CHAPTER II

OVERVIEWS OF THE RESEARCH

2.1 Research framework

General framework and scope of this study is indicated in Figure 2.1. There are six main steps (backbone) starting with an observation of real situations happened to natural resources and management in Kaeng Krachan national park. Block (a) identified information required including exploration of Kaeng Krachan characteristics, Kaeng Krachan's management system and its characteristics. Current faced problems are also needed to identify. Next, general characteristics of the system-of-interests are scoped. At this step, Block (b) indicates information supported that includes both theoretical and reviews of previous documents. Hypotheseses and assumptions of the model are then formulated. Methods for data collection and analyses, and scientific procedures are designed (Block (c)). In model-building process, model components, elements, and relationships among elements are assigned. Constants, initial input values, and fixed values for parameters and other variables are estimated. Testing of model sensitivity and scenario analysis occurs at this step. Present situation of forest ecosystem and other system entities, and information of ecosystem management, are primarily reviewed. Then specific types of problems in Kaeng Krachan are stated.

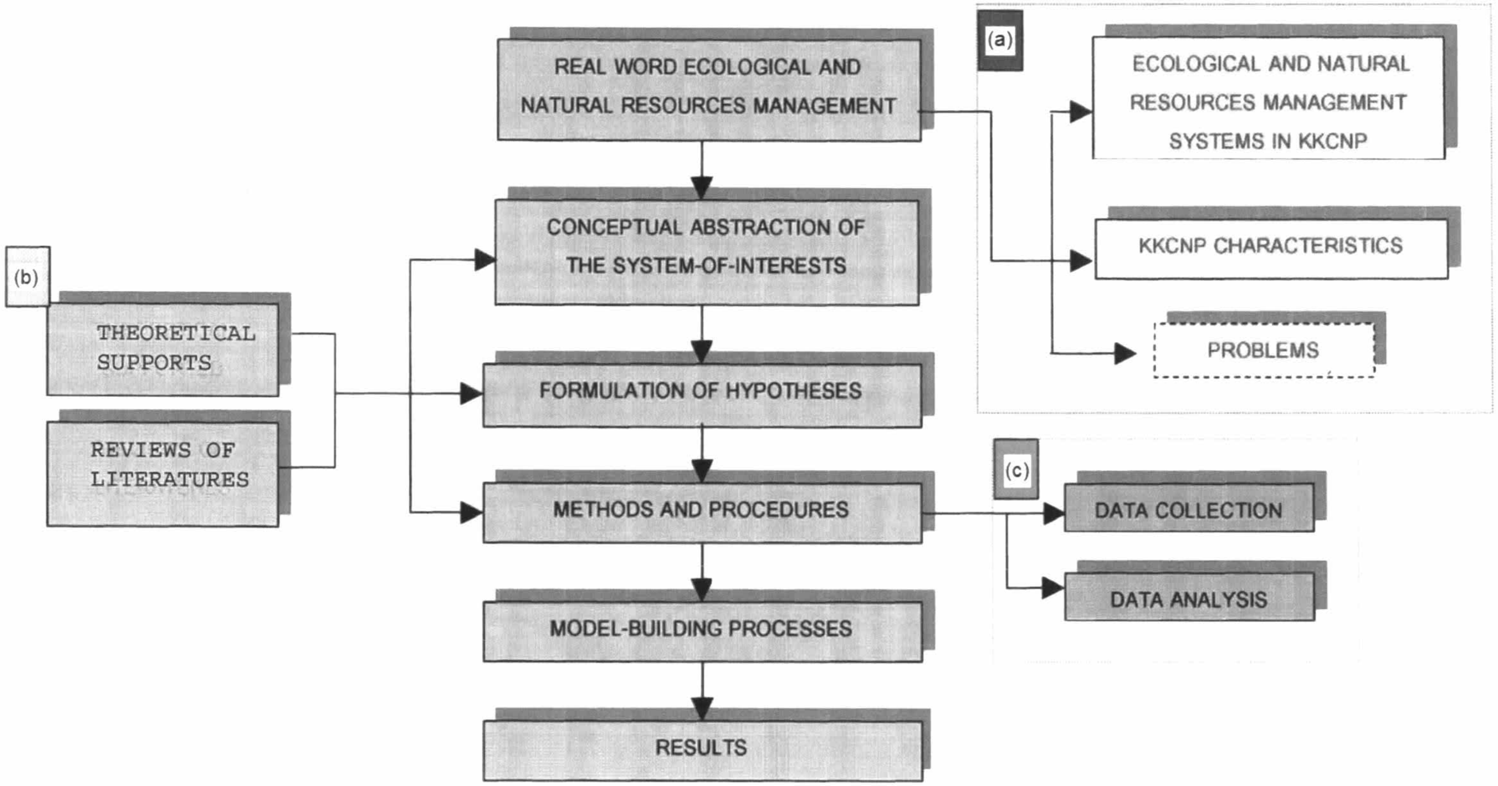

Figure 2.1 Conceptual framework of the research study

2.2 Protected area: A review of national system

This topic describes general information and types of Protected Areas (PAs) at the international and national levels (IUCN, 1978, 1979, 1994 and 1999). Protected Area is described as follows.

> *"An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means."*

The main purposes of management in PAs are also stated by IUCN (1978, 1979 and 1994) as for scientific research; wilderness protection; preservation of species and genetic diversity; maintenance of environmental services; protection of specific natural and cultural features; tourism and recreation; education; sustainable use of resources from natural ecosystems; and maintenance of cultural and traditional attributes. Although all kinds of protected areas meet general purposes stated in that definition, in practice precise purposes for which protected areas are managed differ greatly.

A series of protected areas have been categorized into six main categories based on management objectives. Definitions of categories and examples of each, are provided in Guidelines for Protected Area Management Categories (IUCN, 1994).

National Park and its definition, following the IUCN Protected Area Management Categories, has been classified in CATEGORY II as follows.

CATEGORY II: National Park: protected area managed mainly for ecosystem protection and recreation.

Definition: Natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

Where the site does not meet the internationally recognized definition of a protected area, application of a management category is not appropriate. This is indicated as category unassigned (UA) in UNEP-WCMC protected area lists.

2.2.1 Legal framework: Policy and legislation

The premise official conservation measures of The Kingdom of Thailand were taken in the period of King Ram Khamhaeng the Great. Almost all of protected sites were established surrounded the religious areas and temples and functioned as wildlife sanctuaries (Kasetsart University, 1987). The cessation of conservation occurred occasionally until the establishment of the Royal Forest Department (RFD) in 1896. The current enabling legislation of the RFD, the Forest Act B.E. 2484 (1941), has been induced and modern management practices are applied to achieve the maximum, and theoretically sustainable yield of forest products.

Protected areas legislation, and other nature conservation measures were established in the early 1960s with passing of the two key Acts, The Wild Animals Reservation and Protection Act B.E. 2503 (1960) and The National Parks Act B.E. 2504 (1961). The first ACT made provision for the establishment of wildlife sanctuaries and non-hunting areas. The regulation of hunting and control of wildlife trade provides a limited number of species with total legal protection. The National Parks Act B.E. 2504 (1961) concerned with the establishment and management of national parks (IUCN, 1979; Kasetsart University, 1987). Three years later, The National Forest Reserves Act B.E. 2507 (1964) passed to strengthen the earlier Forest Acts. The 1964 Acts also formalized the legal status of forest parks, however, national parks, wildlife sanctuaries and most non-hunting areas were classified in the latter category.

In December B.E. 2528 (1985), the Thai Cabinet approved a Draft National Forest Policy which reaffirmed previous standing policy of maintaining at least 40% forest covered in the country, and further divided the forests into two categories: protected and productive forests. Protected forests accounted for 15% of total land area. Those included national parks and wildlife sanctuaries, and all sites set aside for conservation, watershed protection, research and recreation. The second category accounted for the remaining forest land, which was to be utilized for the exploitation of timber and forest products.

In May B.E. 2532 (1989), the two Royal Decrees were passed to amend the previous Forest Acts, making provision for a nationwide ban on logging. Provisions were also made to automatically declare invalid logging concessions that remained in forces within national parks and wildlife sanctuaries. Logging ban, in this case, could only be removed by changes in law. The establishment of national parks and wildlife sanctuaries has become the principal means by which remaining forests are protected from logging. Consequently, protected areas were being enlarged rapidly. However, the logging ban did not cover mangroves, and increasing prices of timbers also encouraged illegal logging throughout (Wongpakdee, 1990).

Nature conservation in all fields were strengthened when the Enhancement and Conservation of National Environmental Quality Act B.E. 2518 (1975) was passed. The Act provided the establishment of the National Environment Board, within the Office of the Prime Minister. The Environmental Division has responsibility for environmental information, policy, planning, impact evaluation and standards.

National Park and the Royal Decree occur to conserve both living natural resources and landscapes, and to provide education and recreation to publics. Almost national parks are on the government's land. Theoretically, protection from all illegal activities is enhanced. Wildlife sanctuaries have also been established under the Royal Decree.

Wildlife sanctuary exists mainly for species conservation and protection. Hunting and habitat destroying of all taxa are prohibited. Also, entrances and activities without permission from government are prohibited. Unfortunately, tourism and recreation were not encouraged at that moment (Wongpakdee, 1990).

Non-hunting areas are designated by the Ministry of Agriculture and Cooperatives on either private or state lands to conserve some wild species, for specific purposes. Non-hunting areas are frequently defined by distinct features such as lakes or temple grounds, to protect for example nesting birds. Activities such as agriculture, hunting or timber-clear felling are not prohibited within this area. Access or habitation is not restricted unless proscription by other legislation, such as the National Forest Reserves Act, is indicated (Kasetsart University, 1987). PAs are gazetted when a Royal Decree is promulgated with a map that the boundary lines are indicated. The extension or cancellation of PA can also be authorized by Royal Decree.

2.2.2 Administration and management

In the early 1960s, the Royal Forest Department devolved the responsibility for protected areas upon the National Parks and the Wildlife Sections of its Silviculture Division. The National Park Section was upgraded to "Sub-Division" in 1965 and to “Division” level in 1972. The Wildlife Conservation Division emerged out of the former Section in 1975. Both the National Park Division and the Wildlife Conservation Division had regional offices and operated out of a common headquarter in Bangkok. The National Park Division was headed by the Director of division and was organized by the National Park Committee, which representatives from the governmental departments, the Office of National Environment Board, Kasetsart University, the Tourist Authority of Thailand and others were included. The Division comprises at least seven sub-divisions (Kasetsart University, 1987). Management planning section has been established for the preparation of forest management plans (Anon, 1986). A number of training programs has been organized and planned for park personnel, covered topics such as management skills, law and administration (Wongpakdee, 1990). The Wild Animals Reservation and Protection Committee included members from the Ministry of Agriculture and Cooperatives, and other governmental units to acts as an advisory committee and decision-making body for the Wildlife Conservation Division. Nine sub-divisions were included: extension, technical, wildlife sanctuary, law enforcement, administration, planning, non-hunting management, propagation and foreign affairs. Management budget was first allocated from the government in 1982 and tended to increase every budget year. After the entrance fees collection system was induced in 1991, some national parks and wildlife sanctuaries have increased their own revenues (Wongpakdee, 1990).

PAs management mainly concentrate on demarcation, patrols and law enforcement and occasionally supported by local polices and regional forestry officers. All national parks have their permanent headquarters, although provision of guard stations, tourist accommodation and staff housing is generally inadequate. The supports of staff vehicles, weapons, radios, trails, and infrastructure development tend to be insufficient to meet the local demands. These deficiencies hamper the implementation and education development, interpretation and research activities, although number of parks are explored by visiting scientists and non-governmental nature conservation organizations.

Since October 2002, The Ministry of Natural Resources and Environment has been established. Under the control of Natural resource Division, and The Ministry of Natural Resources and Environment, National Park, Wildlife and Plants Conservation Department has been set up. Then National Park and Wildlife Conservation Divisions are transferred to be under the regulation of the National Park, Wildlife and Plants Conservation Department ever since. Organisations and components of The Ministry of Natural Resources and Environment are shown in Figure 2.2.

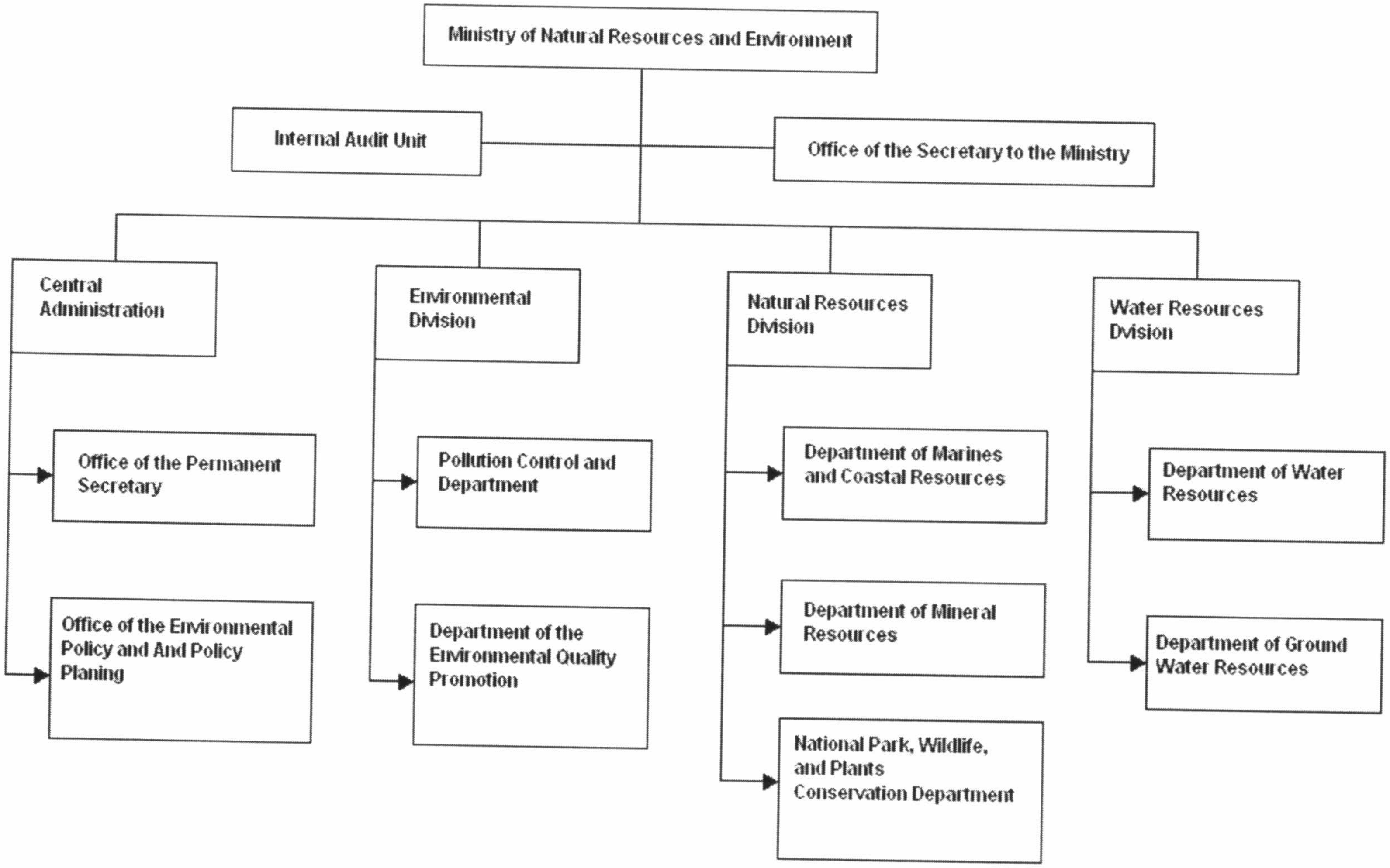

Figure 2.2 Structure of the organisation of the Ministry of Natural Resources and Environment.

(Source: modified from Ministry of Natural Resources and Environment: Electronic Citizen Service)

2.2.3 Natural resources management in Kaeng Krachan National park

Mater Plan of Kaeng Krachan National Park (RFD, 1994) was reviewed. Figure 2.3 describes general characteristics of natural resources management system in Kaeng Krachan. In general, organising management system is divided into threefold: administrative management of ecosystems and natural resources, inside park and infrastructure developments, and problem identification and solving.

Figure 2.3(a) indicates themes of management system that composes of five main components: protection and conservation of forest resources and uses other ecosystem entities; policy planing and technical control; improvement of tourism and recreational services; park administration and management; and resources management at subdivision scales. There are two forest protection units (unit 1 and 2) having responsibility about forest protection and conservation around the core area (at central, western and northern parts). While in the south, forest resource management is rather independent because of the differences of forest ecosystem and some specific characteristics. For forest protection unit 3 and unit 4, and another recreational service section are managed individually, separated from the central administration of Kaeng Krachan headquarter (RFD, 1994).

Figure 2.3(b) indicates that there are three main components involving management of natural resources in KKCNP: ecosystem structures; ecosystem functions; and local communities and people. Ecosystem structures, in general, provide both timber and non-timber forest products. While ecosystem services are resulted from ecosystem functions that provide public services to environment and people such as being a carbon sink and source of forest ecosystems. Those components constitute diversification of environmental amenities and enhance resource managers to manage it in appropriate ways. For timber forest products, over consumption and harvest of those are definitely prohibited in all reserve sites. However, some kinds of non-timber forest products are allowed to collected but within limit and regulation. Planning to use and conserve it in appropriate ways can promote real values of those ecosystem entities in future.

Local communities and people in Kaeng Krachan play important roles to management. At least, more than 500 households have been living inside Kaeng Krachan although those are against to park regulation and government policy. During the past few years, large numbers of local people have moved to live and settle in outside park, but some are still settling inside the core area (100-120 households) (unofficial surveys and personal communications). The urgently need is to manipulate both people and park in appropriate way to reduce conflicts between them.

Figure 2.3(c) denotes that problems found in Kaeng Krachan are from both internal and external factors. An example of internal factor such as infrastructure development induces even large number of visitors to the park. However, this can cause habitat fragmentation to wild animals. Road construction divided forestland into small pieces that may induce ecosystem fragility because alteration of ecosystem structures and functions. In addition, isolation of small islands in Kaeng Krachan reservoir may create difficulties to wild animals if their foraging sites are limited by overflows in rainy season. External causes such as agricultural intensification around the park, illegal logging and wild animal hunting, and impacts from tourism growth usually impose negative impacts to forest ecosystems. Agricultural expansion mainly destroys forest area, increases monoculture, and may increase toxicity in soil if chemical fertilisers, insecticides or other toxic substances are applied in growing seasons. Illegal logging and wild animal hunting may create long-term effects if dominant tree species are cut or rare animal species are hunted. Consequently, types of forest ecosystems may be altered and some wild animal species may be extinct. Growth of tourism encourages infrastructure development to facilitate increasing tourists and visitors. Improper tourist manners are also critical to forest resources and land uses in Kaeng Krachan.

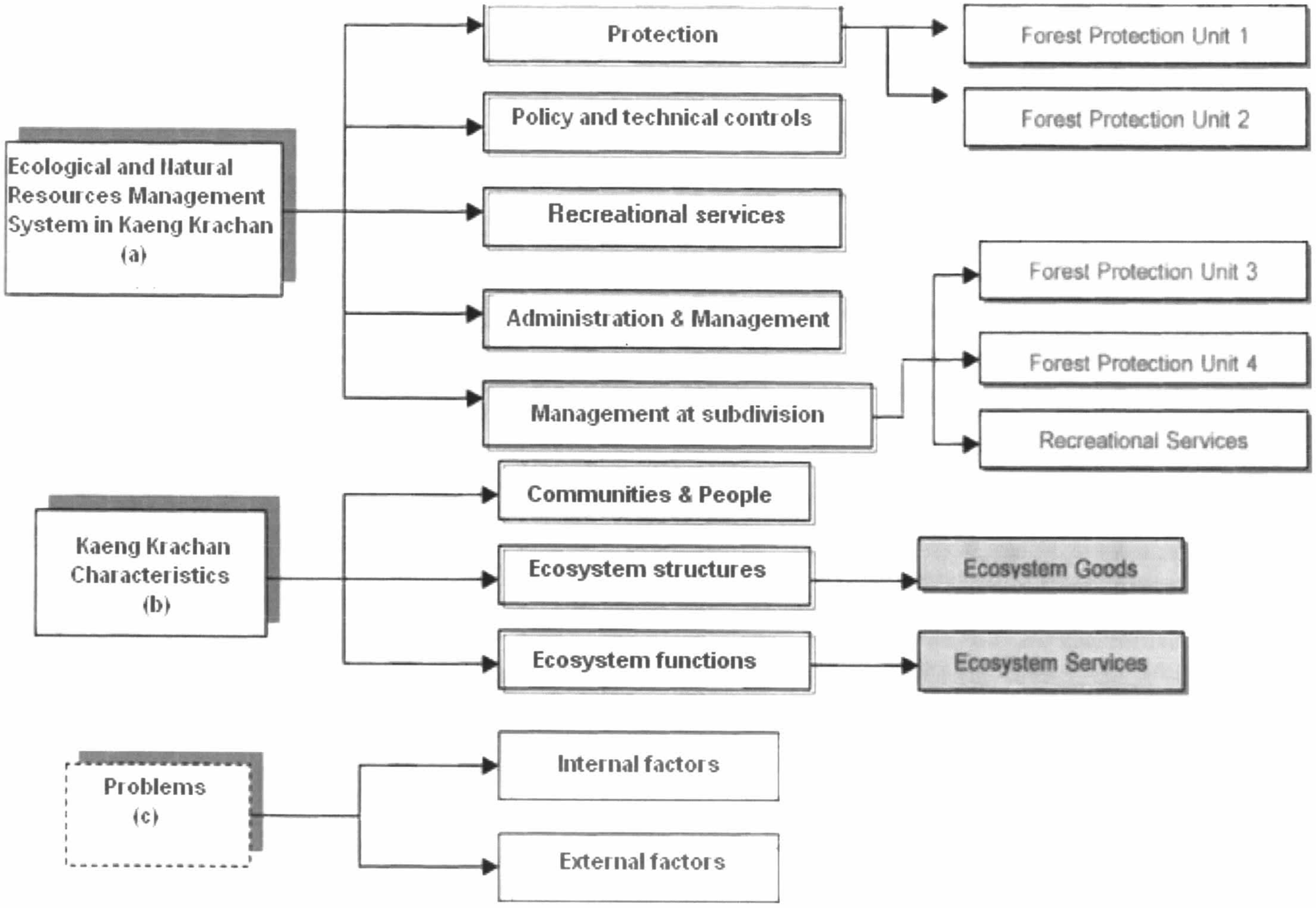

Figure 2.3 Institutional framework and responsibilities to natural resource management in Kaeng Krachan (a); important components of KKCNP (b); and sources of problems in Kaeng Krachan (c). (Source: RFD (1994)).

2.3 Introduction to systems thinking and model

Since the origins of systems analysis can be traced by the military's attempts to deal with complex problems during the World War II, the origination of modeling was first covered. Knowledge of systems analysis and system approach have successfully been applied in a variety of fields including engineering, industrial dynamics, business management, and economics. However, the extents of the model application increased since late 1960. Increasing application of systems theory, system approach, and system analysis has been found as a basic thought in development of modeling in fields of biology, ecology and natural resource management. Regarding this, consideration of economic, cultural and legal factors are incorporated as parts of application (Grant, Pedersen and Marin, 1997).

System analysis includes both a philosophical approach and a collection of techniques, which include simulation developed explicitly to address problems dealing with complex systems is incorporated. It also emphasizes a holistic approach to problem solving in Ecosystem Management (EM), and uses of mathematical models to identify and simulate important characteristics of system of interests. The goal of system approach within the context of ecology and natural resource management is to provide a useful perspective on complex systems that promote good research design and wise resource management decisions. Making decision in EM can not be solved independently by interpretation of observations in a variety of quantitative (description and classification) and quantitative (mathematical and statistical analysis) ways. Problems related to systems with relatively many interrelated components such as forest ecosystem need sets of mathematical equations to describe the interrelationships among these components in method solving. System analysis and simulation focus on the intermediate systems characterized by organized complexity in which system structures are controlled and changed by system dynamics. And that can be described by solving the equations comprising a mathematical model to simulate the dynamic (time-varying) behaviors of the systems. This research has been developed under the umbrella of systems theory and system thinking. System approach then becomes a basic strategy for problem solving. While system analysis is applied to some specific problems in KKCNP. Mathematical and statistical procedures will be used and computer is used for developing a model consensus and simulation.

2.2.4 Systems theory

Systems theory or general systems theory was principally proposed in the year 1940s by the biologist Ludwig von Bertalanffy, and was furthered by W.R. Ashby (psychiatrist) (von Bertalanffy, 1968). von Bertalanffy was both reacting against reductionism and attempting to revive the unity of science. He emphasized that real systems are open to and interact with their environments, and that they can acquire qualitatively new properties through emergence resulting in continual evolution. Rather than reducing an entity to the properties of its elements, systems theory focuses on the arrangement of, and relations between the parts, which connect them into a whole. This particular organization determines a system that is independent of the concrete substances of the elements. The same concepts and principles of organization underline different disciplines (physics, biology, technology, sociology, etc.) providing basis for their unification.

Development of systems theory is rather diverse including conceptual foundations and philosophy, mathematical modeling and information theory, and practical applications. Mathematical systems theory arose from the development of correspondents between models of electrical circuits and other systems. Applications in mathematical systems theory have been done in many disciplines including ecology. Systems theory is closely related to cybernetics, and system dynamics, which model changes in a network of sets of variables, for example, the world dynamics models of J. Forrester (Forrester, 1969 and 1971). Related ideas have been used in the emerging *science of complexity*, studying *self-organization* and heterogeneous networks of interacting actors, and associated domains such as far-from-equilibrium thermodynamics, chaotic dynamics, artificial life, artificial intelligence, neural networks, and computer modeling and simulation.

2.3.1.1 System and systems approach

Understanding of general characteristics and components of a system required more and clearly understanding about ecological modeling. A good perception of systems theory and systems thinking help a lot when one wants to construct a good and reliable model. "*System*" has been described by many scientists and in various disciplines. According to this, von Bertalanffy (1968) have shortly described that systems concepts fundamentally include systems-environment boundary, input, output, process, state, hierarchy, goal-directness, and flows of information. However, system, in general, composes of two basic components: elements and processes. Elements are measurable things that have relationships to each other and those can be linked together. Elements are also called objects, events, compartments, components, patterns, or structures. System's processes can change element from one form to another. Processes may also be called activities, relations, or functions. In a system, elements or processes are grouped to reduce complexity of the whole system to present only interesting conceptual or applied purposes. Depending on system's design, groups and interfaces between them can be either elements or processes with particular variation. Understanding the nature of this variation is central to the application of systems theory to problem solving. Definitions and characteristics of ecosystem and system are complimentary than opposed because they compose of elements and processes. These are usually referred to as ecosystem structures and functions or ecosystem patterns and processes. Forest ecosystem is as an example. The elements of a forest ecosystem might include trees, shrubs, herbs, birds, and insects, while the processes occurred might include growth, mortality, decomposition, and disturbances.

A unique characteristic of system or ecosystem is defined as open or closed to environment (Figure 2.4). The elements or processes can flow into or out of the system. Some systems are open with respect to certain elements or processes while others are closed but those elements or processes do not leave. Ecological systems are open to environment with respect to most elements and processes. Energy and nutrients input into ecosystems are transferred from physical environments, at the same time, some inorganic materials and energy are cycled and released back to environment. Systems also open to outside influences such as disturbances or outbreaks. Employing open and closed ideas to construct an ecological or environmental model can help researcher to define their specific boundaries of both that system and model.

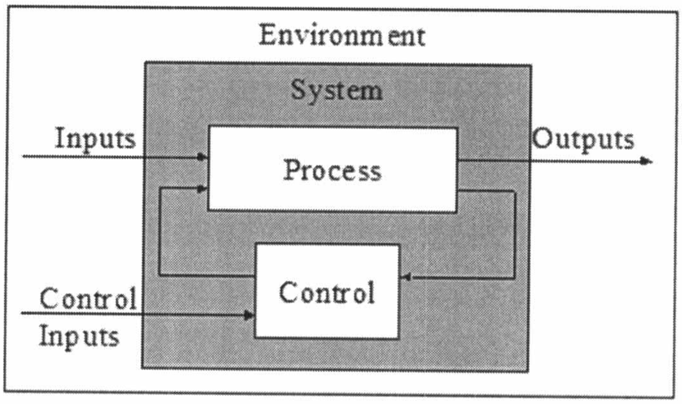

Figure 2.4 A system in interaction with its environment.

The term *"systems"* has been used for centuries. The components of the organizational concepts referred to as the *"systems approach"* which has been used to manage armies and governments for millennia. It was not until the Industrial Revolution of the 19th and 20th centuries that formal recognition of the systems approach to management, philosophy, and science emerged. As the level of precision and efficiency demanded of technology, science, and management increased the complexity of industrial processes, it increasingly became necessary to develop a conceptual basis to avoid being overwhelmed by that complexity. Systems approach emerged as scientists and philosophers identified common themes to managing and organizing complex systems.

Four main concepts that underline the systems approach are specialization, grouping, co-ordination, and emergent properties. Specialization characterizes a system, which divided into smaller components and allowed more specialized concentration on each component. *Grouping* helps a system to avoid generating greater complexity with increasing specialization and when it becomes necessary to group related disciplines or sub-disciplines. *Co-ordination* describes characteristics when components and sub-components of a system are grouped, then the interactions amongst groups are necessary to be coordinated. Finally, dividing a system into rather small subsystems requires understanding the *Emergent Properties* of a system. Belonging to the emergent property, viewing the system as a whole is indeed greater than the sum of its parts.

Systems analysis developed independently of systems theory. The principles of systems theory can be applied and aids decision-makers with problems of identifying, reconstructing, optimizing, and controlling a system while taking into account multiple objectives, constraints and resources. Systems analysis aims to specify possible courses of actions together with their risks, costs and benefits. Ecological modeling to environment or ecosystem management is an example of employing systems theory and systems approach accompanied with using computer to generate new problem-solving method in ecology.

2.3.1.2 Emergent property

Systems have emergent properties. A system is a complex entity that has properties which do not belong to any of its constituent parts, but emerge from the relationships or interaction of its constituent parts. Emergence is a notorious philosophical term of art. A variety of theorists have appropriated it for various. The meanings of emergent properties arise out of more fundamental entities and yet are 'novel' or 'irreducible' with respect to them. There has been renewed interest in emergence within discussions of the behavior of complex systems and debates over the reconcilability of mental causation, intentionality, or consciousness with physicalism (O'Connor and Wong, 2002).

British emergentists of the late-nineteenth and early-twentieth centuries were certainly the first to work out a comprehensive emergentist picture. Much of the defense of emergentism in this era was centered on chemistry and biology. The question was whether or not the constitutive principles and features of these sciences were reducible to those of the corresponding 'lower level' sciences of physics and chemistry, respectively. Reduction-minded 'mechanists', who supposed that the processes of life were governed wholly by physical-chemical principles, contended with the extreme anti-reductionist 'vitalists,' who posited an entelechy, a primitive substance or directing principle embodied in the organism which guided such characteristic vital processes as embryonic development and the regeneration of lost parts (Hans 1909, cited in O'Connor and Wong, 2002).

However, common to all British theorists is a *layered view of nature*. The world is divided into discrete strata, with fundamental physics as the base level, followed by chemistry, biology, and psychology. To each level corresponds a special science, and the levels are arranged in terms of increasing organizational complexity of matter, the bottom level being the limiting case investigated by the fundamental science of physics. As moving up the levels, the sciences become increasingly specialized, dealing only with a smaller set of increasingly complex structures with distinguishing characteristics which are the science's focus. The task of physics is to investigate the fundamental properties of elementary particles and the laws that characterize them, whilst the task of the special sciences is to elucidate the properties had by complex material substances and the laws governing their characteristic behavior and interactions.

Crucial to an account of emergence is a view concerning the *relationship* of such levels. There are two rather different pictures of emergence, one involves the appearance of primitive high-level causal interactions that are additional to those of the more fundamental levels. Another, by contrast, is committed only to the appearance of novel qualities and associated, high-level causal patterns which cannot be directly expressed in terms of the more fundamental entities and principles. Emergent *qualities* are something truly new under the sun, the world's fundamental dynamics remain unchanged. Emergence for such theorists is fundamentally an epistemological, not metaphysical, category.

Predictive: Emergent properties are systemic features of complex systems which could not be predicted from the standpoint of a pre-emergent stage, despite a thorough knowledge of the features of, and laws governing, their parts. *Irreducible-Pattern*: Emergent properties and laws are systemic features of complex systems governed by true within a special science that is irreducible to fundamental physical theory for conceptual reasons. The macroscopic patterns cannot be captured in terms of the concepts and dynamics of physics. Although language of emergence is not used, J. Fodor (1974) expresses this view nicely in speaking of the immortal economist who vainly tries to derive economic principles from a knowledge of physics and the distribution of physical qualities in space-time.

We assumed that the concept of emergence applies to properties (or the event or states consisting in a system's having a property), rather than to a system or object. This is in keeping with the British emergentists' view of emergence as midway between mechanistic reductionism and vitalism of a sort which posited entelechies, substances embodying life-governing principles. Composite objects having ontologically emergent features appear to be truer unities than those lacking such features. Since such features will make a nonredundant difference to the dynamical unfolding of the physical universe, one *must* quantify over their bearers in giving a minimally complete account of this evolution. Such objects are convenient fiction suited to human perceptual and linguistic affinities.

Merricks (2001) takes and affirms emergence as the criterion for the existence of true composites. He does not give an account of what emergence is, apart from its involving macroscopic causal powers that do not take place as the causal powers of and relations among the basic microphysical entities. In any cases, it seems fair to conclude that Merricks believes there are emergent composite *individuals*.

2.3.1.3 System hierarchy

Most systems contain nested systems (subsystems within a larger system). By gradually decomposing an object into smaller parts then further decomposing those parts into smaller ones and so on, give rising to a "*Hierarchy*".

Hierarchical (or nested) systems contain both parallel and sequential components. According to the Principia Cybenetica (Heylighen, 1998), hierarchical system is described as follows.

> *"at the higher levels, you get a more abstract, encompassing view of the whole emerges, without attention to the details of the components or parts. At the lower level, you see a multitude of interacting parts but without understanding how they are organized to form a whole".*

At the upper levels of a hierarchical system, a large amount of precision which can be measured, studied, or managed declines for two reasons.

1) The elements or processes in parallel components of a system are slightly different, therefore, combining them at a broader level increases innate variation of those average components.

2) The elements or processes in sequential components of a system are dependent on each other, therefore, variation in components becomes more additive.

Attempting to measure, study, or manage a system at a precision greater than the innate variation among its components is meaningless. Since moving information between levels of a hierarchy requires time, and that the variation in time needed to process differently within a hierarchy, can lead to innate temporal lags. The problems can be minimized by not trying to consider a system with high precision from a single and central within the upper hierarchical level. Instead, those centralized levels are useful for generalities that allow local variation, while more precision is achieved through independent, parallel processes at more localized levels.

2.3.2 Defining model and simulation

This section explains general knowledge of a model and simulation and model-building processes.

2.3.2.1 Model and simulation

Model, now a day, plays important roles in the thinking of scientists. Definition of a model can be easily defined as any representation of a real system, which may deal with functions and structures of that real system or simplification of reality. The model may involve words, diagrams, mathematical notations, and physical structures in representing the system's characters. Model may have the same meaning as concept, hypothesis, or resemblance. Definition of a model is given in 1978 by J.N.R. Jeffers (Jeffers, 1978), described as "a formal description of the essential elements of problem in system-of-interests".

The same definition has also been described by J. W. Haefner (Haefner, 1996). Description of the model can be explained in several forms including physical, mathematical, or verbal structures. Since a model is the simplification of reality, therefore, it is definitely simpler than the real world. No models can represent all the details or all components of the system-of-interests. Nevertheless, model can represent all essential information and provide important features of what scientists are interested, this can be considered to be good.

Model and its characteristics can be classified in a variety of ways (Haefner, 1996; Grant, Pedersen, and Marin, 1997). However, four types of model are briefly details as follows:

1) *Physical versus abstract*: Abstract model uses symbols rather than physical devices to represent system being studied. The symbolism used can be a written

language, verbal description, or a though process. Difficulties arise when they can not contain adequate description of the system-of-interests.

2) *Dynamic versus static*: Dynamic model describes time-varying relationships amongst objects or components. While static model do not have time-varying factor as an independent variable to influence structures of the model.

3) *Empirical (correlative) versus mechanistic (explanatory)*: They are different in their origins and goals. Empirical model describes only the summary of a set of relationships and the goal is predication, not explanation. Whilst, mechanistic model aims to represent the internal dynamics of the system. The goal is explanation through representation of that casual mechanism that underlying system behavior.

4) *Deterministic versus stochastic*: Deterministic model contains no random variables and the predication occurs under specific sets of conditions. While, the predication of stochastic model depends on a set of specific conditions that are varied every time when solving the model, because of containing some random variables.

5) *Simulation versus analytical*: A model that general solution can be obtained and applied to all situations is an analytical model. In turns, a model which has no specific set of arithmetic operations for each particular solution but a situation can be solved is called a simulation model. Many ecological models are relevant to this model type.

Models then are useful for conceptualizing, organizing and communicating complex circumstances and for understanding, assessing and optimizing estimates of system interactions (Hall and Day, 1977; Starfield and Bleloch, 1986).

Simulation is the process of using a model to mimic system behaviors that are studied. Simulation model generally composes of a series of arithmetic and logical operations that together represent system structures (states) and behaviors (changing of states) of the system-of-interests.

B. C. Patten (1971) provides the two very simple but powerful concepts and the changes of state of the system, which are fundamental to simulation. The system-of interest exits in different states at different points in time. Also, the rules govern the manners in which states of the system changes happened as time passes. The rules governing changes may change from time to time because they are themselves a function of the state of the system.

According to this, when appropriate variables are chosen to describe the system and represent the rules governing changes appropriately, then state of the system can be traced through time, which is to say that behaviors of the system are simulated.

2.3.2.2 Model-building process

Overviews of general steps of the modeling process are described in this topic. Generally, the model-building process composes of four main steps (formulation, verification, calibration, and analysis or evaluation). However, those four main steps can be modified and described in a variety of ways (increase or decrease in numbers of steps) depending on details of model's construction and components (Haefner, 1996). Building a model is an iterative process, which means that a large number of steps need to be taken or simulated repeatedly. Figure 2.5 illustrates each step of model-building process and explanation of each step is described below.

1) *Problem identification*: This step starts with identifying problem(s) of the system that you are interested. This is probably the most important step in the process. Problems can occur when dissatisfaction of the system's dynamics occurred. A dynamic problem can be derived by direct observations and confirmed by documents. A model developer can specify intensity of problems by drawing a graph of selected variables, which the values of that variables can change over time. This graph may not a good abstract representation but characteristics of the problems will be summarized. A modeler can use this graph as a reference mode that serves as a target pattern behavior. In a more complex system, graph of reference modes can be a combination of two or more than two fundamental patterns that are resulted from selected or interesting variables (Ford, 1999).

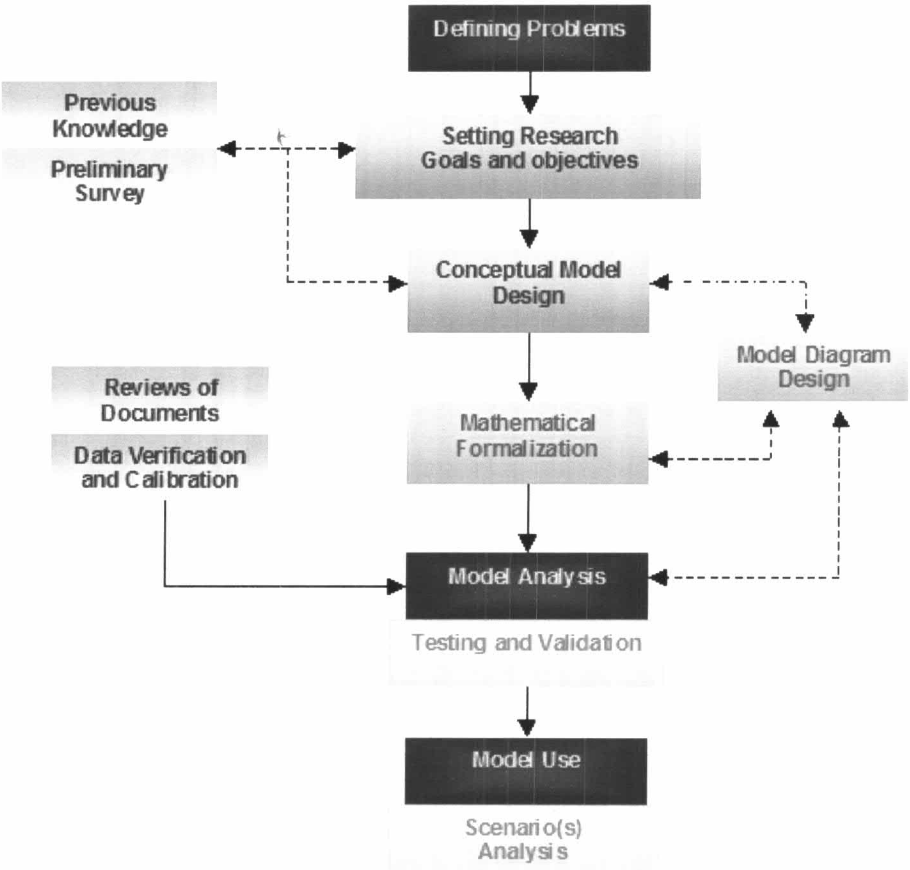

Figure 2.5 Common steps of model-building process.

2) *Setting goals and objectives*: The goal is that what is to be found out with the whole affords. When problems of system-of-interests are identified, their properties needed to be considered to reach the goal. Specific objectives of the model can be set up. More specific objectives can help a modeler or researcher to reach the goal with less difficulties. Making a graph of reference mode is the

best way to specific about the dynamics problems. When drawing graph of reference modes, studying available information, and defining objectives with goal in mind, model in abstract will be identified relating to three dimensions: structural, spatial, and temporal.

a) *Structure*: Structure of the model means elements (objects/ components/ or events), and processes, which are both interesting and important to the system-of-interests. Interactions among objects or components also need to be identified.

b) *Space*: Space of the system means to the specific boundary of the system of which all selected objects or elements are constructed inside. In some cases, whole system is divided into several sub-systems, the space and boundary of each can be either ranged between sub-systems at the same levels or at different levels of system hierarchies. Spatial resolution of the processes of interactions, and evolving of the system are important. This helps researchers to classify the system characteristics in term of their static or dynamic pattern.

c) *Time*: Temporal scale is an important factor that needed to be identified. Time-varying factors help us classify the system-of-interests in form of deterministic or stochastic manner.

However, when the graph of the problem's performances or of the reference mode cannot be drawn, the reasons or that identified problems of building a model needed to be reconsidered. At this step, making a list of policies or actions that might lead to changes of system behaviors may be helpful.

3) *Conceptual model development*: Once, model is identified in three dimensions (structural, spatial and temporal scales), a conceptual model of the system is described. Conceptual model may be a mental, verbal or diagrammatic model. In any conceptual models, following components should be clearly identified.

   a) *Boundaries*: Model's boundary distinguishes specific system or system-of-interest from outside world. When boundaries are identified, information and material flows amongst objects and between systems are declared.

   b) *Variables*: Variables are what characterized elements of the system. These are the quantities that change in the different patterns of system behavior.

   c) *Parameters*: Parameters are also characterized the system. Unlike values of variables, parameters' values will constant throughout the modeling process.

   d) *External factors*: These factors come from outside, as an effect from outside world. Types and values of external factors may change in time, but they do not response to changes within the system.

4) *Mathematical formalization*: Mathematical terms, formulas and equations need to be developed to describe the concepts of conceptual or verbal model. Relationships amongst variables, parameters, factors, and functions or processes can not be described completely in wording forms. They need to be translated into algebraic formulae or mathematical equations to facilitate simulation of model's behavior.

5) *Model calibration and verification*: Once the mathematical equations are solved, the model's values are observed. At this step, researcher will need to change a little bit of some parameters' values to fit the model dynamics. This step is so-called calibration process. When the parameters and variables are meet the standard of the mode's purposes, verification will be done by application of another set of parameters. These will success when the results are compatible with the model expectation.

6) *Model uses*: When the model performances are accepted, some conditions that have not yet happened in the real system can be applied. This step is called scenario analysis. The results of each condition may become important for making the right decisions for system managers.

2.3.2.3 Ecological modeling software

In this research, a holistic model for muti-purpose management of KKCNP including natural system(s) and human enterprise(s) are constructed. The possibility to analyze *in situ* cannot be done in short period of times therefore the idea of compartment-flow modeling can come across. A compartment-flow modeling allows quantitative comparative analysis and enables researcher to adjust the model components to simulate outcomes of specific problems with different applicable management actions.

Now a day, several types of ecological model have been developed from several organizations. However, SIMILE, an ecological modeling software developed by Muetzelfeldt and Taylor (Muetzelfeldt and Talor, 1997 and 1998) is used for model building, making consensus and running simulation because of its capacity of handling a wide variety of concepts, such as system dynamic and individual-based modeling. The systematic structure of SIMILE enables users to construct and control timing attributes in the simulation (Muetzelfeldt and Talor, 1997 and 1998). Its good generic displaying systems are also provided. A model-design process of SIMILE is generally described in Table 2.1.

Model components, parameters, variables, and relationships amongst those indicated in conceptual framework will then be translated into SIMILE notations (compartments, inflows, outflows, exogenous variables, and intermediate variables) before making simulation. Mathematical equations will then be developed.

Table 2.1 General steps of modeling-building process in SIMILE.

(Source: modified from Muetzelfeldt and Talor (1997 and 1998).

Context	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 submodel or of the whole model.
Model characteristics	Submodel or model description stated about key decisions or spatial/temporal scaling.
Interfacing between submodel	In case of many submodels are constructed, information among submodels must be provided and changed for each other.
Submodel design	Submodel will be designed to support the purposes of the model stated above. Inputs are policy keys to the submodel, information from others submodels, and local parameters. Outputs are indicators of performance generated by the submodel, information to other submodels, and any other variables of interest.
Testing submodel as model	All inputs will be set to fixed (or time-dependent) values
Synthesis	Linkage of submodel will be performed.
Using the whole model	Model is ready in use to satisfy the purposes.

2.4 Ecosystem valuation

Due to this research involves tourism, management and local people in protected area, basic knowledge on evaluation of ecosystem benefits need be explained. Ecosystem valuation requires basic knowledge on economic study relating to ecosystem goods and services and other entities. Also, application of techniques in ecosystem valuation processes can be done in a variety of ways depending on several factors such as types and components of environmental resources, budgets, space-and-time factors, human resources and experiences ((King and Mazzotta, 2002).

Ecosystem goods and services can be viewed actually or potentially available to generate actual and potential incomes at present and future. Valuation of ecosystem benefits now a day does not reflect the real values for future generation. This reflects only the current generation's perspective that is inadequate and is not a good measure for future uses (Constanza and Daly, 1990; Johnson and Johnson, 1990; Constanza, 2002). Under-valuation of ecosystem benefits could result in depletion and degradation. Therefore resource managers need to be better informed to achieve economic, social, and environmental objectives in a manner that balances between human needs and ecosystem constraints (Emerton, 2000).

Regarding to this, knowledge on economics relating to ecosystem study and valuation of ecosystem benefits are discussed in this section. Economic valuation of natural resources can serve as making decision factors when alternatives of natural resources management are made. Economic valuation can be useful, by providing a way to justify and set priorities for programs, policies, or actions that protect or restore ecosystem and their services.

2.4.1 Economic values

From economic perspectives, economic value is one of many possible ways, which have been broadly used to define and measure any net changes in the welfare of society. Although other types of values are used, economic values are very much important and useful to consider when making economic choices that involve tradeoffs in allocating resources. Values can be associated equally with the consumption of ecosystem goods and services purchased in market and with the services from environmental amenities for which no payment are made (Binning and Carter, 1996).

The economic value of a particular item can be measured by asking people' opinions on whether they are willing to give up in goods and services in order to obtain other goods or services (Bishop, 1987; and Binning and Carter, 1996). Currency units, usually US dollar (US$), are universal accepted measure of this value (King and Mazzotta, 2002). Amount of money that person willing to pay for goods and services is often referred as *"Willingness To Pay (WTP)"*. By relating quantity demanded and price of goods, demand function of those ecosystem goods can be estimated. Numbers of dollars that person willing to pay for something tell us about how much of all other goods and services willing to give up to get that item. This refers to the law of demand - people usually demanded less of something when it is more expensive (King and Mazzotta, 2002). In general, when price of goods increases, people purchase less of that goods. Then demand curve, the graphical presentation of demand function can be drawn. Market price only tells us the minimum amount that people willing to pay for goods. When people purchase marketed goods, they compare the amount they would be willing to pay for that goods with its market price and only purchase the goods if their WTP equal to, or greater than the price of that goods.

Law of demand is applied when making decision on resource allocation. This can be done by measuring the net economic benefits of environmental goods or services. Economic benefit is often measured by "*Consumer Surplus (CS)*" which is graphically represented by the area under the demand curve (Figure 2.6). Individual CS will change when prices or quality of goods and services changed. Increase and decrease in WTP relate directly to changes of CS and total economic benefits of goods or services (Binning and Carter, 1996; King and Mazzotta, 2002).

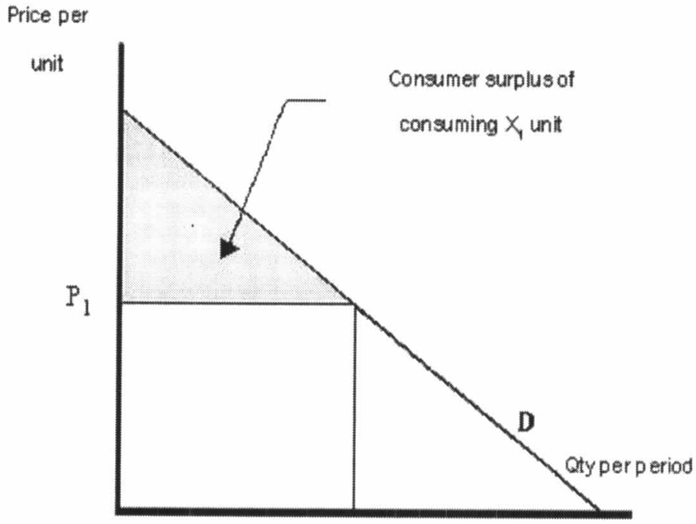

Figure 2.6 Demand curve and consumer surplus.

(Source: King and Mazzotta (2002)).

On the contrary, economic benefits to producers can be measured by purchase surplus, the area above the supply curve and below the market price (Figure 2.7). Supply curve is a graphical presentation of the supply function. Because producers would like to sell more at higher prices, then supply curve slopes upward.

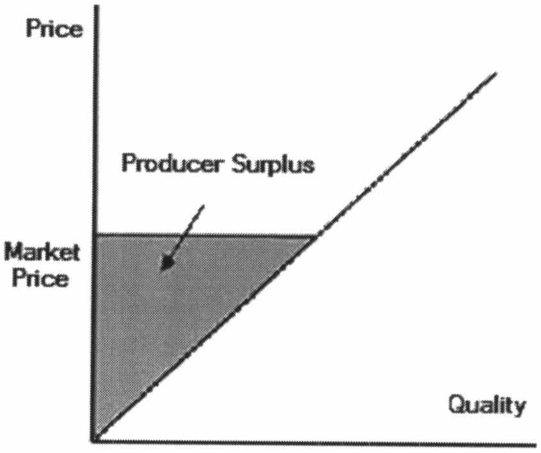

Figure 2.7 Supply curve and producer surplus.

(Source: King and Mazzotta (2002)).

When measuring economic benefits of policy or alternative that affects an ecosystem, economist usually measures total net benefits. Total net economic benefit is the sum of consumer surplus plus producer surplus, less any costs associated with the policy or initiative.

2.4.2 Valuation of ecosystem benefits

Ecosystem valuation can be a controversial task when people try to put a price tag on nature to approach the valuation. Protecting and managing natural resources must often make difficulties in economic decision based either explicitly or implicitly on society's values. Important concepts needed are ecosystem functions and factors for decision making. Details of ecosystem valuation and ecosystem benefit briefly explained in this topic are from the documentation developed by C. Binning and M. Carter in 1996 (Binning and Carter, 1996) and developed by D. M. King and M. Mazzotta in 2002 (King and Mazzotta, 2002).

Ecosystem functions are physical, chemical and biological processes or attributes that contribute to self-maintenance of an ecosystem. Ecosystem functions constitute ecosystem services that generate beneficial outcomes for natural environment and people. Influencing factors (or components) that complicated ecosystem management decision deal tightly with market failures. Those constituents are important because making decision on ecosystem valuation and management usually confronts with market failures related to ecosystems that produce ecosystem services. Ecosystem services that considered as public goods can be influenced by externalities. The property rights on those resources are not clearly defined because no specific groups of people own the resources. So they are open access to the publics and can be overwhelmed by negative externalities. In addition, because there is no incentive to conserve, ecosystems can be over-harvesting and potentially decline in abundance over time (Binning and Carter, 1996).

Ecosystem valuation can help resource managers deal with the effects of market failures, by measuring their costs to society, in terms of lost economic benefits. The costs to society can then be imposed in various ways on those that are responsible or can be used to determine the values of actions to reduce or eliminate environmental impacts.

The *Total Economic Value (TEV)* of environmental amenities comprises *explicit use benefits* as well as *implicit non-use benefits*. Use benefits occur from the physical use of environmental resources such as visiting a national park. The benefits from productive activities such as agriculture and forestry are included in this category (Manophitak, Kunthamdee, and Tonsophon, 1999). Figure 2.8 illustrates types and examples of the TEV. Non-use benefits refer to the benefits, which individuals may obtain from environmental resources without directly using or visiting them. They are classified into five types, as shown on Table 2.2.

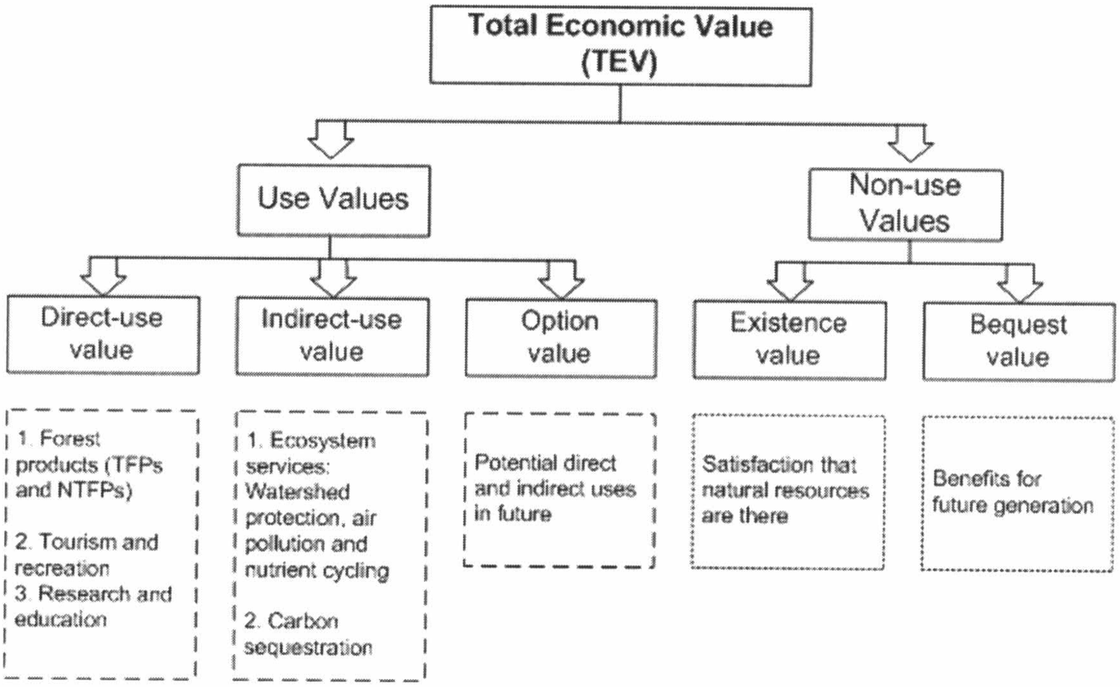

Figure 2.8 Total Economic Valuation (TEV) of environmental resources. (Source: modified from Binning and Carter (1996) and King and Mazzotta (2002)).

Each of those benefits can increase welfare so they must be recognized in any analyses. In this way all the benefits from environmental changes may be incorporated. Evaluation techniques using for estimate Willingness To Pay (WTP) or Willingness To Accept (WTA), and opportunity cost can be varied with market situation. Unlike competitive markets, prices of environmental goods and services can not be observed and measured directly. In their absence, WTP/WTA and opportunity cost can be derived from other kinds of data which provide the opportunities to apply some techniques of valuation. Table 2.3 depicts types of data and some techniques using for estimate Willingness To Pay (WTP) or Willingness To Accept (WTA), and opportunity cost: market value approach, surrogate market approach, and state preference approach.

Table 2.2 Types of implicit non-use benefits of environmental amenities.

Types of non-use benefits	Meaning
Existence value	The welfare obtained from the knowledge that an environmental resource exists. The concept may include the benefits obtained from knowing that culturally important resources are protected.
Vicarious value	The welfare obtained from the indirect consumption of an environmental resource through books and other media.
Option value	Welfare obtained by retaining the option to use an environmental resource at some future date. Option value stems from the combination of the individual's uncertainty about future demand for the resource and uncertainty about its future availability
Quasi-option value	Welfare obtained from the opportunity to get better information by delaying a decision that may result in irreversible environmental loss. This kind of value may be obtained when future technologies or knowledge enhance the value of a natural resource
Bequest value	Welfare that the current generation obtains from preserving the environment for future generations

(Source: Binning and Carter (1996)).

The concept of economic value can therefore be summarized as follows:

Economic value = use values + non-use values

Non-use values = existence value + vicarious value + option value + quasi-option value + bequest value

Table 2.3 Types of data used and techniques for valuation.

Market situation	Data used	Kinds of techniques
Observable market data for prices/ costs	Price or cost of Environmental resources	Market value approaches
	Price or cost or surrogate goods or services	Surrogate market approaches
No observable market data for prices/ costs	Responses to question in a survey which simulates market	Stated preference approaches

(Source: Binning and Carter (1996)).

A part of this research involves directly with valuation of ecosystem goods and services (use of aesthetic values) therefore techniques used are Contingent Valuation and Travel Coat Method.

The knowledge of ecosystem evaluation and techniques of valuation processes have been much developed and applied to environmental resources during the past few decades. For evaluation of non-market forest benefits in monetary terms, development of forest policy and management systems can be assisted. Table 2.4 describes lists of some common methods of valuation. Figure 2.9 presents a general framework of all common techniques of ecosystem valuation when applied to estimate use and non-use benefits.

Table 2.4 Types of data used and techniques for valuation of non-market benefits.

Valuation method	Relevant forest benefits	Strengths and weaknesses
Surrogate market Travel cost (TCM): Use survey data on direct costs (fares, accommodation) and in some cases, opportunity costs of time spent travelling to and from a site, evaluated at some fraction of the average wage rate.	TCM is often used to estimate demand for forest recreation at specific locations. Related methods used mainly in developing countries estimate the value of non-marketed, NTFPs in terms of the opportunity cost of time spent collecting and/or processing them.	Provided the relation between the benefit being valued and the surrogate market is correctly specified, and prices in the surrogate market are not very distorted, such methods are generally reliable. TCM estimates may need to account for various objectives (benefits) in a single trip.
Hedonic pricing: Use statistical methods to correlate variation in the price of a marketed good to changes in the level of a related, non-marketed environmental amenity.	Hedonic pricing is used to estimate the impact of proximity to forested land and/or logging on the prices of residential and commercial property.	Hedonic pricing requires large data sets, in order to isolate the influence of a non-market benefit on market price, relative to other factors
Stated preference Contingent Valuation Method (CVM): Use consumer surveys to elicit hypothetical individual Willingness To Pay (WTP) for a benefit, or Willingness To Accept (WTA) compensation for the loss of that benefit.	Recreational values are often estimated using CVM. It's a way to estimate non-use values, e.g. landscape or biodiversity values, for which price data do not exist.	CVM estimates are generally considered reliable if strict procedural rules are followed. Participatory techniques are more experimental and not widely used to estimate non-market forest benefits. They are good at eliciting qualitative or "contextual" information, but there are doubts about their reliability for estimating WTP.
Contingent Ranking / Focus group: Use participatory techniques in group setting to elicit preferences for non-market benefits, either in relative terms (ranking) or in monetary terms.	Contingent ranking may be used where target groups are unfamiliar with cash valuation.	

(Source: modified from Binning and Carter, 1996).

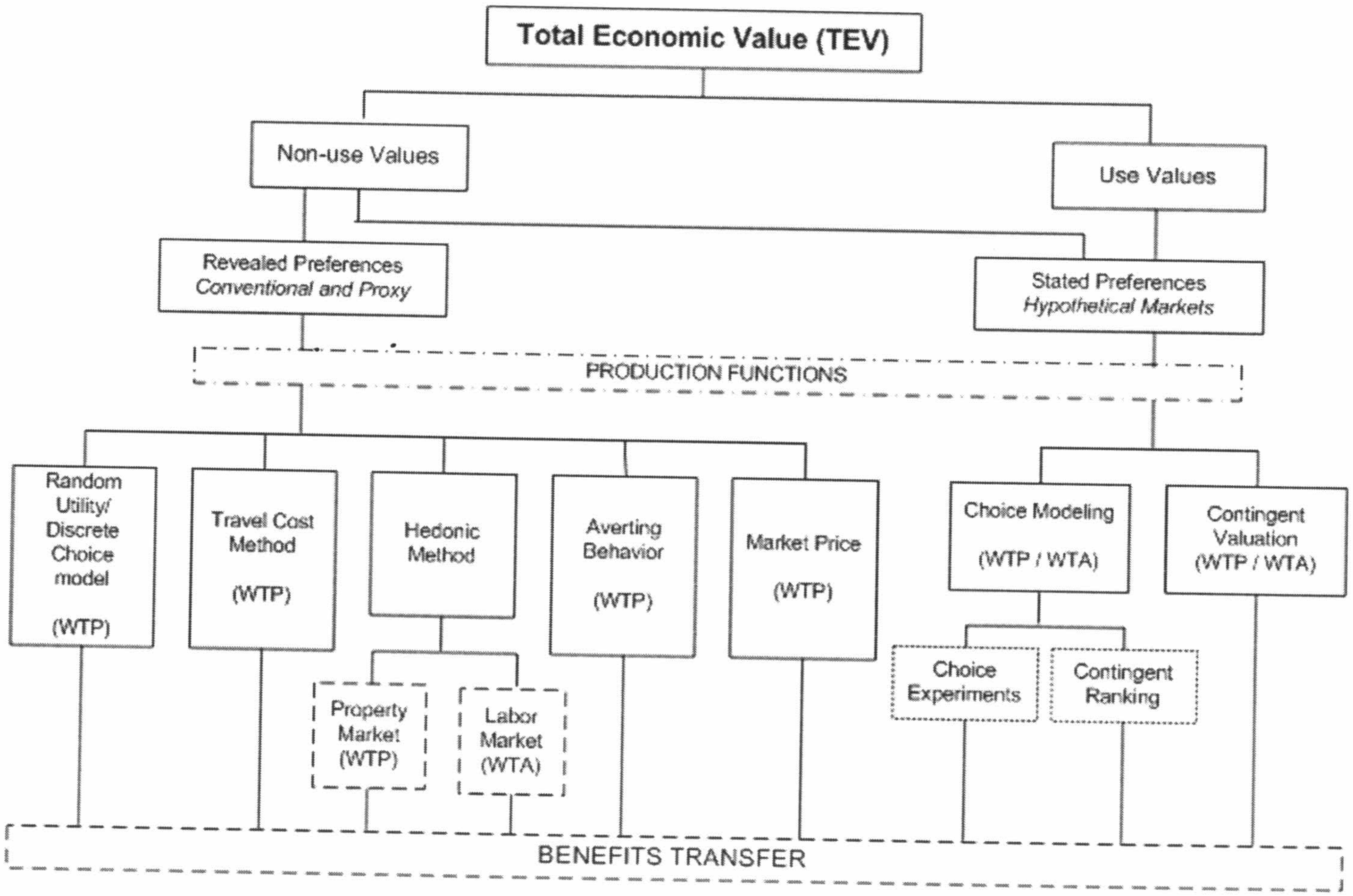

Figure 2.9 Total Economic Valuation (TEV) and valuation techniques.

(Source: Modified from Binning and Carter, 1996).

The *Contingent Valuation Method (CVM)* has been used to estimate economic values of all kinds of ecosystem services. However, for non-use benefits, this method is probably the most widely used and controversial. CVM involves directly asking people to state the values they would be willing or willing to accept to give up for specific environmental or ecosystem services rather inferring from the actual choices. "CVM" sometimes is referred as a "stated" not a "revealed" preference method. CVM is so-called "contingent" valuation because people were asked to state on a specific hypothetical scenario and description of the environment services. Because non-use values involve neither market purchases nor direct participation, therefore these benefits are likely to be implicitly treated as zero unless their dollar values are estimated. The possible option for CVM is by asking, as opposed to observing their actual behaviors. However, asking people to state the values of ecosystem benefits usually leads CVM enormous controversy on its greatest strengths and weaknesses (Binning and Carter, 1996; King and Mazzotta, 2002)

Applying the CVM is generally a complicated, lengthy, and expensive process implemented on specific environmental services and in specific context. Because CVM is enormously flexible in application to estimate the economic values of virtually anything so that when conducting a survey, several consideration issues related such as steps and methods of application needed to be concerned . However, CVM has been widely used, and a great deal of research is being conducted to improve the methodology to make results more valid and reliable for better understanding of its strengths and limitation. Above all, this depends on the research objectives and kinds of environmental problems to be solved (Manophitak, Kunthamdee, and Tonsophon, 1999; King and Mazzotta, 2002).

The Travel Cost Method (TCM) is used to estimated economic use values associated with ecosystems or sites where management for recreation purposes including changes in access costs, elimination of an existing site, addition of a new site, and changes in environmental quality are enhanced. Basic premise of the TCM is the time and travel cost expenses that people incur to visit the site represent the "prices" of access to the site. Thus, people's WTP of visiting the site can be estimated based on numbers of trips that visitor made at different travel costs. This is analogous to estimating people's WTP for marketed goods based on the quantity demanded at different prices. There are several ways to approach the problem by using variation of TCM including Zonal Travel Cost Method (ZTCM), Individual Travel Coat Method (ITCM) and Random Utility Approach (Petcharanond, 1999; UCLA, 1999; King and Mazzotta, 2002).

In general, application of TCM start based on the basic thought that people live further will visit a site less often because it costs more in terms of actual travel cost ad time to reach. Number of visits from the origin zones, at different distances from the site, and travel cost from each zone has been used to derive an aggregate demand curve and recreational or scenic services of the site. The demand curve shows how many visits that people would make at various travel-cost prices. The curve will be used for estimates of visitors' WTP. Factors such as personal interest, level of recreational experience, and personal attitude also affect number of visits (UCLA, 1999).

To apply the TCM, information about exact distance whose individual travels to the site, exact travel expenses, length of trip and time spent at the site needed to be observed. Normally, information will be gathered through survey, on-site, telephone or sometime mail survey can be used. For simpler application, much information may be available from state and county resource agencies or from federal surveys. The most controversial aspect of TCM are accounting for the opportunity cost of travel time, how to handle multi-purposed and multi-destination trips when travel time might not be a cost to some people but part of recreational experience. Information is used to construct the demand function for the site and estimate the consumer surplus (CS) or economic benefits for recreational services of the site.

2.5. Reviews of literatures

Systems theory, systems approach, hierarchy and organization of the system have been widely used and applied in broad arrays to natural resources management. Modeling is used as an integrative tool to management of a complex system and their counterintuitive characteristics. The dynamics have been undertaken principally to discover and model processes of corporations amongst constituents of the model. In specified indicators that suggest corrective actions, choosing adopted policies to cope with a complex system to produce or correct difficulties are actually more intensified than producing solution.

Modeling ecosystem management and environmental resources have been classified and grouped at various levels of application. Several researches had been conducted at different scales of spaces and times (from large to rather small places or from long to short period). This section reviews previous researches on modeling and management of natural resources and ecosystem entities in various perspectives. The application of model in making-decision on choices and alternatives to ecosystem management is also included. Application of ecosystem study, ecosystem analysis and approach incorporation with valuation of ecosystem benefits are broadly described. The ideas and concepts of empirical researches involving ecological-economic model and their attributes are debriefed. More than the differences of an ecological modeling software used, the concepts and ideas of development and the selection of effective indicators or variables are more considerable.

2.5.1 Modeling natural resources and environment

Lists of selected papers intend to describe empirical researches on modeling ecosystems and natural resources management in broad views. The majority of researches were conducted in the reserves but some of them were not. Interesting ecological issues were applied differently depending on specific purposes of studies accompanied with adopted policies consideration and legal constraints.

Jay W. Forrester developed the classical research on ecosystem dynamics apparently in 1969. In his first article, he proposed that the study of complex systems such as ecosystems could not be done separately without encompassing the current laws and present policies of the city. He said that even one can produce satisfied solutions or unexpected difficulties, but many times, those were proved incorrect, ineffective and detrimental in consequences (Forrester, 1969).

Forrester placed the ideas to develop the intuitive responses that were technically called first-order and negative-feedback loops. In the structure of the context, a complex system belonged to the corporation, city or government. Therefore, the system was also driven by intensifying policies of the organizations of which responsibilities are taken. A simple loop in Forrester's idea was quite simple in development because it composed of only one important state variable with a goal seeking. To make matters of development far from the truth, Forrester suggested to avoid misleading in cause-and-effect associations between variables (in case of more than 2 loops were encountered) that were simply moving together as parts of the total dynamics behaviors of the systems because associations between cause-and effect always leaded to interactive and detrimental outcomes (Forrester, 1969).

Forrester's second article later supported his first paper in 1971. The second edition described broad views of social problems involving system dynamics study. In addressing solutions of social difficulties, four possible ways of consequences may be induced. Firstly, an attempt to relieve one set of symptoms may create a new mode of unpleasant system behaviors. Secondly, short-run improvement may clash long-run improvement in term of policy changes. Thirdly, characteristics to be careful is conflicts between the goals of subsystems and the welfare of larger systems. While the quality of lower systems rises, intervention of bigger (boarder) systems may occur. Fourthly, characteristics of social system are inherited, human experiences may lead to intervene and cause errors in developing feedback loop of dynamics system construction. Those consequences mentioned in his second paper should be discussed before misleading in development (Forrester, 1971).

From Forrester's perspectives, at least other three prospects needed to be concerned in order to get closely possible way to success in system improvement. First, all attractiveness of every city in contribution of its desirability or undesirability must be encompassed in order to develop equalizing process of improvement. Second, pressure of one process may distribute throughout, however, this should not harm or disturb other parts of the same system. Finally, determining the future quality of a city may need technological improvements. The publics should recognize that improved technology does not always bring an improved society (Forrester, 1971). Jay W. Forrester's ideas and his articles have long been recognized as basic thoughts of development of modeling environmental management.

Another propose of ecological modeling is trying to extend model's perspectives to forest ecosystem management. Characteristics of forest growth and yield are very important to the development of sustainable forest management schemes especially in tropical forests. Good understanding of forest growth and yield in different areas and at different Silvicultural management regimes are keys to success in developing management plan. Forest management model using SIMILE software, an ecological modeling software selected for this study, was reviewed. The details of development and the results of simulation were not given here but identifying the goals or the purposes of the study. .Application of SIMILE to forest ecosystem management was done by Peter Levy (Levy, 1996). He proposed the idea that maximization of crop yield under the canopy effects can occur by employing pruning system in management. At the maximized level of product components, pruning can be used to maintain the system state. Simulation was done to examine the effects of tree pruning on competition between trees and crops for light and water. Two models MAESTRO, PARCH had been constructed for the project. Full details was given in Levy (1996).

Management of natural resources always involves with policy issues especially in the tropical zones. However, the consequences of well-intended policies were not always obviously generated. One of the weaknesses in forest research is the less possible to demonstrate empirical practices of propositions. In case study, Jerome K. Vanclay

(Vanclay, 1997) developed FLORES model to allow more robust testing of the system-of-interest. In FLORES, underlying social and ecological factors were incorporated and the results were predicted to compare with previous empirical data. Vanclay (1997) developed an ecological model to modeling growth and yield of vegetation in mixed tropical forests in Burmese. His model was constructed with the goal of maximization of vegetative growth and maximization of forest productivity. Idea of diameter-class project management was employed in model-building process. This research represents a classic method for development of growth projection in tropical forests.

Mc Murtrie (1994) used model-based analysis in predication of productivity of pine stands in five areas and those results were compared. Gross primary productivity was estimated related to utilized photosynthetic active radiation, which derived by estimating the extent to which photosynthesis is limited by soil water deficit and low temperature. This research extremely emerged the idea of carbon stock fluctuation and its concentration levels, and carbon stocks in vegetation. This also enhanced empirical research on application of ecological processes into modeling base analysis.

Beukering, Cesar and Janssen (2003) developed a dynamics model for valuation of economic consequences on deforestation and conservation in the Leuser ecosystem, in Northern Sumatra. Issues such as types of forest benefit, allocation of those benefits among stakeholders, and regional distribution of benefits were encountered to evaluate market values of forest products.

A making-decision model was developed and postulated by Prato (1999) for landscape management. Prato included the reasons or choices that decision-maker selected a site/landscape management plan based on biophysical and economic attributes of alternative management, decision-maker's preferences for attributes, and constraints on the selection of a management plan for system construction. This model had been served as an example of multi-attributes evaluation model for land-use and landscape management.

Not only ecological perspectives that had been induced as part for model development, but also some economic-related issues on managing natural resources and forest ecosystems were incorporated. As long as forest ecosystem is a prerequisite for social sustainability (Goodland 1995), multiple-purpose basis has led to a more rigorous and consistent application of economic advances in ecological model development.

An integrated economic-ecological model to analysis and evaluation of management policies nutrient abatement was developed to predict the characteristics of Rhine basin. In this model, economic and ecological effects from management actions and strategies were integrated as important model components. This model required various disciplines in development and making simulation. However, van der Veeren, and Lorenz selected to constitute their model components with management actions that sounded reasonable and possible to do with their spatial attributes (van der Belt, Deutsch, and Jansson, 1998).

Holling (1978) developed the GURI model to simplify important situation in Caroni river basin in South America. Because the region contained large number of population, this made the cities and the surrounding areas become industrial center with most dynamics of various aspects. Investment to expand infrastructure development incorporated with planning. Also, implementation of the development of organizations was autonomous with budgets from both governmental and private sectors. Consequences of the complexities of situations induced pressures to exploit valuable natural resources in that area. Side effects could change and affect quality of the watershed system and its productivity could reduced. Characteristics of local vegetation and forest ecosystems, as well as agricultural lands seemed to be altered and get negative effects from the development.

Baumann (2000) briefed later the article previous described by Holling (1976) about two cultures of ecology. He addressed the fundamental assumptions associated with the two main methodologies in integrative ecology, which was so-called a mathematical modeling.

GURI, a series of mathematical modes, was developed to simulate and allow a quantitative comparison analysis of different possible strategies of actions and potential conflicts between land uses that cannot be analyzed *in situ*. GURI was also developed to describe quantitatively the rain-vegetation, soil-river relationship in the Rio Caroni watershed. Simplifying assumptions were made with applicable degree of aggregation, so any predications could be approximately made. Dynamics of water and its relationships were observed from the time it entered the system as rain until it appeared in the form of runoff. A series of unit area was set by a grid system and each of grid cells was numbered sequentially and provided with climatic, hydrological, topological and vegetation information. A FORTAN program was used for the processing. Seven variables were selected to test the sensitivity experiment, with only tree different values were assigned for each experiment.

Challenges of modeling structures and functions of natural and anthropogenic systems including fundamental constraints relating to scaling mismatches, synthesis of non-homogeneous information, multi-scaled system interactions, complex management systems, uncertainty in causal relationships, assessment of trade-offs, and validation, are also constrained. The researchers proposed that now a day a lot of researches involved natural resource management require basic knowledge on social, economic, ecological, and bio-physical effects of alternatives management interventions (Argent, Grayson, and Ewing, 1999; and Prato, 1999). This idea is widely used, also in mangrove ecosystem management (Grasso, 1998), or in land use management (Twilley et al., 1998).

Hilborn et al. (1995) constructed management model of Serengeti-Mara ecosystems during the Serengeti workshop in Tanzania in 1991. The concepts and details of that model application were published a few years later. Serengeti-Mara ecosystem becomes a site of research since the year 1960. This area was affected by many actions and policies from various governmental and non-governmental sectors. These make Serengeti-Mara become a hot area of management issues for long time. Changes of environmental patterns such as rainfall levels or growth of population surrounding the park induced changes to the city characteristics and to local people's livelihoods. The Tanzania's government agencies must consider the likely consequences of current management actions that affected societies then the options to people must be provided.

Serengeti model was divided into 5 sub-models and was run for a 60-year scenario (during 1960-2020). The program was written in QuickBasic and run on MS-DOS-Compatible manners. Vegetation sub-model was first constructed with the key relationships between population dynamics of the ungulates and amount of dry season food (grass in dry season). Proportion of amount of grass in dry season consumed by ungulates reflected the proportion of resident species and migratory groups. Predator sub-model compared population dynamics of the predators and the kills of prey items. This sub-model showed interactions with the sub-model of ungulates groups. Population density of predators and preys accompanied with other relating factors resulted in changes of the amount of food and feeding area of important species. For inside-park sub-model, the goal was to assess quality and growth of tourism, which had major consequences on Serengeti-Mara's revenues and employment. Growth of tourism increased level of employment while reduced park quality. Therefore, the government needs to adjust budget and human resources in more specific and suitable manners. Because growths and changes of land- uses increased numbers of potential poacher trips in the park and adjacent areas, anti-poaching patrol was assumed to reduce numbers of poacher trips or, at least their effectiveness. Six scenarios were explored against the effect varieties of natural and human-induced changes in Serengeti. Base scenario was set without any changes of current actions. Anti-poaching patrol and poor rainfall level was set to explore changes of wilderness species populations. The results showed that reduction of poaching efforts and poacher kills, and a rebuilding in wildebeest population occurred. Rapid decline in wildebeest numbers happened when raided pest epidemics.

Another example of consensus-based simulation model was developed by Belt, Deutsch, and Jansson (1998). Some of important ecological and economic aspects inside the coastal zone of Pantagonia in South Argentina were observed. The interlinkages amongst those issues were built across to integrate several parts of the system including management of natural resource sectors and stakeholders. Information supported included both ecological, and micro and macro economic data from various governmental and nongovernmental organizations around Pantagonia region. The model simulated economic results of the present values of incomes generated by tourism, fisheries, and estimation of the population costs of clean up of oil spills. The model was set to run for 20 years (from 1980-2020). Possible trade-offs between the incomes generated by fisheries and tourism generated by maximizing the total net present values of the area over time span were examined. The results of this model version provided better understanding of the dynamics and sensitivity of the forces at works. This leaded Pantagonia resource manager specified larger perspectives for the research at this site.

Now a day knowledges on model and model-building processes play important roles and come across several disciplines. Especially in managing natural resources and sustainable development, which several factors are integrated in decision making process. Bellamy and Lowes (2000) concluded that substantial advances in understanding of the interaction of natural and human systems are important and required in sustainable development. Management paradigm of multiple stable states, non-linear systems behaviors, discontinuous changes, self-organization and multiple development pathways have major implications for when changes in complex systems occur.

Recent examples on modeling forests, land-uses, policies and resources management in various aspects are presented by Verheyen et al. (2003), van der Belt et al. (1998), Murphy and Graney (1998), and Sinclair and Arcese (1995).

Further information on ecosystem analysis, model application on ecosystem goods and services can be gathered from Kennedy, Thomas, and Glueck (2001), Johnson and Maxwell (2001), Walters, Korman, Stevens, and Gold (2000), Scheffran (2000), Walters et al. (2000), and Hilborn et al. (1995).

2.5.2 Valuation of ecosystem benefits and techniques

Examples on how to use economic valuation techniques such as CVM and TCM are given in this section. Since the idea of ecosystem management occurred and evolved with challenged ideas of academic researches, agencies and organizations, the concepts concerning ecosystem valuation of use and non-use benefits are incorporated. Over the last couples of decades, CVM and TCM have been applied several times to estimate values of ecosystem or environmental goods and services.

In Thailand CVM and TCM had been used to evaluate various kinds of environmental resources, for examples, economic analysis of coral reefs in Phuket, or water quality improvement of Chao Phraya river basin. However, rarely CVM and TCM have been applied to estimate benefits of recreational activities and consumer surplus in the nature reserves. Using Zonal Travel Cost Method (ZTCM) evaluates the values of recreation site and recreational activities once was said that this method seems to be outdate and unsuitable. However, ZTCM is commonly found for valuation of environmental goods and services in all developing countries especially where and when national forest policy is incorporated and analyzed before constructing of ecosystem valuation in preserved area.

An inventory of selected papers concerning EM, CVM, and TCM over the course of the last couple of decades is attempted. Most of them have been incremental, rather than across-the-broad and listed in reverse chronological order.

Studies of non-market valuation data can be used to inform decision making. Harmon (2001) advocated that application of non-market valuation to improve decision-making is not uniform. The method depends upon characteristics of goods and services and the decisions facing parks officials. Choice modelings, variants of CVM survey and contingent choice survey have been used and applied for gathering data. Those methods are confirmed to be widely used for natural resource valuations by Hanley, Wright and Adamowicz (1998), Wen (1998), Greene, Moss, and Spreen (1997), and Englin, Lambert, and Shaw (1997).

In Thailand, Sreeprachawong (2001) applied CVM and TCM for valuation of coral reefs and uses of available information for developing coral reefs management planning in Phi Phi Islands. He reported that consumer surplus estimated by the TCM reveals the annual value of 8216.4 million Baht (US$205.41 million). The CVM analysis was also used to estimate both the use and non-use values of Phi Phi's coral reefs, representing an annual value of 19895 million Baht (US$497.38 million). While estimated consumer's willingness to pay to increase biodiversity at Phi Phi was averaged at 287 Baht (US$7.18) per visit. This research also recommended the basic entrance fee of 40 Baht (US$41) per person per visit. With having charged the entrance fee of 40 Baht and if visitor choose to visit the coral reef at Maya Bay, the Park could impose an extra fee of 150 Baht (US$43.75) per person per visit with no effect to lower-income visitors. Sreeprachawong (2001) also recommended that both local and foreign visitors should be charged the same user fee to visit the Park.

Sathirathai (1997) studied the roles of local community involvement in conservation of natural resources and use of economic results for policy implication in Surat Thani, in Thailand. The results showed that the economic value of mangrove was estimated in a range of 13339.34 and 17122.42 Baht per rai (US$513.05 to US$658.55 per rai). The estimates included only direct use value in term of off-shore fishery linkages by local communities, and the value in term of coastline protection. Conversion of mangrove forest into shrimp farming is not economically feasible but financially viable. Although, shrimp farming created enormous private benefits, the net social benefits when taking into account its externalities in terms of destruction and pollution, was not economically viable. Moreover, the off-shore fisheries were well managed by local people, the foregone benefits in term of support for off-shore fisheries were even greater. She suggested that Thai's government should encourage local people in participation of the conservation of mangrove forest. However, the results tended to be underestimated because some potential direct use value such as tourism and non-use values were neglected.

Isangkura (1998) proposed that park revenue could be raised by adjusting park entrance fees, which can be done by increasing entrance fees to reflect recreational benefits that national park provides to visitors. He employed the concept of multi-park system and closed-end contingent valuation and contingent ranking methods in valuing the recreational services at Doi Inthanon national park. He stated that some previous researches by Grandstaff and Dixom (1986) and Kaosa-ard et. al. (1995) used travel cost method combined with open-ended contingent valuation method to assess the willingness to pay of visitors and consumer surplus. In case of Khao Yai national park, TCM estimated the direct benefit of 1420 Baht per visit, of which 870 Baht was the CS. The average WTP for entrance fee was 22 Baht per visitor. However, after improvement , the entrance fee increased from 22 Baht to 44 Baht per visitor. The result suggested that increasing WTP per visit suggested some positive marginal benefit of the park and those improvement would yield a net gain to society (Kaosa-ard et. al. 1995).

Tapvong and Kruavan (1998) applied CVM to elicite people's preference, expressed in term of their willingness to pay to improve water quality of Chao Phraya river in Thailand. People were asked about how much extra money they can afford to increase the quality of Chao Praya river. Two scenarios were given as alternatives of quality improvement. Respondents were asked to respond to yes/no questions or Dichotomous CVM questions. They were also asked to give opinions with basic questions such as details and information of wastewater treatment, benefit from water quality improvements, level of improvements as well as payment methods. The finding suggested that the mean value of the fee for the treatment was averaged between 100.81 and 115.03 Baht per month. The amount of fee to pay depended on respondents's backgrounds and their incomes.

Saehae (1995) estimated the demands of new recreational services in Khao Yai national park. There were five new recreational choices imposed to visitors. Visitors were asked to give opinions on the new recreation use fees. CVM employing WTP was used to estimate park revenue generating from those services.

Valuation of natural resources have been used to evaluate recreational site such as national parks. Those have been reported by many researchers such as Mendelsohn, John, Peterson, and Johnson (1992); Lamb and Doerksen (1999); Turner (2000).

Turner (2000) suggested that non-market valuation is a tool of economics that can help alleviate difficulty on budget decision making in national park by estimating value of resources and amenities that are not exchanged in market. A model showing efficiency criteria that can be used by park officials in determining entrance fee levels and resource allocation levels for multi-attributes park levels was suggested.

Some authors extended TCM modeling by developing a utility theoretic system of semi-logarithmic recreation demand equations Englin, Boxall, and Watson (1998) and Fix and Loomis (1998). The model was applied to individual wilderness recreation trips in a system of four Canadian wilderness parks. The resulting demand system was used to examine the impacts of changing U.S.-Canadian currency exchange rates on participation and welfare of U.S. recreationists. Multiple destination trips had also been studied using TCM and CVM analysis. Empirical function for multiple destination trip were developed by Mendelsohn, John, Peterson, and Johnson (1992).

Further information on CVM and TCM analysis and application and empirical research results in valuation of non-market goods and services be gathered from those following papers: Caulkins, Bishop, and Bouwes (1986); Kealy and Bishop (1986); Stynes, Peterson, and Rosenthal (1986); Wilman (1987); Wilman and Pauls (1987); Wilman and Perras (1989).Eberle and Hayden (1991); Rosenthal (1987); Smith (1988); Smith

(1989); Smith and Kaoru (1990); Stynes (1990); Englin and Mendelsohn (1991); Hellerstein (1991); Parsons (1991); Willis and Garrod (1991b).