The Building of Environmental Geographic Information System for Supporting Environmental Policymaking in Korea

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ABSTRACT

The goal of this study is to build a geographic information system for environmental policymaking. To achieve this goal, this study first surveys the local environment status. Based upon the collected environmental data, it forecasts the future environmental status of each city in Gyeongbuk province and generates a geo-referencing code. Finally, by using these data, it builds up a future environmental geographic information system for supporting environmental policymaking. This study consists of three major parts: 1) developing integrated environmental indicators, 2) establishing an environmental capacity database on the local level, 3) building up an environmental capacity geographic information system, and 4) making an environmental policy monitoring system. The results of this study will contribute to establish a warning system to prevent an excess of environmental capacity. They will also provide the framework and standard for integrating various environmental databases with a local environmental and geographic information system.

Key words: *Environmental indicators, geographic information system, geo-coding and geo-referencing, environmental policy*

I. Introduction

In the 21st century, the quality of the environment is one of the most important factors for strengthening of national competitiveness and determination of the quality of life. In Korea, the citizen's concerns on the environmental amenities are gradually increasing. However, the environmental condition of the South Korea is relatively weak because of the high density of the population, the lack of developable land space, and the rapid urbanization and industrialization. These natural and social conditions have deteriorated the environmental status such as air pollution, water pollution, solid waste problem, ocean pollution and so on.

In order to solve these environmental problems, the Korean government has improved the environment-related organizations and laws and greatly expanded the government budget for the environment protection. It also develops the several environmental indicators (EIs) in order to measure the environmental quality and focuses on the sustainable development to protect the natural and social environments in the Korean Peninsula.

The Korean government has constructed the National Information Infrastructure (NII) to use land effectively by constructing digital territory through the building of databases such as population, housing, land, traffic, and environment and so on. However, in the national level these databases do not contribute to understand systematically the environment status because current indicators only include the physical indicators such as atmosphere pollution, water quality, and solid waste except the social indicators such as environmental education, environment technology and so on. Furthermore, it is very difficult to grasp the local environmental problems because

environmental databases do not integrate with geographic information system. Therefore, this study intends to build the environmental geographic information system and contributes to establish the environmental policy monitoring system (EPMS).

In order to establish EPMS, it develops the integrated EIs including the social environmental indicators and the physical environmental indicators and collects integrated environmental indicator data by time series base. It also builds a relative integrated environmental indicator database (IEID). This research builds a environmental geographic information system (EGIS) through geo-coding and geo-referencing on each environmental data. EGIS will be connected with analysis programs such as SAS or SPSS for execution of a time series analysis, a causal relation analysis, a correlation analysis, and a spatial analysis in order to build up the EPMS. The result of this study will contribute to make a tailored environment policy because it can provide the future local environmental information and execute the simulation process on each development project.

II. Review of Environmental Information Systems in Korea

1. The Status of Geographic Information System

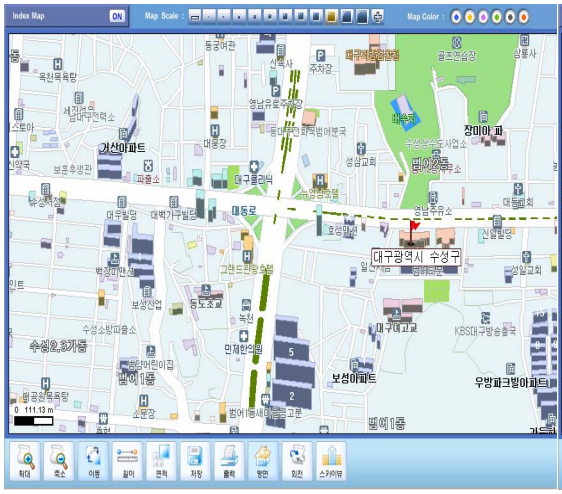
At present, National Geographic Information System (NGIS) and Korea Statistical Information System (KOSIS) are the representative information systems in Korea. The goal of the NGIS is to provide the geographic information for the environmentally sound and sustainable land development. The major issues of the NGIS can be categorized as follows; 1) Establishment of spatial databases for the NGIS: 2) Establishment of data standardization: 3) Assistance of GIS-related technical

development: 4) Development of framework for utilization and application of the NGIS. KOSIS is built for efficient management the statistical data such as economy, population, land, and housing and so on. One of the major functions of KOSIS is to provide statistical information for a variety of users.

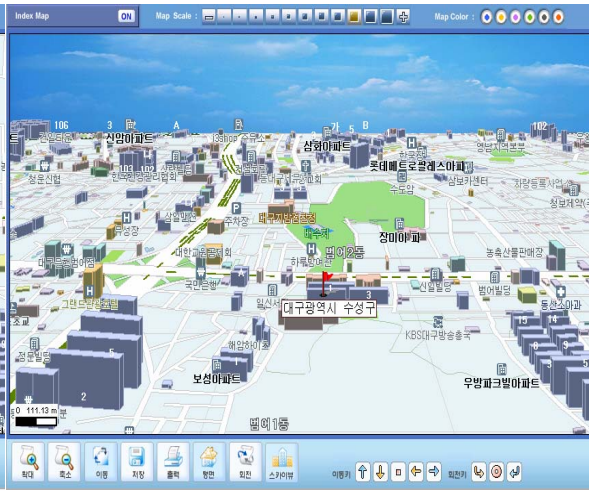
Address and facility searching is major function of Internet map services like Figure 1. However, this figure conceptually differs with statistical geographic map. Therefore, in order to convert this figure to the digital map, geo-coding process is necessary and statistical data should be integrated.

a: South Korea

b: Daegu city, South Korea



c: Susung-Gu, Daegu city, South Korea

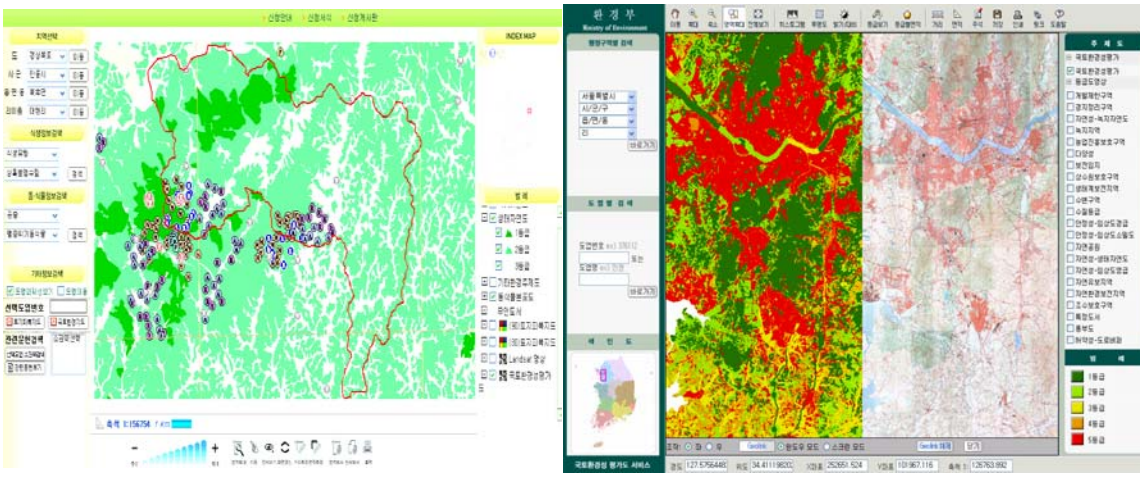


d: 3 Dimension map, Susung-Gu

<Figure 1> Internet map search service in Daegu City

2. The Environmental Geographic Information System

The Ministry of Environment only supplies physical environmental statistical data such as air, water, and solid waste like Figure 2 but it does not provide the social environmental data such as environment education, budget, and environmental technology which are important factors in building the environmental policy (http://ngis.me.go.kr/egis/).

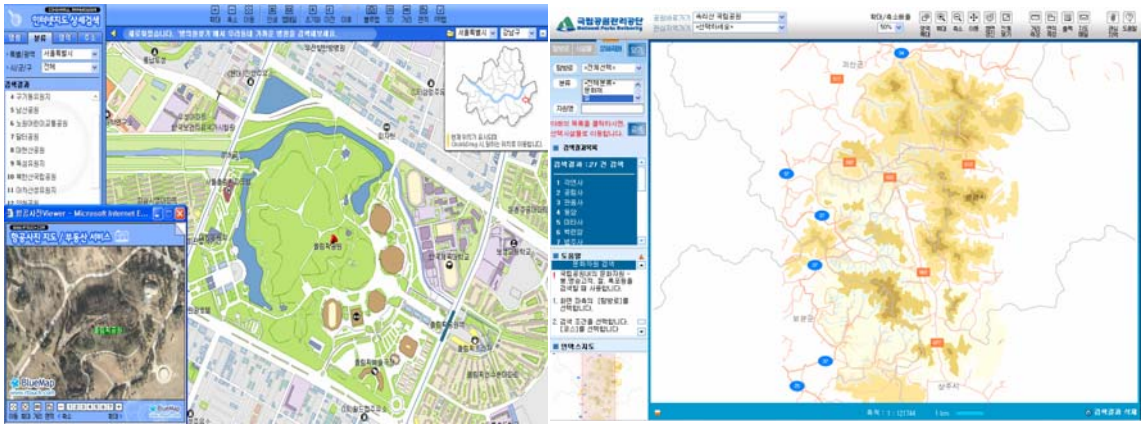


a: Geographic information system web service

b: National territory environmental character grade map

<Figure 2> Web geographic information service from the Ministry of Environment

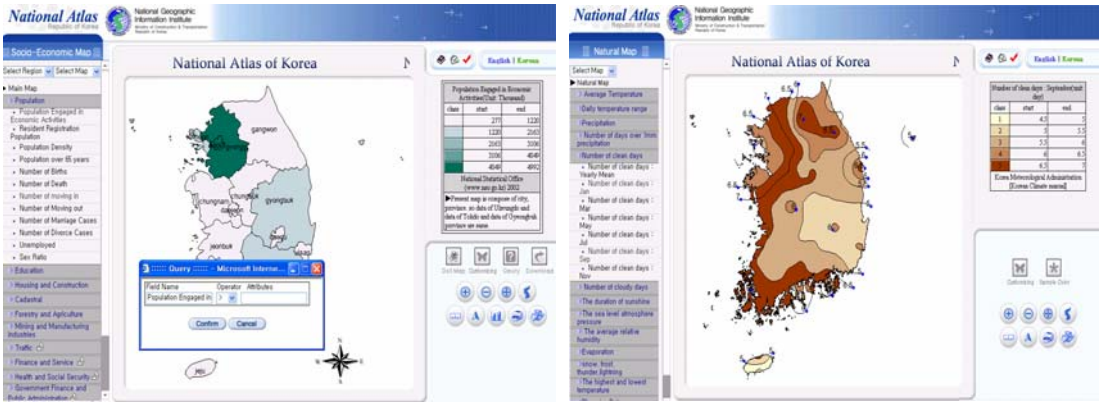
Korea Forest Research Institute also services a nationwide forest map that shows the location of national forest resources such as botanical species and the rarity of plant habitat. And National Park Authority provides satellite pictures such as climbing routines, facilities, and culture resources of each natural park on the web (http:/www.npa.or.kr/).



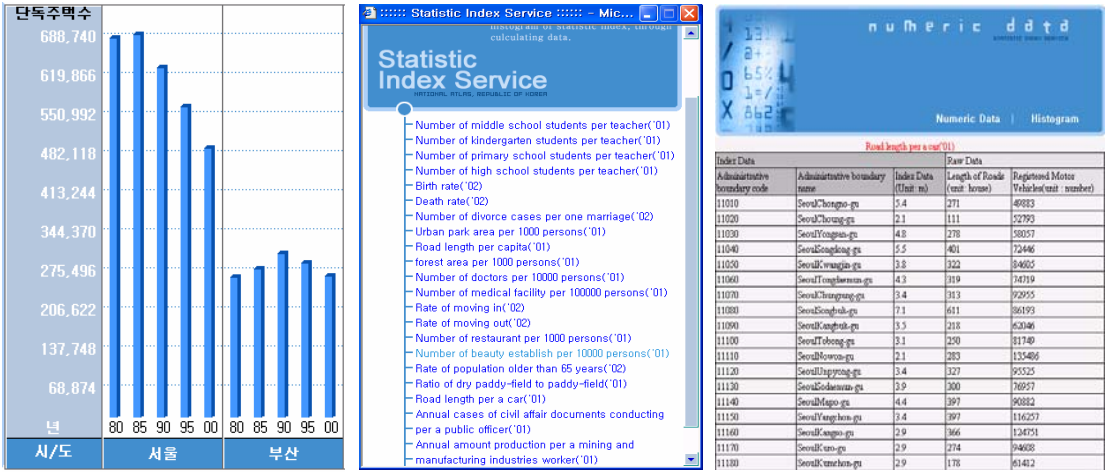
a: Web map service with satellite picture b: National park information system

<Figure 3 > Satellite picture service and national park information system

National Geographic Information Institute is servicing a National Atlas that collects a representative statistical data such as population, industry, economy, and environment on its website (http://www.ngi.go.kr). However, this database only the aggregated statistical data at the nation and city level instead of the micro data in the level of each census tract. Therefore, there are some limitations to use these data for analyzing the local environmental status.



a: Query of attribute data and display

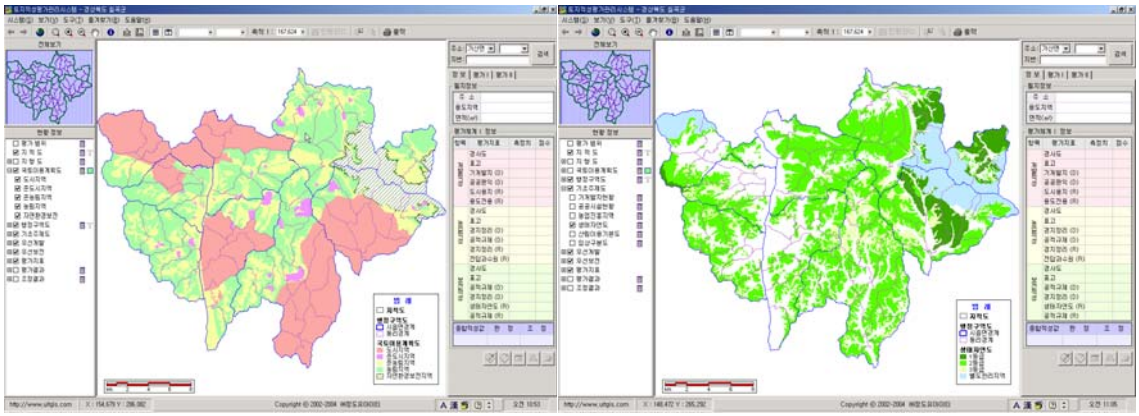


b: Download of raw data

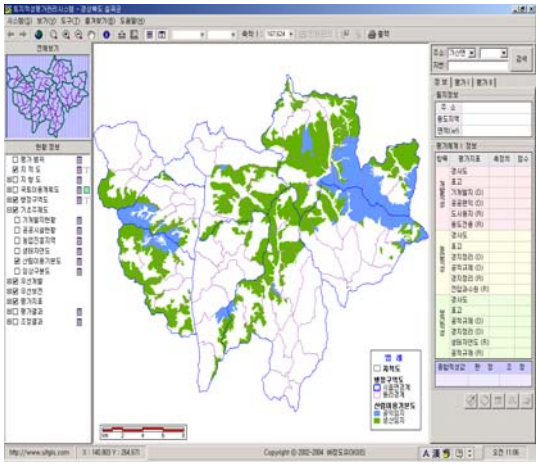
<Figure 4> National statistical map service from National Geographic Institute

3. Land Suitability Assessment System

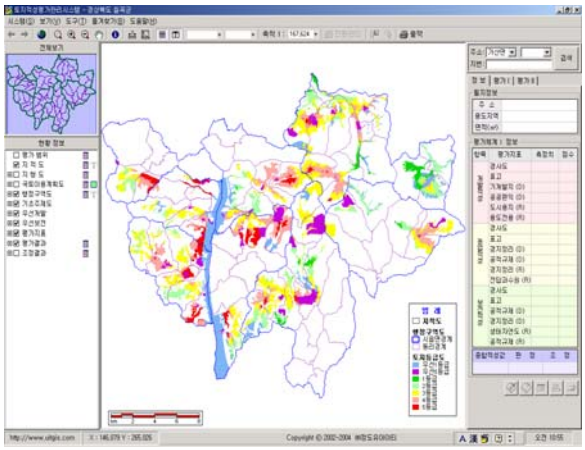
The Land Suitability Assessment System is newly introduced to provide criteria for land use classification in order to prevent unplanned development. It classifies land-use types into five grades: priority preservation, preservation, agriculture, development, and the developed area grade. The land suitability assessment should be executed before processing the land development in order to select the suitable land for the development like Figure 5.



A: Landuse map b: Ecosystem map



C: Forest use map



d: Final suitability map

<Figure 5> Land Suitability Assessment System

After reviewing the environmental geographic information systems, this research could figure out that most of map focused on the visualization of information but they do not provide the analytical procedure for getting the secondary information. In addition, Social indicators which are important factors in building of environmental policy are not included in environmental geographic information system. Moreover, there is no environmental geographic information system which provides realistic solutions on what relationship is existed among EIs?, which EIs cause environmental problem?, How will environmental problems change in the future? What is the most suitable solution to prevent the deterioration of local environmental problem?

Therefore, this research links integrated environmental indicator data with geographical data, and analyzes the relationship among EIs through time series analysis, spatial analysis, causal analysis, and correlation analysis, and suggests a tailored environmental policy which is necessary in each local government level through forecasting and monitoring the environmental status.

III. Research Methodology

1. Research Area

The Province of Gyeongbuk is located in the south-east part of Korean Peninsula. Its area is larger than that of other local governments and has various cities such as industrial-centered, rural-centered, and cultural-centered city. And its environmental problems differ from any other local government. Up to now, environmental policy of provincial government could not solve the specific environmental problems of each city because most of local environmental policy was established by the provincial government without considering environmental problems of each city.

<Figure 6> Location map of Gyeongbuk Province

2. The Development of Integrated Environmental Indicators

Based upon the environmental law, this research intends to re-categorize the integrated EIs including environmental management indicators such as environmental budget, environmental education, and environmental technology like Table 1 because environmental management indicators are important EIs affecting the level of future natural and living environment.

<Table 1> Examples of Integrated Environmental indicators based on Korea Environmental law

Natural Environment	Landscape	Climate	Duration of Sunshine
			Damages from Storms and Floods
		Topography	
		Soil	Soil Pollutant Emitting Facilities
			Soil Pollution by Pollutant
		River and Marsh	Area and Length of Rivers
			Water Supply Source Protection Areas
		Sea and Coast	Length of Coast and Island Area
			Marine Pollution Accidents
		Forest	Forest Land Area by Forest Type
			Growing Stock by Forest Type
			Forest Damaged Area
	Ecosystem	Korean Species	
		Designation of Endangered, Vulnerable Wildlife	
Living Environment	Environment Pollution	Air	SO_2, NO_2, and CO Emissions
			Total Suspended Particulate Concentration
			Air Pollutant Emitting Facilities
		Water	BOD and COD Density of Rivers and Streams
			Drinking Water Quality
			Waste Water Discharging Quantity
		Water Supply and Drainage	Water Supply Rate
			Sewerage System Supply Rate
		Wastes	Disposal of General Wastes
			Waste Recycling Rate
		Noise and Vibration	Noise and Vibration Generating Facilities
	Housing Environment	Population	Population Density
			Trend in Population
			Number of Livelihood Protection Persons

		Industry and Energy	Number of Industries Total Energy Consumption
		Roads and Transportation	Length of Roads Motor Vehicle Registration Traffic Accidents
		Land Use	Natural Environmental Preservation Area Dwelling Zone Area
		Parks and Green zone	Green zone area Park Area per one Person National and Local Cultural Property
Environment management	Environment Administration	Environmental Law	
		Environmental Finance	Environmental Budget Collection of Waste Treatment Charge Collection of Environmental Improvement Charge
		Environmental Information	
	Environmental improvement	Environmental Technology	Supporting Amount on Environment Technology Field Umber of Environmental Companies
		Environmental Education	Environmental Subjects Selected School Environment Technology Manpower
		Environmental Impact Assessment Consultations	
		Co-work System between Government and Nonprofit Corporations	

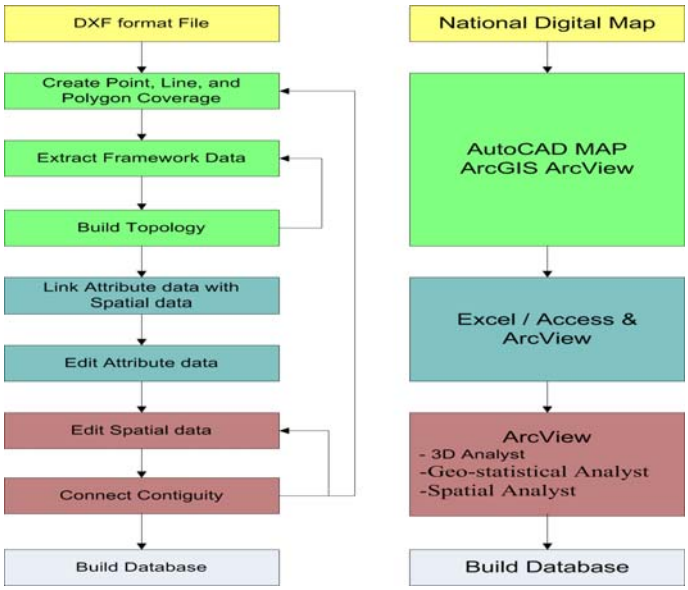
And this research collects the integrated environmental indicator data produced in several government agencies such as Korean Research Institute for Human Settlement, National Geographic Information Institute, the Ministry of Government Administration and Home Affairs, the Ministry of Construction and Transportation, and the Minister of Information and Communication.

3. Analysis Software

This research builds up environmental database using Excel and Access (XLS file Format) and link environmental database with geographic information using ArcView

8.3 (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 environmental database and geographic information like Figure 7.

It also uses the SAS® Bridge for ESRI to link geographic environmental data with analysis program such as SAS, SPSS. And analysis programs are used to identify what kind of relationships are existed among EIs through various analyses such as logistic analysis, correlation analysis, time series analysis, and so on.



<Figure 7> Data conversion for building EGIS

VI. The Building of Environmental Policy Monitoring System

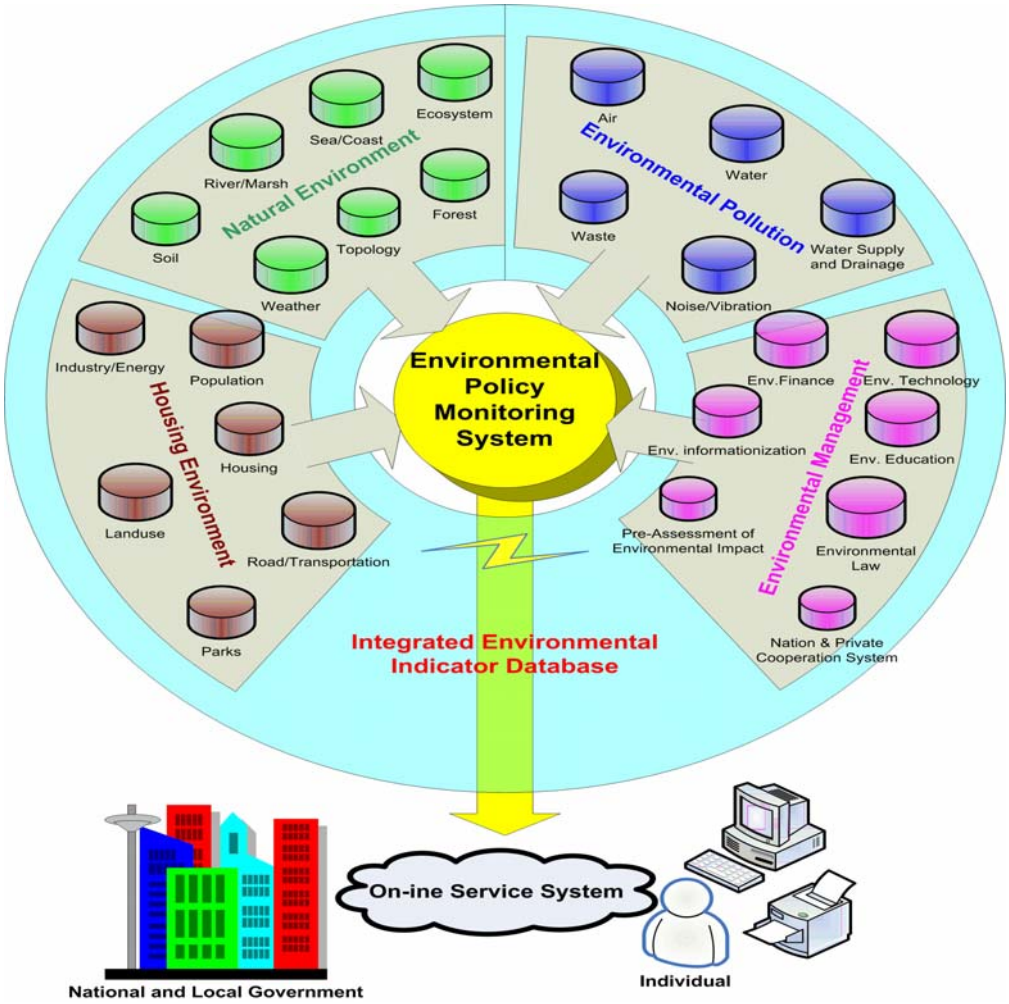
1. The Building of Integrated Environmental Indicator Database

1) This research re-categorizes EIs including environmental management indicators based on the environmental law and selects practically measurable indicators.

2) It analyzes the structure of environmental data, the building procedure of NGIS, and the method of data update.

3) It identifies current administrative districts of each city and the postcode systems for geo-coding and geo-referencing.

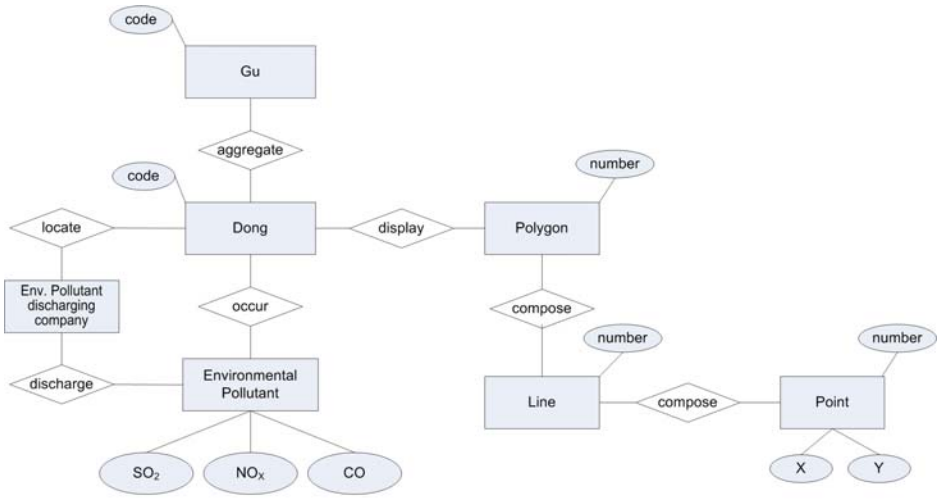
4) It collects the integrated environmental indicator data in each local government level. And insufficient or outdated data are supplemented by field or questionnaire surveys, linear models, and log models.



<Figure 8> The Building of Integrated Environmental Indicator Database

5) It builds up IEID by using a relative data model because this data model can implement the spatial analysis and arithmetic analysis.

6) It links environmental data with spatial units such as point, line, and polygon using Extension Entity Relationship Data Model. For example, entities are consisted of *Gu, Dong* (administrative district), and pollutants like Figure 8. And relationships like "occur", "aggregate", and "locate" are existed between these entities. And entities are displayed by spatial units which have location information.



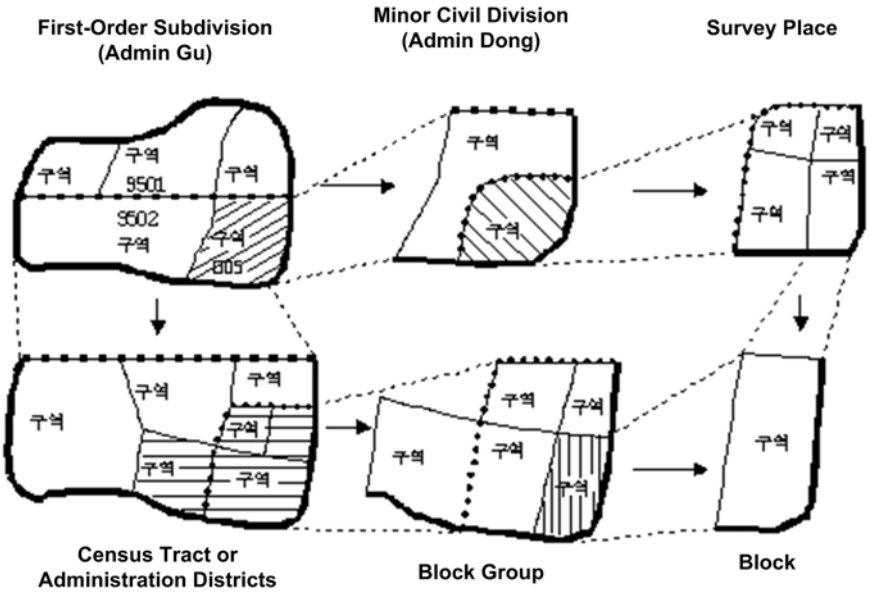
<Figure 9> Example of Entity Relationship Data Model

7) 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.

2. The Building of Environmental Geographic Information System

This research builds Environmental Geographic Information System through linking IEID with geographic information of each local area by Geo-coding and Geo-Referencing method. Specific procedures for building EGIS are summarized as follows:

1) This research searches the way which encodes location information such as postcodes or administrative districts on IEID.
2) Each integrated environment indicator data will be assigned to administrative districts such as *Province, City, Gun, Gu, Eup, Myon or Dong* depending upon survey boundary. And it analyzes the geographic topology structure such as point, arc, and polygon in order to link IEID with administrative area.



<Figure 10> Geo-Coding and Referencing System

3. The Building of Environmental Policy Monitoring System

This research builds Environment Policy Monitoring System (EPMS) by connecting an EGIS with analysis programs like SPSS or SAS and executes time series analysis, causal relation analysis, and correlation analysis. More specifically, EGIS connects with an SAS or SPSS statistics programs using the SAS bridge® for ESRI and executes various analysis for building a tailored environmental policy.

V. Conclusion and Policy Implications

This research developed the integrated environmental indicators and they are assigned to the administrative districts in order to integrate the environmental database with geographic location where the environmental problems were generated. And these databases were connected with analysis program using SAS Bridge program in order to analyze a local environmental status. Based upon these analyses, this study can forecast the future environmental state in specific local areas and display the degree of severity of environmental problems visually using the EGIS. More specifically, EPMS can predict the future environmental status of each city through simulating the policy factors. Based on these simulation results on the environmental policy of each city, we can monitor the environmental policy of each city and suggest a tailored environmental policy. EPMS can be used as a decision making supporting system for building the local environmental policy. It also suggests some lessons on the other policy building such as landuse planning and environmental impact assessment in the Gyeongbuk province.

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