CHAPTER III

RESEARCH METHODOLOGY

3.1 Study Site

This study was conducted in Kaeng Krachan National Park, located between 12° 35' – 13° 11'N and 99° 07' – 99° 35'E at the Tenasserim range in Southwest of Thailand. The park has been established in April 1983. With an area of 291,500 hectares, this makes KKCNP become the largest terrestrial national park in Thailand (Figure 3.1).

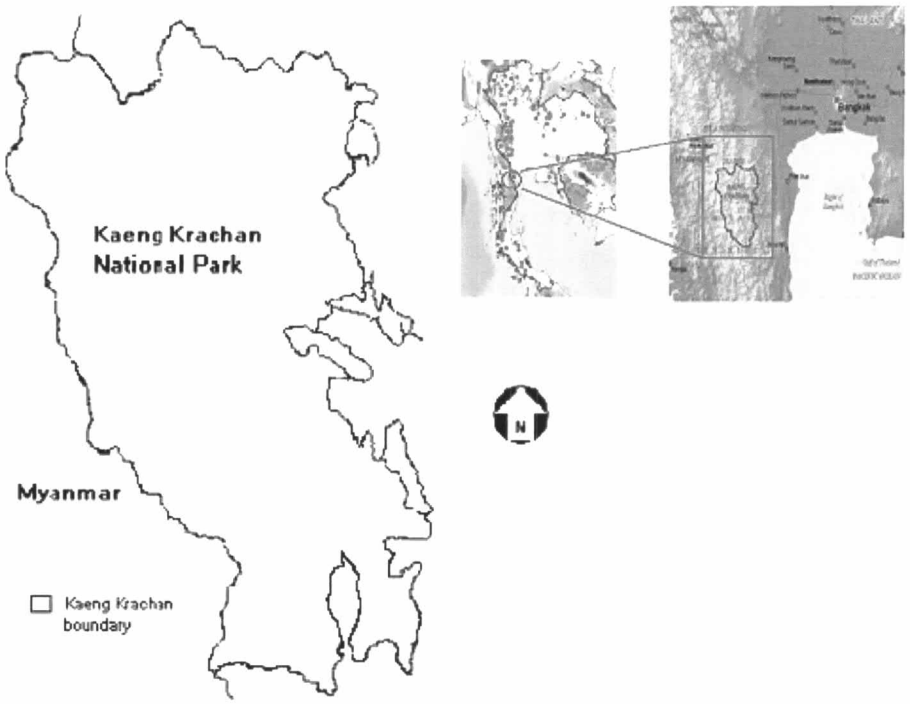

Figure 3.1 Kaeng Krachan National Park established in April 1983. KKCNP ranges approximately 291,500 hectares in the southwestern part of Thailand. (modified from RFD, 1994).

Kaeng Krachan ranges in elevation from 800 – 1200 m from east to west over the Kaeng Krachan watershed area of 46.5 km^2. Rainfall averages 750 - 1200 mm annually and falls in bimodal pattern from the early of May to the end of June and from the early of September to the end of December. Forest covers approximately 95% of the whole

park area. A large number of ecosystem goods and services provided as major food sources to supply local people for long times (Round, 1985; RFD, 1994). The Royal Forest Department reported that more than 80% of the whole vegetation covered are primitive evergreen forests, located mainly in central and southern parts (RFD, 1994). The rest are a mixture of mixed deciduous and dry dipterocarp forests (10%). Agricultural area and abandoned area covers totally 4% of the whole terrestrial part. Aquatic plants occupied only 2 per cent. More than 80% of the whole area comprises of vegetation therefore the park becomes appropriate natural habitat for several kinds of wildlife species.

The areas surrounding KKCNP have high agricultural potentials, and those have undergone significant transformation for cultivation, particularly for pineapple, banana and lime plantations. The area along the borderline has lower potentials and remains substantially forested, although illegal logging and slash-and-burn cultivation extensively increased. The consensus in 1999 recorded that more than 500 local residents settle inside Kaeng Krachan, with particularly dense settlement in the middle-east and southern parts (RFD, 1994). Land tenures outside KKNCP is a mixture of private (rural farming) and communal (business enterprise) ownerships. Wild elephants once ranged across most parts of Kaeng Krachan. As human population growth and land transformation increase around the borders of the park, especially in the southern plateau, elephants have become dense at some specific sites (RFD, 1994 and 2002). Area outside the boundary also has high agricultural potential and human population density by comparison with the area inside where more intact forest.

3.1.1 Overview of Kaeng Krachan National Park

KKCNP encompasses the full extent of the Tenasserim range in the west. Topography is mountainous with the highest peaks at Panoen Thung and Khao Sam Yod. Petchaburi and Bang Kloi watersheds are the main sources of water of Kaeng Krachan reservoir. While Pran Buri watershed feeds the Pran Buri reservoir in the south (Sayer, 1981). The weather is rather wet in rainy season but dry for a short period of time

during summer. Humidity remains high throughout the year with high precipitation level in rainy season. The annual precipitation levels recorded during 1952-1998, from 16 meteorological stations in Petchaburi and Prachuab Khirikhan provinces were estimated. In general, the lowest precipitation level (lower than 50 millimeters) was found in April, during summer time. While highest level (higher than 250 millimeters) was in October. Annual temperature ranges generally from 10 to 40 degrees Celsius (IUCN, 1978, 1979 and 1994).

A major reservoir Kaeng Krachan reservoir, with area of 46.5 square kilometers contains approximately 710 million cubic meters of water capacity to supply large amount of water to both agricultural and industrial sectors in Petchaburi and Prachuab Khirikhan provinces. Inside the park, Kaeng Krachan dam was constructed in 1969. The main purpose of the dam is to irrigate agricultural land, to supply water to industrial and tourism sectors at Hua Hin district in Prachuab Khirikhan province, and to generate hydroelectric power supplying local people in the surrounding areas (RFD, 1994).

3.1.1.1 Land uses

Land use in KKCNP is classified into two main categories: undisturbed and disturbed areas. Undisturbed areas cover all types of primary forests and some parts of transitional or secondary forests which returned by natural and human restorations. Disturbed areas include agricultural land and human settlement area. Undisturbed area covers around 95 percents while disturbed area covers approximately 5 percent of the whole terrestrial part. Agricultural area covers totally 4% and is classified as 2% of agricultural land and 2% of abandoned area (RFD, 1994).

One major problem in KKCNP, like in other terrestrial national parks, is agricultural intensification from indigenous or local people who originally lived inside the park area. It is believed that agricultural land inside the park still increases because local people continuously enlarge their cropping areas although this activity is prohibited by Thai's government. Many regulations are set up to eliminate this problem, for example,

removing indigenous people and some residents to settle in specific sites. Each household has been given a specific size of land for agricultural activities. However, they are not allowed either to move to occupy a new site or to enlarge their agricultural land inside the park. By doing this, difficulties have sequentially been diminished. However, new problems such as overuses of chemical fertilizers and pesticides occurred. Contamination of toxic substances in water system in KKCNP now becomes an interesting issue to discuss. Adjacent area of the park is highly degraded and some are turned into agricultural land (IUCN, 1994; RFD, 1994).

3.1.1.2 Vegetation

Forest ecosystem is a major component in KKCNP. Total forest area is approximately 95% of the whole park area. The land holds a very rich and diverse in terrestrial lives. Several kinds of forest ecosystems provide large valuable forest resources as well as ecosystem goods and services to local people (Round, 1985). RFD officers previously reported that more than 80% of the whole vegetation covered in Kaeng Krachan are evergreen forests (RFD, 1994). The left is classified as 10% of mixed deciduous and dry dipterocarp forests. General characteristics of vegetation community in KKCNP are shown in Table 3.1.

Table 3.1 General characteristics of vegetation community in KKCNP observed in 1993.

Forest type	Averaged tree density (Ind./ha)	Averaged GBH (cm)	Averaged height (m)
Moist evergreen forest	1219	45.73	9.17
Dry evergreen forest	2282	45.70	10.77
Mixed deciduous forest	738	51.69	9.69
Dry dipterocarp forest	1500	36.32	8.27

(Source: modified from RFD (1994)).

Evergreen forest locates mainly in central and southern parts. This is classified into moist and dry evergreen forests according to specific forest characteristics such as dominance species and growth forms. Mixed deciduous forest locates in the middle and northern parts while dry dipterocarp forest locates in the north and eastern parts of the park. Forest area is a major component in KKCNP therefore protection and restoration of forest ecosystems become one important task needed urgently to be managed. In this study, information of forest ecosystems its characteristics are used to construct an ecosystem management model of this site.

3.1.1.3 Community and people

Characteristics and socioeconomic status of local people settled inside and surrounding KKCNP were observed by RFD officials in 1993. Twenty-four villages (3 villages and 21 villages from inside and outside KKCNP, respectively), totally 255 households (60 households and 195 households from inside and outside KKCNP, respectively) were selected and interviewed. It was found that at least 78.30% of people living in the park established their cropping area near their accommodation sites. Almost local villagers (73.6%) did not have property rights on land. However, they can use the land for agricultural activities. Some of them (26.7%) have property rights, however, the rights cannot transfer to other people (RFD, 1994).

The size of land for accommodation was averaged at 0.19 hectare per household. Averaged agricultural area of local people outside KKCNP was approximated at 4.74 hectares per household. However, they required at least 5.84 hectares per household that will be enough for cropping and animal husbandry (RFD, 1994).

However, there had been reported that Kaeng Krachan was still being pressured by local residents. Because number of households increased from 422 to more than 800 households in a few years (approximately 400 households increased) (RFD, 1994). Those local people disturb approximately 40.03 squared kilometers (1.37 per cent of total park area) (RFD, 1994).

General characteristics of local people inside KKCNP were summarized. People whose age less than 10 years (21.46%) and between 20-30 years (23.37%) were major groups of population. Average numbers of person per household (household size) was about 4.5 persons. Almost all of people in this area passed, at least, primary school level. Only 3.5 percent of sampling group was undergraduate students. The main problem was water shortage that usually occurred in dry season.

Main type of occupation of local people was agriculturalist. Most of them (88.3%) cultivated marketed plants such as corns, Maize, vegetables, Soya beans and bananas. Polyculture farming system was dominated in the area. For animal husbandry, ungulates and avian groups were often cultivated in farms (57.1% and 28.6% respectively).

Averaged annual income per household were estimated at 38,903THB (US$ 864.5) and 41,031THB (US$ 911.8), of people inside and outside KKCNP, respectively. Among those people, agriculture generated highest income level (42,244THB or US$ 938.75) when compared to other occupations. However, socio-economic well-being of those people was not secure because no money deposit and some of them had debts (RFD, 1994).

3.1.1.4 Tourism and recreation

Apart of information about tourism and recreation in Kaeng Krachan is supported from Kaeng Krachan headquarter. However, less number of documentary validations are provided. Therefore, almost information in this part is from interviewing forest officers and local residents. Usually, those information and details can be seen in several Websites for traveling.

KKCNP becomes an interesting site for tourist and visitor because of three main reasons. Firstly, the park is not far from Bangkok. This makes visitors come easily by both public and private transportations. Visitors can also find accommodation easily in Kaeng Krachan and around the neighboring places such as in Hua Hin district. However, the costs of accommodations are differed depending on the level of

convenience provided. Secondly, there are many interesting and visiting points in Kaeng Krachan. Also large numbers of recreational activities are provided that visitors can select and enjoy. Among these visiting points, camping area at KKCNP headquarter, Panoen Thung and Ban Krang campsites, and Paala aau waterfall are the most popular places for visitors (RFD, 1994). Thirdly, the park is closed to other interesting sites such as Hua Hin and Cha am beaches in Prachuab Khirikhan province. People can go to several sightseeing places within one day. Because of these three reasons, KKCNP becomes one of the most interesting terrestrial national park for both natives and foreigners.

Number of visitors in KKCNP have been recorded since 1982. Data in some years were missing because inconveniences to collection. The records showed that numbers of visitors increase every year with different increasing rates (RFD, 1994). Maximum number of visitors (229,024 visitors) found by the end of the year 1998, one year after the year of economic crisis in Thailand. However, averaged number of visitors tends decrease every year. The majority of visitors traveled to KKCNP usually spent overnight outside the park. This might because of the accommodation provided inside Kaeng Krachan is not good and not convenient enough.

Types of transportation to Kaeng Krachan were also recorded during 1998-2000 (raw collected in this study). It was found that visitors usually came by private cars or vans rather than by public buses. From tourists' opinions, this site needs to be improved in terms of infrastructure development and transportation services in order to facilitate visitors who do not have their own vehicles when traveling to the site. Some tourist agencies, visitors and park officers (RFD, 1994), also confirm this statement.

Due to growing tourism and recreation, previous data recorded suggest that socioeconomic status of local people and of the surrounding area can become attractive issues to management. Fortunately, this research focuses on those interesting issues including valuation of recreational benefits by CVM and TCM analyses. Introduction of new recreational services are suggested to park managers

with hopes that those may possibly embrace monetary management if they can be proved to increase quality of lives of local people in real situation.

3.2 Model development

This research attempts to combine ecological aspects with socio-economic viewpoints. A system-dynamics model is constructed mainly to explore present status of forest ecosystem, socioeconomic status of local community in the park, tourism and agricultural patterns. Thus, important factors considering having effects on those aspects were included. At least three sub-models are developed to link all possible interesting aspects in Kaeng Krachan. Methods of model development and data collection and analysis involved several steps as follows.

3.2.1 Model construction

The compartment-flow modeling has been developed under the two basic concepts of system hierarchy and system approach as described in Heylighen (1998). The model-design processes are described generally in Keen and Spain (1992), Haefner (1996), and Ford (1999).

1. Structures and functions (processes) and boundaries of the system-of-interest are defined. Main structures (stocks or compartments) and functions (flows or processes) of the system-of-interest are identified and linked.
2. Variables and factors, which can affect changes of components (stocks) and of processes (flows), in qualitative and quantitative values, are defined in separated systems.
3. Relationships between components and processes of the same and at different levels are defined.
4. Relationships between components and between processes, and between components and processes in separated systems accompanied with their related variables are described.

5. All possible connections among components, processes, and variables in specific systems at different levels are linked and described in verbal diagram. This is so-called a conceptual framework of the system-of-interest (one system).
6. The whole framework of the system will then be drawn. Connections and linkages between components and variables will be linked. This is named as conceptual model.
7. Those main structures will finally be translated into model diagrams. Changes of the states of those basic components induce changes of system's characteristics and system's behaviors.

In this study, SIMILE ecological modeling software is used for running and simulation. The model-design process in SIMILE was developed by Muetzelfeldt and Taylor (1997 and 1998) is used. General steps of modeling process of SIMILE are explained in Table 3.2.

Following the latest Master Plan of Kaeng Krachan, management operations are classified into natural and human operations (RFD, 1994). Figure 3.2 depicts general framework and important components in multi-objective management model in KKCNP. There are two main components that can attack people's considerations. One is about the land use system in the park and another is about the operation from government.

Table 3.2 Components and general steps of model construction and descriptions.

Component	Description
Content	Scope or boundary of this study. Interesting topics or issues in the study area.
Issues	Important topic for modeling.
Indicators of performance	Outputs from the computer models that researcher will use to evaluate how well any particular management policy perform.
Policy levers (Management actions)	Management actions or policy keys to be able to evaluate.
Propose of the model	Purposes of each sub-model or of the whole model.
Model characteristics	Sub-model or model description stated about key decisions or spatial/temporal scaling.
Interfacing between sub-model	In case of many sub-models are constructed, information among submodels must be provided and changed for each other.
Sub-model design	Sub-model will be designed to support the purposes of the model stated above. Inputs are policy keys to the sub-model, information from others sub-models, and local parameters. Outputs are indicators of performance generated by the sub-model, information to other sub-models, and any other variables of interest.
Testing sub-model as model	All inputs will be set to fixed (or time-dependent) values
Synthesis	Linkages of sub-model will be performed.
Using the whole model	Model is ready in use to satisfy the purposes.

(Source: Muetzelfeldt and Taylor, 1997 and 1998).

In this study, the model components are developed and classified following present land use types in the park. Three main components are considered: forest, agriculture and community and people. In forest section, forest yields, size of forestland and forest structure and its compositions that will effect by human and natural factors are concerned. For agriculture, this part involves agricultural practices by local people. The most interesting issues are about the potentials of crop production, investment

and side effects from agricultural practices. In community and people sector, this part begins with the question that why there are some people living inside the park. People's behaviors and community characteristics are also interested. The question always asked by people from outside park is what will happen to forest ecosystems if those people continue living inside.

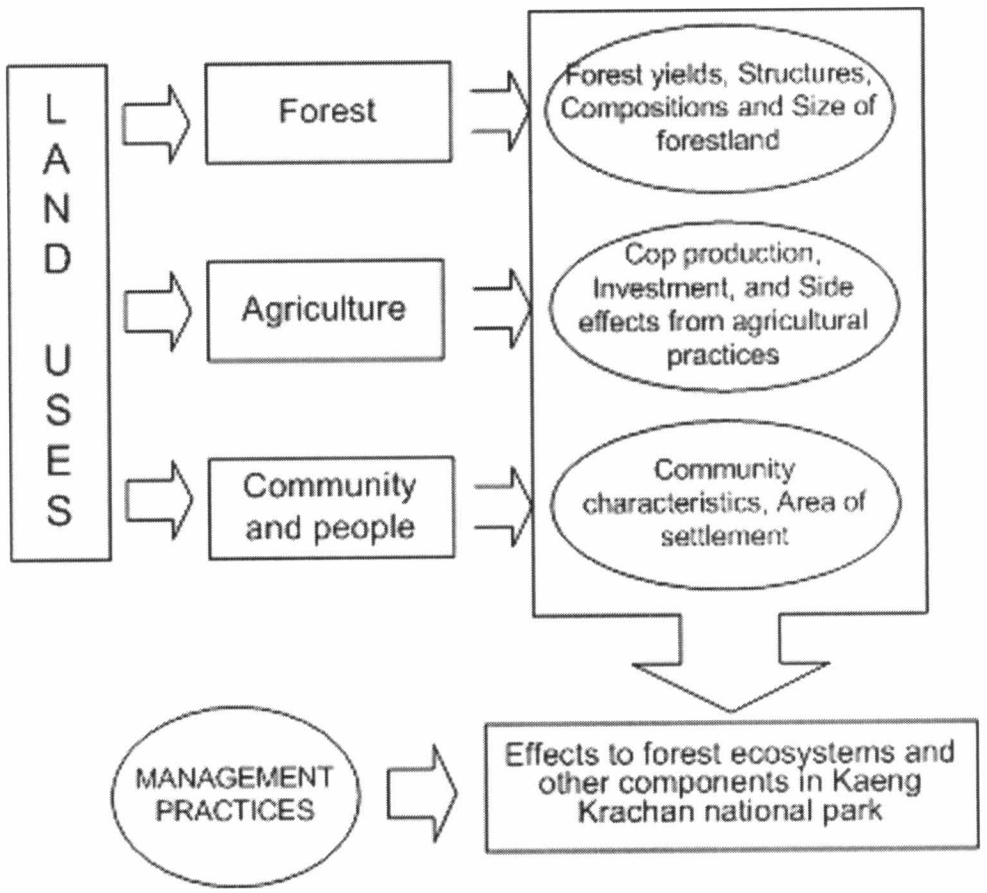

Figure 3.2 Conceptual framework of multi-objective management model of Kaeng Krachan National Park.

Basically, those components create some critical effects to forest ecosystems and other components such as soil and water system in Kaeng Krachan national park. Therefore, most interesting issues to park or forest manager should involve what they can do to reduce effects from those components.

3.2.2 Sub-model development

This section describes conceptual framework of three sub-models developed in this research. Multi-objective Management Model of Kaeng Krachan National Park (KPM Model) indicates several important components including forest compositions, relations among land-uses, community and people, and implementation of current management operations. At least three sub-models are developed separately and each of them is described individually. However, some relationships are shared amongst those three sub-models and information flows amongst those components are indicated.

3.2.2.1 Description of Forest sub-model

Vegetation and its characteristics are very important components in KKCNP. Evergreen forest comprises more than 80% of the whole park area. Forest sub-model includes details of forest ecosystems such as forest structure and its compositions. Factors that influence forest growth and yield are divided into two aspects: natural and human-induced factors. Causes of changes of forestland, level of utilization of forest resources, and forest management operations managed by forest officers are included as influencing factors to forest components in this sub-model. Management procedures and park regulations usually concentrate on protection and conservation of forest resources. Exploitation and overuses of forest resources in national park are extremely prohibited. Some management programs such as restoration and worker employment are incorporated as model-driven factors. General framework of forest sub-model is depicted in Figure 3.3.

Natural factors (e.g., climates, altitudes, differing precipitation regimes, phenotypes of plants and species compositions) can influence forest characteristics in several ways. Climatic types such as rain, dry or warm effect growth and distribution patterns of plant species (both woody and non-woody plants). Those conditions can determine regeneration and survival of seedlings of some particular species, or may promote species coexistence (Harpen, 1977; Pacala and Tilman, 1994; George and Bazzaz,

1999a and 1999b; Beckage and Clark, 2003). Short-term fluctuation of climatic condition may not be a crucial factor that modifies the beginning, intensity and end of annual tree growth. However, the condition may lead a bigger threat to forest species by pathogen organisms and may increase mortality in the middle growth state (FAIR3-CT96-1310, 2002).

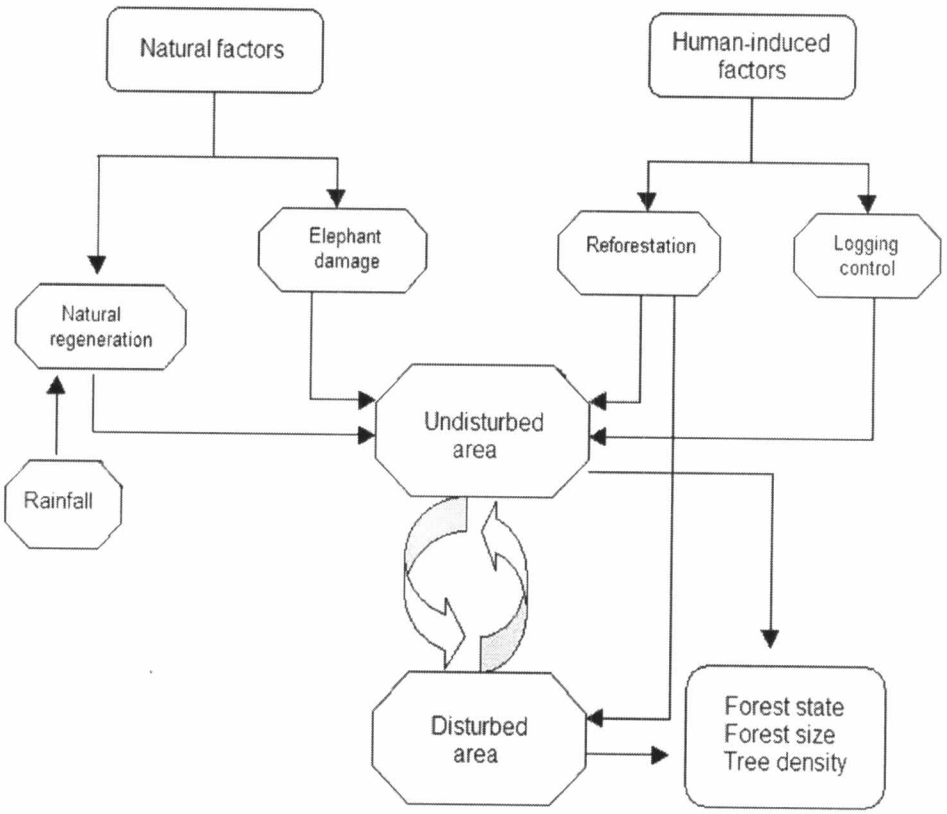

Figure 3.3 Conceptual framework of forest sub-model composes of both natural and human-induced factors which can influence changes of land use in KKCNP. In forest sub-model, state of the forest, tree density and forest size are main structures that are observed.

Clinton, Yeakley and Apsley (2003) reported that species-specific rates of mortality are likely to be varied due to microclimate-related increased susceptibility at the species level, to some certain proximal cases. In this study, survivals and recruitments of small

trees (saplings and seedlings) are suggested responsively to available water in soil which varies due to differences of precipitation levels. Percentages of small trees possibly survived and recruited at different times are assumed to be differentiated by amount of water in soil or rainfall levels. Annual rainfall records from 16 meteorological stations situated around KKCNP and at Hua Hin district in Prachuab Khirikhan province are averaged. Numbers of saplings and seedlings naturally survived and recruited at the beginning state of tree growth indicate tree density in different size-classes.

Wild animals such as wild elephants can create particular problems to young trees (saplings and seedlings) in KKCNP in some ways. Since total numbers of wild elephants tend to increase dramatically in short-term periods accompanied with agricultural intensification around the park. The situation induces quarrels between local people and elephants on land-uses both in this study area and in the eastern parts of the country (RFD, 2002). The likely situation has been found in several reserve sites in the tropics and always created conflicts between local people and elephants (Sitati et al., 2003). Those conflicts also found to happen in several forms and frequently occur in close proximity to protected sites (Parker and Osborne, 2001). Such as a case of African elephants, which always created some considerable impacts on people in the unusual position (IUCN, 2000). Issues of human-elephant conflicts have been reported by several researchers (Barnes, 1996; Hoare, 2000; O'Connel-Rodwell et al., 2000).

Like in other reserve sites, Kaeng Krachan becomes increasingly significant as human populations have expanded and encroached upon elephant habitat, particular where people practice cultivation (RFD, 1994; Hoare and du Toit, 1999; RFD, 2002). As the elephant population starts to increase and moves across their ranges to exploit some cultivated crops and forestland, a perennial problem occurred ever since. Some interesting observations have been reported unofficially by local residents and park officers. They reported that elephants destroyed plenty of cultivated plants, and a large number of saplings and seedlings when they moved across their ranges (RFD, 2002).

In long term, this may be critical to forest ecosystems if plenty of seedlings or saplings of important plant species are extremely devastated. This event possibly induces effects on changes of tree distribution and forest growth. Vegetative patterns and species compositions may be altered as well as forest sizes and tree density may sequentially decline. Even we do not know exactly whether disturbance by elephants caused changes of vegetation and forest characteristics in KKCNP or not. But for forest managers and local communities, wild elephants pose serious challenges to managing them, to reduce conflicts and unpredictable problems in suitable manners. This KMP Model case study therefore represents a common model of forest management by including elephant situation as an important component. The degree of disturbance on vegetative patterns and on forest area are determined when total numbers of elephants population in KKCNP is changed.

In Kaeng Krachan National Park Management Model (KPM Model), reforestation and increment to control forest destruction are also discussed as operations to forest protection and conservation induced by human. Reforestation aims to return forest area by replantation of small trees or by seed distribution. In general, native species and fast-growing species are selected (F/FRED, 1994; Hossain, 1999). Some other plant species that can tolerate a wide range condition and need less to take care after replantation are also preferred in restoration process. Another human operation is the control of forest destruction. In this area, illegal logging has long been concerned as a very important problem. Even though the logging control management procedure has long been induced but management process is not clearly discussed.

The weakness of present forest management in Kaeng Krachan is found when there is no certain program that has been set up separately for both reforestation and illegal logging. These two processes are always embedded as parts in a more important management project (RFD, 1994). Consequently, the advantages and disadvantages of these processes have never been obviously determined. However, in model building, reforestation and logging control are partially included as important factors that influence changes of forest yields and sizes. Those components are constructed

based on available information from Kaeng Krachan Headquarter and raw data collection, as well as personal communication to forest officers and local villagers. Reforestation in this sub-model is determined by estimation of numbers of trees possibly survive and size of forestland that can be returned when reforestation indices' values are varied during simulation. While logging control aims to reduce intensity of illegal logging by increasing capability of forest protection. According to this, numbers of forest officers are changed, then intensity of illegal logging process can be determined.

3.2.2.2 Description of Agriculture sub-model

Agriculture sub-model mainly interests in crop cultivation by residential population living in KKCNP. This sub-model excludes animal husbandry because this agricultural practice has not been concerned as a major problem that alters characteristics of land use in the park although there are small number of cattle cultivated inside (RFD, 1994). However, in other reserve sites such as Cha Choengsao wildlife sanctuary in the East and Huai Kha Khaeng wildlife sanctuary in the western part, animal husbandry by local villagers places major problem such as grazing to forest compositions and crop plantation (RFD, 2002).

Crop farming system in Kaeng Krachan becomes one of the most interesting issue to forest officers even they can move almost residential people to settle in specific site in the core area. Almost local people living in side the park are classified as indigenous and Karen people who establish their community for long time, before KKCNP establishment (RFD, 1994). Those people somehow against the law that they should not settle and must move out of the core area (RFD, 1994). Now a day, there is no evidence that how much amount of land inside KKCNP has been disturbed and converted into agricultural land. But, from personnel communication with some forest officers in Kaeng Krachan in early 2004, each household use approximately less than 0.32 hectare for crop cultivation (personal communication).

Conceptual framework of Agriculture sub-model is depicted in Figure 3.4. Cropping system in Kaeng Krachan challenges resource manager when some problems relating to crop plantation such as contamination of toxic substances from chemical fertilizers, pesticides or herbicides are proclaimed. Therefore, this study attempts to bring about more specific answers, which questions are usually asked about the degree or level of contamination in Kaeng Krachan water system (RFD, 1994). Three main components relating to cropping system are designed in this framework. The first component covers mainly growing process until harvesting phase. The second component relates with crop harvesting process. These two steps are set separately because there are many different processes to conduct such as application of fertilizer and pesticides needed to be done along growing step but these are exempted in harvesting process in second stage. The third component concerns more about keeping raw products in store, waiting to sell out in market. Three processes can occur during keeping crop products in storage place. Some amount of crops may be decayed and lost due to animal foraging.

Crop productions and yields are interested in this sub-mode. Normally, crop cultivation is not allowed to conduct in protected areas. But in this Kaeng Krachan case, park officer can do only move people to settle in specific zone. Instead of enforcing people stop using chemicals or toxicants in growing process, alternatives must be declared rationally that why people should decrease or stop using those substances. Therefore, input and output factors or materials need to be weighted and compared to hint local people on advantages and disadvantages of present crop cultivation system in this area.

Factors presumed to influence crop cultivation by local people inside park are considered from both nature and human. By nature, influencing factors composed of two components. Firstly, level of water in soil that can be determined by precipitation and differentiated by duration or season in a year. Secondly, specific type of disturbance such as raiding by wild elephants. As previously stated, human population growth and land transformation can put pressures on elephants (RFD, 2002). Issues of

human-elephant conflicts are rested in several reserve sites (Barnes, 1996; Hoare, 2000; O'Connel-Rodwell et al., 2000). This issue becomes increasingly significant as human populations have expanded and encroached upon elephants' habitats (Hoare and du Toit, 1999; RFD, 2002).

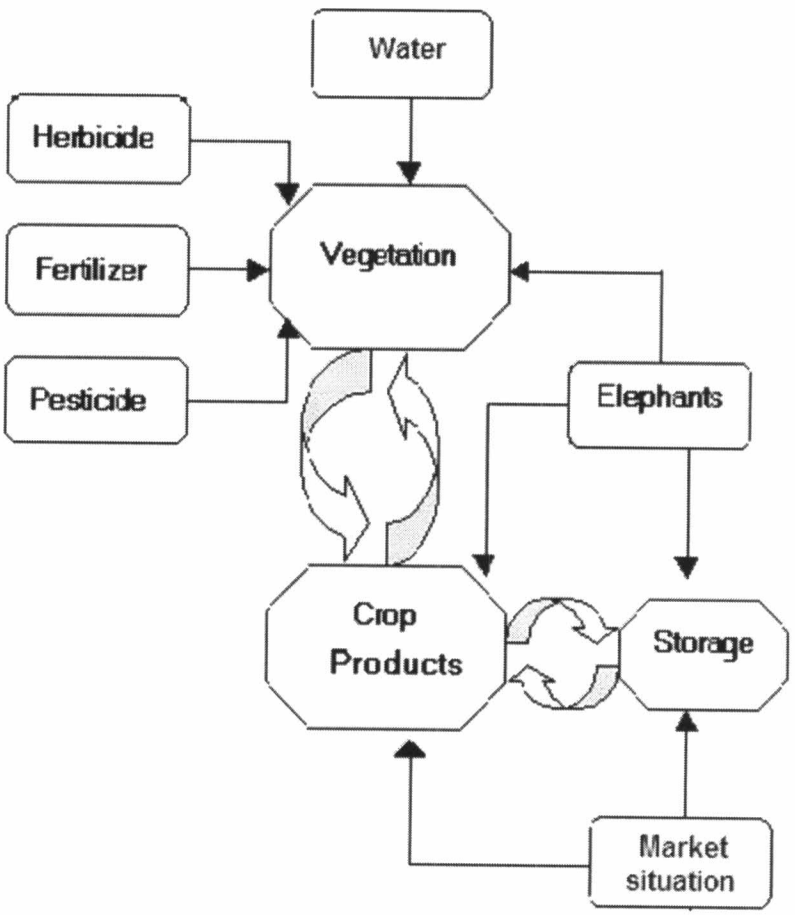

Figure 3.4 Conceptual framework of agriculture sub-model. Three main components including vegetation growth process, crop harvesting and selling process are indicated.

Raw data of precipitation level are collected and averaged from 16 meteorological stations situated around KKCNP and at Hua Hin district in Prachuab Khirikhan province. Total number of elephants in Kaeng Krachan are roughly estimated between

100 to 200 individuals (personal communication with forest officers in early of the year 2004). However, other details of elephants and the distribution patterns are still covered and unrevealed.

Agriculture sub-model constructed in this study may not cover all interesting aspects of agricultural patterns in Kaeng Krachan. Also, the results may not accurately and precisely estimated because of lacking of information. However, results can be applied to tackle some relating problems around that area.

3.2.2.3 Description of Community sub-model

All kinds of nature reserves in the tropics, also in Thailand, have long been faced with major problems from local residents or indigenous people (IUCN, 1978 and 1979; Kasetsart University, 1987; IUCN, 1994 and 1999). In Kaeng Krachan, community settlement and its structure become an interesting issue since change of population size is believed to be a cause of change in amount of land uses.

It is reported that increasing population size in KKCNP induces deforestation because people needed to occupy larger area for living and growing crops (RFD, 1994). From latest field observation and personal communication to both local villagers and forest officers in KKCNP, at least 75 households are still living inside along the Kaeng Krachan river basin in reservoir, up to the headwater. Numbers of households are much different from the result of previous report done by forest officer in 1993 (RFD, 1994). Park officers said that they move from upstream downward to settle near Kaeng Krachan dam and somewhere around the reservoir. Also, large number of people in current generation (almost teenagers) usually go for works in the city rather than continue doing agricultural practices inside the park because they feel much better in their quality of lives and become close to new and modern society. The rests in the park area are old generations and children (personal communication). As regards, community structure and socio-economic of people become interesting issues to this study.

This community sub-model indicates general characteristics of community structure and people inside KKCNP. Two main components are described and those indicate describe population structure and socio-economy. Demographic data such as number of households, number of males and females, growth factors and environmental quality are included. Socioeconomic status of local people related to living activities are also observed and modeled to determine people well-beings. This sub-model also examines effects of population on changes of land uses such as size of community settlement and agricultural area. General conceptual framework of community sub-model is depicted in Figure 3.5.

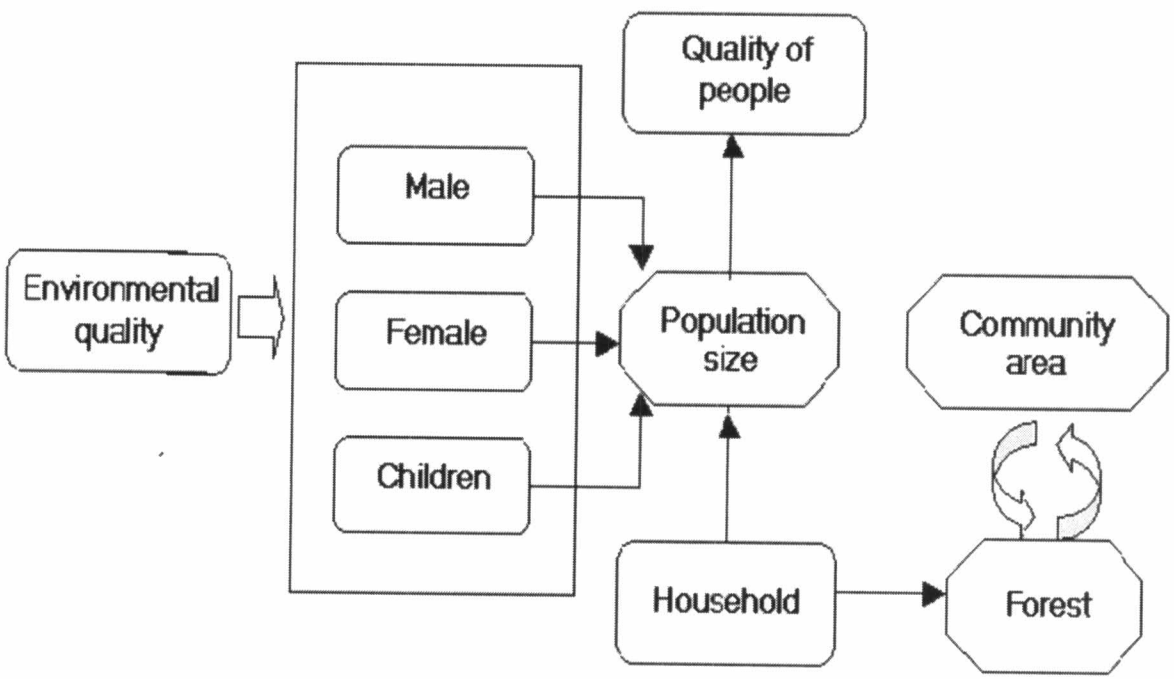

Figure 3.5 Conceptual framework of community sub-model. Three components including people and community structure and socio-economy are indicated.

3.3 Data collection and analysis

3.3.1 Forest assessment

Evergreen forests occupied as the main forest type, comprise more than 80% of the whole forests. Therefore, tree assessment is conducted only in evergreen forests based on possibility of approaching the sites. Systematic Sampling Method following Krebs (1989) and Pielou (1995) is employed for sampling plot construction as follows..

1. Thirty temporary sampling plots were totally established. Fifteen temporary circular plots with radius of 15 meters were constructed.
2. Fifteen 1X1 m^2 plots were temporarily constructed inside of each circular plot.
3. Data on tree and saplings and seedlings were collected.
4. In each circular plot, trees with Diameter at Breast Height (DBH) larger than 4.5 cm were measured and numbers of trees were counted.
5. Total trees were grouped and classified by their DBH size into five size classes.

   Size class 1: $4.5 \leq DBH \leq 10.0$ cm

   Size class 2: $10.1 < DBH \leq 20.0$ cm

   Size class 3: $20.1 < DBH \leq 40.0$ cm

   Size class 4: $40.1 < DBH \leq 60.0$ cm

   Size class 2: $DBH \geq 60.0$ cm
6. Relative tree density (per hectare) and biomass (ton/ hectare) of each size class were calculated.
7. Total tree numbers (individuals), relative tree heights and aboveground biomass were estimated by application of DBH value to regression equations developed by Ogawa et al. (1965).

8. Species composition was not included in this research because the model will be constructed and simulated based on system-thinking concept, not individual-based model. Therefore, species identification is omitted.
9. Seedlings and saplings were also counted and set as initial input numbers at the beginning stage of tree growth
10. Average tree density, total tree numbers and forest state were estimated.

3.3.2 Land use survey

Data on land uses in KKCNP was supported from Department of Land Development, the Royal Thai Survey Department, and the Royal Forest Department of Thailand. Historical maps with scales varying from 1:25000 and 1:50000, and historical works (RFD, 1994) were verified and discussed.

Quantitative records on amount ant types of land uses were collected from several governmental offices in Petchaburi province, Statistical Division of Petchaburi province and Office of the national park.

Some pieces of information were gathered from rapid appraisal method, and by questionnaires in Appendix B.

The process for rapid appraisal is included as ground check for land uses. Those following steps are as follows.

1. Five sampling villages located inside and outside KKCNP were selected as sampling groups. Local villagers, at least 10% of the total households of each village, were sampled and interviewed informally by using sets of questionnaire.
2. Pattern of crop farming system was investigated. Information needed including crop species, sizes of agricultural land and information on uses of fertilization, pesticides, herbicides and other toxic substances.
3. Information on production and selling process are also needed.
4. Questionnaires were interpreted and measures of agricultural project worth were estimated following Gittinger (1994).

5. Agricultural productivity was estimated.

Information which can influence relationships among components of agricultural practices were identified will be translated into model variables and parameters.

3.3.3 Community and demography assessment

Community analysis involved determining of population numbers of next generation, socio-economic status and demographic factors that can influence population community. Information gathering was done by questionnaire interviews (APPENDIX B).

Questionnaires were analyzed and demographic data such as number of households, household members, sex ratio, number of children were collected and estimated. Growth factors were also determined.

3.4 Valuation of ecosystem benefits

3.4.1 Site selection

Tourism and recreational activities available in KKCNP were recorded. Observation on visitors' characteristics and visiting sites were selected based on previous surveys and suggestion from park officers.

1. Three sampling sites were selected for data observation on visitor characteristics (Figure 3.6).

   A. Kaeng Krachan Headquarter (Tourist information center)

   B. Pano en thung and Ban Krang campsites

   C. Paala Auu waterfall

2. One thousand sets of questionnaire were totally distributed. The first 400 sets were were distributed at Kaeng Krachan Headquarter, other 300 sets were passed to Panoen thung and Ban Krang campsites. The left 300 sets were distributed at Paala Auu waterfall. Visitors and tourists were randomly sampled and interviewed.

3. Factor analysis employing Principal Component Analysis (PCA) was applied to questionnaire analysis for selection of independent variables.

Figure 3.6 Sampling sites for questionnaire survey: KKCNP headquarter (A); Panoen Thung and Ban Krang campsites (B); and Paala aau waterfall (C). (Source: RFD, 1994)

4. Logistic Regression analysis (LRA) was also applied to estimate the possibility that visitors will be willing to pay for recreation choices and service fees of new proposed recreational services.

5. Travel Cost Method (TCM) was used in this research to estimate economic use values of recreation benefits on recreational purposes. The means of determining values for stuffs which were generally not bought and sold and therefore fall outside of the market's pricing system were determined.

Raw data on tourism and recreation and tourism management in Kaeng Krachan were collected mainly from Kaeng Krachan headquarter. Primary records were found in RFD (1994). Number of visitors come to KKCNP were analyzed starting in the year 1982. However, the records were absent in some years during 1991-1997 (RFD, 1994).

3.4.2 Determining recreation fees: CVM analysis

Due to growing tourism in Kaeng Krachan and the surrounding areas, resource manager need to cumulate essences of tourism in justification the priorities in policy or actions of the resource planning. Sustainable development concerned that local people should involve and share their opinions in managing natural resources. In this Kaeng Krachan case study, we used idea of ecotourism management to enhance participation of local people to the park by encouraging them to establish new recreational services which benefits are shared between park and people.

Three types of recreational services have been introduced: buses service, home stay service, and forest ranger service. Visitors were asked to share their opinions to determine service fees and charging systems of each. Questionnaire survey was used to collect information and opinions from visitors. Historical records were analyzed incorporated with primary data sets to predict visitors' characteristics in attending recreational activities in KKCNP. This research employed Contingent Valuation Method (CVM) for data analysis.

The steps to come up with TEV are as follows.

1 Primary data survey (Questionnaire survey)

One thousand sets of questionnaire were distributed designed to collect general information of tourism in KKCNP. Information collected divided into 3 parts.

Part 1: Socioeconomic status and behavioral pattern of tourist/visitor for outdoor recreation (questions 1-17).

Part 2: Level of information accessibility (questions 18-25).

Part 3: Tourists satisfaction and introducing of new recreational activities in KKCNP. This provides information and importance of each recreational services introduced for tourism improvement in this specific area (questions 26-42).

2 Historical records

Historical records are very important for natural resources analysis This will be analyzed incorporated with primary data sets to predict visitors' characteristics in attending recreational activities in KKCNP. In this research, historical data are used to determine characteristics of visitors' in willingness to pay and charging system of new recreational services. Secondary data involves historical records of tourism performances including numbers of visitors/tourists, numbers and types of vehicles, numbers of forest officers, annual budget allocation from central government, and role of local community on tourism management in KKCNP.

3 Statistical Analysis

Factor Analysis (FA) employing Principal Component Analysis (PCA), and Logistic Regression Analysis (LRA) employing Maximum Likelihood Estimation (MLE) were used for selection of dependent variables and determined probability of WTP in responded to yes-no question (Hair, Rolph, Roland, and William, 1998). Demands of each new recreational service can be estimated by multiplying relative number of visitor with estimated percentage of visitors who are willing to pay for recreational use fees. Average Consumer Surplus (CS) per year for new recreational services were also estimated.

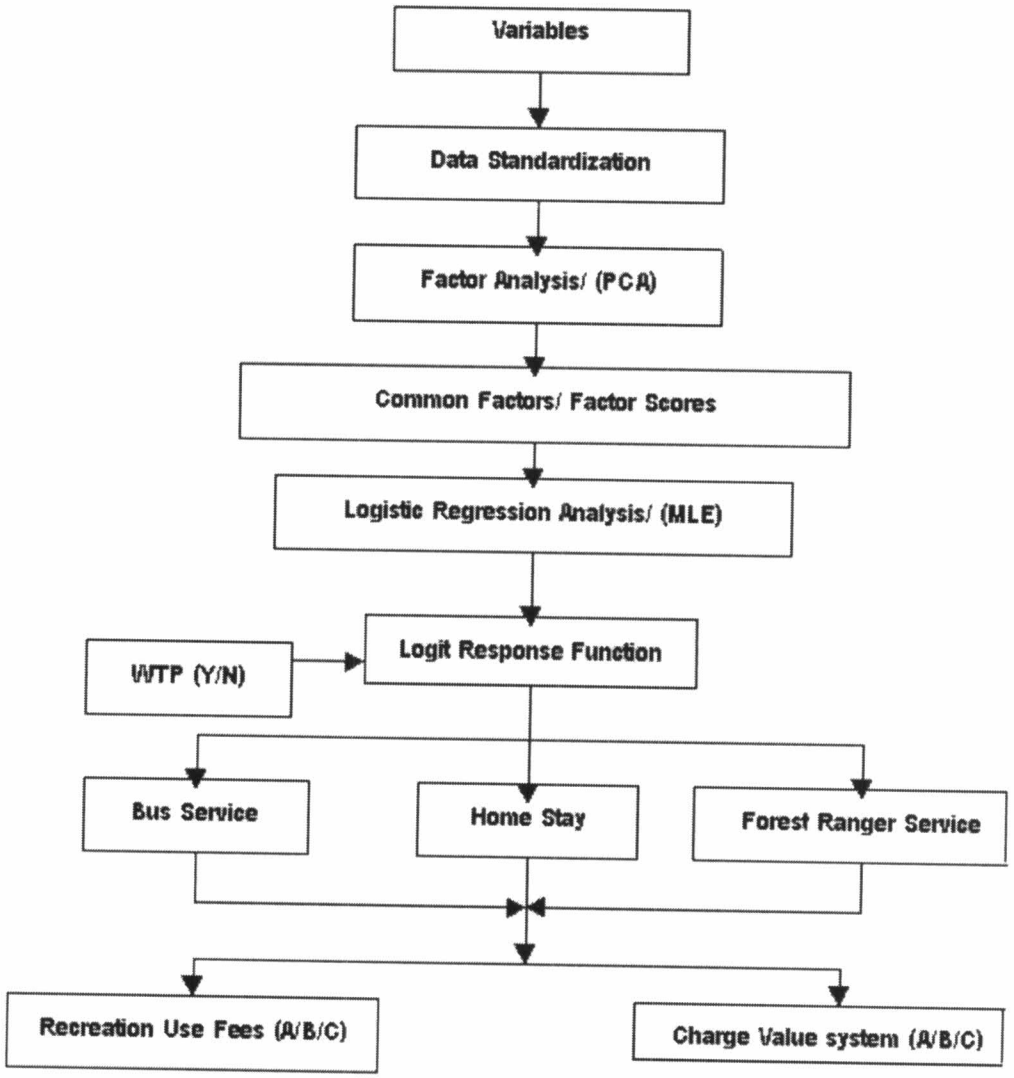

Figure 3.7 Statistical analysis for determining of WTP probability, charge value systems, and recreation use fees for new recreational activities.

Figure 3.7 indicates important steps in CVM analysis. Variables interested and considered having effects on visitors in determining WTP will be analyzed and grouped. New common factors are a common product of many related socioeconomic variables. New grouped variables (factors), after FA is performed in this step, indicate that no relationships amongst them. Common Factors resulted from Factor Analysis will be used as new variable input in Logistic Regression Analysis (LRA) to predicted probability of WTP in responded to yes-no question.

This means that WTP is a function of factors extracted (equation 3.1).

$$WTP_i = F(F_1, F_2, ..., F_p) \quad (3.1)$$

where

WTP_i = Willingness To Pay of visitor i

F_p = Factors 1 to p

In LRA, coefficient values in Logistic Response Function are estimated employing Maximum Likelihood Estimation (MLE). Response function is used to predict probability of each case (visitor) in willing to pay for each of new services. Cases responded to yes-no question are assigned as a dummy variables and only two qualitative values (yes or no). Dummy variables will be set in dichotomous variables with values given as described below.

Given

Y_{ix} = 1 When visitor Willing to pay for recreational service

0 When visitor Unwilling to pay for this service

Where

Y_{ix} = Case or visitor responded to WTP question

i = Number of case (visitor) *i* to *n*

x = Types of services

Case responded with $\Pr(Y_{ix} = 1) \geq 0.5$ will be picked up and referred as WTP resulted from responding to common factors in equation (3.1). Results of LRA are logistic response function.

In this case common factors (F_p) is treated as new variable input in LRA. When FA generates more than 2 factors ($p \geq 2$), logistic response function is affected from common factors factor (F_1 to F_p). Relationship between dependent variables (Y_{ix}) and

explanatory variables or common factors (F_1 to F_p) is described in nonlinear form (equation 3.2). The relationship between dependent variables (Y_{ix}) and explanatory variables (F_1 to F_p) can be adjusted in linear form by taking logarithmic of explanatory variables. Logit response function in equation 3.2 is a result of taking logarithmic equation.

$$Log(S) = \beta_0 + \beta_1 F_P + ... + \beta_1 F_{P-1} \qquad (3.2)$$

where

$P(Y_{ix}=1)$ = Probability of Willingness To Pay for new service of each case

β = Coefficient value of each common factor (F)

X = Service types (Bus service, Home stay service, Forest ranger Service

F_p = Common factors 1 to p

If value of *S* in equation 3.2 is greater than 1, this implies that there is more chance that the answering "YES" for choosing new services is true based on their determining variables (common factors) analyzed by Factor Analysis. At the end of this step, relative number of visitors who preferred and are willing to pay for recreational fees introduced in this study will be estimated. Also, recreational use values for bus service, home stay service, and forest ranger service are calculated. Demands for each new recreational service can be estimated by multiplying relative number of annual visitors with estimated percentage of visitors who are willing to pay for recreational use fees (equation 3.3).

$$D_X = \%N_X * TVT \qquad (3.3)$$

where

D_x = Demand of service X

$\%N_{YX}$ = Percentage of visitors who willing to pay for service x

TVT = Average number of visitors in KKCNP by the end of 2001

X = Service types: Bus service (A); Home stay service (B); and Forest ranger service (C)

Average Consumer Surplus (CS) per year for new recreational services can be estimated by multiplying demands (average number of visitors per year for each recreational service) of each service with recreational use fee (of that service) which visitors prefer and are willing to pay.

3.4.3 Valuation of Kaeng Krachan site value: TCM analysis

This section describes methodology of Travel Cost Method (TCM) analysis for valuation of recreational site value, KKCNP. The economic use value associated with ecosystem services used for recreation is estimated following methodology in King and Mazzotta (2002), Petcharanond (1999) and UCLA (1999). Data required for Zonal Travel Cost Method (ZTCM) analysis are divided into primary and secondary data.

1 Questionnaire survey

Almost all of these can be gathered from questionnaire interviews. Questionnaire used for data collection is the same set as used in Contingent Valuation Method (CVM) analysis (Appendix B). Information collected including as follows.

1) Number of visits from each origin zone (defined by zip code).

2) Demographic information of people from each zone.

3) Round-trip mileage from each zone (e.g. mile/kilometer).

4) Travel costs (US$ per mile/ THB per kilometer)

5) The value of time spent at traveling, or the opportunity cost of travel times

6) Exact distance that each individual traveled to the site (e.g. miles/kilometers).

7) Exact travel expenses (currency unit: US$ or THB).

8) The length of trip (e.g. days).

9) Total amount of time spent at site (e.g. hours/days).

10) Other locations visited during the same trip, and amount of time spent at each.

11) Other reasons for the trip

12) Quality of the recreational experience at KKCNP.

13) Perceptions of environmental quality at KKCNP.

Data analysis is divided into eight main steps as shown in Figure 3.8.

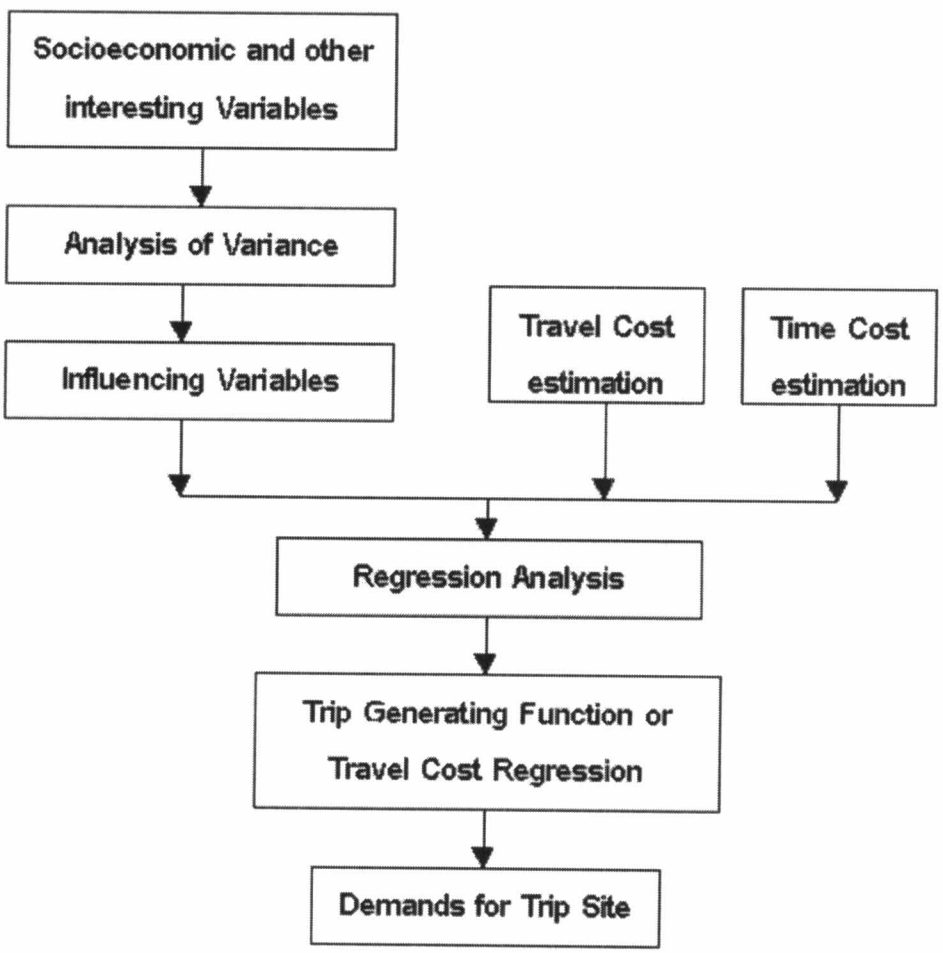

Figure 3.8 Statistical analysis for ZTCM.

2 Calculation

1) Defining influencing variables

Socioeconomic variables and other interesting variables from interview were selected and identified as factors influenced visitors characteristics for traveling in KKCNP.

2) Estimation of visitation rate and round trip travel time

Visitors required answering their zip code and these codes were used to classified visitors following their place of origins. Then total distance between visitors' origins and KKCNP can be calculated. Sampling visitors are classified into different zones dividing from distance between their origination and KKCNP site. Visits of each zone are estimated per 1000 visitors per year (visits/1000).

3) Calculation of Transportation cost or distance cost.

Fixed values of following variables are needed for calculation of transportation costs.

a) Average distance of different zones (Z_i) (km).

b) Average speed limit is assumed at 60 km/hr.

c) Round trip travel time (hr) for traveling at KKCNP is estimated with speed limit at 60 km/hr.

d) Cost per distance unit (THB/km) is calculated from estimates relative value of fuel cost per distance unit (fuel cost/ km). Average fuel cost is assumed at 16 THB per liter. Average distance per liter is assumed at 7 km./l. Amount of fuel used per distance unit is estimated at 0.143 lit/km and fuel cost per distance unit is estimated at 2.30 THB/km.

However, estimation of cost per distance unit, and other miscellaneous cost such as cost of insurance or fixation cost were added to estimate. In this study, other miscellaneous expenses are added for 0.70 THB/km. Therefore, average cost per distance unit (distance cost) was assumed as 3.0 THB/km.

4) Calculation of Time cost or opportunity cost

Time cost was estimated from full wage rate assigned by Thai government. The average wage rate was 150 THB/person/day. Average working hour per day was assumed at 8 hrs/day. Therefore, time cost per hour was about 18.75 THB/hr. In developing countries, using full wage rate in estimation was argued because this makes travel cost value higher than it should be. Therefore, one-third of full wage rate was used instead of full wage rate. This study employed full wage rate in time cost estimation used in TC calculation.

5) Calculation of Travel cost of each zone (Z_i)

Travel cost of different zones (Z_i) will be calculated by multiplying of round trip travel time (hr) with distance cost (3.0 THB/km) plus multiplying of round trip travel time (hr) with travel cost (18.75 THB/hr) (equation 3.4).

Total Travel Cost = (Round Trip Travel Time x Distance Cost) (3.4)
+ (Round Trip Travel Time x Travel Cost)
+ Miscellaneous cost

Travel Cost was defined as a function of three components: distance cost (DC), Time Cost (TMC), and Miscellaneous Cost (F), as shown in equation 3.5.

$$TC_{ij} = F(DC_{ij}, TMC_{ij}, F_i, X_{ij}) \quad (3.5)$$

where

TC_{ij} = Travel Cost of visitor i from zone j

DC = Distance Cost

TMC = Time Cost

F = Miscellaneous Cost

X = Other socioeconomic variables

I = Visitor i to n

J = Zone j to m

6) Running Regression to establish functional relationship between visitation rate and travel cost (TC).

There are at least 4 types of Trip Generating Function (TGF) which are commonly used in calculations. Different types of TGF resulted from regression will affect value of consumer surplus estimates in final step. Table 3.3 provides for types of TGF commonly used.

Table 3.3 Types of Trip generating Function (TGF).

Functional form	Equation description
Quadratic	$V / P = a - bTC + gTC^2$
Semi-log (independent)	$V / P = a - b \ln(TC)$
Semi-log (dependent)	$\ln(V / P) = a - bTC$
Double log	$\ln(V / P) = a - b \ln(TC)$

7) Tracing of demand curve for trip site was calculated follows King and Mazzotta (2002).

8) Results are total estimates of economic benefits from recreational uses of the site per year, or consumer surplus per visit (calculation of CS or area under the demand curve).