendation is furnished to the user.

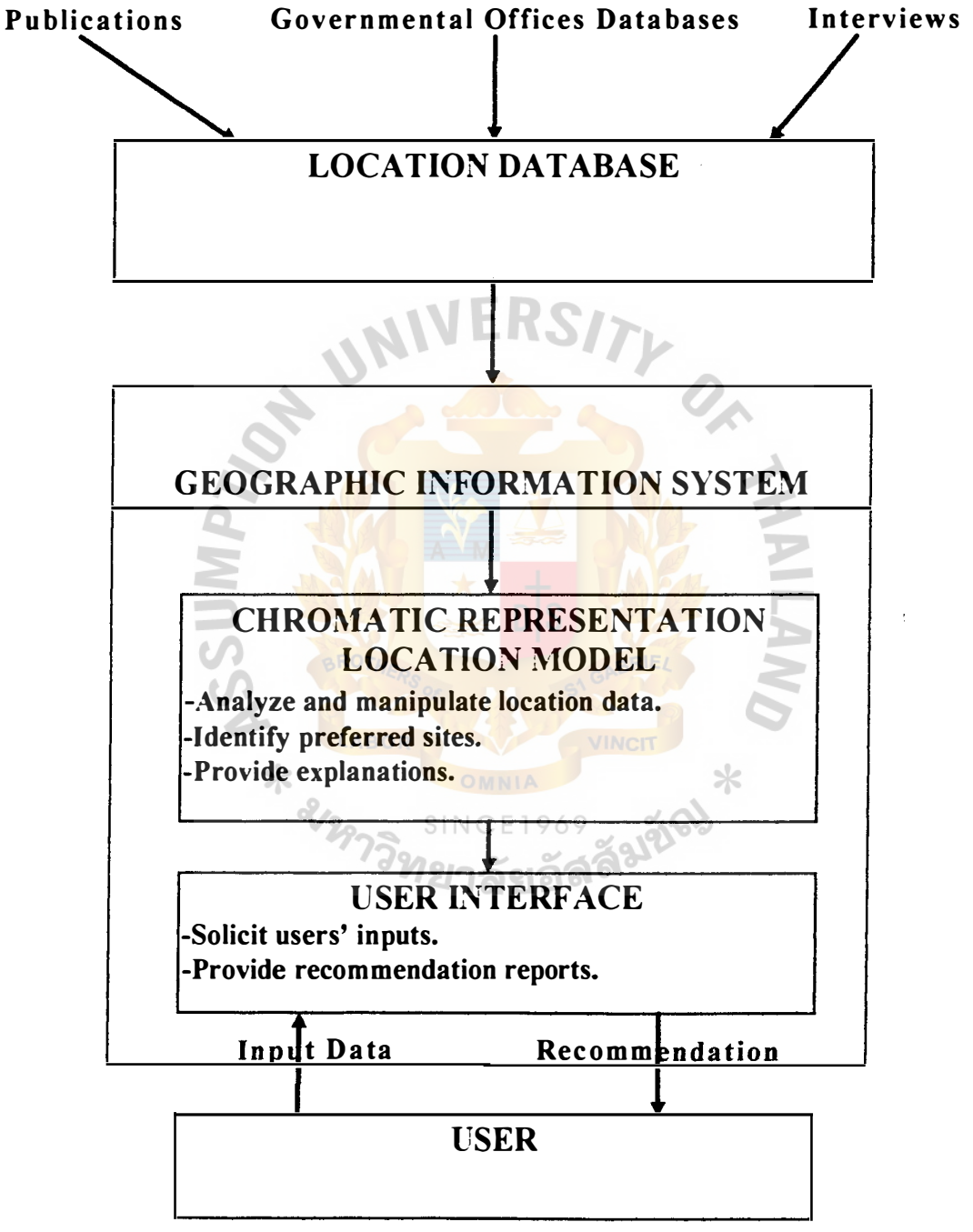

Figure 3. The Conceptual Framework for a Geographic Information System-Based Decision Support System (GISDSS) for Facility Location

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C. A DATABASE MANAGEMENT SYSTEM (DBMS)

Location databases acquired from the data environment are stored, edited, manipulated, updated, and retrieved by the system's DBMS. According to Turban (1995), a DBMS performs three basic functions; storage, retrieval, and control:

-Storage. DBMS vary in the configuration of the stored data.

-Retrieval. The feature of the DBMS most visible to the users is data retrieval. Current DBMS offer great flexibility in terms of how the information is retrieved and displayed.

-Control. Much of the control activity of the DBMS is invisible to users. The users ask for some information and receive it without knowing the processes that the DBMS has performed.

A GIS represents a prime choice for the accomplishment of these database management tasks, due to two reasons: Firstly, the GIS possesses powerful spatial-database handling capabilities necessary for the analysis of a tremendous amount of location data. Secondly, it facilitates updates of dynamic location databases, which are essential for ensuring data integrity.

Location information at province level is acquired through various data acquisition techniques, including peer interviews,

questionnaires, dialogs with business owners or corporate facilities planners, site visits, and compilation of location data from published or computer-based sources. The numerous information obtained was subsequently analyzed and classified into meaningful location databases. Representative sources of location information are provided in Appendix A. Table II lists the location factors, subfactors, and location information that are incorporated in the system.

Table II. Location Factors Used in a GISDSS for Facility Location

Factors	**Subfactors**	**Data Used to Represent each Subfactor**
Market	Income trends	Per capita income Income per family Expense per income ratio Gross Provincial Product
	Magnitude	Average family size Total population in area
Transportation	Truck transportation	Availability Frequency of service Access to highways Cost
	Rail transportation	Availability Cost Frequency of service
	Water transportation	Availability Number of port
	Air transportation	Availability Number of airport
	Mail and parcel service	Number of post offices

Table II. Cont.

Factors	Subfactors	Data Used to Represent each Subfactor
	Others	Availability of bus, taxi, and car rental
Utilities	Water	Water supply
	Electricity	Electricity sales Number of users
	Fuel	Monthly fuel expense per household
Raw Materials	Number of business firms	Number of business firms established
Investment Promotion Zones	Availability Zoning	Availability Zoning
Availability of Industrial Parks	Availability	Availability
Land Cost	Cost of land	Cost of land
Environmental	Air pollution	Noise Traffic Noxious gases Odor Local regulatory bodies
	Weather	Average temperature Rain condition
	Waste disposal	Regulatory bodies Availability Cost
	Sewage disposal systems	Availability Cost
	Garbage disposal	Availability

Table II. Cont.

Factors	Subfactors	Data Used to Represent each Subfactor
		Cost of service
	General services	Fire protection Police Security Entertainment facilities
Governmental Considerations	Special regulations related to industries	Special regulations related to industries
	Taxes	Corporate income tax
	Government administration in area	Number of government administration in area
Labor	Availability	Labor force
	Costs	Wage rates
	Labor Law	Labor Law
	Unemployment rate	Unemployment rate
Land Area		Land Area
Population		Population

As a consequence of the aforementioned data acquisition, widely-accepted location factors, have been identified. Following itemize the ordered ranking of important location factors evaluated from all sources of location data in Thailand:

-Market

-Transportation

-Utilities

-Raw materials

-Investment promotion zones

-Availability of industrial parks

-Land cost

-Environmental concerns

-Governmental considerations

-Labor

D. A MODEL BASE MANAGEMENT SYSTEM (MBMS)

The most important characteristic of an MBMS is that it should enable a DSS to evaluate decision alternatives by employing a model base of algorithmic procedures and management protocols. Major functions, or capabilities, of the MBMS (Turban, 1995):

-Creates models easily and quickly, either from scratch or from existing models or from the building blocks.

-Allows users to manipulate the models so that they can conduct experiments and sensitivity analyses ranging from "what-if" to goal seeking.

-Stores and manages a wide variety of different types of models in a logical and integrated manner.

-Accesses and integrates the model building blocks.

-Catalogs and displays the directory of models for use by several individuals in the organization.

-Tracks models, data, and application usage.

-Interrelates models with appropriate linkages through the database.

-Manages and maintains the model base with management functions analogous to database management: store, access, run, update, link, catalog, and query.

The GISDSS for facility location employs a chromatic representation location model as an MBMS. The model evaluates location alternatives and recommends the most suitable site through the adoption of the hue, saturation, and value (HSV) color model. Hue distinguishes among colors such as red, green, blue, and magenta. Saturation refers to how far color is from a gray of equal intensity. Value refers to the perceived intensity of a self-luminous object, such as a light bulb, or the sun.

A color model specifies a 3D color coordinate system and a visible subset in the coordinate system in which all colors in a particular color gamut lie (Foley et al., 1990). The HSV color model,

as illustrated in Fig. 4, is the hexcone or six-sided pyramid subset of the 3D cylindrical coordinate system. The top of the hexcone corresponds to the value (V) of 1, representing the maximum color brightness. Varying the angle around the V axis results in changing hues, e.g. 0° for red, 120° for green, 240° for blue, as depicted in Fig. 5. Color saturation ranges from 0 on the center line (V axis) to 1 on the triangular sides of the hexcone.

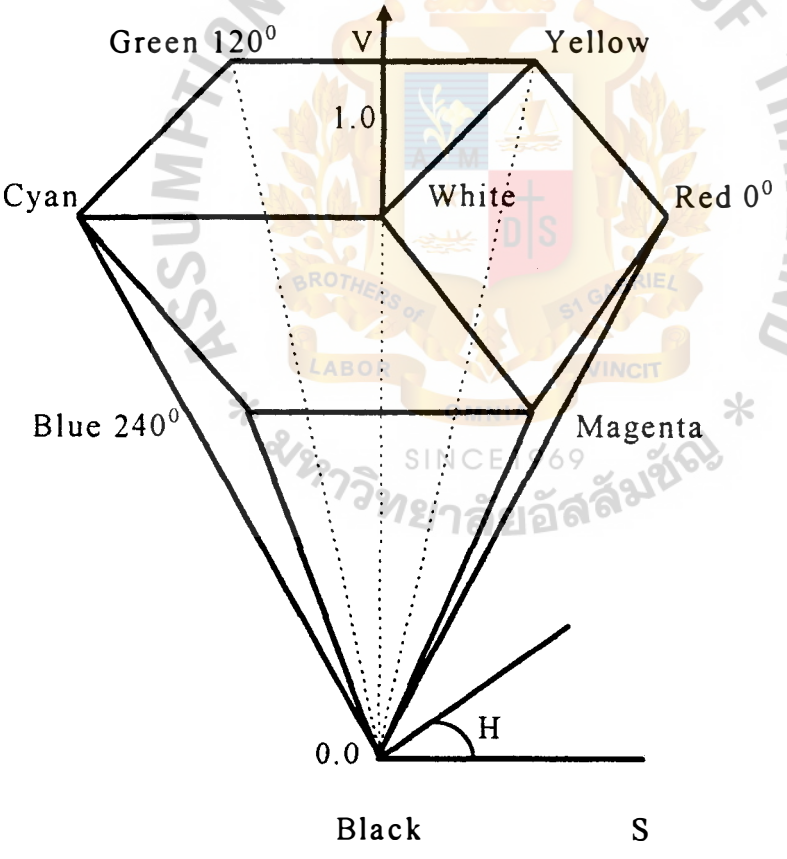

Fig. 4. An HSV Color Model

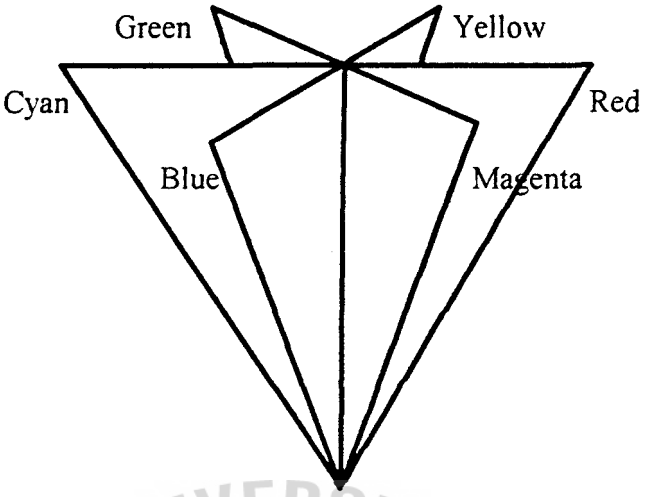

Fig. 5. Various Hue Angles

The chromatic representation location model regards a hue as a location factor, hence various hue angles may be specified for all factors under consideration. Location factors correspond to the hue angles are shown in Table III:

Table III. Various Hue Angles Specified by Different Location Factors

Location Factors	Hue Angles	Color
Market	0	Red
Transportation	120	Green
Utilities	240	Blue
Raw Materials	60	Yellow
Investment Promotion Zones	180	Cyan

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Table III. Cont.

Location Factors	Hue Angles	Color
Availability of Industrial Parks	300	Magenta
Land Cost	90	Light Yellow
Environmental Concerns	150	Light Green
Governmental Considerations	30	Light Red
Labor	210	Light Blue

A triangular plane, shown in Fig. 6, depicts a location factor whose hue angle lies at 0° or red. Factor weights, or degrees of importance, can be stated by varying the color saturation, ranging from 1 as unimportant to 0 as the most important. Table IV represents HSV color coordinates based on degrees of importance for each location factors.

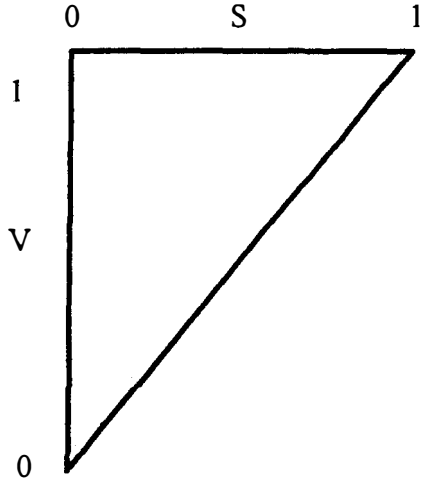

Figure 6. A Triangular Plane for 0° Hue Angle

Table IV. HSV Color Coordinates for Different Location Factors

Location factor	(H,S,V) Color Coordinates
Market	(0,0,V)
Transportation	(120,0.1,V)
Utilities	(240,0.2,V)
Raw Materials	(60,0.3,V)
Investment Promotion Zone	(180,0.4,V)
Availability of Industrial Parks	(300,0.5,V)
Land Cost	(90,0.6,V)
Environmental Concerns	(150,0.7,V)
Governmental Considerations	(30,0.8,V)
Labor	(210,0.9,V)

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Scores for candidate sites, based on any location factors, can be expressed by varying the vertical value (V), with 1 as the lowest and 0 as the highest.

The factor's weighted score can be located on the triangular plane should the vertical value, or a factor's score, and the saturation, or a factor's weight is known. For instance, Bangkok receives the lowest score on the land cost location factor then the factor's weighted score of Bangkok, represented by HSV color coordinate,

would be (90,0.6,1). The chromatic representation of the factor's weighted score can thus be numerically specified and graphically displayed through the HSV color coordinates. Table V to VIII illustrate the factor's weighted score in terms of HSV color coordinates for each locations.

Table V. HSV Color Coordinates for Market, Transportation, and Utilities

Province	Market	Transportation	Utilities
Bangkok	(0,0,0)	(120,0.1,0)	(240,0.2,0)
Samutprakarn	(0,0,0)	(120,0.1,0.3)	(240,0.2,0)
Nonthaburi	(0,0,0)	(120,0.1,0.3)	(240,0.2,0)
Pathumthani	(0,0,0)	(120,0.1,0.3)	(240,0.2,0.1)
Pranakornsri-Ayuthaya	(0,0,0.3)	(120,0.1,0.4)	(240,0.2,0.3)
Angthong	(0,0,0.6)	(120,0.1,0.6)	(240,0.2,0.5)
Lopburi	(0,0,0.3)	(120,0.1,0.3)	(240,0.2,0.4)
Singburi	(0,0,0.5)	(120,0.1,0.7)	(240,0.2,0.4)
Chainat	(0,0,0.6)	(120,0.1,0.5)	(240,0.2,0.6)
Saraburi	(0,0,0.3)	(120,0.1,0.3)	(240,0.2,0.3)
Chonburi	(0,0,0.1)	(120,0.1,0)	(240,0.2,0)
Rayong	(0,0,0.1)	(120,0.1,0.1)	(240,0.2,0)
Chantaburi	(0,0,0.4)	(120,0.1,0.5)	(240,0.2,0.3)
Trad	(0,0,0.6)	(120,0.1,0.8)	(240,0.2,0.5)
Chacherngsao	(0,0,0.3)	(120,0.1,0.4)	(240,0.2,0.5)
Prajinburi	(0,0,0.6)	(120,0.1,0.5)	(240,0.2,0.5)
Nakornnayok	(0,0,0.3)	(120,0.1,0.8)	(240,0.2,0.3)
Srakaew	(0,0,0.8)	(120,0.1,0.6)	(240,0.2,0.7)

Table V. Cont.

Province	Market	Transportation	Utilities
Nakornratcha-sima	(0,0,0)	(120,0.1,0.1)	(240,0.2,0.2)
Burirum	(0,0,0.3)	(120,0.1,0.4)	(240,0.2,0.8)
Surin	(0,0,0.7)	(120,0.1,0.4)	(240,0.2,0.7)
Srisaket	(0,0,0.8)	(120,0.1,0.4)	(240,0.2,1)
Ubonratcha-thani	(0,0,0.1)	(120,0.1,0.1)	(240,0.2,0.3)
Yasothorn	(0,0,0.9)	(120,0.1,0.5)	(240,0.2,0.9)
Chaiyapum	(0,0,0.4)	(120,0.1,0.4)	(240,0.2,0.5)
Amnardcharoen	(0,0,0.9)	(120,0.1,0.9)	(240,0.2,0.8)
Nongbualumpoo	(0,0,0.8)	(120,0.1,0.9)	(240,0.2,0.9)
Khonkaen	(0,0,0.1)	(120,0.1,0.1)	(240,0.2,0.1)
Udornthani	(0,0,0.3)	(120,0.1,0.1)	(240,0.2,0.6)
Loei	(0,0,0.7)	(120,0.1,0.2)	(240,0.2,0.8)
Nongkhai	(0,0,0.7)	(120,0.1,0.5)	(240,0.2,0.6)
Mahasarakam	(0,0,1)	(120,0.1,0.5)	(240,0.2,1)
Roi-ed	(0,0,0.9)	(120,0.1,0.4)	(240,0.2,0.8)
Kalasin	(0,0,1)	(120,0.1,0.5)	(240,0.2,0.8)
Sakonnakorn	(0,0,0.6)	(120,0.1,0.2)	(240,0.2,0.1)
Nakornpanom	(0,0,0.8)	(120,0.1,0.6)	(240,0.2,0.9)
Mukdaharn	(0,0,1)	(120,0.1,1)	(240,0.2,1)
Chiangmai	(0,0,0.1)	(120,0.1,0.1)	(240,0.2,0.1)
Lampun	(0,0,0.5)	(120,0.1,0.6)	(240,0.2,0.5)
Lampang	(0,0,0.3)	(120,0.1,0.2)	(240,0.2,0.4)
Utaradit	(0,0,0.6)	(120,0.1,0.2)	(240,0.2,0.7)
Phrae	(0,0,0.7)	(120,0.1,0.2)	(240,0.2,0.7)
Nan	(0,0,0.6)	(120,0.1,0.2)	(240,0.2,0.6)

Table V. Cont.

Province	Market	Transportation	Utilities
Payao	(0,0,0.8)	(120,0.1,0.8)	(240,0.2,0.7)
Chiangrai	(0,0,0.2)	(120,0.1,0.2)	(240,0.2,0.3)
Maehongsorn	(0,0,0.8)	(120,0.1,0.2)	(240,0.2,0.6)
Nakornsawan	(0,0,0.2)	(120,0.1,0.1)	(240,0.2,0.5)
Uthaithani	(0,0,0.7)	(120,0.1,0.7)	(240,0.2,0.7)
Kampaengpet	(0,0,0.7)	(120,0.1,0.4)	(240,0.2,0.5)
Tak	(0,0,0.7)	(120,0.1,0.2)	(240,0.2,0.4)
Sukothai	(0,0,0.4)	(120,0.1,0.5)	(240,0.2,0.5)
Pitsanulok	(0,0,0.3)	(120,0.1,0.2)	(240,0.2,0.5)
Pichit	(0,0,0.3)	(120,0.1,0.5)	(240,0.2,0.4)
Petchabun	(0,0,0.7)	(120,0.1,0.5)	(240,0.2,0.5)
Ratchaburi	(0,0,0.3)	(120,0.1,0.3)	(240,0.2,0.3)
Kanchanaburi	(0,0,0.3)	(120,0.1,0.3)	(240,0.2,0.3)
Supanburi	(0,0,0.4)	(120,0.1,0.3)	(240,0.2,0.3)
Nakornpathom	(0,0,0.1)	(120,0.1,0.3)	(240,0.2,0.1)
Samutsakorn	(0,0,0)	(120,0.1,0.4)	(240,0.2,0)
Samutsongkram	(0,0,0.2)	(120,0.1,0.7)	(240,0.2,0.2)
Petchaburi	(0,0,0.3)	(120,0.1,0.4)	(240,0.2,0.3)
Prajuabkirikhan	(0,0,0.3)	(120,0.1,0.2)	(240,0.2,0.4)
Nakornsri-thammarat	(0,0,0.1)	(120,0.1,0.2)	(240,0.2,0.3)
Krabi	(0,0,0.5)	(120,0.1,0.8)	(240,0.2,0.4)
Pang-nga	(0,0,0.5)	(120,0.1,1)	(240,0.2,0.4)
Phuket	(0,0,0.1)	(120,0.1,0)	(240,0.2,0.2)
Suratthani	(0,0,0.2)	(120,0.1,0.2)	(240,0.2,0.3)
Ranong	(0,0,0.8)	(120,0.1,0.2)	(240,0.2,0.5)
Chumporn	(0,0,0.5)	(120,0.1,0.6)	(240,0.2,0.4)
Songkla	(0,0,0.1)	(120,0.1,0)	(240,0.2,0.1)

Table V. Cont.

Province	Market	Transportation	Utilities
Satun	(0,0,0.5)	(120,0.1,1)	(240,0.2,0.5)
Trang	(0,0,0.5)	(120,0.1,0.2)	(240,0.2,0.4)
Pattalung	(0,0,0.5)	(120,0.1,0.8)	(240,0.2,0.5)
Pattani	(0,0,0.4)	(120,0.1,0.2)	(240,0.2,0.5)
Yala	(0,0,0.5)	(120,0.1,0.7)	(240,0.2,0.4)
Narativas	(0,0,0.6)	(120,0.1,0.2)	(240,0.2,0.5)

Table VI. HSV Color Coordinates for Investment Promotion Zones, Availability of Industrial Parks, and Land Cost

Province	Investment Promotion Zone	Availability of Industrial Parks	Land Cost
Bangkok	(180,0.4,1)	(300,0.5,0.2)	(90,0.6,1)
Samutprakarn	(180,0.4,1)	(300,0.5,0.3)	(90,0.6,0.8)
Nonthaburi	(180,0.4,1)	(300,0.5,1)	(90,0.6,0.9)
Pathumthani	(180,0.4,1)	(300,0.5,1)	(90,0.6,0.8)
Pranakornsri-Ayuthaya	(180,0.4,0.5)	(300,0.5,0.1)	(90,0.6,0.3)
Angthong	(180,0.4,0.5)	(300,0.5,1)	(90,0.6,0.2)
Lopburi	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.2)
Singburi	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.2)
Chainat	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Saraburi	(180,0.4,0.5)	(300,0.5,0.3)	(90,0.6,0.3)
Chonburi	(180,0.4,0.5)	(300,0.5,0.1)	(90,0.6,0.9)
Rayong	(180,0.4,0)	(300,0.5,0)	(90,0.6,0.8)

Table VI. Cont.

Province	Investment Promotion Zone	Availability of Industrial Parks	Land Cost
Chantaburi	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.6)
Trad	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.4)
Chacherngsao	(180,0.4,0.5)	(300,0.5,0.3)	(90,0.6,0.2)
Prajinburi	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Nakornnayok	(180,0.4,0.5)	(300,0.5,1)	(90,0.6,0.5)
Srakaew	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Nakornratcha-sima	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.8)
Burirum	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Surin	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Srisaket	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Ubonratchathani	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.5)
Yasothorn	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Chaiyapum	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Amnardcharoen	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Nongbualumpoo	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Khonkaen	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.9)
Udornthani	(180,0.4,0)	(300,0.5,0.4)	(90,0.6,0.1)
Loei	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Nongkhai	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Mahasarakam	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Roi-ed	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Kalasin	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Sakonnakorn	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Nakornpanom	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)
Mukdaharn	(180,0.4,0)	(300,0.5,1)	(90,0.6,0)

Table VI. Cont.

Province	Investment Promotion Zone	Availability of Industrial Parks	Land Cost
Chiangmai	(180,0.4,0)	(300,0.5,1)	(90,0.6,1)
Lampun	(180,0.4,0)	(300,0.5,0.4)	(90,0.6,0.2)
Lampang	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.7)
Utaradit	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Phrae	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.4)
Nan	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.4)
Payao	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Chiangrai	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.8)
Maehongsorn	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Nakornsawan	(180,0.4,0)	(300,0.5,0.4)	(90,0.6,0.4)
Uthaithani	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.2)
Kampaengpet	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Tak	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.4)
Sukothai	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.2)
Pitsanulok	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Pichit	(180,0.4,0)	(300,0.5,0.4)	(90,0.6,0.6)
Petchabun	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.1)
Ratchaburi	(180,0.4,0.5)	(300,0.5,0.4)	(90,0.6,0.6)
Kanchanaburi	(180,0.4,0.5)	(300,0.5,1)	(90,0.6,0.6)
Supanburi	(180,0.4,0.5)	(300,0.5,1)	(90,0.6,0.6)
Nakornpathom	(180,0.4,1)	(300,0.5,1)	(90,0.6,0.8)
Samutsakorn	(180,0.4,1)	(300,0.5,0.4)	(90,0.6,0.7)
Samutsongkram	(180,0.4,1)	(300,0.5,1)	(90,0.6,0.5)
Petchaburi	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.7)
Prajuabkirikhan	(180,0.4,0)	(300,0.5,0.4)	(90,0.6,0.6)

Table VI. Cont.

Province	Investment Promotion Zone	Availability of Industrial Parks	Land Cost
Nakornsri-thammarat	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.7)
Krabi	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Pang-nga	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.2)
Phuket	(180,0.4,0)	(300,0.5,1)	(90,0.6,1)
Suratthani	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.7)
Ranong	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.6)
Chumporn	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.7)
Songkla	(180,0.4,0)	(300,0.5,0.4)	(90,0.6,0.9)
Satun	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.3)
Trang	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.5)
Pattalung	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.7)
Pattani	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.4)
Yala	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.5)
Narativas	(180,0.4,0)	(300,0.5,1)	(90,0.6,0.4)

Table VII. HSV Color Coordinates for Raw Materials and Environmental Concerns

Province	Raw Materials	Environmental Concerns
Bangkok	(60,0.3,0)	(150,0.7,1)
Samutprakarn	(60,0.3,0)	(150,0.7,0.9)

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Table VII. Cont.

Province	Raw Materials	Environmental Concerns
Nonthaburi	(60,0.3,0)	(150,0.7,1)
Pathumthani	(60,0.3,0.1)	(150,0.7,0.9)
Pranakornsri-Ayuthaya	(60,0.3,0.4)	(150,0.7,0.4)
Angthong	(60,0.3,0.5)	(150,0.7,0.5)
Lopburi	(60,0.3,0.4)	(150,0.7,0.4)
Singburi	(60,0.3,0.5)	(150,0.7,0.6)
Chainat	(60,0.3,0.6)	(150,0.7,0.3)
Saraburi	(60,0.3,0.3)	(150,0.7,0.6)
Chonburi	(60,0.3,0)	(150,0.7,0.9)
Rayong	(60,0.3,0.1)	(150,0.7,0.8)
Chantaburi	(60,0.3,0.5)	(150,0.7,0.5)
Trad	(60,0.3,0.7)	(150,0.7,0.5)
Chacherngsao	(60,0.3,0.5)	(150,0.7,0.3)
Prajinburi	(60,0.3,0.6)	(150,0.7,0.6)
Nakornnayok	(60,0.3,0.3)	(150,0.7,0.4)
Srakaew	(60,0.3,0.7)	(150,0.7,0.2)
Nakornratcha-sima	(60,0.3,0.2)	(150,0.7,0.7)
Burirum	(60,0.3,0.8)	(150,0.7,0.1)
Surin	(60,0.3,0.7)	(150,0.7,0.1)
Srisaket	(60,0.3,0.9)	(150,0.7,0)
Ubonratcha-thani	(60,0.3,0.2)	(150,0.7,0.3)
Yasothorn	(60,0.3,0.9)	(150,0.7,0.1)
Chaiyapum	(60,0.3,0.6)	(150,0.7,0.4)
Amnardcharoen	(60,0.3,0.9)	(150,0.7,0.3)
Nongbualumpoo	(60,0.3,0.8)	(150,0.7,0.2)

Table VII. Cont.

Province	Raw Materials	Environmental Concerns
Khonkaen	(60,0.3,0.2)	(150,0.7,0.8)
Udornthani	(60,0.3,0.4)	(150,0.7,0.3)
Loei	(60,0.3,0.8)	(150,0.7,0.2)
Nongkhai	(60,0.3,0.7)	(150,0.7,0.2)
Mahasarakam	(60,0.3,1)	(150,0.7,0)
Roi-ed	(60,0.3,0.8)	(150,0.7,0)
Kalasin	(60,0.3,1)	(150,0.7,0)
Sakonnakorn	(60,0.3,0.8)	(150,0.7,0.1)
Nakornpanom	(60,0.3,0.8)	(150,0.7,0.1)
Mukdaharn	(60,0.3,1)	(150,0.7,0)
Chiangmai	(60,0.3,0.1)	(150,0.7,0.8)
Lampun	(60,0.3,0.5)	(150,0.7,0.5)
Lampang	(60,0.3,0.4)	(150,0.7,0.5)
Utaradit	(60,0.3,0.6)	(150,0.7,0.3)
Phrae	(60,0.3,0.6)	(150,0.7,0.3)
Nan	(60,0.3,0.6)	(150,0.7,0.4)
Payao	(60,0.3,0.8)	(150,0.7,0.4)
Chiangrai	(60,0.3,0.4)	(150,0.7,0.7)
Maehongsorn	(60,0.3,0.6)	(150,0.7,0.5)
Nakornsawan	(60,0.3,0.4)	(150,0.7,0.7)
Uthaithani	(60,0.3,0.7)	(150,0.7,0.4)
Kampaengpet	(60,0.3,0.6)	(150,0.7,0.2)
Tak	(60,0.3,0.6)	(150,0.7,0.5)
Sukothai	(60,0.3,0.5)	(150,0.7,0.6)
Pitsanulok	(60,0.3,0.5)	(150,0.7,0.4)
Pichit	(60,0.3,0.4)	(150,0.7,0.4)
Petchabun	(60,0.3,0.7)	(150,0.7,0.3)
Ratchaburi	(60,0.3,0.2)	(150,0.7,0.7)

Table VII. Cont.

Province	Raw Materials	Environmental Concerns
Kanchanaburi	(60,0.3,0.3)	(150,0.7,0.5)
Supanburi	(60,0.3,0.3)	(150,0.7,0.5)
Nakornpathom	(60,0.3,0.1)	(150,0.7,0.9)
Samutsakorn	(60,0.3,0.8)	(150,0.7,0.9)
Samutsongkram	(60,0.3,0.3)	(150,0.7,0.8)
Petchaburi	(60,0.3,0.3)	(150,0.7,0.5)
Prajuabkirikhan	(60,0.3,0.4)	(150,0.7,0.5)
Nakornsri-thammarat	(60,0.3,0.3)	(150,0.7,0.7)
Krabi	(60,0.3,0.7)	(150,0.7,0.9)
Pang-nga	(60,0.3,0.5)	(150,0.7,0.8)
Phuket	(60,0.3,0.3)	(150,0.7,0.9)
Suratthani	(60,0.3,0.4)	(150,0.7,0.6)
Ranong	(60,0.3,0.4)	(150,0.7,0.5)
Chumporn	(60,0.3,0.4)	(150,0.7,0.7)
Songkla	(60,0.3,0.1)	(150,0.7,0.7)
Satun	(60,0.3,0.6)	(150,0.7,0.8)
Trang	(60,0.3,0.3)	(150,0.7,0.5)
Pattalung	(60,0.3,0.4)	(150,0.7,0.4)
Pattani	(60,0.3,0.6)	(150,0.7,0.4)
Yala	(60,0.3,0.5)	(150,0.7,0.5)
Narativas	(60,0.3,0.4)	(150,0.7,0.4)

Table VIII. HSV Color Coordinates for Labor and Governmental Considerations

Province	Labor	Governmental Considerations
Bangkok	(210,0.9,0.5)	(30,0.8,0)
Samutprakarn	(210,0.9,0.5)	(30,0.8,0)
Nonthaburi	(210,0.9,0.6)	(30,0.8,0)
Pathumthani	(210,0.9,0.5)	(30,0.8,0)
Pranakornsri-Ayuthaya	(210,0.9,0)	(30,0.8,0.3)
Angthong	(210,0.9,0.4)	(30,0.8,0.2)
Lopburi	(210,0.9,0.2)	(30,0.8,0.4)
Singburi	(210,0.9,0.4)	(30,0.8,0.5)
Chainat	(210,0.9,0.4)	(30,0.8,0.5)
Saraburi	(210,0.9,0.4)	(30,0.8,0.2)
Chonburi	(210,0.9,0.4)	(30,0.8,0.1)
Rayong	(210,0.9,0.1)	(30,0.8,0.3)
Chantaburi	(210,0.9,0.3)	(30,0.8,0.4)
Trad	(210,0.9,0.8)	(30,0.8,0.6)
Chacherngsao	(210,0.9,0)	(30,0.8,0.3)
Prajinburi	(210,0.9,0.1)	(30,0.8,0.5)
Nakornnayok	(210,0.9,0.6)	(30,0.8,0.3)
Srakaew	(210,0.9,0.6)	(30,0.8,0.7)
Nakornratcha-sima	(210,0.9,0.4)	(30,0.8,0.4)
Burirum	(210,0.9,0.4)	(30,0.8,0.8)
Surin	(210,0.9,0.4)	(30,0.8,0.8)
Srisaket	(210,0.9,0.8)	(30,0.8,0.9)
Ubonratcha-thani	(210,0.9,0.3)	(30,0.8,0.4)
Yasothorn	(210,0.9,0.8)	(30,0.8,0.9)

Table VIII. Cont.

Province	Labor	Governmental Considerations
Chaiyapum	(210,0.9,0.4)	(30,0.8,0.5)
Amnardcharoen	(210,0.9,1)	(30,0.8,0.7)
Nongbualumpoo	(210,0.9,1)	(30,0.8,0.8)
Khonkaen	(210,0.9,0.1)	(30,0.8,0.3)
Udornthani	(210,0.9,0.3)	(30,0.8,0.5)
Loei	(210,0.9,0.9)	(30,0.8,0.7)
Nongkhai	(210,0.9,0.4)	(30,0.8,0.8)
Mahasarakam	(210,0.9,0.7)	(30,0.8,1)
Roi-ed	(210,0.9,0.4)	(30,0.8,0.8)
Kalasin	(210,0.9,0.5)	(30,0.8,0.8)
Sakonnakorn	(210,0.9,0.7)	(30,0.8,0.7)
Nakornpanom	(210,0.9,0.6)	(30,0.8,0.9)
Mukdaharn	(210,0.9,0.8)	(30,0.8,1)
Chiangmai	(210,0.9,0.5)	(30,0.8,0.2)
Lampun	(210,0.9,0.2)	(30,0.8,0.5)
Lampang	(210,0.9,0.1)	(30,0.8,0.5)
Utaradit	(210,0.9,0.6)	(30,0.8,0.5)
Phrae	(210,0.9,0.4)	(30,0.8,0.5)
Nan	(210,0.9,0.7)	(30,0.8,0.6)
Payao	(210,0.9,0.6)	(30,0.8,0.7)
Chiangrai	(210,0.9,0.4)	(30,0.8,0.2)
Maehongsorn	(210,0.9,1)	(30,0.8,0.7)
Nakornsawan	(210,0.9,0.3)	(30,0.8,0.6)
Uthaithani	(210,0.9,0.6)	(30,0.8,0.6)
Kampaengpet	(210,0.9,0.4)	(30,0.8,0.7)
Tak	(210,0.9,0.4)	(30,0.8,0.7)
Sukothai	(210,0.9,0.6)	(30,0.8,0.7)

Table VIII. Cont.

Province	Labor	Governmental Considerations
Pitsanulok	(210,0.9,0.3)	(30,0.8,0.5)
Pichit	(210,0.9,0.5)	(30,0.8,0.4)
Petchabun	(210,0.9,0.4)	(30,0.8,0.6)
Ratchaburi	(210,0.9,0.1)	(30,0.8,0.2)
Kanchanaburi	(210,0.9,0.2)	(30,0.8,0.3)
Supanburi	(210,0.9,0.3)	(30,0.8,0.2)
Nakornpathom	(210,0.9,0.5)	(30,0.8,0)
Samutsakorn	(210,0.9,0.5)	(30,0.8,0)
Samutsongkram	(210,0.9,0.8)	(30,0.8,0.1)
Petchaburi	(210,0.9,0.4)	(30,0.8,0.2)
Prajuabkirikhan	(210,0.9,0.2)	(30,0.8,0.4)
Nakornsri-thammarat	(210,0.9,0.2)	(30,0.8,0.5)
Krabi	(210,0.9,0.4)	(30,0.8,0.6)
Pang-nga	(210,0.9,0.6)	(30,0.8,0.5)
Phuket	(210,0.9,0.7)	(30,0.8,0.3)
Suratthani	(210,0.9,0.2)	(30,0.8,0.4)
Ranong	(210,0.9,0.8)	(30,0.8,0.4)
Chumporn	(210,0.9,0.4)	(30,0.8,0.3)
Songkla	(210,0.9,0.1)	(30,0.8,0.2)
Satun	(210,0.9,0.7)	(30,0.8,0.4)
Trang	(210,0.9,0.2)	(30,0.8,0.4)
Pattalung	(210,0.9,0.8)	(30,0.8,0.6)
Pattani	(210,0.9,0.3)	(30,0.8,0.6)
Yala	(210,0.9,0.3)	(30,0.8,0.5)
Narativas	(210,0.9,0.6)	(30,0.8,0.7)

An overall score for each candidate site may be determined as a scalar sum of all factor's weighted scores. The outcome of the summation for the overall score for each candidate site is illustrated as Table IX:

Table IX. An Overall Score for Each Location

Province	**Overall Score**
Bangkok	1.1
Samutprakarn	1.01
Nonthaburi	1.22
Pathumthani	1.11
Pranakornsri-Ayuthaya	0.48
Angthong	0.79
Lopburi	0.71
Singburi	0.87
Chainat	0.81
Saraburi	0.66
Chonburi	0.93
Rayong	0.78
Chantaburi	0.84
Trad	1.11
Chacherngsao	0.46
Prajinburi	0.82
Nakornnayok	0.91
Srakaew	0.97
Nakornratcha-sima	0.98
Burirum	0.94

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Table IX. Cont.

Province	Overall Score
Surin	0.93
Srisaket	1.18
Ubonratcha-thani	0.75
Yasothorn	1.18
Chaiyapum	0.82
Amnardcharoen	1.23
Nongbualumpoo	1.26
Khonkaen	0.96
Udornthani	0.59
Loei	1.15
Nongkhai	0.93
Mahasarakam	1.19
Roi-ed	0.93
Kalasin	0.99
Sakonnakorn	1.01
Nakornpanom	1.08
Mukdaharn	1.24
Chiangmai	1.06
Lampun	0.64
Lampang	0.86
Utaradit	0.91
Phrae	0.83
Nan	1.03
Payao	1.02
Chiangrai	0.95
Maehongsorn	1.25

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Table IX. Cont.

Province	Overall Score
Nakornsawan	0.82
Uthaithani	0.97
Kampaengpet	0.87
Tak	0.96
Sukothai	1.04
Pitsanulok	0.79
Pichit	0.76
Petchabun	0.85
Ratchaburi	0.70
Kanchanaburi	0.80
Supanburi	0.81
Nakornpathom	1.11
Samutsakorn	1.01
Samutsongkram	1.11
Petchaburi	0.85
Prajuabkirikhan	0.67
Nakornsri-thammarat	0.93
Krabi	1.04
Pang-nga	1.03
Phuket	1.21
Suratthani	0.87
Ranong	1.07
Chumporn	0.94
Songkla	0.77
Satun	1.07
Trang	0.78

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Table IX. Cont.

Province	Overall Score
Pattalung	1.13
Pattani	0.86
Yala	0.85
Narativas	1.01

Total scores for all locations will subsequently be scaled into the values, ranging from 0 as the best location to 1 as the worst, by setting both H and S equal to zero. The most suitable site can then be visualized in the HSV color model with the best location in black at the apex of the hexcone and the worst site in white at top of the vertical axis. Table X. expresses the result:

Table X. HSV Color Coordinates for All Provinces Based on Total Scores

Province	HSV Coordinates
Chacherngsao	(0,0,0)
Pranakornsriayuthaya	(0,0,0.03)
Udornthani	(0,0,0.16)
Lampun	(0,0,0.23)

Table X. Cont.

Province	Total Scores
Saraburi	(0,0,0.25)
Prajuabkirikhan	(0,0,0.26)
Ratchaburi	(0,0,0.30)
Lopburi	(0,0,0.31)
Ubonratchathani	(0,0,0.36)
Pichit	(0,0,0.37)
Songkla	(0,0,0.39)
Rayong	(0,0,0.40)
Trang	(0,0,0.40)
Angthong	(0,0,0.41)
Pitsanulok	(0,0,0.41)
Kanchanaburi	(0,0,0.42)
Chainat	(0,0,0.44)
Supanburi	(0,0,0.44)
Chaiyapum	(0,0,0.45)
Nakornsawan	(0,0,0.45)
Prachinburi	(0,0,0.45)
Phrae	(0,0,0.46)
Chantaburi	(0,0,0.47)
Petchabun	(0,0,0.48)
Petchaburi	(0,0,0.48)
Yala	(0,0,0.48)
Lampang	(0,0,0.50)
Pattani	(0,0,0.50)
Kampaengpet	(0,0,0.51)
Singburi	(0,0,0.51)

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Table X. Cont.

Province	Total Scores
Surattani	(0,0,0.51)
Nakonnayok	(0,0,0.56)
Utaradit	(0,0,0.56)
Chonburi	(0,0,0.59)
Nakornsrithammarat	(0,0,0.59)
Nongkhai	(0,0,0.59)
Roi-ed	(0,0,0.59)
Surin	(0,0,0.59)
Burirum	(0,0,0.60)
Chumporn	(0,0,0.60)
Chiangrai	(0,0,0.61)
Khonkaen	(0,0,0.63)
Tak	(0,0,0.63)
Srakaew	(0,0,0.64)
Uthaithani	(0,0,0.64)
Nakornratchasima	(0,0,0.65)
Kalasin	(0,0,0.66)
Samutsakorn	(0,0,0.66)
Narativas	(0,0,0.69)
Sakonnakorn	(0,0,0.69)
Samutprakarn	(0,0,0.69)
Payao	(0,0,0.70)
Nan	(0,0,0.71)
Phang-nga	(0,0,0.71)
Krabi	(0,0,0.73)
Sukothai	(0,0,0.73)

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Table X. Cont.

Province	Total Scores
Chiangmai	(0,0,0.73)
Ranong	(0,0,0.76)
Satun	(0,0,0.76)
Nakornpanom	(0,0,0.78)
Bangkok	(0,0,0.80)
Nakornpathom	(0,0,0.81)
Pathumthani	(0,0,0.81)
Samutsongkram	(0,0,0.81)
Trad	(0,0,0.81)
Pattalung	(0,0,0.84)
Loei	(0,0,0.86)
Srisaket	(0,0,0.90)
Yasothorn	(0,0,0.90)
Mahasarakam	(0,0,0.91)
Phuket	(0,0,0.94)
Nonthaburi	(0,0,0.95)
Amnardcharoen	(0,0,0.96)
Mukdaharn	(0,0,0.98)
Maehongsorn	(0,0,0.99)
Nongbualampoo	(0,0,1)

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E. A DIALOG GENERATION AND MANAGEMENT SYSTEM (DGMS)

The design of an appropriate DSS user interface could be an important determinant of success of the DSS implementation. This design is influenced, according to Harrison et al., (1989), by the following user characteristics:

-DSS execution time;

-learning time of the DSS;

-ease of recall;

-the system's versatility;

-errors made by end users;

-quality of help provided by the DSS;

-adaptability to changes in the users' computer competency;

-concentration level required by end users;

-fatigue from using the system;

-uniformity (standards) of the commands; and

-the fun the user derives while using the system.

List of capabilities provided by a DGMS is append below (Turban, 1995):

-captures, stores, and analyzes dialog usage, which can be used for improving the dialog system,

-interacts in several different dialog styles,

-presents data with a variety of formats and output devices,

-accommodates the users with a variety of input devices,

-gives users "help" capabilities, prompting, diagnostic and suggestion routines, or any other flexible support,

-provides user interface with database and model base,

-creates data structures to describe outputs,

-stores input and output data,

-provides color graphics, three-dimensional graphics, and data plotting,

-has windows to allow multiple functions to be displayed concurrently,

-can support communication among and between users and builders of DSS,

-provides training by examples (guiding users through the input and modeling process), and

-provides flexibility and adaptiveness so the DSS will be able to accommodate different problems and technologies.

A DGMS handles the communication between the GISDSS and the user. An effective interaction between the DGMS component within the system environment and the users ensures validity of the GISDSS for facility location.

The GIS's programming language, Avenue, is employed to customize the GIS part of the system. It is used as the tool for the GIS to communicate with the user interface.

The user interface instructs and provides information to users as they proceed through a consultation session. All of the user interface functions are accomplished by Visual Basic programs. The functions handled by Visual Basic programs are as follows:

-soliciting user inputs,

-generating graphical display,

-retrieving location information from the GIS,

-processing data, such as computing overall score for each location from data retrieved from location databases and users,

-sending the overall score of the recommended provinces to the GIS for graphical displaying, and

-preparing explanation reports.

Users' requirements, e.g. weights of location factors, and location preferences serve as inputs to the system. Recommendation outputs furnish users with the most suitable facility locations. The system also makes transparent its recommendations via explanation reports.

Figure 7 demonstrates a selection from a consultation session. Additional portions of the system' consultation session are presented in Appendix F.

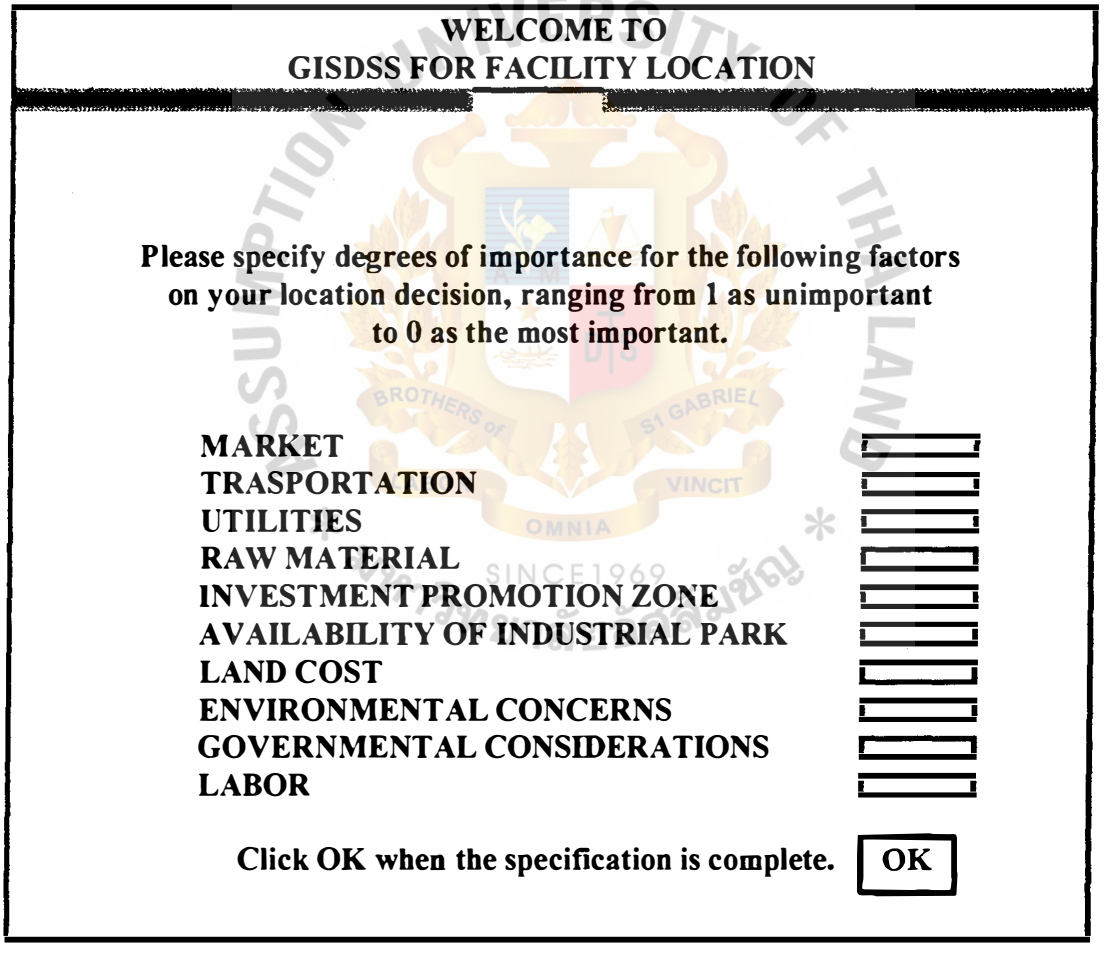

Figure 7. A Selection from a Consultation Session

The user can specify the degrees of importance for the listed factors, ranging from 1 as unimportant to 0 as the most important. However, as we mentioned earlier about the ranking of location factors, we gave the factors' weight to all factors as follows: 0 for Market, 0.1 for Transportation, 0.2 for Utilities, 0.3 for Raw Materials, 0.4 for Investment Promotion Zones, 0.5 for Availability of Industrial Parks, 0.6 for Land Cost, 0.7 for Environmental Concerns, 0.8 for Governmental Considerations, and 0.9 for Labor.

When users complete all the specifications and click OK button, the program will compute the overall score for each location by the scalar sum described earlier. Scores for each candidate site based on any location factors are stored in the GIS and have never been changed. However, the factors' weights can be changed according to the user inputs. The program will subsequently scale the total scores for all locations into the values ranging from 0 as the best to 1 as the worst, and send the value of all locations to the GIS for graphically display and to the user interface in terms of best ranking locations.

The explanation on why any province is recommended as the best location is also furnished. If a location gets 0 to 0.3 on the score based on any location factors, those factors will become its advantages. On the other hand, if the location gets 0.31-1 on the score

based on any location factors, those factors will become its disadvantages. The reason that we set 0.31-1 as the disadvantages because some provinces do not have any more score than 0.6 which there will be no disadvantages for those provinces at all.

By setting the value of H and S equals to zero, the color shown in the GIS will be varying from black to white. In order to avoid the confusion on where those recommended provinces are, the GIS program is set to graphically display only 5 best provinces. As the total scores for all five provinces are relatively close to one another, the color intensity of those provinces are almost indifferent.

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GISDSS FOR FACILITY LOCATION

RECOMMENDED PROVINCES

CHACHERNGSAO

PRANAKORNSRIAYUTHAYA

UDORNTHANI

LAMPUN

SARABURI

CONTINUE

GISDSS FOR FACILITY LOCATION

CHACHERNGSAO

Advantages:

Low Cost of Land
High Labor Force
Availability of Industrial Parks

Disadvantages

Low Utilities
Not so Good Transportation

To see graphical display click CONTINUE.

CONTINUE

Figure 7. Cont.

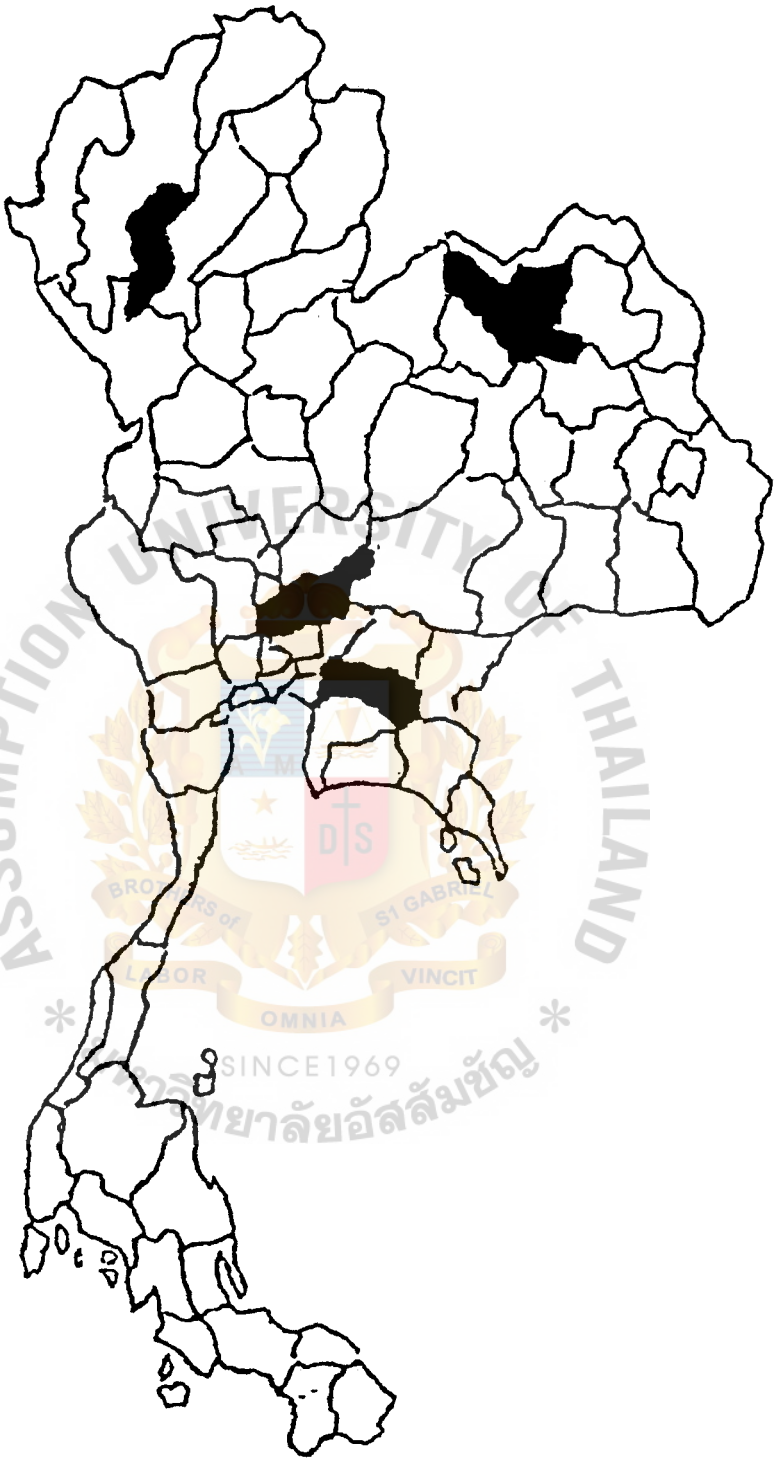

Figure 7. Cont.

V. CONCLUSION

A. RESEARCH SUMMARY

This research has fulfilled the objective of developing a geographic information system-based decision support system, incorporating a geographic information system (GIS), a chromatic representation location model, and interactive graphical user interface concepts to reach accurate and timely location decisions.

A literature survey was conducted to investigate location research that has been done to date. An analysis of this survey showed that there was a small set of location factors that had important affect on making location decisions. These factors thus were utilized in the system developed. The system was developed for use in manufacturing industries. The problem of being unable to identify numerical location information on nonquantifiable factors can be solved by exploiting the information that can be used to represent those factors. For instance, availability of raw materials can be measured by the number of manufacturing companies established.

The prototype system employed a chromatic representation location model as its location model. The model is a novel one which has never been used by any location analysts in solving for location

decisions. A GIS which was selected as a database management system, and an interactive graphical user interface were adopted to help facilities analysts lessen the time and effort in obtaining location decision solution.

With the effective integration of past location studies as well as research on advanced concepts, a geographic information system-based decision support system for facility location was developed to support facilities analysts in arriving at high quality decisions on locating manufacturing facilities in Thailand.

B. ACHIEVEMENTS

The major contributions of this research are as follows:

1. Ranking of Location Factors.

The ranking on key location factors that have important influence on locating facility in Thailand has been identified. They are market, transportation, utilities, raw materials, investment promotion zones, availability of industrial parks, land cost, environmental concerns, governmental considerations, and labor. Solving the location problems by focusing on these key factors, instead of putting large effort on many factors that have little

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influence on locating facility, would help reduce time consuming on arriving at the suitable locations.

2. A Chromatic Representation Location Model.

The adoption of the chromatic representation location model to formulate the location model is accomplished. The model can not only show the recommended locations in numerical format but also be able to display those locations in graphical format by employing the GIS mapping capability.

3. Development of a GISDSS for Facility Location

To facilitate system's database management system, model base management system, and dialog generation management system, the advanced tools; a GIS, a chromatic representation location model, and a Visual Basic programming language are integrated in developing a GISDSS. The integrated system has been operated successfully according to both developers' and users' requirements.

C. FUTURE RESEARCH

The GISDSS for facility location has been developed and evaluated for making decision at the province level. Decision-making at the lower levels in the hierarchy can be further explored. Employing the analytic hierarchy process (AHP) (Saaty, 1980) for

priority setting of the location factors' weight can also be investigated. This will facilitate the problem of having difficulty in giving the weight to the factors because, according to the AHP, each factor can be identified and evaluated with respect to other related factors.

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APPENDIX A

REPRESENTATIVE SOURCES OF LOCATION INFORMATION

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Location Factors	Sources
Utilities	
• Water	Ministry of Interior -Dept. of Local Administration -The Metropolitan Waterworks Authority -The Provincial Waterworks Authority -The Office of Accelerated Rural Development Ministry of Agriculture and Cooperatives -Royal Irrigation Dept.
• Electricity	Ministry of Interior -The Metropolitan Electricity Authority -The Provincial Electricity Authority
• Fuel	Ministry of Interior
Raw Materials	Ministry of Commerce -Dept. of Commercial Registration -Dept. of Internal Trade -Industrial Directories
Transportation	Ministry of Transport and Communication -The Dept. of Land Transport -Dept. of Aviation -The Dept. of Highways -The Port Authority of Thailand -The State Railway of Thailand -Post Office
Land Cost	Ministry of Interior -Dept. of Land

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Market	Ministry of Commerce -Dept. of Internal Trade Bank of Thailand Ministry of Interior -Dept. of Local Administration
Environmental Concerns	Ministry of Interior Ministry of Agriculture and Cooperatives -Royal Irrigation Dept. Ministry of Public Health
Labor	Ministry of Labour and Social Welfare
Governmental Considerations	Ministry of Interior Ministry of Commerce
Investment Promotion Zones	Board of Investment
Industrial Park	Industrial Estate Authority of Thailand

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APPENDIX B

TAXONOMY OF LOCATION FACTORS

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Utilities

- Water
  - Availability and trend in water production
  - Trend in water consumption
  - Characteristic
    - Purity
    - Acidity
  - Water sources
    - Municipal water systems
      - sources of supply
      - capacity
      - average use
      - costs
    - Ground water
      - cost of wells
      - pumping cost
      - regulations
    - Surface water
      - cost
      - regulations
- Electricity
  - Availability including suppliers
  - Demand rate
  - Capacity to meet demand
  - Cost
- Fuel
  - Availability
  - Cost
  - Proximity to suppliers
  - Demand rate

Raw Materials

- Proximity to raw material sources
- Price
- Competition for materials
- Delivery

Transportation

- Truck transportation
  - Availability
  - Access to highways
  - Cost
  - Frequency of service
- Rail transportation
  - Availability
  - Cost

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  - Frequency of service
  - Proximity to railroad
- Water transportation
  - Availability
  - Rates
  - Frequency of service
  - Proximity to port
- Air transportation
  - Availability
  - Proximity to airport
  - Frequency of service
- Mail and parcel service
  - Availability
- Others
  - Taxi
  - Car rental
  - Bus

Availability

Site Consideration

- Land Costs
- Natural resources
- Flood
- Size

Markets

- Income Trends
  - Per capita income
  - Total family income
  - Disposable income
- Magnitude
  - Average family size
  - Total population in area
- Competition

Environment

- Air Pollution
  - Noise
  - Smoke
  - Traffic
  - Noxious gases
  - Odor
  - Local regulatory bodies
- Weather
  - Maximum temperature
  - Average temperature
  - Rain condition

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- Waste Disposal
  - Regulatory bodies
  - Cost
  - Availability
- Sewage Disposal Systems
  - Availability
  - Cost
- Garbage Disposal
  - Availability
  - Cost of service
- General Services
  - Fire protection
  - Police
  - Security
  - Janitorial
  - Property maintenance
  - Entertainment facilities
  - Food vending

Labor

- Availability
- Costs
  - Wage rates
  - Fringe benefits
- Labor Law
- Union Activity
- Unemployment Rate

Governmental Concerns

- Special Regulations Related to Industries
- Taxes and Financial Inducements
- Government Administration in Area

Investment Promotion Zone

- Availability
- Zoning

Industrial Estate

- Availability

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APPENDIX C

RANKINGS OF PROVINCES ON EACH LOCATION FACTOR

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Market Factor	Land Cost Factor
Bangkok	Mukdaharn
Nonthaburi	Yasothorn
Pathumthani	Mahasarakam
Samutprakarn	Kalasin
Samutsakorn	Burirum
Nakornratchasima	Nakornpanom
Chonburi	Amnardcharoen
Chiangmai	Roi-ed
Rayong	Srisaket
Phuket	Surin
Songkla	Loei
Nakornpathom	Nongkhai
Khonkaen	Nongbualumpoo
Nakornsrithammarat	Sakonnakorn
Ubonratchathani	Chaiyapum
Chiangrai	Udornthani
Suratthani	Petchabun
Nakorasawan	Kampaengpet
Samutsongkram	Srakaew
Saraburi	Lampun
Pranakornsriayuthaya	Singburi
Chacherngsao	Chacherngsao
Kanchanaburi	Sukothai
Ratchaburi	Lopburi
Udornthani	Angthong
Lanpang	Phang-nga
Prajuabkirikhan	Uthaithani
Pitsanulok	Utaradit
Lopburi	Krabi
Burirum	Chainat

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Petchaburi	Maehongsorn
Pichit	Saraburi
Nakornnayok	Pranakornsriayuthaya
Pattani	Satun
Chaiyapum	Payao
Chantaburi	Prajinburi
Supanburi	Pitsanulok
Sukothai	Pattani
Singburi	Nan
Pattalung	Phrae
Pang-nga	Tak
Satun	Narativas
Krabi	Trad
Yala	Nakornsawan
Trang	Yala
Chumporn	Samutsongkram
Lampun	Ubonratchathani
Prajinburi	Nakornnayok
Narativas	Trang
Sakonnakorn	Prajuabkirikhan
Utaradit	Ratchaburi
Trad	Kanchanaburi
Chainat	Chantaburi
Nan	Pichit
Angthong	Supanburi
Uthaithani	Ranong
Phrae	Chumporn
Tak	Pattalung
Loei	Lampang
Nongkhai	Samutsakorn
Kampaengpet	Petchaburi

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Petchabun	Suratthani
Surin	Nakornsrithammarat
Srisaket	Rayong
Payao	Chiangrai
Nakornpanom	Samutprakarn
Srakaew	Pathumthani
Ranong	Nakornratchasima
Maehongsorn	Nakornpathom
Nongbualumpoo	Nonthaburi
Roi-ed	Khonkaen
Amnardcharoen	Songkla
Yasothorn	Chonburi
Kalasin	Phuket
Mukdaharn	Chiangmai
Mahasarakam	Bangkok

Environmental Concerns	**Governmental Considerations**
Kalasin	Bangkok
Mahasarakam	Nakornpathom
Mukdaharn	Nonthaburi
Roi-ed	Pathumthani
Srisaket	Samutprakarn
Burirum	Samutsakorn
Nakornpanom	Ratchaburi
Sakonnakorn	Supanburi
Surin	Angthong
Yasothorn	Petchaburi
Kampaengpet	Chiangmai
Loei	Songkla

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Nongbualumpoo
Nongkhai
Srakaew
Chacherngsao
Chainat
Petchabun
Phrae
Ubonratchathani
Udornthani
Amnardcharoen
Utaradit
Nakornnayok
Pranakornsriayuthaya
Chaiyapum
Lopburi
Nan
Narativas
Pattalung
Pattani
Payao
Pichit
Pitsanulok
Uthaithani
Angthong
Kanchanaburi
Supanburi
Chantaburi
Lampang
Lampun
Maehongsorn
Petchaburi

Chiangrai
Saraburi
Samutsongkram
Ratchaburi
Nakornnayok
Kanchanaburi
Chacherngsao
Rayong
Phuket
Khonkaen
Chumporn
Pranakornsriayuthaya
Chantaburi
Lopburi
Nakornratchasima
Pichit
Prajuabkirikhan
Ranong
Satun
Suratthani
Trang
Ubonratchathani
Yala
Utaradit
Udornthani
Singburi
Prajinburi
Pitsanulok
Phrae
Phang-nga
Nakornsrithammarat

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Prajuabkirikhan
Ranong
Tak
Trad
Trang
Yala
Saraburi
Prajinburi
Singburi
Sukothai
Suratthani
Ratchaburi
Chiangrai
Chumporn
Nakornratchasima
Nakornsawan
Nakornsrithammarat
Songkla
Samutsongkram
Chiangmai
Khonkaen
Phang-nga
Rayong
Satun
Nakornpathom
Pathumthani
Samutprakarn
Samutsakorn
Chonburi
Krabi
Phuket

Lampun
Lampang
Chaiyapum
Chainat
Krabi
Nakornsawan
Nan
Pattalung
Pattani
Petchabun
Trad
Uthaithani
Payao
Sakonnakorn
Srakaew
Sukothai
Tak
Amnardcharoen
Narativas
Maehongsorn
Loei
Kampaengpet
Chonburi
Kalasin
Nongbualumpoo
Nongkhai
Surin
Roi-ed
Srisaket
Yasothorn
Nakornpanom

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Nonthaburi	Mahasarakam
Bangkok	Mukdaharn

Availability of Industrial Parks	**Investment Promotion Zone**
Rayong	Yasothorn
Pranakornsriayuthaya	Yala
Chonburi	Uthaithani
Bangkok	Utaradit
Saraburi	Amnardcharoen
Samutprakarn	Udornthani
Chacherngsao	Ubonratchathani
Udornthani	Trang
Songkla	Trad
Samutsakorn	Tak
Ratchaburi	Surin
Prajuabkirikhan	Suratthani
Pichit	Sukothai
Nakornsawan	Srisaket
Lampun	Srakaew
Yasothorn	Songkla
Yala	Singburi
Uthaithani	Satun
Utaradit	Sakonnakorn
Amnardcharoen	Roi-ed
Ubonratchathani	Ranong
Trang	Rayong
Trad	Prajuabkirikhan
Tak	Prajinburi
Surin	Pitsanulok

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Suratthani
Supanburi
Sukothai
Srisaket
Srakaew
Singburi
Satun
Samutsongkram
Sakonnakorn
Roi-ed
Ranong
Prajinburi
Pitsanulok
Phuket
Phrae
Phang-nga
Petchaburi
Petchabun
Payao
Patumthani
Pattani
Pattalung
Nontaburi
Nongkhai
Nongbualumpoo
Narativas
Nan
Nakornsrithammarat
Nakornratchasima
Nakornpathom
Nakornpanom

Pichit
Phuket
Phrae
Phang-nga
Petchaburi
Petchabun
Payao
Pattani
Pattalung
Nongkhai
Nongbualumpoo
Nakornsrithammarat
Narativas
Nan
Nakornratchasima
Nakornpanom
Nakornsawan
Mukdaharn
Mahasarakam
Maehongsorn
Lampang
Lampun
Lopburi
Loei
Krabi
Khonkaen
Kampaengpet
Kalasin
Chumporn
Chiangmai
Chiangrai

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Nakornnayok	Chantaburi
Mukdaharn	Chaiyapum
Mahasarakam	Chainat
Maehongsorn	Burirum
Lampang	Chonburi
Lopburi	Supanburi
Loei	Saraburi
Krabi	Samutsongkram
Khonkaen	Ratchaburi
Kanchanaburi	Pranakornsriayuthaya
Kampaengpet	Nakornnayok
Kalasin	Kanchanaburi
Chumporn	Chacherngsao
Chiangrai	Angthong
Chiangmai	Samutsakorn
Chantaburi	Samutprakarn
Chaiyapum	Pathumthani
Chainat	Nonthaburi
Burirum	Nakornpathom
Angthong	Bangkok

Labor	**Utilities**
Chacherngsao	Bangkok
Pranakornsriayuthaya	Chonburi
Lampang	Nonthaburi
Prajinburi	Rayong
Khonkaen	Samutprakarn
Ratchaburi	Samutsakorn
Rayong	Chiangmai
Songkla	Khonkaen

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Kanchanaburi	Nakornpathom
Lopburi	Patumthani
Lampun	Sakonnakorn
Nakornsrithammarat	Songkla
Prajuabkirikhan	Nakornratchasima
Suratthani	Phuket
Trang	Samutsongkram
Chantaburi	Chantaburi
Nakornsawan	Chiangrai
Pattani	Nakornnayok
Pitsanulok	Petchaburi
Supanburi	Kanchanaburi
Ubonratchathani	Nakornsrithammarat
Udornthani	Pranakornsriayuthaya
Yala	Ratchaburi
Angthong	Supanburi
Burirum	Suratthani
Chainat	Saraburi
Chaiyapum	Ubonratchathani
Chiangrai	Chumporn
Chonburi	Lampang
Chumporn	Lopburi
Kampaengpet	Krabi
Krabi	Pichit
Nakornratchasima	Prajuabkirikhan
Nongkhai	Tak
Petchabun	Trang
Petchaburi	Yala
Phrae	Phang-nga
Roi-ed	Singburi
Saraburi	Ranong

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Singburi
Surin
Tak
Bangkok
Chiangmai
Kalasin
Nakornpathom
Patumthani
Pichit
Samutprakarn
Samutsakorn
Nakornnayok
Nakornpanom
Narativas
Nonthaburi
Payao
Phang-nga
Srakaew
Sukothai
Utaradit
Uthaithani
Mahasarakham
Nan
Phuket
Sakonnakorn
Satun
Ranong
Samutsongkram
Mukdaharn
Pattalung
Srisaket
Satun
Trad
Angthong
Pattalung
Pattani
Narativas
Lampun
Chacherngsao
Sukothai
Prajinburi
Kampaengpet
Pitsanulok
Petchabun
Chaiyapum
Nakornsawan
Maehongsorn
Nongkhai
Udornthani
Nan
Chainat
Srakaew
Surin
Payao
Phrae
Utaradit
Uthaithani
Amnardcharoen
Loei
Roi-ed
Kalasin
Burirum

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Trad
Yasothorn
Loei
Maehongsorn
Nongbualumpoo
Amnardcharoen

Nongbualumpoo
Nakornpanom
Yasothorn
Srisaket
Mukdaharn
Mahasarakham

Transportation

Bangkok
Chonburi
Songkla
Phuket
Nakornratchasima
Khonkaen
Udornthani
Chiangmai
Ubonratchathani
Rayong
Nakornsawan
Tak
Narativas
Ranong
Maehongsorn
Suratthani
Pitsanulok
Loei
Lampang
Sakonnakorn
Phrae
Trang
Utaradit

Raw Materials

Bangkok
Chonburi
Samutprakarn
Nonthaburi
Nakornpathom
Songkla
Chiangmai
Rayong
Patumthani
Nakornratchasima
Khonkaen
Ratchaburi
Ubonratchathani
Samutsakorn
Supanburi
Kanchanaburi
Saraburi
Nakornsrithammarat
Petchaburi
Phuket
Trang
Samutsongkram
Udornthani

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Nan	Nakornsawan
Pattani	Lopburi
Nakornsrithammarat	Pranakornsriayuthaya
Chiangrai	Chiangrai
Prajuabkirikhan	Prajuabkirikhan
Nakornpathom	Suratthani
Supanburi	Lampang
Samutprakarn	Pichit
Ratchaburi	Chumporn
Kanchanaburi	Pattalung
Saraburi	Narativas
Nonthaburi	Ranong
Lopburi	Chacherngsao
Patumthani	Pitsanulok
Chacherngsao	Chantaburi
Chaiyapum	Sukothai
Roi-ed	Angthong
Surin	Lampun
Pranakornsriayuthaya	Singburi
Kampaengpet	Yala
Burirum	Phang-nga
Petchaburi	Chaiyapum
Srisaket	Kampaengpet
Samutsakorn	Phrae
Kalasin	Prajinburi
Petchabun	Chainat
Chantaburi	Utaradit
Sukothai	Nan
Mahasarakham	Pattani
Nongkhai	Tak
Pichit	Satun

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Prajinburi	Maehongsorn
Chainat	Surin
Yasothorn	Petchabun
Srakaew	Nongkhai
Nakornpanom	Srakaew
Chumporn	Uthaithani
Angthong	Nakornnayok
Lampun	Trad
Samutsongkram	Roi-ed
Singburi	Burirum
Uthaithani	Sakonnakorn
Yala	Loei
Nakornnayok	Nakornpanom
Payao	Payao
Pattalung	Krabi
Krabi	Srisaket
Trad	Amnardcharoen
Nongbualumpoo	Yasothorn
Amnardcharoen	Kalasin
Mukdaharn	Mahasarakham
Phang-nga	Mukdaharn
Satun	Nongbualumpoo

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APPENDIX D

A LIST OF ACTIVITIES ELIGIBLE FOR BOI PROMOTION

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Activities Eligible for BOI Investment Promotion

1. Agriculture Products and Commodities

-Large-scale cultivation.

-Processing of agriculture products.

-Processing or preservation of food.

-Animal feed.

-Oil production from agricultural products.

-Corn products.

-Stick lac products.

-Rubber products.

-Livestock raising or meat processing.

-Animal products,

-Cultivation of mulberry trees and silk worm farming.

-Silk thread making.

-Deep-sea and off-shore fishing.

-Slaughtering and disemboweling chickens for export.

-Manufacturing products made from bamboo, rattan or corypha palm leaf for export.

-Production and multiplication of vegetable seeds.

-Rabbit raising and processing for export.

-Pig slaughter and processing.

-Cattle slaughter and processing.

-Production of milk powder.

-Full-cycle production of soybean and oil extraction.

2. Minerals, Metals, and Ceramics

-Mineral ore exploration.

-Mining or dressing of ores.

-Refining.

-Metal processing.

-Manufacturing ceramic products.

3. Chemicals and Chemical Products

-Chemical and products.

-Soda ash.

-Carbon black.

-Petrochemicals.

-Pharmaceutical products.

-Fertiliser.

-Paints or similar products.

-Paper.

-Carbon paste products.

-Pulp paper products.

-Acetylene black products.

-Petroleum products.

-Salt products industry.

-Wood pulp, rayon fiber, wood pulp for rayon fiber.

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4. Mechanical and Electrical Equipment

-Engine production or assembly.

-Mechanical equipment production or assembly.

-Electrical production or assembly.

-Machinery or electrical equipment part production or assembly.

-Vehicle component or part production.

-Electronics goods production or assembly.

-Oil drilling platform production.

5. Other Products

-Production, assembly of clocks, watches or component parts.

-Production, assembly of cameras.

-Manufacture of stationery, educational equipment or parts.

-Manufacture, assembly of sports equipment, musical instruments or toys.

-Manufacture of medical supplies or medical, scientific equipment.

-Plastic or plastic-coated products.

-Manufacture of dress ornaments or cutting and polishing of gem stones.

-Umbrella manufacture.

-Rubber tree products.

-Production of lenses, spectacles or parts.

-Production of fire hydrants or components.

-Building, repairing large ships for maritime transportation.

-Building, repairing small ships for maritime transportation.

-Production of arms and ammunition.

-Natural, synthetic fiber product manufacture.

-Tyre cords.

-Fabric printing.

-Production, assembly of measuring & testing equipment or parts.

-Hand tool production.

-Prefabricated housing or parts.

-Zip manufacture.

-Glove manufacture.

-Manufacture of abrasive sheets.

-Match manufacture for export.

-Artificial flowers and trees for export.

-Cellophane manufacture.

-Scale ice.

-Ferro-cement ship building.

-Manufacture of socks.

-Carpet manufacture.

-Manufacture of packaging materials.

-Grinding wheels.

-Adhesive tape products.

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-Rubber soles production (sheet and patterned).

-Cloth wall-covering.

-Embroidered cloth products.

-Manufacture of synthetic fiber.

-Non-dairy creamer products.

-Sports shoes.

-Manufacture of aqueous electrolytic cell cases or parts for export.

-Soft gelatin capsule products.

-Jewelry boxes and display cases.

-Sheet glass production for construction.

-Production of coated aluminium sheet for printing.

-Production of razor blades and handles.

-Shipyard.

-Dyeing of yarns or fabric.

-Shipbreaking industry.

-Production primarily for export.

-Production of ready-made garments for export.

-Building of fiberglass reinforced plastic boats.

-Production of steamed rice using modern technology.

-Canned seafood production for export.

-Yarn spinning industry.

-Weaving or knitting industry.

-Glass fiber or glass fiber products.

-Foamed glass or foamed glass products.

6. Service

-Industrial estates.

-Hotels.

-Water transportation.

-Car parking.

-Vehicle, machinery or engine repair service.

-Warehousing.

-Hospitals.

-Cold storage.

-Loading, unloading facilities for sea transport.

-Movie film processing.

-Tourist promotion services.

-X-ray computer service center.

-International trading.

-Crop dying and silo facilities.

-Modern rice mill.

-Container repair, maintenance and refurnishment.

-Modern packaging of vegetables, fruits, fresh plants and flowers for export.

-Natural gas transport.

-Convention hall.

-Grading facility for agricultural products.

-Ferryboat services.

-Disinfection services for products mainly for export.

-High-powered ship services.

-Agricultural export zone.

-Petrochemical industry service facility.

-International trade exhibition center.

-Mass transit system.

-Concession expressways.

-Container yard.

-Production or sale of water for industrial use.

-Research & development.

-Commercial airport.

-Air transport.

-Communication service via satellite.

-Flatted factory.

All listings are subject to changes at the discretion of the Office of the Board of Investment, Office of the Prime Minister. For details of activities eligible for promotion, please consult the Information and Promotion Services Division of the Board of Investment.

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APPENDIX E

LOCATION DATABASES FOR ALL PROVINCES

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Province	GPP in Mil. Baht	Per Capita Income(Baht)	Family Size	Income per Family(BHT)	Expense per Income Ratio
Bangkok	1,652,599.50	238,849	3.1	21,550	82.8
Samutprakarn	174,615.20	189,182	3.3	17,145	72.4
Nontaburi	73,569.40	105,099	3.5	36,888	63.3
Patumthani	119,219.30	236,078	4	15,539	77.8
Pranakornsriayutthaya	60,619.20	83,613	6.3	11,376	89.6
Angthong	11,118.50	41,180	3.3	11,414	70.6
Lopburi	30,134.10	40,232	3.7	9,331	73.4
Singburi	9,662.00	40,597	3.4	9,525	103.5
Chainat	14,309.90	38,780	3.4	9,574	94.4
Saraburi	61,057.20	115,420	3.6	10,582	81.9
Chonburi	193,790.10	206,599	3.5	12,223	90.9
Rayong	83,657.10	168,324	3.4	13,254	87
Chantaburi	23,068.00	54,023	3.8	12,410	79.2
Trad	14,320.90	75,772	3.5	11,696	92.3
Chacherngsao	50,870.50	85,210	3.9	11,820	104.5
Prajinburi	23,028.40	49,206	3.8	8,117	75.3
Nakornnayok	8,811.00	36,259	3.6	9,526	96.9
Srakaew	12,375.80	31,173	3.4	7,189	93.6
Nakornratchasima	95,110.30	37,623	3.9	8,803	84.1
Burirum	30,340.80	20,983	4.1	6,446	100.1
Surin	24,553.80	19,004	4.1	6,517	106.8
Srisaket	24,842.20	18,199	4.1	7,149	99.2
Ubonratchathani	38,407.20	23,419	4.2	6,950	82.7
Yasothorn	10,727.80	19,123	3.8	6,581	91.1
Chaiyapum	25,980.60	24,487	3.9	7,166	68.4
Amnardcharoen	7,983.70	23,008	4.1	7,027	92.2
Nongbualumpoo	8,732.80	18,700	4.2	7,147	91.1
Khonkaen	60,201.20	34,879	3.8	9,438	78.9
Udomthani	37,894.90	26,762	4	7,766	96.6

Loei	14,890.40	26,169	4	6,875	96.1
Nongkhai	20,089.40	23,579	4.2	8,733	93.6
Mahasarakham	18,401.70	19,702	3.8	5,171	98.6
Roi-ed	24,235.10	20,247	3.7	6,746	99.2
Kalasin	18,925.60	21,122	4	6,079	109.4
Sakonnakorn	21,291.10	21,206	4	7,746	79.3
Nakornpanom	13,133.20	19,779	4	6,196	89.3
Mukdaharn	7,056.30	25,112	4.4	7,455	92.6
Chiangmai	71,394.70	49,614	3.2	9,806	92.2
Lampun	23,613.80	54,916	3.3	8,735	81.8
Lampang	31,275.60	40,723	3.5	8,208	81.7
Utaradit	15,022.70	32,729	3.5	8,181	80
Phrae	12,171.70	24,007	3.4	8,261	65.6
Nan	11,489.50	26,232	3.9	6,913	96.4
Payao	12,869.50	25,791	3.3	6,129	96.4
Chiangrai	31,516.20	28,521	3.5	7,955	91.8
Maehongsorn	4,763.20	28,019	4.3	6,187	81.5
Nakornsawan	38,166.10	34,887	3.3	8,551	105.1
Uthaithani	10,785.80	35,133	3.5	8,203	79.9
Kampaengpet	24,251.20	35,875	3.6	8,142	89.1
Tak	12,726.30	36,052	3.5	7,604	91
Sukothai	16,635.30	28,291	3.4	8,320	66
Pitsanulok	27,485.80	34,530	3.3	7,587	72.8
Pichit	15,459.20	26,792	3.4	10,324	76.7
Petchabun	24,768.90	27,070	3.7	8,204	63.7
Ratchaburi	44,469.20	57,454	3.7	12,621	88.9
Kanchanaburi	39,581.50	58,726	3.9	10,230	94.9
Supanburi	22,799.40	40,530	3.7	7,428	89.4
Nakornpathom	62,701.30	81,962	3.8	14,737	83.4
Samutsakorn	82,743.30	212,708	3.3	15,997	73.1
Samutsongkram	8,084.80	40,223	3.5	10,925	83.7
Petchaburi	22,799.40	53,899	3.6	10,590	74.7

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Prajuabkirikhan	27,856.30	64,482	3.6	7,923	112.5
Nakornsrithammarat	52,744.90	33,617	4.1	9,681	96.4
Krabi	18,036.50	57,809	3.9	8,758	100
Phang-nga	14,772.70	62,596	3.4	8,696	81.8
Phuket	27,063.40	143,949	3.3	15,437	90.7
Suratthani	45,295.00	53,859	3.9	12,771	79.5
Ranong	11,204.10	84,882	3.7	9,359	98.9
Chumporn	20,765.60	49,324	3.4	9,874	89.6
Songkla	72,123.20	58,305	3.5	11,089	81.5
Satun	11,279.80	46,999	4.6	8,977	89.3
Trang	23,873.40	40,327	4.1	11,733	84.9
Pattalung	14,691.50	29,740	3.8	8,474	96.2
Pattani	26,895.40	46,133	4.6	6,876	92.5
Yala	18,630.20	48,016	3.8	7,114	94
Narativas	19,200.30	30,918	4.2	6,715	104.5

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Province	Population	Labor Force	Area (square km)	Min. Daily Wage Rates
Bangkok	5,604,772	1,133,237	1,565.07	162
Samutprakarn	956,266	524,872	1,004.09	162
Nontaburi	800,741	65,731	622.3	162
Patumthani	592,328	234,734	1,525.86	162
Pranakornsriayutthaya	721,496	114,879	2,556.64	130
Angthong	289,397	6,212	968.37	130
Lopburi	756,484	26,032	6,199.75	130
Singburi	225,080	6,651	822.48	130
Chainat	352,534	5,836	2,469.75	130
Saraburi	596,533	69,364	3,576.49	140
Chonburi	1,028,625	144,231	4,363	140
Rayong	504,631	52,261	3,552	130
Chantaburi	484,170	9,248	6,338	130
Trad	220,000	1,982	2,819	130
Chacherngsao	627,119	96,095	5,351	130
Prajinburi	436,956	29,564	4,762.36	130
Nakornnayok	241,939	4,019	2,122	130
Srakaew	521,432	4,471	7,195.14	130
Nakornratchasima	2,510,839	76,710	20,493.96	140
Burirum	1,494,836	6,884	10,322.88	130
Surin	1,367,685	5,886	8,124.06	130
Srisaket	1,422,527	2,680	8,839.98	130
Ubonratchathani	1,731,105	12,025	15,744.85	130
Yasothorn	549,466	1,953	4,161.66	130
Chaiyapum	1,115,519	6,777	12,778.29	130
Amnardcharoen	360,340	1,986	3,161.25	130
Nongbualumpoo	486,153	585	3,859.09	130
Khonkaen	1,726,594	34,211	10,885.99	130

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Udornthani	1,491,560	13,631	11,730.30	130
Loei	630,876	1,291	11,424.61	130
Nongkhai	888,702	6,268	7,332.28	130
Mahasarakham	927,753	2,699	5,291.68	130
Roi-ed	1,310,095	5,899	8,299.45	130
Kalasin	974,460	5,439	6,946.75	130
Sakonnakorn	1,077,208	3,925	9,605.76	130
Nakornpanom	703,935	4,548	5,512.67	130
Mukdaharn	326,188	2,406	4,339.83	130
Chiangmai	1,573,757	34,958	20,107.06	140
Lampun	408,804	26,657	4,505.88	130
Lampang	807,362	28,396	12,533.96	130
Utaradit	481,563	3,998	7,838.59	130
Phrae	494,637	6,612	6,538.60	130
Nan	484,116	3,582	11,472.07	130
Payao	517,622	4,205	6,335.06	130
Chiangrai	1,261,138	8,081	11,678.37	130
Maehongsorn	229,284	318	12,681.26	130
Nakornsawan	1,131,900	13,674	9,597.68	130
Uthaithani	328,978	4,803	6,730.25	130
Kampaengpet	766,048	7,000	8,607.49	130
Tak	471,596	8,308	16,406.65	130
Sukothai	627,090	4,287	6,596.09	130
Pitsanulok	865,408	9,677	10,815.85	130
Pichit	601,117	5,678	4,531.01	130
Petchabun	1,040,917	5,980	12,668.42	130
Ratchaburi	813,293	39,800	5,196.46	130
Kanchanaburi	766,352	18,966	19,483.15	130
Supanburi	853,313	9,786	5,358.01	130
Nakornpathom	753,599	123,120	2,168.33	162
Samutsakorn	407,146	226,644	872.35	162
Samutsongkram	207,707	5,681	416.71	130

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Petchaburi	453,391	8,097	6,225.14	130
Prajuabkirikhan	468,880	27,972	6,367.62	130
Nakornsrithammarat	1,511,857	23,041	9,942.50	130
Krabi	344,610	6,134	4,708.51	130
Phang-nga	229,704	4,857	4,170.89	140
Phuket	221,835	7,543	543.03	162
Suratthani	861,233	28,052	12,891.47	130
Ranong	151,868	5,308	3,298.05	140
Chumporn	448,087	7,151	6,009	130
Songkla	1,191,233	57,680	7,393.89	130
Satun	253,177	3,388	2,478.98	130
Trang	576,060	18,078	4,917.52	130
Pattalung	498,805	2,333	3,424.47	130
Pattani	590,735	8,918	1,940.36	130
Yala	418,790	8,360	4,521.08	130
Narativas	646,871	5,112	4,475.43	130

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Province	Bus	Truck	Taxi	Total	Port	Airport
Bangkok	24,647	98,234	61,350	184231	yes	yes
Samutprakarn	2,717	25,088	1,606	29411	-	-
Nontaburi	1,018	16,632	2,574	20224	-	-
Patumthani	1,000	16,954	6	17960	-	-
Pranakornsriayuthaya	1,115	13,263	1,834	16212	-	-
Angthong	693	5249	105	6047	-	-

Lopburi	1354	18160	169	19683	-	-
Singburi	395	5000	21	5416	-	-
Chainat	303	8028	71	8402	-	-
Saraburi	912	24414	23	25349	-	-
Chonburi	1946	41630	1649	45225	yes	yes
Rayong	1063	19607	21	20691	yes	-
Chantaburi	1428	8818	438	10684	-	-
Trad	633	3606	245	4484	-	-
Chacherngsao	1032	14598	2066	17696	-	-
Prajinburi	473	7343	892	8708	-	-
Nakornnayok	315	4731	0	5046	-	-
Srakaew	402	6350	483	7235	-	-
Nakornratchasima	2921	43582	1656	48159	-	yes
Burirum	1017	12703	827	14547	-	-
Surin	1111	14908	460	16479	-	-
Srisaket	1065	12447	61	13573	-	-
Ubonratchathani	2233	19034	1293	22560	-	yes
Yasothorn	517	7556	297	8370	-	-
Chaiyapum	963	14409	1758	17130	-	-
Amnardcharoen	25	3871	233	4129	-	-
Nongbualumpoo	444	3635	91	4170	-	-
Khonkaen	2326	25342	1885	29553	-	yes
Udornthani	2059	22607	1817	26483	-	yes
Loei	599	8176	1661	10436	-	yes
Nongkhai	404	7817	930	9151	-	-
Mahasarakham	459	8554	1055	10068	-	-
Roi-ed	1558	12484	2574	16616	-	-
Kalasin	592	10727	1681	13000	-	-
Sakonnakorn	1301	7826	1531	10658	-	yes
Nakornpanom	465	4053	1945	6463	-	-
Mukdaharn	43	3033	858	3934	-	-
Chiangmai	989	20055	1184	22228	-	yes
Lampun	469	5279	19	5767	-	-

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Lampang	632	9615	12	10259	-	yes
Utaradit	394	5252	163	5809	-	yes
Phrae	479	9530	44	10053	-	yes
Nan	186	5529	6	5721	-	yes
Payao	139	4830	6	4975	-	-
Chiangrai	1198	11901	237	13336	-	yes
Maehongsorn	32	701	16	749	-	yes
Nakornsawan	1619	19193	252	21064	-	yes
Uthaithani	299	5234	44	5577	-	-
Kampaengpet	415	15378	37	15830	-	-
Tak	394	3811	164	4369	-	yes
Sukothai	869	9344	31	10244	-	-
Pitsanulok	967	10205	294	11466	-	yes
Pichit	504	7801	436	8741	-	-
Petchabun	535	8858	1282	10675	-	-
Ratchaburi	1007	25177	214	26398	-	-
Kanchanaburi	1374	24914	22	26310	-	-
Supanburi	835	29986	537	31358	-	-
Nakornpathom	1017	50030	100	51147	-	-
Samutsakorn	939	12033	280	13252	-	-
Samutsongkram	345	5142	216	5703	-	-
Petchaburi	739	12683	91	13513	-	-
Prajuabkirikhan	223	13003	3	13229	-	yes
Nakornsrithammarat	824	13122	275	14221	-	yes
Krabi	220	4348	33	4601	-	-
Phang-nga	506	2863	0	3369	-	-
Phuket	1586	5835	540	7961	yes	yes
Suratthani	759	11551	53	12363	-	yes
Ranong	470	3471	0	3941	-	yes
Chumporn	400	5771	27	6198	-	-
Songkla	4613	21938	178	26729	yes	yes
Satun	373	2199	24	2596	-	-
Trang	727	5657	940	7324	-	yes

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Pattalung	569	4335	14	4918	-	-
Pattani	476	4279	139	4894	-	yes
Yala	372	4840	197	5409	-	-
Narativas	377	3490	157	4024	-	yes

Rail Transportation Costs by Distance

(Baht per ton)

km	Class 3	Class 4
50	35.1	30.6
100	70.2	61.1
150	105.3	91.7
200	140.4	122.2
300	200.2	174.4
500	313	272.2
700	419	365.2
1,000	578	505.2

Specimen product lists:

Class 3: Electrical appliances, automobiles, tin, logs, timber, and tiles.

Class 4: Fresh fish, rice, maize, rubber, jute, kenaf, cement, lignite, fluorspar, manganese, gypsum fertilizer, fresh fruits, paddy, bran, marl, sand, gravel, vegetables, coconuts,steel.

Province	No.of Users	Electricity Sales(kwh)	Water Supply (cu.m.)	Monthly Fuel Expenses per Household (BHT)	Telephone
Bangkok	1,487,893	21,525,223,831	1,491,125,250.00	1,003.29	Yes
Samutprakarn	182,388	7,918,147,378	50,416,359	661.67	Yes

Nontaburi	209,517	1,682,882,262	7,458,391	1,587.81	Yes
Patumthani	156,891	3,777,285,708	23,252,065	867.87	Yes
Pranakornsriayutthaya	133,285	1,926,686,749	6,461,593	456.37	Yes
Angthong	58,359	221,190,353	3,264,873	598.7	Yes
Lopburi	140,314	569,914,914	17,522,472	492.66	Yes
Singburi	48,565	225,769,966	2,304,224	775.99	Yes
Chainat	66,962	117,460,612	1,927,320	529.47	Yes
Saraburi	114,310	4,542,633,732	6,740,622	706.34	Yes
Chonburi	231,093	2,948,121,537	59,362,613	915.25	Yes
Rayong	120,994	2,490,157,307	13,032,213	962.87	Yes
Chantaburi	108,220	419,817,280	11,144,113	866.29	Yes
Trad	44,800	169,229,400	5,856,812	801	Yes
Chacherngsao	108,221	1,316,902,790	13,590,442	663.62	Yes
Prajinburi	118,077	399,776,158	4,976,901	466.6	Yes
Nakornnayok	42,446	134,374,330	3,567,476	521.6	Yes
Srakaew	36,953	72,796,832	3,379,376	402.69	Yes
Nakornratchasima	432,907	1,467,326,205	12,826,612	454.54	Yes
Burirum	226,158	273,242,918	6,497,719	439.66	Yes
Surin	202,928	241,657,236	7,265,821	349.52	Yes
Srisaket	219,348	197,373,831	4,054,789	384.63	Yes
Ubonratchathani	257,284	368,269,177	12,703,644	379.5	Yes
Yasothorn	94,598	97,050,330	3,085,470	414.86	Yes
Chaiyapum	193,607	240,196,542	9,853,986	356.88	Yes
Amnardcharoen	58,379	54,011,244	1,233,501	393.43	Yes
Nongbualumpoo	78,149	71,735,544	1,059,751	379.48	Yes
Khonkaen	302,563	762,959,211	37,899,599	462.27	Yes
Udornthani	249,801	455,948,498	19,639,884	426.24	Yes
Loei	113,216	116,791,614	4,647,608	628.79	Yes
Nongkhai	144,236	175,955,053	5,093,499	592	Yes
Mahasarakham	167,237	167,015,847	3,694,683	363.66	Yes
Roi-ed	229,565	249,595,765	4,972,105	415.89	Yes
Kalasin	164,181	228,347,622	4,331,922	419.65	Yes
Sakonnakorn	175,798	185,668,489	6,092,072	418.57	Yes

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Nakornpanom	112,132	119,188,490	5,314,191	292.71	Yes
Mukdaharn	51,581	70,876,858	1,672,465	393.3	Yes
Chiangmai	358,114	1,072,529,811	23,709,324	530.51	Yes
Lampun	105,199	355,062,113	2,219,760	573.24	Yes
Lampang	183,600	329,073,170	9,381,031	496.69	Yes
Utaradit	94,600	180,456,469	239,404	507.3	Yes
Phrae	114,171	148,597,088	4,798,891	504.03	Yes
Nan	92,563	95,371,890	2,815,394	355.68	Yes
Payao	114,944	121,397,225	4,625,729	450.57	Yes
Chiangrai	254,298	353,551,531	9,855,240	398.68	Yes
Maehongsorn	24,595	38,466,900	2,027,875	318.83	Yes
Nakornsawan	200,138	466,672,765	4,114,300	525.84	Yes
Uthaithani	59,316	90,540,390	1,117,521	435.89	Yes
Kampaengpet	119,553	215,437,393	4,179,826	600.71	Yes
Tak	71,042	164,283,355	7,813,711	437.55	Yes
Sukothai	113,998	182,129,080	6,784,834	578.14	Yes
Pitsanulok	155,170	382,216,665	2,818,108	448.43	Yes
Pichit	106,698	172,886,233	5,995,923	559.27	Yes
Petchabun	164,553	242,631,363	5,964,794	481.06	Yes
Ratchaburi	141,546	951,671,234	7,901,460	691.57	Yes
Kanchanaburi	128,384	584,365,898	6,510,702	718.08	Yes
Supanburi	166,689	414,584,326	10,507,416	643.24	Yes
Nakornpathom	160,583	1,867,884,181	7,576,545	959.24	Yes
Samutsakorn	115,349	3,345,814,725	5,078,358	629.97	Yes
Samutsongkram	32,751	115,664,644	3,529,356	617.33	Yes
Petchaburi	84,083	270,969,238	7,149,606	615.35	Yes
Prajuabkirikhan	84,483	456,948,276	6,005,966	782.87	Yes
Nakornsrithammarat	241,442	609,199,947	7,022,486	511.04	Yes
Krabi	45,149	132,494,942	4,440,205	614.07	Yes
Phang-nga	41,007	166,892,411	1,628,367	459.82	Yes
Phuket	56,831	595,211,359	9,704,060	852.58	Yes
Suratthani	148,304	602,444,858	12,941,486	601.01	Yes
Ranong	23,383	147,865,356	2,995,395	668.49	Yes

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Chumporn	67,414	213,496,274	8,589,021	543.74	Yes
Songkla	224,282	1,266,306,887	23,232,182	526.36	Yes
Satun	39,872	121,005,120	2,676,640	721.55	Yes
Trang	88,707	303,804,361	6,605,408	544.99	Yes
Pattalung	92,035	126,120,661	2,854,908	544.38	Yes
Pattani	94,645	242,580,797	375,356	405.69	Yes
Yala	67,902	195,897,917	2,350,732	524.95	Yes
Narativas	96,672	171,691,342	5,058,808	436.05	Yes

Water Rates (Baht per cubic meter)

Min. charge 100 Baht

Water Used (cubic meters)	Price (Increase 0.5 B/mth until rate)	
0-10	6.5	10
11-20	9.5	13
21-30	12.5	16
31-50	15.5	19
51-80	17.5	21
81-100	17.75	21.25
101-300	18	21.5
301-1,000	18.25	21.75
1,001-2,000	18	21.5
2,001-3,000	17.75	21.25
3,001-up	17.5	21

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Electricity Rates for Regional Areas

Type of Activity		Demand Charge Baht/kW	Energy Charge Baht/kW	Service Charge Baht
1. Small business			min. charge: 87.85 Bht/mth	
with billing demand	First 35 kWh	-	89.89	-
less than 30 kW	Next 115 kWh	-	1.12	-
	Next 250 kWh	-	2.13	-
	Above 400 kWh	-	2.42	-
2. Medium business with billing demand between 30 kW-2,000 kW and average use of electricity for last 3 months not exceeding 355,000 kWh/mth				
(a) Normal Rate:	>69 Kvolt	175.7	1.02	-
average use	22-33 Kvolt	196.26	1.06	-
of electricity for last 3 months not exceeding 250,000 kWh/mth	<22 Kvolt	221.5	1.09	-
(b) Time of Use Rate:	>115 Kvolt	102.8	1.53,0.67,0.61	400
average use of	>69 Kvolt	158.88	1.63,0.68,0.62*	400
electricity for last 3	22-33 Kvolt	200.93	1.77,0.69,0.62*	850
months exceeding 250,000 kWh/mth	<22 Kvolt	214.95	1.89,0.73,0.66*	850
3. Large business with billing demand > 2,000 kW or average use of electricity for last 3 months exceeding 355,000 kWh/mth				
(a) Time of Day Rate:	>69 Kvolt	224.3,29.91,0**	1.02	-
	22-33 Kvolt	285.05,58.88,0**	1.06	-
	<22 Kvolt	332.71,68.22,0**	1.09	

(b) Time of Use Rate: same as 2 (b) same as 2 (b) same as 2 (b) same as 2 (b)

*Depending on Time of Use Rate, which is divided into three intervals: Mon-Sat 9.00 to 22.00 (on peak); Mon-Sat 22.00 to 9.00 (off peak) and Sunday (24 hrs) 00.00 to 24.00 (off peak), respectively.

**Depending on Time of Day Rate, which is divided into three intervals: 18.30 to 21.30 (on Peak); 8.00 to 18.30 (partial peak) and 21.30 to 8.00 (off peak), respectively.

Source: Provincial Electricity Authority.

Province	No.of Parks	Average Land Price (BHT)	Zone	Average Temperature
Bangkok	3	67,072	1	28.8
Samutprakarn	2	21,306	1	n.a.
Nontaburi	0	24,108	1	n.a.
Patumthani	0	21,342	1	n.a.
Pranakornsriayutthaya	4	4,553	2	n.a.
Angthong	0	3,873	2	n.a.
Lopburi	0	3,825	3	27.9
Singburi	0	3,602	3	n.a.
Chainat	0	4,247	3	n.a.
Saraburi	2	4,469	2	n.a.
Chonburi	4	30,220	2,3	27.8
Rayong	6	16,117	3	28
Chantaburi	0	10,102	3	27.2
Trad	0	6,013	3	27.3
Chacherngsao	2	3,630	2	n.a.
Prajinburi	0	4,740	3	27.9

Nakornnayok	0	7,928	2	n.a.
Srakaew	0	3,345	3	27.5
Nakornratchasima	0	21,809	3	26.9
Burirum	0	2,389	3	n.a.
Surin	0	2,793	3	26.5
Srisaket	0	2,740	3	n.a.
Ubonratchathani	0	6,688	3	26.8
Yasothorn	0	2,243	3	n.a.
Chaiyapum	0	3,006	3	26.6
Amnardcharoen	0	2,510	3	n.a.
Nongbualumpoo	0	2,908	3	n.a.
Khonkaen	0	24,694	3	26.5
Udornthani	1	3,009	3	26.2
Loei	0	2,817	3	25.1
Nongkhai	0	2,875	3	25.8
Mahasarakham	0	2,273	3	n.a.
Roi-ed	0	2,637	3	26.4
Kalasin	0	2,377	3	n.a.
Sakonnakorn	0	2,963	3	25.8
Nakornpanom	0	2,496	3	25.7
Mukdaharn	0	2,059	3	26
Chiangmai	0	30,934	3	25.2
Lampun	1	3,493	3	26.2
Lampang	0	11,438	3	26
Utaradit	0	4,142	3	27.1
Phrae	0	5,155	3	25.9
Nan	0	5,101	3	25.5
Payao	0	4,608	3	24.9
Chiangrai	0	21,104	3	24.3
Maehongsorn	0	4,330	3	25.5
Nakornsawan	1	6,117	3	27.7
Uthaithani	0	4,031	3	n.a.
Kampaengpet	0	3,286	3	27

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Tak	0	5,275	3	25.4
Sukothai	0	3,667	3	n.a.
Pitsanulok	0	4,813	3	27.5
Pichit	1	10,402	3	n.a.
Petchabun	0	3,102	3	26.5
Ratchaburi	1	9,540	2	n.a.
Kanchanaburi	0	9,981	2	27.2
Supanburi	0	10,691	2	27.9
Nakornpathom	0	22,290	1	n.a.
Samutsakorn	1	13,208	1	n.a.
Samutsongkram	0	6,355	2	n.a.
Petchaburi	0	14,274	3	27.6
Prajuabkirikhan	1	9,057	3	27.3
Nakornsrithammarat	0	15,634	3	n.a.
Krabi	0	4,218	3	n.a.
Phang-nga	0	3,890	3	27
Phuket	0	30,381	3	27.8
Suratthani	0	15,277	3	26.9
Ranong	0	10,748	3	27.1
Chumporn	0	10,930	3	26.8
Songkla	1	25,261	3	27.1
Satun	0	4,564	3	27.3
Trang	0	8,174	3	27
Pattalung	0	11,091	3	n.a.
Pattani	0	4,951	3	26.9
Yala	0	6,333	3	n.a.
Narativas	0	5,858	3	26.9

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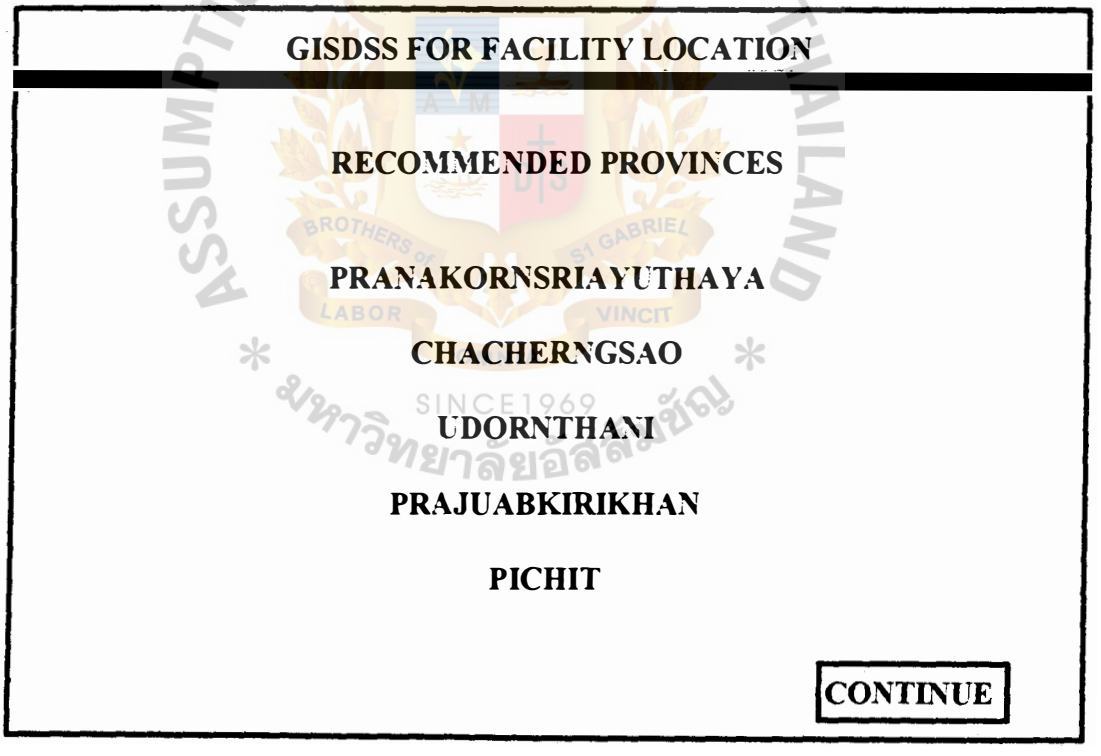
APPENDIX F

AN ADDITIONAL PORTION OF A SYSTEM'S CONSULTATION SESSION

The recommendation output provided by the system after receiving the factors' weight from user as follows: 0 for Market; 0.1 for Land Cost; 0.2 for Transportation; 0.3 for Utilities and Raw Material; 0.4 for Labor; 0.5 for Industrial Parks and Investment Promotion Zone; and 0.6 for Environmental Concerns and Governmental Considerations.



GISDSS FOR FACILITY LOCATION

PRANAKORNSRIAYUTHAYA

Advantages:

- **High Labor Forces**
- **Many Industrial Parks**
- **High Purchasing Power**

Disadvantages

- **Low Utilities**
- **Not so Good Transportation**

To see graphical display click CONTINUE. **CONTINUE**

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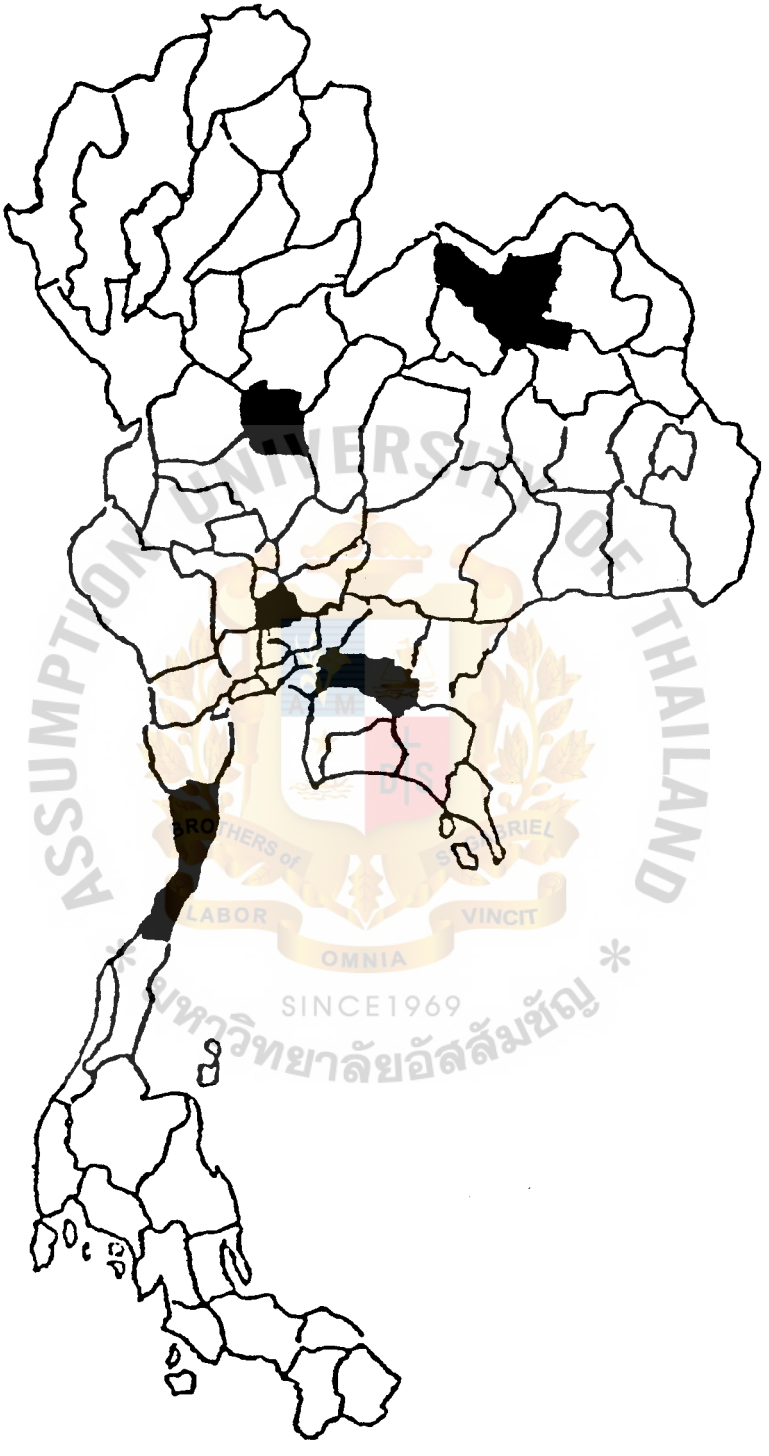

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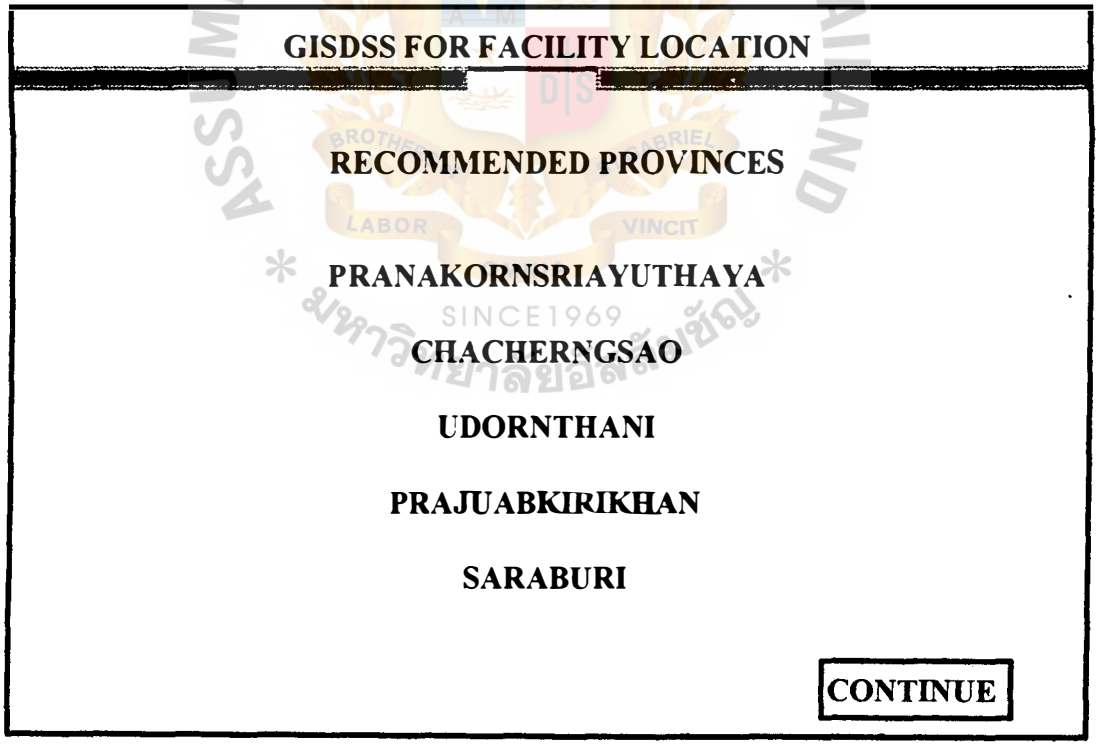
The recommendation output provided by the system after receiving the factors' weight from user as follows: 0.2 for Market and Raw Material; 0.1 for Land Cost and Utilities; 0.5 for Transportation; 0 for Investment Promotion Zone; and 1 for Labor, Industrial Parks, Environmental Concerns and Governmental Considerations.



GISDSS FOR FACILITY LOCATION

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Advantages:

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To see graphical display click CONTINUE. **CONTINUE**

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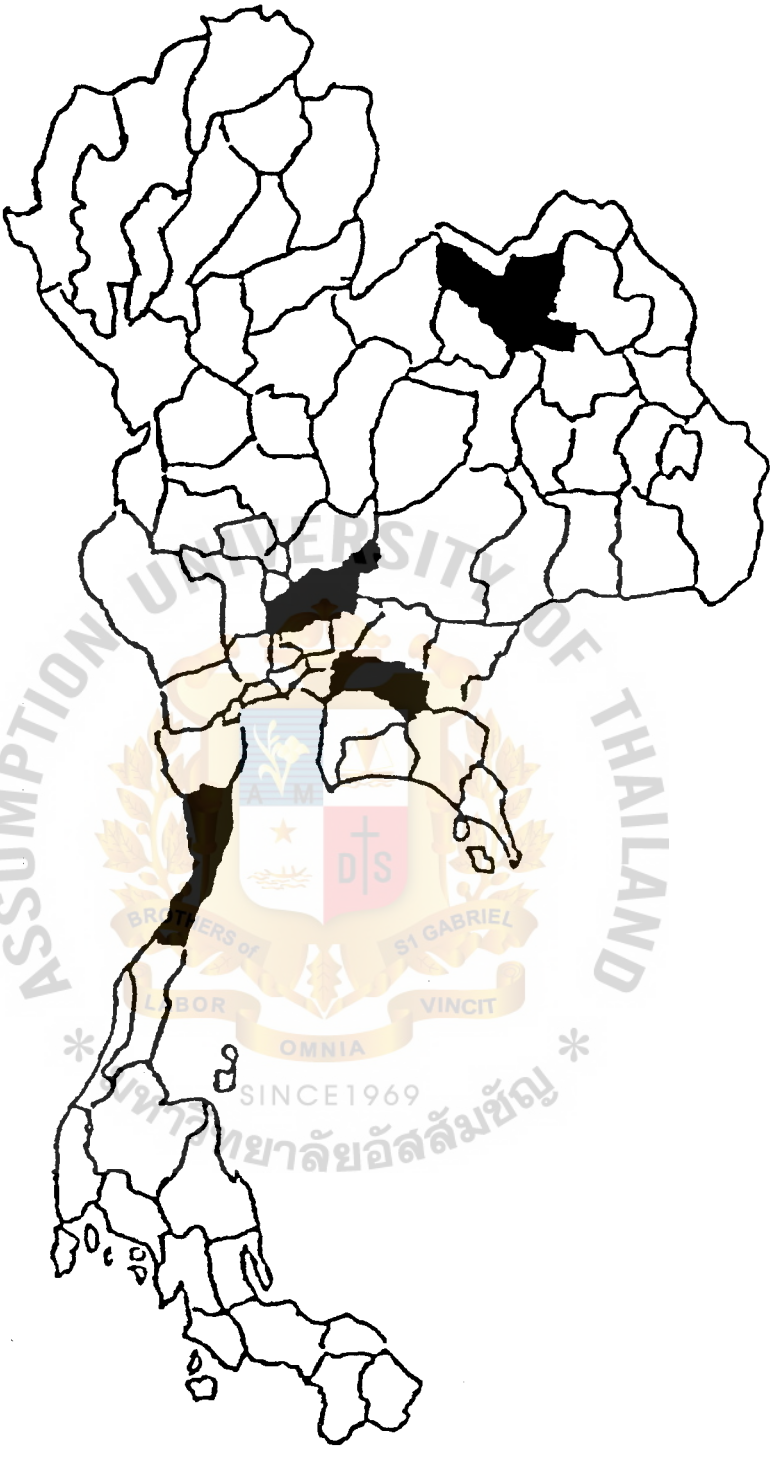

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