CHAPTER III

POTENTIAL SITE SELECTION

Geographic Information System Definition

Geographic information system (GIS) is a system of computer hardware and software designed to collect, manage and analyze large volume of spatially referenced data and associated attributes (Carter, 1988, Dopson, 1993, and Peuquet, 1993).

Geographic Information System Theory

GIS can be described in term of general functional characteristics. The functional components of GIS can be grouped into five categories (Sarapirom and Chantaprab, 1994) : user interface, system/database management, database creation/data entry, data manipulation and analysis, and display and product generation.

1. User interface is the human operator communicates with the database and GIS application modules. The user interface consists of software capabilities that simplify and organize the interaction between the user and the GIS software.

2. Database management provides the environment within GIS function controlled. The system management is furnished by the operating system of the host computer.

3. Database creation/data entry refers to the process of bringing data into the electronic environment of GIS. A GIS database is often conceptualized as a series of thematic categories or layers of information. These layers contain information from aerial photography, satellite data, conventional maps and others sources. Data entry is the process of loading data into a GIS database. A data base may be created by digitizing or scanning. Generally, two types of data collected are geographic and accompanying feature attribute data. Geographic information is usually digitized from existing maps or images. Attributes identify the feature represent in the form of numeric or textual information.

4. Data manipulation and analysis are combining data from multiple spatial data categories and performing analytical statistical, measurement and other operation on the GIS data sets to transform the data into information suitable for a given application.

5. Display and product generation are the presentation and production of the GIS analysis result.

Geographic Information System Application

Tourism development is a human activity that the occurrence relates to human's decision. Geographic information system (GIS) can support the decision making with a powerful set of tools for the manipulation and analysis of spatial information. The objective of deplaying GIS in this study is to determine the best site for tourism area following the criteria of the development master plan. This process based on multicriteria evaluation technique (MCE) to evaluate the suitability of sites falling within the feasible area identified using GIS overlay procedure (Carver, 1991). Multicriteria evaluation methods can use for various purposes because they are applicable to each situation involving a classification. This approach can be used in planning research in many different ways.

Voogd (1983) studied about the potential housing sites using multicriteria evaluation technique. He found that this technique suitable for urban planning.

Carver (1991) used GIS and multicriteria evaluation technique to search for suitable sites for the disposal of radioactive waste in UK. He concluded that GIS and multicriteria techniques are the powerful sets of tools that can provide the user with the means to evaluate various alternatives on the basis of multiple and conflicting criteria and objectives.

Aksornkit *et al.* (1994) reported the GIS is useful for site selection for tourism in Pang-nga. This study used Potential Surface Analysis (PSA) technique to analysis and overlaid these factors. The emphasized factors were physical and environmental factors. The output provided the potential area for three types of tourism, namely, historical or cultural tourism site, passive tourism site, and active tourism site.

Potential Site Selection Methodology

The aim of this study is to determine impacts of tourism area expansion on Ko Samui/Surat-thani coastal area. The meaning of tourism area in this study refers to resorts, hotels, restaurants, cafeteria and other tourism service area. For coastal/marine tourism, beaches and gulfs area are the most attractive places for develop to tourism site (TISTR, 1988). The others types of tourism, the falls and cultural places, are the less attractive for develop to resorts area because these are usually back and forth tourism.

The criteria for developing tourism beach from Ko Samui/Surat-thani Tourism Development Master Plan (TISTR, 1985) divided tourism beach to three types.

1. Progress beaches tourism should not develop more than 60% of total beach area and far from sandy beach at least 50 meters by flood tide consideration. There are Chaweng, Lamai, Thong Yang and Nathon.

2. Natural beach tourism can develop for tourism less than 30% of total beach area and should be far from sandy beach at least 50 m by flood tide consideration. There are Maenam, Bo Phut, Bang Rak, Choeng Mon and Thong Ta Kien.

3. Conservative beach preserve the natural and environment. There are Ka Ki Bay, Laem Set, Laem So, Leam Ko Phan and Laem Son.

There are many condition that a land has considered to convert an area into tourism site. In this case most of conditions were physical factors (TISTR, 1988).

- beach distance
- road distance
- slope gradients
- legal status followed as development master plan, namely, forest area, and original community area which were excluded from the analysis.

These factors were selected and listed by importance order (TISTR, 1988 and Aksornkit, 1994) for coastal tourism development.

Materials and equipment

Data derivation were done by using several software and equipment.

1. ARC/INFO. software was developed by ESRI company, USA. This software was used for data capture which provided database for decision making analysis.

2. IDRISI. software was developed by Clark University, USA. This software was used for data analysis.

3. Calcom Digitizer is the equipment used for data capture with ARC/INFO.

4. 1:50,000 topographical maps were prepared and published by the Defense Mapping Agency Topographic center (in Washington DC.) in cooperation with the Royal Thai Survey Department. The study area was in 4928 I and 4928 II sheet , L7017 series and 2-RTSD edition.

Identifying the Criteria

Identifying criteria can be approached by considering site characteristics and situation conditions. Site characteristics refer to surface and near surface qualities the land must possess for the land use activity being proposed. Site characteristic might include such factor as the slope of land, land cover type and other criteria that are derived from the physical qualities of land at each site. Situation comprise relationship between each site and surrounding areas. In this study, Ko Samui region was considered site characteristics and situation conditions for tourism area. These considerations suggested that the following factors included in the analysis.

1. Beach Distance

The distance from beach was an important factor for coastal tourism because of the attractive for tourists. Most resorts situated near the beach would be quite advantageous.

This factor derived from 1988 land use image that was classified from TM data in previous chapter. Classified image was reclassified to beach Boolean image. Boolean image was created into beach distance by IDRISI (Figure 3.1)

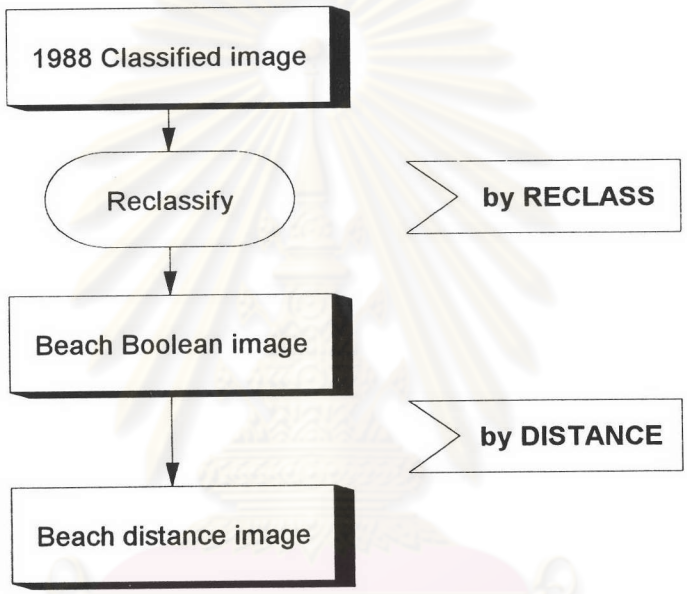


Figure 3.1 The process of beach distance factor generation diagram

2. Road Distance

The distance from road was as important as beach distance. Because of the accessibility to tourism area depend on the road distance. The tourism place that exist near the road would have the potential for development.

To obtained this factor, digitized into a vector form from the 1:50,000 topographical map of the study area by ARC/INFO software and registered to the UTM reference. The vector data were transformed into raster form by IDRISI software (Figure 3.2).

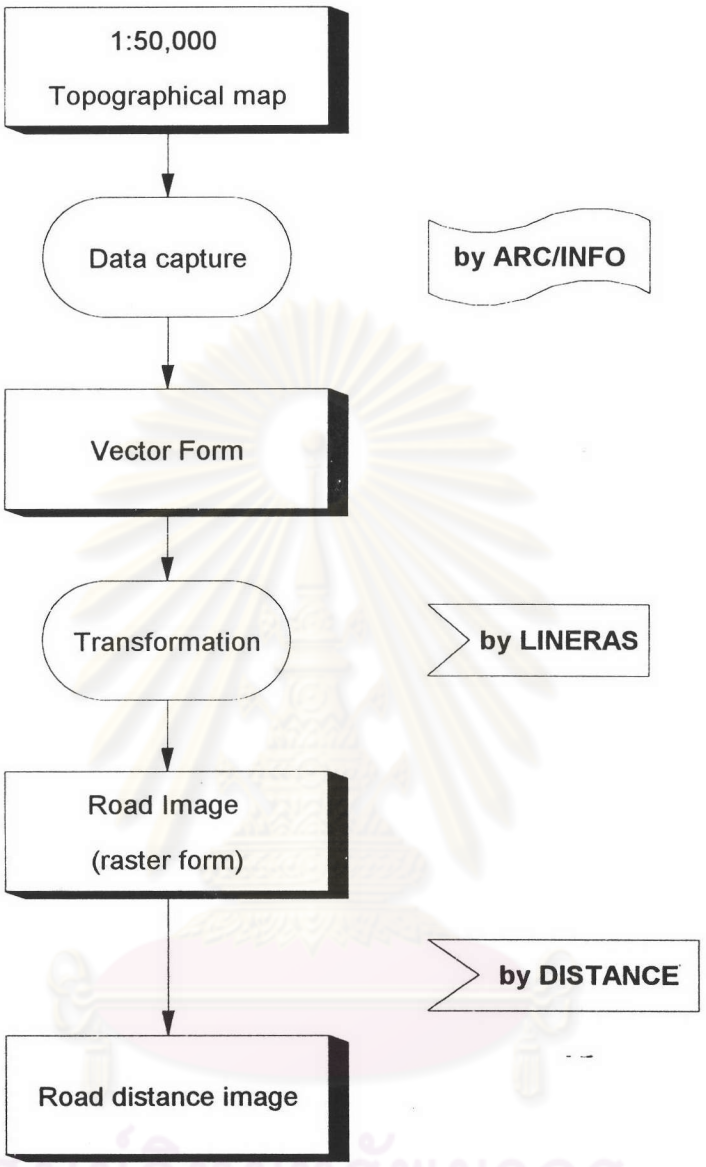


Figure 3.2 The process of road distance factor generation diagram

3. Slope Gradients

Most tourism areas development would find appropriate slope. Steeper slopes increase construction costs and risk for erosion. So slope selection for tourism area is suggested to be these slopes having less than 8% (Aksornkit, 1994).

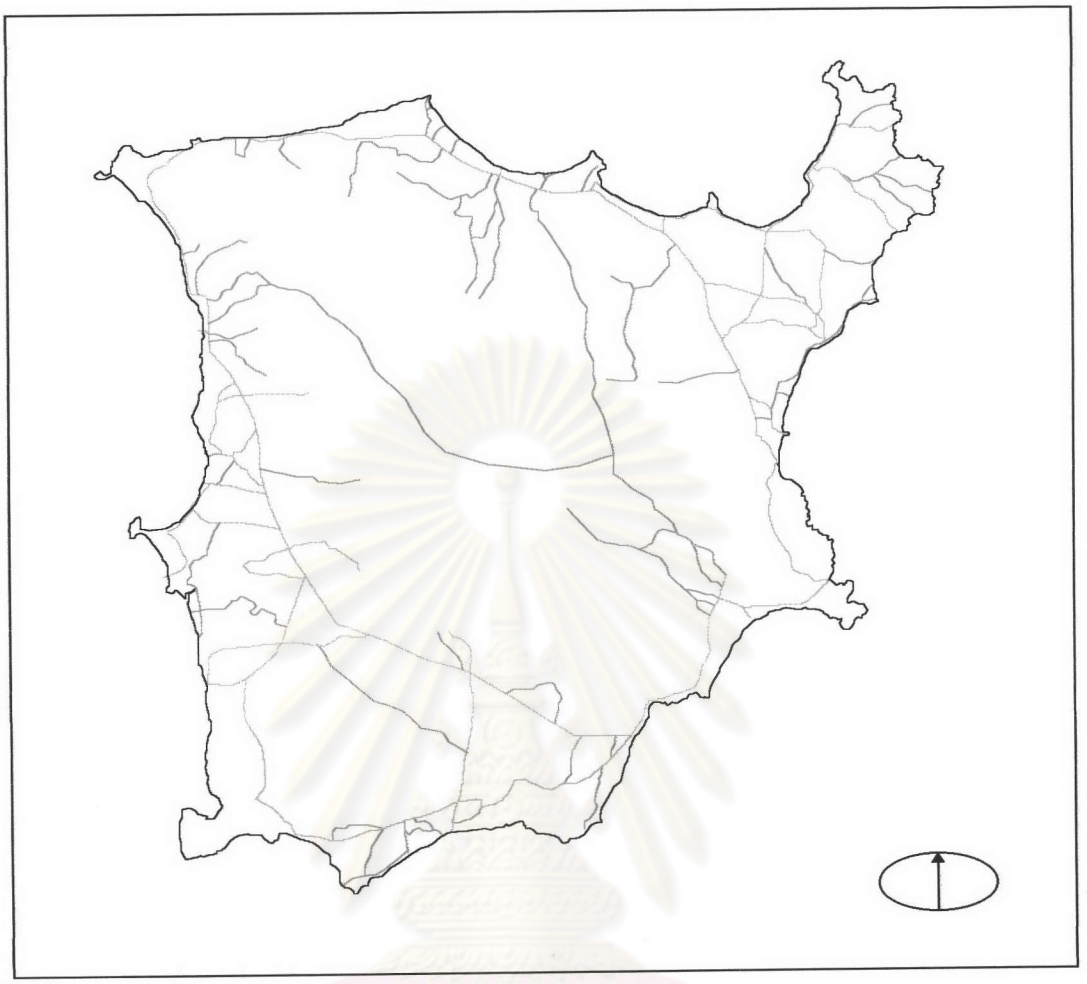


Plate 3.1 Road factor map

This data derived by digitized contour lines from 1:50,000 topographical map by ARC/INFO in vector form. The contour lines were interpolated to altitude map by SURFER program. This altitude map was generated the slope gradients by IDRISI program (Figure 3.3).

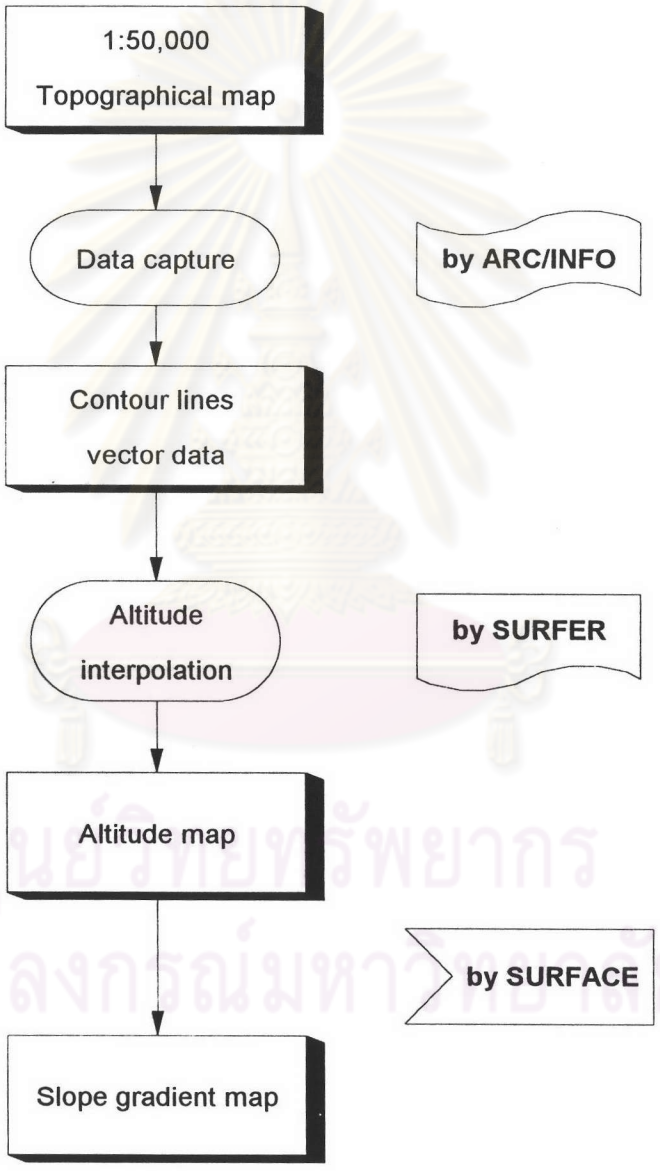


Figure 3.3 The process of slope gradients generation diagram

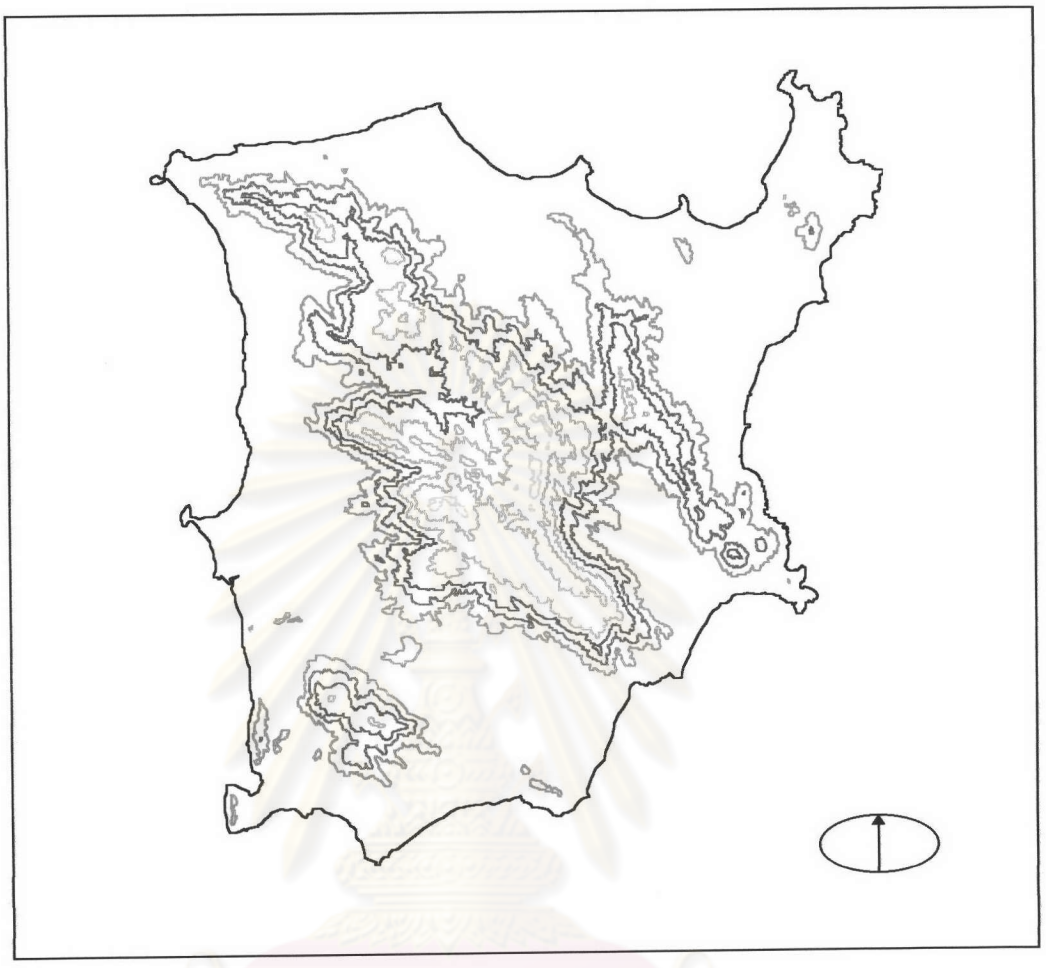


Plate 3.2 Contour line of Ko Samui

4. Beach Constraints

Beach development for tourism area should have the distance from beach at lease 50 meters. So the boundaries within 50 meters area was the constraints that no development can be considered (TISTR, 1988).

This map can be obtained by reclassifying the beach distance to the Boolean image by IDRISI program. The area that have distance less than 50 metered from the beach was excluded. The result showed the consideration area that have the distance more than 50 meters from the beach (Figure 3.4).

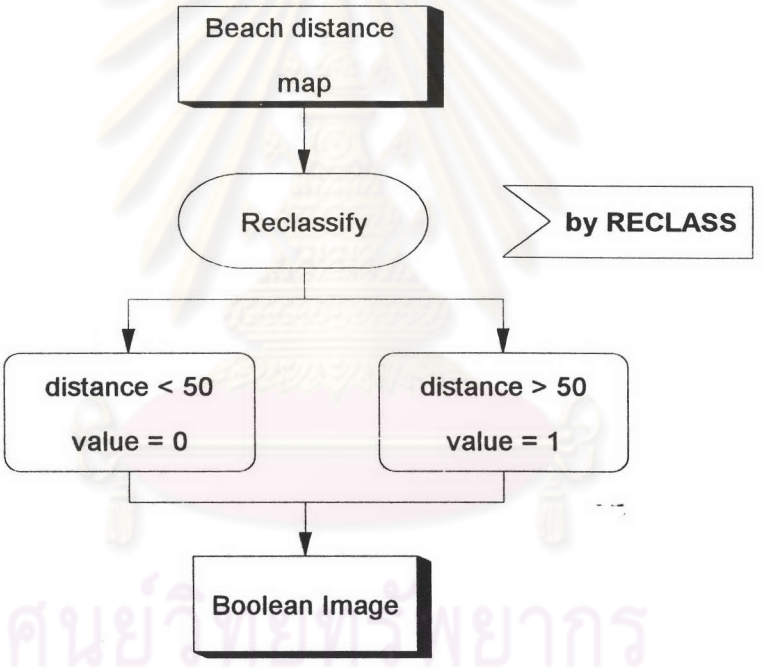


Figure 3.4 The process of beach constraint generation diagram

5. Forest Constraints

Area of forest should be no development because the forest area is the preservation area. So forest area was the constraints for the tourism development.

To generate this factor can be produce by the same method of beach constraints which used 1988 land use image for the raw image.

6. Original Community Constraints

Ko Samui has original community before tourism development. Original community was excluded in this study because this community is the urban characteristic area like the tourism area in the satellite data. So the potential site selection process was not included the original community area.

This data can be captured from 1:50,000 topographical map by ARC/INFO in the vector form. Then converted to raster form by IDRISI.

Criteria Decision Procedure

This procedure, factors was combined into a single decision image which can call a suitability or potential map. The factors was combined in the form of a weighted linear combination (Voogd, 1983). This procedure can be done as follow.

1. Standardization

Before criteria combination, it is necessary that factors be standardized because of the different scales. This mean that the worst criterion score will always have a standardized score of 0, and the best a score of 1 (Eastman *et al.*, 1995). The transformation in this case provided by STRETCH module in IDRISI.

2. Weights

Weights or criterion priorities refers to specify the importance of individual factors relate to the others included in the evaluation. The development of weights technique for this study was used pairwise comparison which in the context of decision making process known as the Analytical Hierarchy Process : AHP (Saaty, 1990).

Table 3.1 9-point rating scale

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely	very strong	strongly	moderately	equally	moderately	strongly	very strong	extremely
less important					more important			

Pairwise comparison matrix derived by factor relative consideration with important priority. In making these judgments, a 9 point rating (Table 3.1) is used (Saaty, 1990). This study used three weighting pairwise comparison in order to compare weighting result.

Each factor is of equal importance to itself. For the first pairwise (Table 3.2), beach distance was equally importance to road distance, and it thus received a rating of 1. Relative to being near beach, other rated the relative importance of being near slope as very strong less importance (1/8). The next rating were then based on the second column, relative to being near the road, slope were rated as being very strong less importance (1/8). The others weighting have the same interpretation but decrease the importance of slope gradient factor in order to vary weighting.

Table 3.2 First pairwise comparison matrix of factor scores

	Beach distance	Road distance	Slope gradient
Beach distance	1	1	8
Road distance	1	1	8
Slope gradient	1/8	1/8	1

Table 3.3 Second pairwise comparison matrix of factor scores

	Beach distance	Road distance	Slope gradient
Beach distance	1	1	5
Road distance	1	1	5
Slope gradient	1/5	1/5	1

Table 3.4 Third pairwise comparison matrix of factor scores

	Beach distance	Road distance	Slope gradient
Beach distance	1	1	3
Road distance	1	1	3
Slope gradient	1/3	1/3	1

The factor scores was calculated into the weights by WEIGHT module in IDRISI. The formula for factors weighting calculation were defined as :

$$W_i = \sum_{j=1}^{k} Si \Big/ \sum_{j=1}^{k}\sum_{i=1}^{k} S$$

where

W_i = factors weighting

S = factors score

i = row i^{th} of matrix

j = column j^{th} of matrix

k = the number of row and column of matrix

Then provided the result in Table 3.5, 3.6 and 3.7.

Table 3.5 First weighting from first pairwise comparison matrix

Factors	Weighting
Beach distance	0.4706
Road distance	0.4706
Slope gradient	0.0588

Table 3.6 Second weighting from second pairwise comparison matrix

Factors	Weighting
Beach distance	0.4545
Road distance	0.4545
Slope gradient	0.0909

Table 3.7 Third weighting from third pairwise comparison matrix

Factors	Weighting
Beach distance	0.4286
Road distance	0.4286
Slope gradient	0.1429

3. Weights combination

Weighted linear combination was performed by the MCE module in IDRISI with three factors and their weights and indicated the three constraints. This constraints were beach constraint, forest constraint, and original community constraint. Factors were combined by mean of a weighted linear combination. Constraints were Boolean in character and serve to exclude certain areas from consideration. This procedure started by multiplying each factor by a weight then the constraints are applied by successive multiplication to zero out excluded areas. The result was a suitability map. The weighted linear combination could be defined as.

$$S = \sum W_i X_i C_j$$

where

S = suitability

W_i = weight of factor i

Xi = criterion score of factor i

C_j = criterion score (0/1) of constraint j

4. Potential site selection

To select the best site used RANK module. This stage generated ranked image that has a 25 × 25 meter cell size. Then reclassified the ranked image.

The conclusion of potential site selection performed in Figure 3.5.

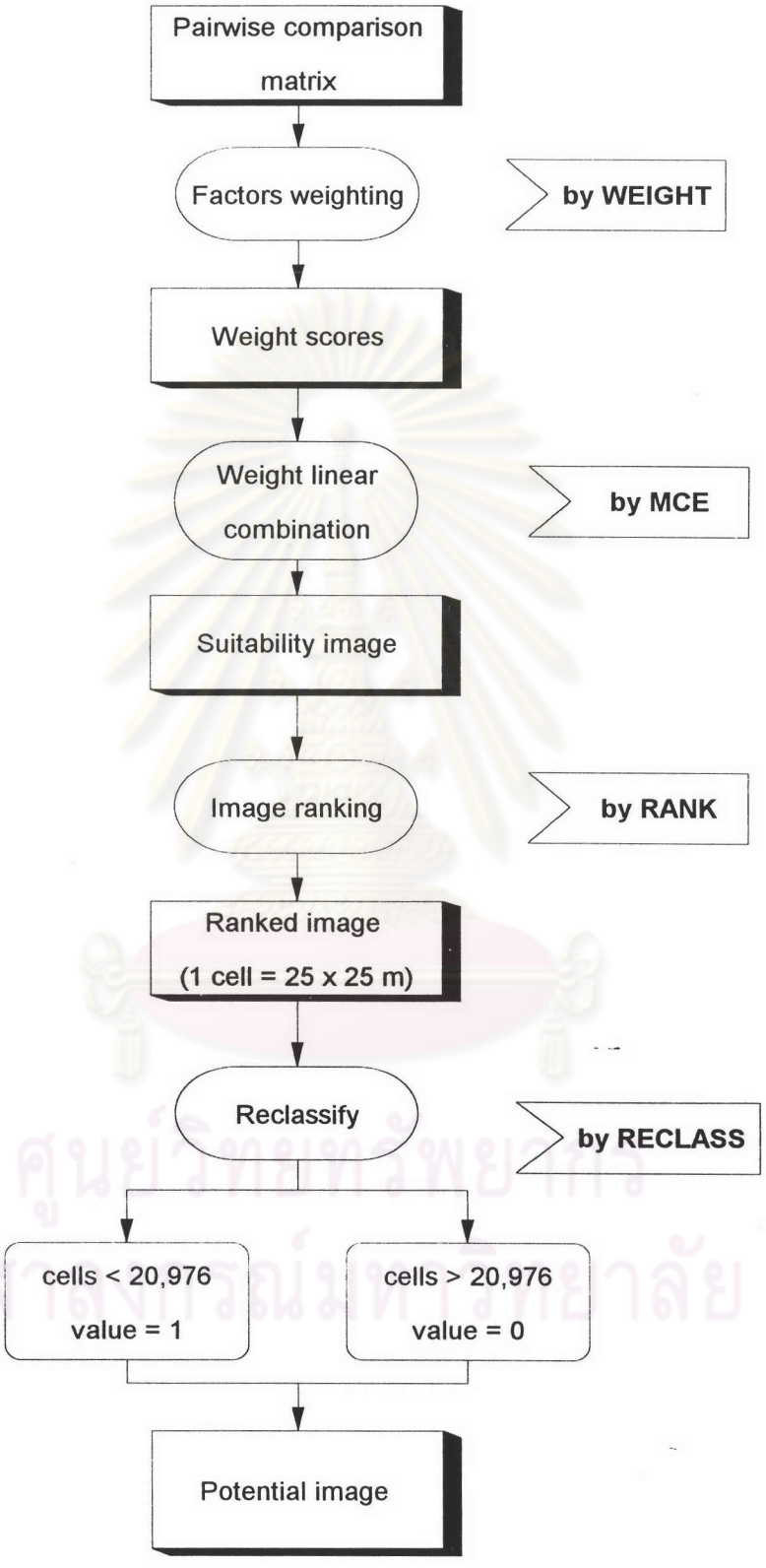


Figure 3.5 The process of potential image generation diagram

Potential Site Selection Result

Potential area

The potential for tourism area at Ko Samui showed in Plate 3.3, 3.4 and 3.5. The best site for this study was generated from first weighing (Plate 3.3). Because this potential area located in the scope of master plan and carrying capacity criteria. The second and third weighting provided the similar output, and the potential sites did not match the master plan criteria. Therefore, the first weighting performed the most suitable map.

The result showed the potential area for future development (since 1988) were beach nearby areas around the island. There were Chaweng, Lamai, Bophut, Bangrak, Maenam, Nathon, and Taling-ngaam beach. The include potential area is 13.11 square kilometers.

scale 1:150,000

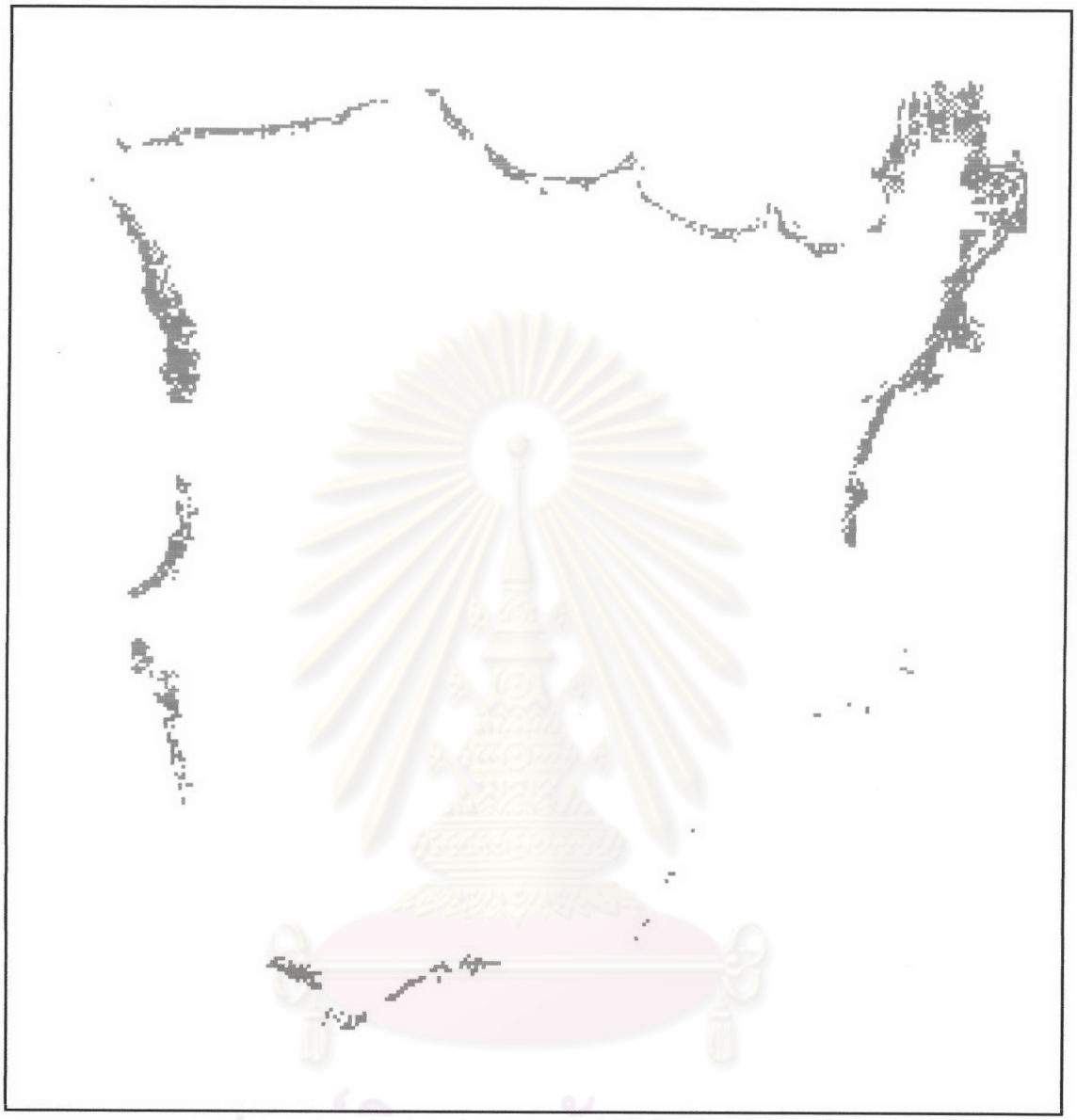
N

Plate 3.3 Potential area for tourism development from first weighting

scale 1:150,000

N

Plate 3.4 Potential area for tourism development from second weighting



scale 1:150,000

N

Plate 3.5 Potential area for tourism development from third weighting

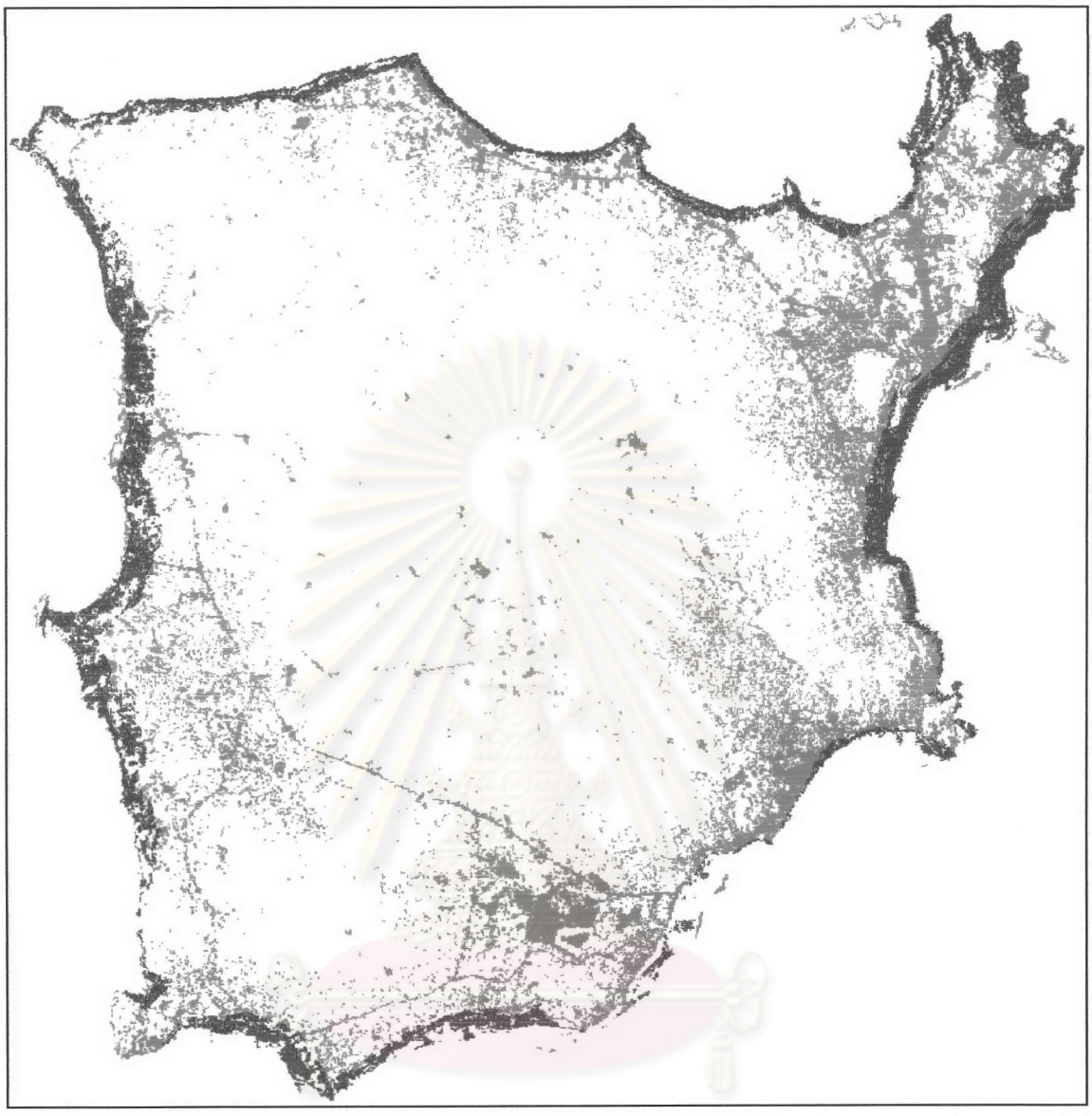
Justify the Tourism Impact Area

This process is justify tourism impact on coastal area. It is refer to tourism area that expanded out of the potential area. It indicated that there are over limit of carrying capacity of the island. The procedure was done by comparison between the best potential area and urban Boolean of 1994 classified image by cross-tabulation technique using CROSSTAB module in IDRISI.

The comparison of the potential site and the present tourism area in 1994 output showed in Plate 3.6. This site is the tourism area in 1994 that expanded over the boundary of the potential site. The red area (Plate 3.6) distributed in the middle of the island was tourism area expansion in the present. The cross-tabulation between potential area and the urban area in 1994 showed that the development of urban area exceeded the extent of potential area.

Table 3.8 Potential area and urban area in 1994 cross-tabulation

1994	potential area			
Boolean (pixel)	non potential	km2	potential area	km2
non UB	316382	197.74	5011	3.13
UB	52702	32.94	21105	13.2



scale 1:150,000

N

UN
PA
UBOUT
UBIN

Remark UN : unclassified

PA : potential area

UBOUT : urban area located outside potential area

UBIN : urban area located within potential area

Plate 3.6 Crosstabulation between potential area and urban area in 1994

Discussion

Potential area can obtain by GIS technique that integrate many of relative factors. The suitable site for tourism development (Plate 3.3) located around the island and near the beach. The criteria's analysis follow as the carrying capacity study and master plan of tourism development. These two studies focused only the coastal tourism. Therefore, natural beach areas are the major factors that were considered. Tourism place accessibility is importance as well as beach distance. So the distance from beach and road are the first priority in consideration. Other factors were minor priority that powerful as should be. Multicriteria evaluation methods can also imply a significant enrichment of urban and regional planning (Voogd, 1983). Furthermore, these procedure have several advantages. First, the ratings are independent of any specific measurement scale. Second, by its very nature, encourages discussion, leading to a consensus on the weightings to be used.
In addition, criteria that were omitted from initial deliberations are quickly uncovered through the discussion that accompany this procedure.

There is no single rule for factors weighting. Factors weighting depend on factors priority and user consideration, and the criteria of previous studies. This case used three different weightings base on the master plan criteria, the previous studies, and the legal status. The outputs seem to less difference. Because beach distance factors was as important as road factor that had the same weight, so slope factor was the less consideration. This study chose the potential site from the first weighting. The best site of individual beach located within the scope and criteria of master plan and carrying capacity. In this study, the aesthetic value of coastal area was excluded. Thus, one of important factors was omitted in order to determine the potential areas. As a result of this study, areas in beach vicinity, that formerly indentified as incapable of being the tourism sites, were shown to have much sinificance in the development of potential areas. Potential site will be change, if factors and priority have changed. The factors weighting variation is important for GIS application.

The comparison of suitable site and present tourism area by overlay approach provide inappropriate site. The overlap area (blue site in Plate 3.6) is the tourism site within

carrying capacity of the island. The outside is tourism widespread over capacity. Therefore, criteria identifying is important for further analysis. For this study, this technique is useful and can provide the satisfy result base on the criteria of previous study (TISTR, 1988).

By the cause of this suitable area result is sketchy evaluation from the past (1988) for recent compared that data used is basic physical factors. In fact, tourism expansion also consider many factors beside physical factor.

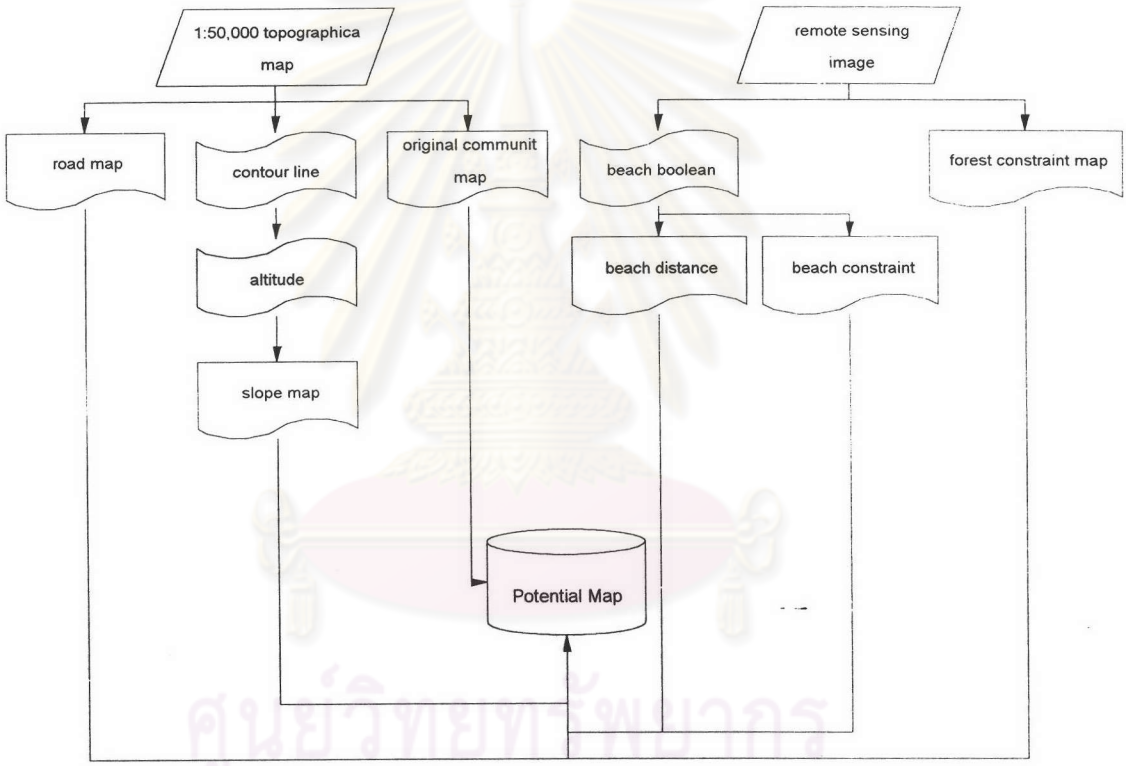


Figure 3.6 The process of factors derivation

However, the accuracy of GIS tool depend on some error. Major sources of error are data source error and human error. The digital cartographic data can come from a variety of source, and usually originate from source material in multiple formats. This study used remote sensing and 1:50,000 topographical map as data sources. These data have different scale and coordinate system. Both data sources generated six factors for further

analysis (Figure 3.6). The generation procedure for each factor was differential complexity and has error for each stage. These error was propagated according to the stage of analysis and the number of factors. In GIS analysis, the data should be transformed in the same scale and coordinate system. This procedure generates data source error. Human error is error from human in data capture stage. Data capture usually use digitizer for cartographic map that will be digitized by human. So data digitizing accuracy depend on human skill.

In this case, slope factor generation was the highest error because error was propagated from, first, contour was digitized from 1: 50,000 topographical map, then interpolated an altitude, and finally altitude was transformed to slope (Figure 3.6). The other factors have the same error characteristics. An error propagation has effect on accuracy and precision of GIS result. Therefor, GIS application should be concern about source of error and error propagation which can indicate GIS modeling accuracy.