The Building Strategies of Web-based National Park Monitoring System in Korea

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Abstract: The goal of this study was to propose building strategies of web-based national park monitoring system (WNPMS) using geographic information analysis system. To accomplish this study, at first, this study selected and made integrated management indicators considering physical, ecological, and socio-psychological carrying capacity in national park. Secondly, this study built up an integrated management indicator database and loaded this database in geographic information system. Thirdly, this study connected this system with statistical analysis program for execution of various multivariate analysis and spatial analysis. Finally, WNPMS could identify the relationship among visitors, natural resources, and recreation facilities in national park, and forecast the future management status of each national park in Korea. The results of this study will contribute to prevent the damage of natural resources facilities, improve visitor's satisfaction, prevent an excess of carrying capacity at national park, and established tailored management strategies of each national park.

Key Words : *Web-Based National Park Monitoring System, Integrated Management Indicator, Carrying Capacity, National Park, Geographic Information Analysis System*

I. Introduction

The 68% of animals and plants that inhabit Korea is in national park, national park occupies more than 90% of the 9-10 green nature level area, and national park occupies 53.5% of the natural environment conservation area in Korea. Therefore national parks should be considered preferentially for natural environment conservation in Korea. However, the 42.8% of the Korean tourist visited national parks in year 2005. With increase in leisure time due to the growing of income and the spread of the 5 days work week, the national park became major tourist attraction in Korea. Therefore, the establishment of management policy to respond to these trends is most important thing for sustainable use and the conversation of natural resources.

On the other hand, in order to lead an knowledge society the Korean government has established the National Information Infrastructure and digitized various data such as population, housing, land, traffic, and environment etc. into a database to institute a Digital Korea. But the theoretical and practical research towards the usage of information technology for the management of environmental protection region including national parks is still in the early stages. There is almost no research towards development of management indicator considering carrying capacity, database construction, and analysis method for national park monitoring.

Also environmental thematic maps such as, eco-map, land cover map etc. and satellite images that are being constructed only serve the function of showing the current status through a digital map and there are no guidelines made in terms of how to use various data for national park management. As a matter of fact, the Geographic Information System serviced by Korea National Park Service (www.npa.go.kr) does not differ greatly with pictures that indicate mountain paths and facilities and has limitations to use for establishing policies on national park management.

Problems that arise in national parks are not from one simple cause, because the problems are mutually related to visitors, recreation resources, and facilities. So in order to grasp the fundamental problem and establish efficient management policy, all relationships such as between visitors and recreation resources, visitors and facilities, recreation resources and facilities, visitors and visitors, etc. must be considered comprehensively.

Therefore, it is necessary to select and develop management indicators and build a database accordingly. And load the database on geographic information system with analysis programs. And then, identify relationships existed between management indicators. However, up until now, there have been a lack of research on how to link the geographic information system and analysis program, how to analyze the data, and how to utilize the analytic results in the decision making process, and so on.

Hence, the purpose of this research is to propose building strategies of web-based national park monitoring system (WNPMS) using geographic information analysis system. The integrated management indicators, databases, satellite images, geographic information system linking analysis program those are provided by this research will be applicable to not only national parks but various kinds of parks and other environmental sensitive areas and can be used to efficient tool to solve various types of environmental problem. Fundamentally, the goal of this research will contribute to establish online national environment management system by creating a process that loads the data from geographic information to an analysis program and then input the analysis results on the geographic

information system again in internet.

II. Review of Related Literatures and Systems

After carefully examining the already existing Literatures and related information systems,

First, even though national parks retain the most representative environmental, cultural and recreational values of Korea, management indicators have never been developed for the management of national park. Especially, the factors that affect the carrying capacity need to be included in management indicators for the accomplishment of original objective for national park, i.e. environmental resources conservation and sustainable usage. Therefore, management indicators considered national park carrying capacity has never been developed.

Second, most of the existing research has focused on visitors, resources and facilities separately and lacked research in understanding the reciprocal relationships among management sectors, i.e. visitors, recreation resources, and facilities. As a results, the knowledge that is actually required in establishing a national park management policy has not been provided, such as what relationship exist between the increase of visitors number and the degree of resource and facility damage in the activity space.

Third, up to now, accumulated data about visitor's behavior, facility, and recreation resource in national parks have not been loaded in to geographic information and are left in books and excel files lowering the efficient usage of the data. But there is close to no research done in how to load the data on geographic information for national park management. Therefore it was extremely hard to grasp important factors in national park management such as the exact location the facility or resource damage occurred, the periodic and special change of visitor's behavior, the visitor's movement characteristic classified by space and time, and so on.

Fourth, the existing research did not consider the temporal changes of the management indicators and limited the specific time periods, which made it difficult to grasp the aggravation or improvement process of management problems. Therefore, this research hopes to understand the transformation process and causes of management problems through building time series database and establish an appropriate management policy.

Finally, because national park management issues, such as national park facility and resource damage, fall in visitor satisfaction, carrying capacity calculation etc., are related to various factors, there needs to be a multilateral analysis between management indicators to find causes of these problems and prepare a prevention countermeasure.

In addition, in order to establish a tailored management policy that reflects the problems of each national park, linking the databases with analysis program to find the origin of the problems and submitting management policy solving problem are necessary. However, currently there is a lack of research in how to construct a geographic information database, link the database with an analytical program and also what method is needed for analysis.

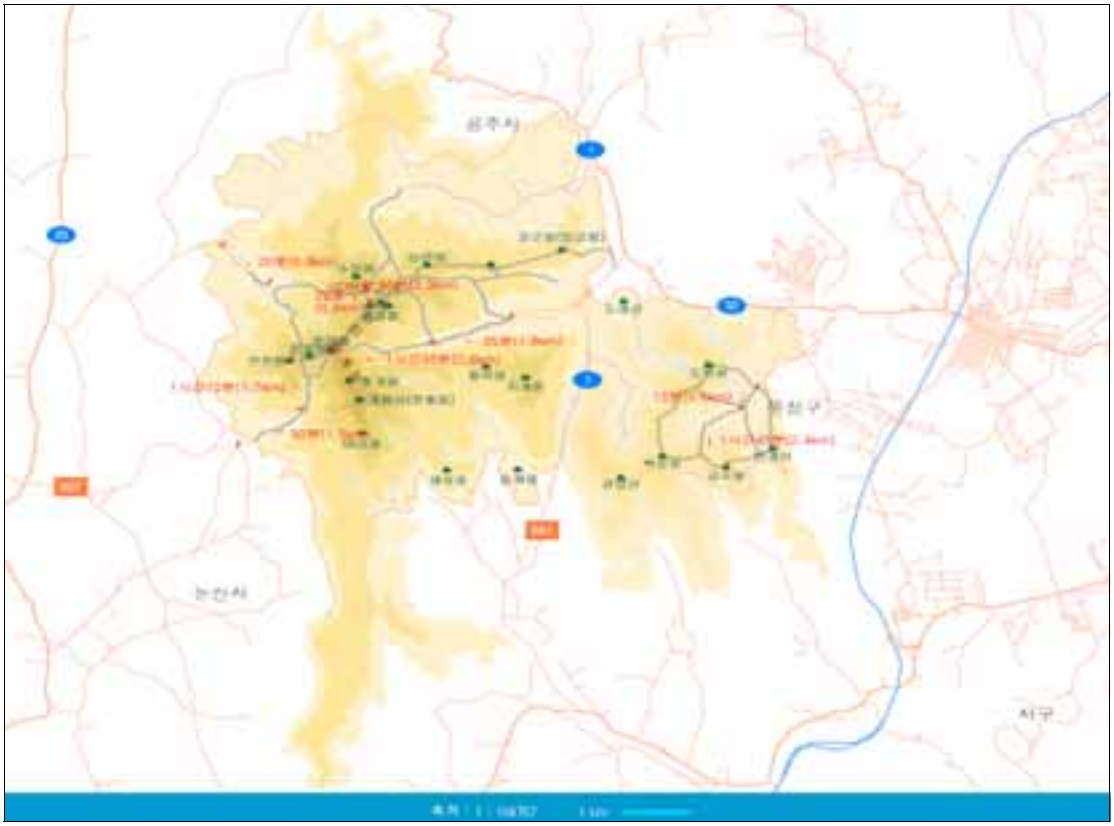
III. Research Methodology

1. Temporal Range

The time range of this research is from 1968, when the research subject KyeryongSan was authorized as a national park, to the present. However, various thematic maps such as stock maps, land cover maps, satellite images, etc and attribute data such as visitor's behavior data, recreation resource data and other data needed to build a geographic information analysis system, were gathered starting different years and have different cumulative periods. Therefore there maybe some discrepancies in the time range.

2. Spatial Range

The spatial range of this research is the KyeryongSan national park considering the number of visitors, the types of recreation resources, the quantity of facilities, management problems that are currently occurring, ease of data collection, park dimensions, time to build a system, etc. Approximately one million persons visit KyeryongSan national park per year. And due to its high density, many problems such as resource and facility damage, Disorder, and social conflicts, etc occurred. On the other hand, KyeryongSan national park possesses more accumulated data than other national parks, which eases research.(Figure 1)



<Figure 1> KyeryongSan National Park (www.nap.go.kr)

3. Research Process and Conceptual Figure

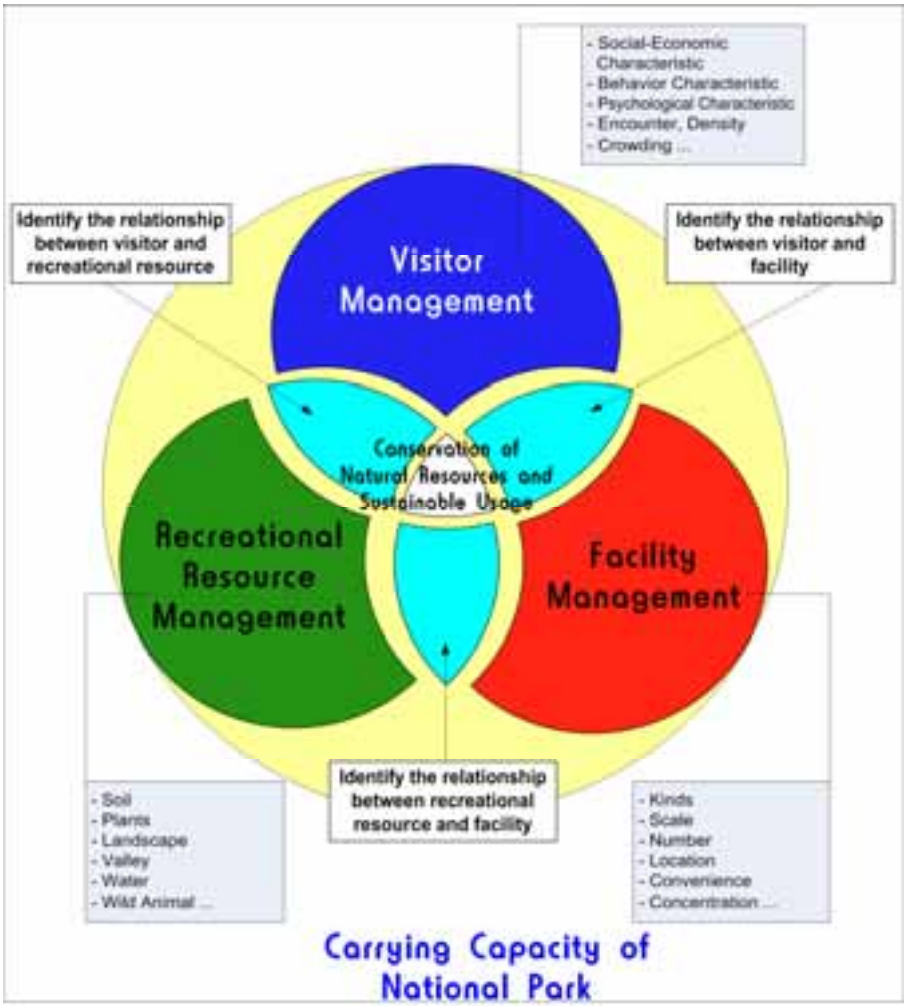
First, this research selects and develops a integrated management indicator considering the carrying capacity of national park.

Second, this research collects time series data and satellite images that correspond to the integrated management indicators based on relational database model.

Third, this research loads the database to the geographical information gearing an analysis program and executes various analyses such as time series analysis, multiple regression analysis, correlation analysis, etc to identify the relationships among management indicators.

Fourth, this research establishes the tailored management policy, forecasts the future status of management indicators, and monitors based on the results of analyses such as which factors affect the damage of resource and facility and the decline of visitor's satisfaction?, where and when the problems occur?, how the situation might

worsen in the future?, at which point there needs be a countermeasure?, and so on. (Figure 2)



<Figure 2> The Conceptual Figure of the National Park Monitoring System

3. Development of integrated management Indicators

Because national parks have two different objectives at the same time, the conservation of natural resource and the sustainable usage, carrying capacity should be considered certainly for the management of national park. Therefore this research aims to develop integrated management indicator that include not only physical indicators such as the number of recreation resources and facilities etc., but also the indicators considering the national park's physical, ecological, social-psychological carrying capacity such as crowding, encounter, expectation, and so on.

In order to develop integrated management indicators, this research reviews domestic and international research papers and reports on carrying capacity. Especially, sustainable tourism indicators developed from the

WTO (World Tourism Organization) and the related indicators submitted by IUCN (International Union for Conservation of Nature) and UNEP (United Nations Environment Program) are carefully examined to select indicators those are applicable to the Korean national parks. Also, park management methods such as ROS (Recreational Opportunity Spectrum), LAC (The Limits of Acceptable Change), VIM (Visitor Impact Management) etc., are carefully examined. The selected indicators considered and sorted according to the current domestic environmental laws to maximize the effectiveness of the research. Finally, the research aims to apply sectoral frame work (Maclaren, 1996) and develop indicators that have not yet been considered.

<Table 1> Examples of integrated management indicators that consider carrying capacity

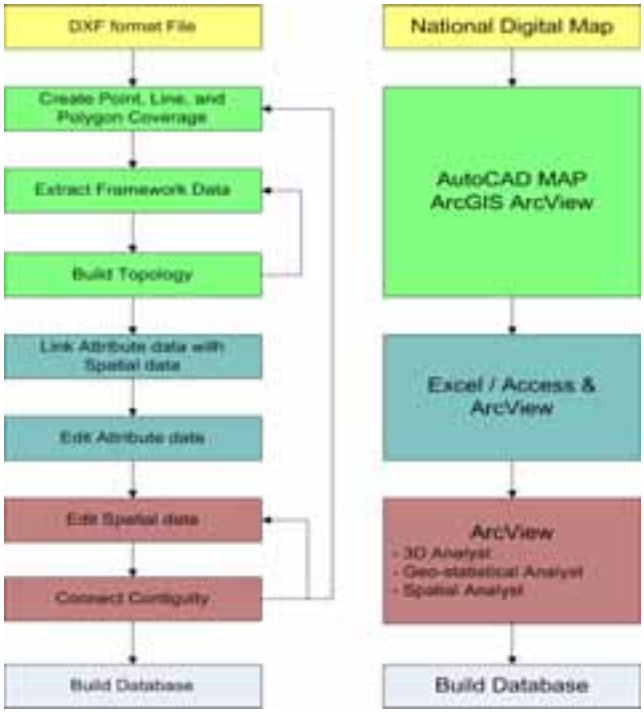
Carrying Capacity	Management Sectors	Management Indicators	
Social Carrying Capacity	Visitors	Visitor Behavior	Visit Season
			Company Type
			Lodging Type…
		Social – economic Characteristic	Occupation
			Income Level
			Education Level
			Residence…
		Individual Characteristic	Gender
			Age…
		Psychological Characteristic	Expectation
			Density
			Satisfaction …
		Use Level…	A Number of Visitors
			Orderly Visit Manner…
Ecological Carrying Capacity	Recreational Resources	Soil	…
		Plants	…
		Wild Animal …	…
Physical Carrying Capacity	Facilities	Scale	…
		Location	…
		Convenience …	…

4. Analysis Software

This research builds up environmental database using Excel and Access (XLS file Format) and link environmental database with geographic information using ArcView 9.0 (SHP file format) with extensions such as Spatial Analyst, 3D Analyst, and Geo-statistical Analyst, because XLS and SHP file formats are compatible with most GIS software and easy to link to environmental database and geographic information like Figure 3.

It also uses the SAS® Bridge for ESRI to link geographic environmental data with an analysis program such as SAS, SPSS. Also the analysis programs are used to identify what kind of relationships exist among EIs through

various analyses such as logistic analysis, correlation analysis, time series analysis and so on.



<Figure 3> Data Conversion for Building GIAS

IV. The Building of Web-based National Park Monitoring System

1. The Building of Integrated Management Indicator Database

1) Using the already developed integrated management indicators, this research collects time series data as soon as possible to grasp the change process of integrated management indicators. That is, Increase in visitors → Induce recreation resource and facility damage → Compose a response policy that examines a series of cause and effect.

2) For satellite images, use LANDSAT, SPOT, IKONOS, and KOMSAT etc. constructed form the Ministry of Environment, Satellite Technology Research Center (http://satrec.kaist.ac.kr/), and so on. (Figure 4)

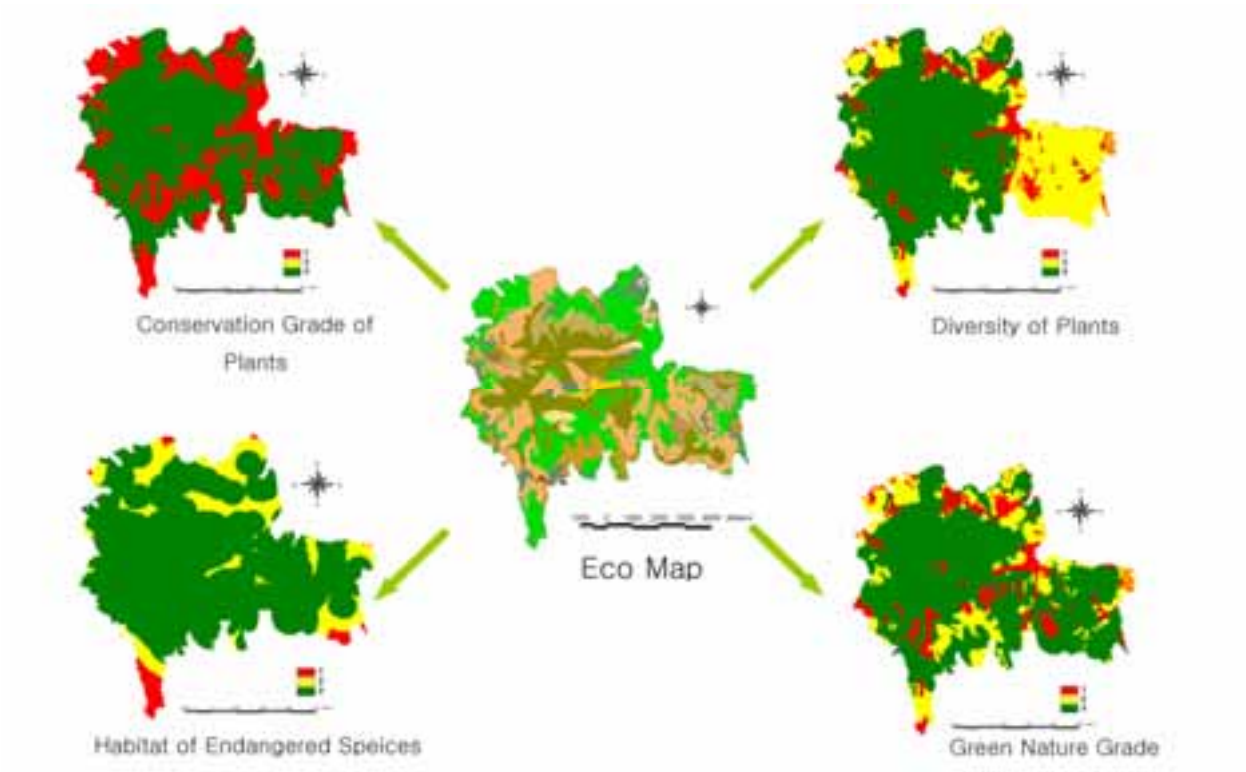
3) This research builds up integrated management indicators database by using a relative data model because this data model can implement the spatial analysis and arithmetic analysis.

4) This research links collected data with spatial units such as point, line, and polygon using Extension Entity

Relationship Data Model. It designs a spatial database schema per spatial units using tabular type data structure because tabular type data structure is easy to insert and delete environmental data, and to transfer its data to other analysis programs.

a: LANDSAT satellite image

b: land classification map



c: eco map and reclassified maps

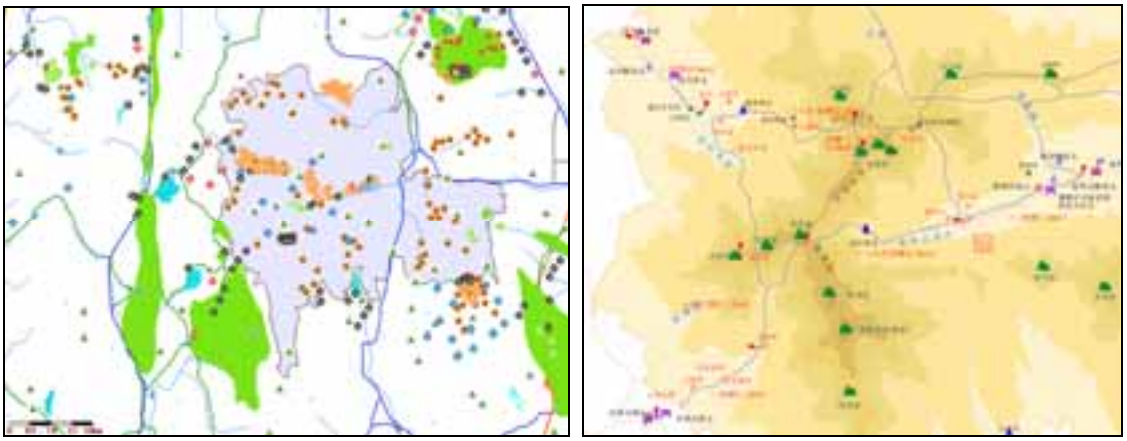
<Figure 4> Examples of thematic map in KyeryongSan National Park

2. Loading Database to the Geographic Information System

By loading the built database with the actual geographical position of the national park space, it eases approaching geographic information in the space and related information. Also it will present the position information and characteristic information visually, increasing the actuality or reality of the information.

In order to load the database on to geographic information, according the characteristic of the indicator decide which data form between point, line, and polygon should be synced. Also, another thing that must be taken in to account is assigning each indicator UFID (Unique Feature IDentifier). This type of code assignment will become a standard for expansion and manipulation of future data.

A problem that arises when database is loaded on geographic information system is the renewal of data. Because the cycle and scale differs for each data, the period of data renewal needs to be considered. Therefore, instead of loading various data on to one layer, this research uses one layer per attribute data.



<Figure 5> Examples of Geographic Information System loaded Integrated Management Indicator Database

1) Getting a grasp on the characteristic of data corresponding to indicators loaded with geographic information
   a. Identify the research method and period of data.
   b. Confirm if the existing maps such as facility allocation map, hiking map, natural resource inventory map, are digitized and draw thematic map for any missing information.
2) Identify the geographic topology relationship of database
   a. Confirm spatial range, data structure, scale, etc., should be included in each indicator.

b. Develop a topology relationship according to the spatial boundary of each indicator.

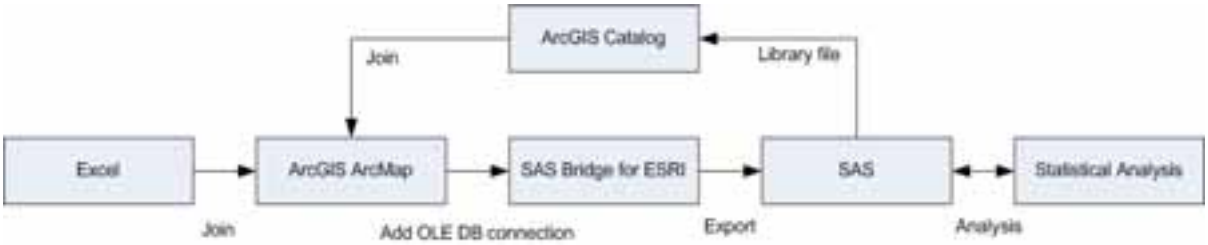
c. Assign a geographical position depending on the spatial characteristic of each indicator.

d. Enable the query of geo referenced data depending on the data user's objective, and ease the integration and division of data to increase the application possibility in the future.

3. The Building of Geographic Information Analysis System

1) This research applies the OLAP (On-line Analytical Processing) method enabling each indicator to become function as a variable in analysis programs such as SPSS or SAS etc.

; This research builds the geographic information analysis system (GIAS) by gearing GIS with analysis programs like SPSS or SAS and executes various analyses to solve management problems such as time series analysis, causal relation analysis and correlation analysis. More specifically, GIS gears with a SAS or SPSS programs using the SAS bridge® for ESRI and executes various analysis for building a tailored management policy. (Figure 6)

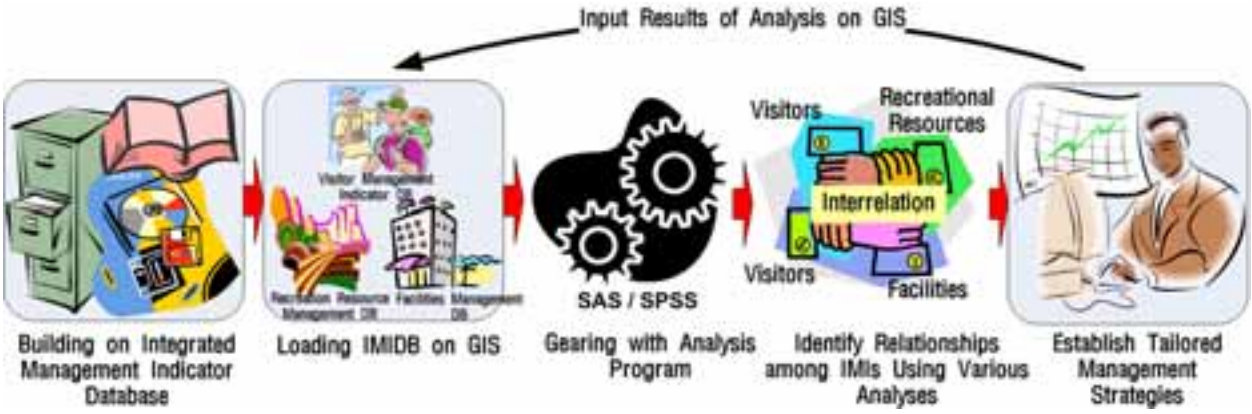


<Figure 6> Gearing Process between GIS and SAS

2) Each data corresponding to indicators is imported into analysis programs and various analysis methods are executed such as correlation analysis, regression analysis, logistic regression analysis and multidimensional scaling analysis etc., to identify the relationships among management indicators. Therefore the results of various analyses are available for establishment of fundamental management policy to solve specific management problems and provide scientific proof to establish a preventive management countermeasure.

3) Using the deduced analysis results, prediction models for the future status of the research area's visitors,

resources and facilities can be developed. Also, in order to verify the model's validity main indicators can be manipulated to confirm the consistency between actual and predicted values. For example, if visitor number at specific national parks increase the same amount as it does currently for the next 5 years, how much hiking road damage will occur can be predicted and observing the current policy results, the most beneficial policy can be selected to be executed at the most appropriate time. When a model's validity is confirmed through this process, utilizing the current planning factors, problems that can occur in the future and the extent of its scope can be predicted to submit a management policy accordingly.



<Figure 4> The Conceptual Figure of National Park Online Monitoring System

V. Conclusions

First, this research is based on international organizations such as WTO, UNEP, IUCN etc. to contribute by providing a guide for selecting and developing a integrated management indicator for visitor, resource and facility management that takes in to account the national park's carrying capacity.

Second, this research executes time series analysis, cause and effect relationship and correlation relationship between indicators analysis etc. to find out the cause many problems in a specific activity space or area, to predict how the indicators will change in the future and to visually present when, where and what kind of environmental problems will arise. These steps that the research is taking will be able to contribute by providing theoretical basis for solving the predicted problems

Third, this research can be applied in the development of various theoretical models for the relationship between

visitor, resource and facility. Therefore, the management indicator database that is loaded in the geographic information is used in an analysis program to construct a theoretical model that examines the management indicators that affect increase in visitor numbers, resource and facility damage, national park use satisfaction etc.

Fourth, this research overcomes fragmented angles, one of the main problems in managing national parks, and provides frame work with a multidimensional angle that interprets indicators that affect national park management and national park planning. Therefore, instead of only using the relationship between specific areas and specific indicators, through this the establishment of a integrated database this research considers various relationships and develops a balanced and appropriate management policy, in order to achieve two very differing objective of national parks, environment conservation and sustainable usage.

Fifth, already existing research only researched each category and lacked the inducement of synthesis between studies and methodology. By solving one problem this research will be able to submit precedents of fundamental causes of why a certain issue or problem arises and where it arises. The results of this research will be able to contribute in realizing the problems that occur in nature or environment as a whole and the organic relationships of the larger environment such as the relationship between sociological environment and natural environment.

Sixth, the synthesizing methods of the data, constructing and manipulating the data, methods of constructing a data base that facilitates renewal, and also geographic information loading scheme, satellite images handing scheme, using the collected data in analysis programs to enable various analysis scheme, etc. that use identifiers submitted through the research process can contribute to research methodology and encouragement of related research.

Seventh, by developing an indicator that affects national park carrying capacity, this research can be utilized as a standard in managing natural resource centered leisure space such as county, provincial parks and natural recreation forests etc.

Eight, because this research visually shows the management indicators that are combined with geographic information, not only is it easy to recognize the factuality of the data but the current condition and analysis results. Also with the basis of the aforementioned advantages, the research can contribute to speediness of execution and efficiency and the finding of a fundamental solution of the mistakes and problems in execution because not only is the analysis and assessment of a policy is possible but policy results can be predicted and visually presented.

Finally, if GPS and 3D geographic information system is applied in the future, real-time data renewal and the approach and analysis of information on the web without any temporal or spatial limitations and simulation of the of

management plans execution will be possible. These processes will be applicable in fostering a foundation for an information technology society.

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