CHAPTER 2
BACKGROUND INFORMATION

2.1 Important of Accommodation Development in Sukhothai

During the past decade, tourism has been view as a "big business" which involves a large number of activities by many people at various levels. In addition to the economic benefits, tourism is attractive to many developing countries because it generally requires less per capita investment and less technological and labor skills than industrial development. Moreover, when compared with other type of economic development, tourism is usually less likely to create environmental problems (Gunn, 1994). The relationship between tourism and the main component of the man-nature system are subject to much discussion but relatively little investigation based on the hypothesis that tourism generates environmental externalities exceed level of disturbance of the environment significant and irreversible change occur which alter the basic processes and characteristics of the environment (Harry and Parpaitis, 1992).

The likelihood and severity of impacts related to the type of development. Thus, in order to develop appropriate development guidelines the type of development must be defined. There are three major types of tourism development. These are tourist accommodations, recreation facilities, and infrastructure. Development of tourist's accommodation includes hotels, bungalows, resorts and other type of service such as restaurants, shopping centers, visitor information centers, cultural centers, etc.

Chula-Unisearch, Chulalongkorn University (1997) studied the feasibility of investment development in tourism. This study suggested two-day traveling route for the northern provinces. It recommended Sukhothai province to be one of the group of northern provinces, with highly potential to developed to accommodate area for tourism. But in fact, tourism package or tourist company which set up for touring on Sukhothai province was found in low number, when comparing with neighbor province such as Tak and Lampang which have the high number of tourist package and tourist's destination to travel in that province.

2.2 Site Requirement for Development Tourist Accommodation Development

When tourism demanded in an area, the reason is mostly that there is a need for economic development; perhaps this is why previous tourism development emphasized only economic issue and neglected environment issue (Boonyobhas, 1996). Tourism is not a single activity but a complex of activities involving mainly travel, accommodation, sightseeing, shopping, and entertainment. Similarly, the tourist product is a multidimensional entity, which include resource at a destination (inherent attractions), facilities at a destination (accommodation, catering, recreation, transport, information and assistance), transport to the destination (Helen, 1992).

Like other land development, tourism affects the environment during the construction and the operation period. Some of the impacts can be seen and measured, while some others can be seen but are very difficult to quantify. The measurement methods vary from a simple investigation to very complicated methods; normally the quantitative measurement is simpler to conduct. In order to make the information about the environmental impacts useful in the planning process, the impacts have to be significant and the information about that impact must be cost effective to acquire (Boonyobhas, 1996). Therefore, the potential of the impact used instead of the actual estimation. Although there are many impact generated from development of tourism facilities, this study will focus on only major physical impact and use them as essential indicators.

When analyzing the impact of tourism on the environment, reference usually made to the devastating effects mass tourism has on the natural environment. Only recently, the question whether or not cities, originally design to host people, might have similar problems with tourism has arisen. A development may either interfere with people's view of the scenery or remove observations. For example, a new tall building may block the view of green space from an existing building, or on the other hand, razing buildings to create a plaza may open previously blocked views especially Sukhothai province, which have historical park. Land developments may destroy, impair access to, or crowd landmarks of cultural significance such as those with historical, archaeological, or paleontological value. The importance of these landmarks is determined in term of rarity, distance to closest similar example, interest to tourist and the public, and interest to scholars.

Boonyobhas (1996) describe about the factor which support tourism development have five major resources; land, water, vegetation, wildlife and weather or climate. The tourist accommodation contains three levels of physical development, bungalow (low density), medium density hotel, and high-density hotel. Most development occurs on land; therefore, the concentration of impacts is likely to affects the land. However, the consequence of land-based development often causes impacts on freshwater, vegetation, and wildlife.

The construction of accommodations, recreation facilities, and infrastructure normally are involved with land clearing, grading, and changing landform. Therefore, the major problem on land development is soil erosion. Although the erosion problem in the operation phase is not obvious and rapid as during construction, it is continuous and cumulative. The consequential problem such as sedimentation, siltation, water flow disruption, landslide, and loss of soil fertility are difficult to overcome after the construction is finished. Protection can be achieved, but the total prevention of soil erosion is impossible. The other important problem on land is surface runoff, which occurs during both the construction and operation phases. Soil erosion is associated with runoff. In general, areas with high erosion are usually having high runoff. In contrast, high runoff does not always lead to high erosion if the particular area covered with a non-erodable surface. Besides increasing potential of soil erosion, increasing runoff reduces the groundwater recharge. In areas of limited water supplies, the recharge impact can be significant, so the runoff has to be considered. Upstream, development must be planned so as not to aggravate flooding problem downstream. Erosion caused by rainfall and surface runoff and affected by a number of natural and anthropogenic agents. It may be expressed as the relation between the erosivity of rainfall, i.e., and the potential ability of rain to cause erosion, and soil erodibility, i.e., the susceptibility of the soil to erosion.

Most precipitation reaching the ground is disposed of in three ways. Some absorbed directly by the soil in a process known as *infiltration*. Some called *depression storage* collects on the ground in small hollow and pockets. The remainder called *overland flow*, runs off the surface, eventually joining streams, and rivers. Land developments potentially affect water quality in many ways. For example, the amount and nature of wastes may overwhelm local sewage treatment facilities. When septic tanks are used, the waste generated may exceed the capacity of the soil to remove or degrade wastes, and may thus affect underground and surface waters. Changes in land contours, vegetation, and permeable land cover during and after construction may increase the amount and content of storm runoff. Thus, the assessment of the impact on water quality must consider all such possible.

A very important concern relative to development is the demand for water and its resulting impact on available supplies. If development affects the water quality of the area by polluting surface and groundwater sources, then an increasing quality demand of water would imply that supplies be drawn from alternate or perhaps even inferior sources. Add demand from development may also occasionally cause shortages, necessitating rationing of water for bathing and watering lawns, or even for drinking.

The distance from transportation facility was an important factor for tourist accommodation development because of the accessibility to tourism area depends on the road distance. The accommodation place that exists near the road would have the potential for development.

Governmental regulations and environmental laws are very important constraint for selecting places for constructing tourist accommodation. Areas that are environmentally or economically suited for development but are not complied with the law should be avoided. This study concerned governmental constraints which included environmental impact assessment guidelines for hotel and accommodation development project and constraint from environmental law such as Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (A.D. 1992), National Park Act B.E. 2504 (A.D.1961), National Reserved Forest Act B.E. 2507 (A.D.1964), National Reserved Forest Act B.E. 2507 (A.D.1964).

Environmental Impact Analysis (EIA) is potentially an important instrument for furthering sustainability in public and private decision-making. EIA is an action-forcing mechanism concerned with the potential (or real) impacts of proposed (or existing) human activities (and their alternatives) on the human and natural environments. Government in Thailand has generally been reluctant to apply EIA requirements, generally designed for project assessment, to policies, programs, and policies.

There are group of acts such as Building control Act B.E. 2522 (A.D.1979), Notification of Ministry of Science Technology and Environment issued under the National Environment Quality Act B.E. 2535 (A.D.1992), Town Planning Act. B.E. 2518 (A.D. 1975) etc.

The Archaeological and Historical Constraints were obtained from Archaeological and Historical Constraints from Works of Art, Historical Places, Antiquities, and Artistic Objects Laws. B.E. 2504 (A.D. 1961) which provide by the Fine art Department, Ministry of Education, which created map from the Fine Art Act.

For tourist accommodation development, the most important requirement is an aesthetic and pleasing environment, which normally implies that development will take place near the historical places in historical zone, up in the highland overlooking the surrounding forest area, near creeks or lakes for water based development, etc. It also requires adequate infrastructure and accessibility. Having close proximity to other activities or recreation facilities is more desirable for the development of high-density types of development than for the low density types which require more privacy.

2.3 Component of Environmental Planning

The previous section review effects that is associated with tourism development. In this section, the underlying philosophy of the mapping methods selected and developed in this study will be discussed. This will show how the foundation of the mapping approaches to demonstrate in the next few sessions formed.

The suitable area for tourist accommodation development map requires processing of several kinds of information of the area to be mapped. The amount of information to be handles and processed is dependent on the size of the area; the larger is the more resources are required. In this sense, a tool with simple technology may be very different to operation indeed. On the other hand, such a tool can be simply operated using the advantage of today's technologies – geographic information system, remote sensing, and personal computers.

2.3.1 Geographic Information System as a tools in Environmental Planning

Geographic Information System (GIS) is a term that has been applied quite loosely. For the purpose of this study, a brief working definition of GIS by Dueker (1979) as *"a special case of information systems where the database consists of observations on spatially distributed features, activities, or events, which are definable in space as points, lines or areas. A GIS manipulates data about these points, lines, and areas to retrieve data for ad hoc queries and analyzes"* is used.

While many of these capabilities also exist in other types of systems, such as visualization and virtual reality systems, GIS are unique because of their emphasis on providing users with a representation of objects in a cartographically accurate spatial system and on support analysis and decision-making.

Decision may be characterized as *single-* or *multi-objective* in nature, based on either a *single criterion* or *multiple criteria.* While one is occasionally concerned with single criterion problems, most problems approached with a GIS are multi-criteria in nature. For example, to identify areas of concern for soil erosion based on slope land use soils type and the like. In these instances, our concern lies with how to combine these criteria to arrive at a composite decision. Therefore, the first major area of concern in GIS concerning Decision Theory is Multi-Criteria Evaluation (MCE).

Multi-criteria evaluation (MCE) modeling techniques are a good example of how a single model can adequately cope with multiple representations. There are numerous examples in the literature of MCE models being integrated with GIS to solve a number of site search and suitability analysis problems, including regional land use planning in the Netherlands (Janssen & Rietvelt 1990), nuclear waste disposal in the UK (Carver 1991) and industrial location in developing countries (Eastman et al. 1993).

Most commonly, we deal with decision problems of this nature from a single perspective. However, in many instances, the problem is actually multi-objective in nature (Diamond and Wright, 1988). Identification of land sites that meet particular criteria is one of the main spatial analytical applications of GIS. A systematic approach to site selection provided by the techniques of multi-criteria evaluation and these techniques can incorporate within GIS. The purpose of MCE is to help decision-makers distinguish between several possible options, where the preference for each of the options may depend upon several factors, each of importance by different members of the community (Jones, 1996). In other words, there may be no right answer, but the approach does at least enable the decision-maker to take account of different level of perceived importance for different factors.

In the nuclear waste example the main stakeholders involved are the nuclear industry, the general public and the environmental lobby each of which can be assumed to have distinctive objectives in mind concerning the search for a suitable site for a nuclear waste disposal facility. The basic objectives of each stakeholder can be summarized as: nuclear industry (minimize costs and maximize safety); general public (maximize distance and minimize health risks); and environmental lobby (minimize environmental impact and minimize health risks). However, with the ultimate and basic objective of all stakeholders being the same (i.e. the identification of a mutually acceptable site) the decision problem can effectively be addressed by all parties using a single MCE setting model with the differences in the stakeholders specific objectives being expressed through use of different data sets and weighting schemes. The result from such an approach is three different surfaces describing the suitability of different areas of the UK for nuclear waste disposal according to the specific objectives of the stakeholders. Since these have been drawn using the same model, the surfaces are immediately compatible and so can easily be compared to identify commonalties and individual compromise solutions via simple map overlay techniques.

Hussey et, al. (1996) applied GIS to selection of landfill sites, this study carried out using GIS as a tool in the identification of suitable landfill sites for the County Dublin. Parameters selected, based on the proposed EU Landfill Directive and on regulations from other jurisdictions. Data sets were collected for these parameters and they were integrated into a proprietary GIS, analysis was carried out to identify suitable landfill sited based on certain minimal conditions and a sensitivity analysis was carried out to determine the influence of variations in the parameters selected. An analysis of the trip time from Dublin city to identified sites carried out.

Chamchalio (1996) studied on tourism potential site selection by using Geographic Information System (GIS) and Multicriteria Evaluation technique (MCE) to compare with urban area in 1994. In this process, several factors were considered namely beach distance, road distance, slope gradient, and legal status, beach constraint, forest constraint and original community, in accordance with the master plan and carrying capacity of the island. The output showed the tourism development area of Ko Samui was greater than the potential area. This caused impact on land use change and environmental degradation.

2.3.2 Remote Sensing as a data collection in Environmental Planning

Of all the various data sources applied to GIS, one of the most important is undoubtedly that provided by remote sensing. Through the use of satellites, we now have a continuing program of data acquisition for the entire world with time frames ranging from a couple of weeks to a matter of hours. Very importantly, we also now have remotely sensed image in digital form, allowing rapid integration of the results of remote sensing analysis in GIS.

Benefits from merging of GIS and remote sensing technologies are well recognized. On one side, GIS can be use for improving the information extraction potential of remotely sensed data (e.g. Tangjaitrong, 1994). On the other side, remote sensing data can used for updating GIS information (e.g.). For the context of this study, a brief review about the uses of remotely sensed data is limited to their roles in updating GIS information only. Remote sensing and image processing are powerful tools for many research and application areas. Remote Sensing may be defined as the process of deriving information by means of systems that are not indirect contact with the objects or phenomena of interest. Image processing specifically refers to manipulating the raw data produced by remote sensing systems.

Remote sensing often requires other kind of ancillary data to achieve both its greatest value and the highest levels of accuracy as a data and information production technology. Geographic information systems can provide this capability. They permit the integration of datasets acquired from library; laboratory and field work with remote sensed data. On the other hand, applications of GIS are heavily dependent on either the timeliness or currency of the data they contain, as well as the geographic coverage of the database. For a variety of applications, remote sensing, while only one source of potential input to a GIS, can be valuable. Remote sensing can provide timely data at scales appropriate to a variety of applications. As such, many researchers feel that the use of geographic information systems and remote sensing can lead to important advances in research and operational applications. Merging these two technologies can result in a tremendous increase in information for many kinds of users (Star and Estes, 1990).

2.3.3 Mathematical Model as analytical tools in Environmental Planning

The mathematical model is a simplification of the real world to aid interpretation and understanding. It simulates the effect of a set of processes, and forecasts an overcome. An environmental model simulates the functioning of environmental processes (Maidment, 1996). Mathematical Models used for a wide variety of applications but it is possible to categorize all models by their characteristics, which ultimately control the model's suitability for any given purpose. Unfortunately, these characteristics do not form a neat hierarchy and authors vary in their terminology. At the most basic level, models can be divided into conceptual and mathematical (Steyaert, 1993). Conceptual models are used to identify the major components of a system and possible relationships. Therefore, they cannot be used for prediction. Finally, mathematical models attempt to quantify relationships within a system and use algebraic equations to forecast outcomes. These are usually so complex that a computer is requires for running them.

Mathematical models have a further set of characteristics. At the two extremes an empirical model attempts no explanation of the processes involved in the system but is merely expresses a statistical relationship derived from observing inputs and outputs of the system, while a process model simulates each process involved and according to known physical laws, forming a much more complex model. These model also known as *black box* and *white box* model respectively. In practice, most models are *gray box* and thus combine empirical relationships and physical processes within the known structure of the system.

As the process of model selection is complex, there is often a trade off between various aspects. For example, a complex process model is likely to be lumped spatially while a simpler empirical model might have reduced granularity with respect to time and space. The implication for the time taken to run the model and the computing platform required. Although the basic assumptions and methods within the model, and their applicability to the problem at hand, should form the basis of any decision, practicalities such as availability of data, availability of the model and its format often take over. It is frequently difficult to obtain precise details of a model.

The wide range of mathematical model which have been developed by physical geographers, ecologists and others have logical structure and involve complex mathematical calculations which make computers ideal for their implementation. GIS need to incorporate a modeling component in order to predicting potential outcomes and evaluate alternatives (Peuquet et al., 1993). Current spatial modeling capability in GIS are generally limited to such name, suggests, is the automated version of the cartographic process of detecting spatial correlation between two variables by overlaying maps show their distributions. Adjacency analysis, or buffering, consists of drawing boundaries at a specified distance around a point, linear or aerial feature on a map. Only the simplest of environmental process can be analyzed with overlay and buffering operations. Operations that mathematically combine and relate attributes from many objects on many maps, some in a very application-specific context, are needed to provide any real descriptive or predictive power in GIS (Peuquet et al., 1993).

2.3.4 User as operator of Environmental Planning

The GIS is used to input raw or processed data and theory and produce more direct information for decisions making. This often involves very complicated data processing techniques and scientific or socio-economic hypotheses. The initial investment is at the same level of other tasks but the following-up investment on research and expertise is higher. However, the strength of GIS technology can be maximally realized in this kind of applications and both short-term and long-term return of investment is often very significant. The most important component of a GIS is GIS personnel - the people who use the system, maintain databases, provide technical support and, more importantly, making decisions using the system.

These people can be large sources of uncertainty in GIS, for example, in digitizing process, digitizing operators who understand the particular maps makes fewer errors when inputting data into GIS. Many decision-making processes depend upon the expertise of professional in particular application areas. Some potential for encoding this expertise forming rules that can be processed by an automated inference mechanism. The rule can be qualified to take account of uncertainty in their relevance and of uncertainty in the data, using methods such as fuzzy logic and Bayesian Probability. They can also be combined with functions or programs that solve sub-problems using conventional procedural programming methods.

2.4 Uncertainty in GIS

The world is full of *uncertainty*, much of which has a direct effect on the kinds of predictions we want to make in land evaluation. No serious land evaluation could exist without any *estimation of uncertainty* in its results. Uncertainty refers to our imperfect and inexact knowledge of the world. We can distinguish two classes of uncertainty: data uncertainty and rule uncertainty (Eastman et al., 1993). Data uncertainty has to do with our observations of nature or society. We can unsure of what exactly we observe or measure. Rule uncertainty has to do with how we reason with these observations. We are unsure of the conclusions we can draw from (even perfect) data (Rossiter, 1994).

This section discusses various aspects of uncertainty, including the concepts of data and rule uncertainty, spatial variability of land characteristics, and 'fuzzy' logic. The emphasis is on how to describe and evaluate uncertainty, and how to determine and express the uncertainty, especially over space, of our predictions in land evaluation.

2.4.1 Data Uncertainty

Practically, we rarely know the true value of a parameter or datum. Two source of uncertainty are measurement and sampling. There is always uncertainty incorporate into our interesting data. For example, a slope of 18% may represent an important threshold. However, because of the manner in which slope that was measured, as 17% really is 17%. While we may have considerable confidence that it is most likely around 17%, we may also need to admit that there is some finite probability that is as high as 19%. Alternatively, expression of database uncertainty is likely to rely upon probability theory.

a. Measurement Uncertainty

There is always some uncertainty in measurement, because of limited precision of the measuring device. This can usually be determined from the characteristics of the device and by repeated sampling and statistical characterization. These errors are usually (correctly) considered independent, normally distributed, and more-or-less exactly characterizable. In a land evaluation context, they are rarely significant, when compared with sampling errors.

b. Sampling Uncertainty

Usually we are only being able to measure a small part of the object of interest; this generally causes *sampling* error. These errors are more difficult to characterize and correct for than measurement errors. We must make (sometimes unjustified or un-testable) assumptions about our sampling strategy. The type and magnitude of these errors can be determined by repeated sub-sampling or by more exhaustive sampling.

For both types of data errors, there is extensive statistical theory. In the usual case in natural resources or economic survey, we obtain an *expected value* (usually given by the mean) and a *variance* of a normal or Student's distribution, which can be used to express the uncertainty of the expected value. If the distribution of errors known to have a non-normal form, we can estimate the parameters of a different distribution. Usually we are only being able to measure a small part of the object of interest; this causes sampling error. These errors are more difficult to characterize and correct for than measurement errors. We must make (sometimes unjustified or un-testable) assumption about our sampling strategy. The type and magnitude of these errors can be determined by repeated sub-sampling or by more exhaustive sampling.

2.4.2 Decision Rule Uncertainty

Not all uncertainty relates to measurement error. For example, we may have great difficulty in defining steep. It may be that we are comfortable with the notion that slopes less than 10% are definitely not steep, and that those over 20% define are steep, be quite uncomfortable with defining a single point at which slope change from being shallow to steep. Uncertainties such as this are best handled with Fuzzy Set theory (Zadeh, 1965), in which the possibility (as distinct from the probability) of a slope being considered as steep is seen to continuously change from 0 at 10% to 1 at 20%. This is a human conceptual issue, and is a type of uncertainty that is distinctly different from uncertainty about the exact value of a specific slope (Eastman, 1995).

A decision rule is nothing more than a procedure to guide the combination of selected criteria from the GIS database and evaluate criteria relative to disposition of a specific problem of task (Lein, 1997). A decision rules may, therefore, involve simply setting a threshold value during a search or identifying a specific attribute, or it may describe a more complicated set of operations requiring the comparison of several multi-criteria evaluation. A decision rule generally explains a fixed set of GIS procedures and operation for combining criteria into a derivative product based on the command syntax of the GIS software. In this context, decision rules are the mechanism whereby the data in the GIS database transformed into meaningful information – something that conveys a specific concept, theme, or new variable to the decision maker (Lein, 1997).

Decision rule uncertainty is that which arises from the manner in which criteria are combined and evaluated to reach a decision. A very simple from a decision rule uncertainty is that which relates to parameters or thresholds used in the decision rule. A more complex issue is that which relates to the very structure of the decision rule itself. This is sometimes call *specification error* (Alonso, 1986), because of uncertainties that arise in specifying the relationship between criteria (as a model) such that adequate evidence is available for the proper evaluation of the hypotheses under investigation. When uncertainty is present, the decision rule will need to incorporate modifications to the choice function or heuristic to accommodate the propagation of uncertainty through the rule and replace the *hard* decision procedures of certain data with the *soft* ones of uncertainty. A variety of theoretical constructs have been developed to accommodate this uncertainty, including Bayesian Probability theory, Certainty Factor, Dempster-Shafer, Theory of Evidence and Fuzzy Set theory (see Lee et al., 1987).

2.5 Crisp Sets and Fuzzy Sets

A major contribution of human expertise is an awareness of the reliability of factual evidence and of the rules that may be used to draw conclusions from pieces of evidence. The need to incorporate this awareness of uncertainty in rule-based systems has long been recognized and many of the earliest examples of expert systems included some capability for representing and reasoning with uncertainty. Fuzzy logic is an organized method, which allows computer programs to deal with the imprecision of data, especially that which deals with human reasoning. In reality, information is often puzzling and unclear. It is a matter of drawing conclusions or classifying subjects according to the pieces of evidence.

2.5.1 Concept

Crisp set are classification in which individuals in some given universe of discourse were dichotomized into two groups: members (those that certainly belonging in the set) and nonmembers (those that certainly do not). A sharp, unambiguous distinction exists between the member and nonmembers of the class or category represent by the crisp set.

When the *concept* being classified is not precisely defined (especially in the case of *linguistic* uncertainty) the techniques of fuzzy logic that may be applicable.

Many decision-making and problem-solving tasks are to complex to be understood quantitatively, however, people succeed by using knowledge that is imprecise rather than precise. Fuzzy set theory, originally introduced by Lotfi Zadeh in the 1960's, resembles human reasoning in its use of approximate information and uncertainty to generate decisions. It was specifically designed to mathematically represent uncertainty and vagueness and provide formalized tools for dealing with the imprecision intrinsic to many problems. By contrast, traditional computing demands precision down to each bit. Since knowledge can be expressed in a more natural by using fuzzy sets, many engineering and decision problems can be greatly simplified.

Fuzzy set theory implements classes or groupings of data with boundaries that are not sharply defined (i.e., fuzzy). Any methodology or theory implementing "crisp" definitions such as classical set theory, arithmetic, and programming, may be "fuzzified" by generalizing the concept of a crisp set to a fuzzy set with blurred boundaries. The benefit of extending crisp theory and analysis methods to fuzzy techniques is the strength in solving real-world problems, which inevitably entail some degree of imprecision and noise in the variables and parameters measured and processed for the application. Accordingly, linguistic variables are a critical aspect of some fuzzy logic applications, where general terms such a "large," "medium," and "small" are each used to capture a range of numerical values. While similar to conventional quantization, fuzzy logic allows these stratified sets to overlap (e.g., a 85 kilogram man may be classified in both the "large" and "medium" categories, with varying degrees of belonging or membership to each group). Fuzzy set theory encompasses fuzzy logic, fuzzy arithmetic, fuzzy mathematical programming, fuzzy topology, fuzzy graph theory, and fuzzy data analysis, though the term fuzzy logic is often used to describe all of these.

Fuzzy logic emerged into the mainstream of information technology in the late 1980's and early 1990's. Fuzzy logic is a departure from classical Boolean logic in that it implements soft linguistic variables on a continuous range of truth values which allows intermediate values to be defined between conventional binary. It can often be considered a superset of Boolean or "crisp logic" in the fuzzy set theory is a superset of conventional set theory. Since fuzzy logic can handle approximate information in a systematic way, it is ideal for controlling nonlinear systems and for modeling complex systems where an inexact model exists or systems where ambiguity or vagueness is common. A typical fuzzy system consists of a rule base, membership functions, and an inference procedure. This study aims to show that complicated problems do not always need sophisticated tools to solve. It attempts to develop an operational tool with potential application in solving real environmental problems using existing knowledge. The problem chosen was tourist accommodation site selection. The proposed tool was a *"systematic approach"* that can be used to produce the most suitable area in Sukhothai province for tourist accommodation development maps.

Fuzzy sets are classifications in which the boundaries between classes are not distinct. Fuzzy logic is increasingly used for the handling of uncertainty in geographical databases (Burrough and Frank, 1996). The concept of Fuzzy set was introduced to describe imprecision that is characteristic of much of human reasoning, particularly in domain such as pattern recognition, communication of information, and abstraction.

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A fuzzy set can be defined mathematically by assigning to each possible individual in the universe of discourse a value representing its grade of membership in fuzzy set. This grade corresponds to the degree to which that individual is similar or compatible with the concept represented by the fuzzy set.

Formally, a fuzzy set can be defined as follows:

Let X be universe of points (or objects) with a generic element of X being denoted by x. *A fuzzy set* of X, labeled A, is characterized by a *membership or characteristic function*, μ_A, which is associates with each point in X a real number in the closed interval (0,1). The value of μ_A (x) at x represents the grade of membership of x in A, defined either by enumeration or by a function:

$$A = \{(X, \mu_A (x)) \mid x \in X\}$$

Where the membership function.$0 \le \mu_A \le 1$ Intuitively, 1 means totally in the set, 0 means very not in the set. Traditional crisp sets only allow values of 0 or 1, corresponding to false/true, out/in, wrong/right etc.

The assumption underlying fuzzy set theory is that the transition from membership to non-membership is seldom a step function (Gopal and Woodcock, 1994). Rather, there is a gradual but specifiable change from membership to non-membership. In (classical) set theory, a membership function $\mu_A(x)$ has only two values 0,1.

A good example is the concept of steep slopes. We decide that 18 % slopes or steeper is definitely 'steep' (fuzzy membership 1), and that 10 % slope or less is definitely not ' steep' (fuzzy membership 0). We must now decide how to qualify slope between 10% and 18%; a typical (and arbitrary) choice is Sigmoidal membership function, which is define by the relation $\mu = \cos^2 \alpha$, where μ is the membership grade. We determine α from two points: the lower and upper limits of our concept:

$$\alpha = \frac{\pi}{2} x \frac{(x - l_1)}{(l_2 - l_1)}, x \le l_2$$

If $x \ge l_2$ then $\mu = 1$.

Membership functions are at the discretion of the analyst. The idea is to quantify the linguistic uncertainty. Here are two examples of membership functions for monotonic concept, e.g. steep.

The Sigmoidal function is intuitively appealing, but the linear function may provide a reasonable approximation, and makes fewer assumptions about how our concept of membership changes in the range where the possibility is in the interval (0,1). Other function forms are used when the concept has a minimum membership at some value and less membership at both a higher and lower value. For example, 'moderate deep' soils could be considered to have membership 1.0 between 60 and 80 cm., tapering off at 0 at 40 and 100 cm. So using expert opinion and the wide variety of functional forms available

2.5.2 Operations on Fuzzy Sets

As with Boolean operation, a full set of logic operation exists for working with fuzzy sets. However, their nature is somewhat different from what we are familiar with. In addition, several operations prove to be useful in working with these concepts.

Table 2-1 Common Fuzzy Operators

Fuzzy Complement	$\mu A(x) = 1 - \mu A(x)$
Fuzzy Union	$\mu A \cup B(x) = \max[\mu A(x), \mu B(x)]$
Fuzzy Intersection	$\mu A \cup B(x) = \min[\mu A(x), \mu B(x)]$
Algebraic Product	$\mu A \mu B(x) = [\mu A(x) * \mu B(x)]$
Algebraic Sum	$\mu A(x) + \mu B(x) = [\mu A(x) + \mu B(x) - \mu A(x) * \mu B(x)]$

Source: Lein (1996)

2.5.3 Applications

Human experts solve problems using factual knowledge and reasoning ability. Experts express their assessment using qualitative linguistic values. Fuzzy set in this context can be used to mathematize this linguistic value and obtain a consensus if expert provide different (linguistic) values. Thus, they provide a consistent way to measure and model qualitative values that is useful for subsequent decision-making. Fuzzy set theory can also used in GIS applications. More specifically, it can be used to represent under uncertainty in spatial databases and manipulate uncertainty as data are transformed by various GIS function. For example, a map overlay function results in the creation of a composite map that contains uncertainty and errors. Using fuzzy sets, it is possible to compute the uncertainty in the composite map if the membership values of sites in each cover class were known for each map layer. Fuzzy sets can also be used to estimate similarity and other relationships. Fuzzy relation databases can handle imprecision in data representation and manipulation and allow for individualization of data.

Fuzzy Logic has been gaining increasing acceptance during the past few years. There are over two thousand commercially available products using Fuzzy Logic, ranging from washing machines to high-speed trains. Nearly every application can potentially realize some of the benefits of Fuzzy Logic, such as performance, simplicity, lower cost, and productivity. Fuzzy Logic has been found to be very suitable for embedded control applications. Several manufacturers in the automotive industry are using fuzzy technology to improve quality and reduce development time. In aerospace, fuzzy enables very complex real time problems to be tackled using a simple approach. In consumer electronics, fuzzy improves time to market and helps reduce costs. In manufacturing, fuzzy is proven invaluable in increasing equipment efficiency and diagnosing malfunctions.

Tangjaitrong (1994) applied fuzzy logic concept to mapping landslide hazard prediction. This study using fuzzy logic to setup the logistic model that used to predicted landslide hazard and setting the approximating of soil thickness that is the important rule to predicted the landslide hazard map. This study received assistance from several experts in fields associated with landslide phenomena. The proposed system was initially designed to use the information from the GIS. Expert interview was therefore limited to the uses of the available data to predict landslides. This controlled the knowledge acquisition procedure to a notable extent using knowledge which given from expert interview employed to build fuzzy membership function.

Bryant (1997) used fuzzy set concept to determine the feasibility of developing an automated expert system as a tool for using soil taxonomy to identify soils from stored data. The rules for the first four soil orders were translated into decision tree format and heuristic knowledge (expert rules) added to prevent indecision in case of missing data. This study recommend changes in policy and procedures for recording soil description data; development of the knowledge base to incorporate fuzzy logic techniques for identification and improve the expert rules with links to demon GIS program data input; and prototype feature improvement to complete a user-friendly expert system for all orders in soil taxonomy.

Eddy (1996) applied fuzzy logic in a GIS framework, which is a valuable method to assist in mineral resource assessments (MRA) in areas where data are sparse. This study used a digital geological map, backed by a digital geological data model, derived from published legends and reports. Together they functioned as a spatial-attribute relational data model' that provides evidence, in the form of derivative maps, to support mineral potential according to deposit model criteria. A knowledge-base was created with fuzzy membership functions linked to the classes of each derivative map that indicate favourability between geological features present in the database with those required by model criteria. A fuzzy-logic-based 'inference net', as implemented in the GIS modeling language, was used to combine spatial evidence to determine mineral resource potential for three mineral deposit sub-types. This method is shown to be valuable for providing an 'audit trial' for the complex decision-making process associated with resource assessment; it provides a means for experimenting and testing various hypotheses and viewpoints associated with mineral deposit models, and mimics some aspect of how geologists determine mineral potential for a region using information provided in geological maps and mineral deposit model literature.

Gopal and Woodcock (1994) applied fuzzy sets in map accuracy assessment to expand the amount of information that can be provided regarding the nature, frequency, magnitude and source of errors in a thematic map. The need of using fuzzy sets arises from the observation that all map locations do not fit unambiguously in a single map category. Fuzzy sets allow for varying levels of set membership for multiple map categories. A linguistic measurement scale allows the kind of comment commonly made during map evaluations to be used to qualify map accuracy. The suitability of fuzzy sets in the map accuracy context is demonstrated by deriving a set of measures to analyze the nature, frequency, source, and magnitude of errors.

With the development of GIS, environmental managers have more readily accessible data needed for environmental decision-making, but they need sufficient decision support tools in GIS to assist the decision-making processes. Researchers and software developers have perceived these needs and conducted various studies and routines for processing these data for multi-criteria decision-making. However, further study is needed to explore different methods for processing the available data and identifying parameters and decision objectives, to research various approaches to incorporating multiple criteria and involving decision makers in the process, and finally, to evaluate these methods and approaches in real-world decision environments. Guidelines to procedures for different kinds of decision-making are needed to make better-informed decisions.