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The Use of geographic information system for planning rural water resources systems

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농어촌지역의 수자원시스템 계획을 위한 지리정보 시스템의 활용

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ABSTRACT: Rural water resources systems may be largely constituted by two parts. One is rural water supply systems such as reservoirs, wells, pumping stations. The other is rural water demand systems which include municipal water, irrigation water, industrial water, livestocks water, inland fisheries water and environmental water in rural areas. planning to develop rural water resources systems is a very hard task because of their complicated factors and the large number of spatial data to investigate and manipulate. A Geographic Information System(GIS) will be a powerful and efficient tool to handle the spatial data and to plan the land use. All data can be efficiently maintained and easily updated. This paper refers to the construction of a GIS for planning rural water resources systems applied to Kokseong County, Cheonnam Province, Republic of Korea. The Geographic Information was constituted by 4 layers of base map and 11 layers of thematic map.

요 약

농어촌지역의 수자원시스템은 크게 두부분으로 구성된다. 그 하나는 저수지, 양수장, 보 등의 농어촌용수 공급시스템이고, 또 다른 하나는 농어촌지역내의 생활용수, 농업용수, 공업용수, 수산용수, 환경용수 등의 농어촌용수 수요시스템이다.

농어촌용수 수자원시스템의 개발계획은 농어촌유역만이 지니고 있는 복잡한 요소들을 모두 고려하여야 하는 매우 어려운 작업이며, 합리적인 계획을 위한 조사와 분석 또한 상당한 양의 지

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형공간분석이 요구된다. 지리정보시스템은 계획에 필요한 지형자료를 입력하고 저수지 적지, 토지이용 등의 계획을 수립할 수 있는 강력하고 효율적인 수단으로 판단되며, 입력된 모든 자료들은 쉽게 관리 및 갱신할 수 있다.

본 연구는 전남 곡성군을 대상으로 농어촌용수 수자원시스템 개발계획을 위한 지리정보시스템의 구축을 목적으로 한다. 기본도는 등고,도로,수계,행정경계의 4개 층으로 구성하며, 개발계획을 위한 주제도는 농어촌용수구역, 저수지유역, 관개지구, 경지정리지구 등의 11개 층으로 구성하였다.

INTRODUCTION

Recently, the interest of developing rural areas in the Republic of Korea is inspired by the economic unbalance between urban areas and rural areas. The main purposes are to improve the agricultural structure and environment of rural areas which can be achieved by farm mechanization, expansion of social welfare facilities, development or reinforcement of rural water supply systems and proper land use planning. For the above purposes, the government of the Republic of Korea visualized a large scale project that is to plan and develop reasonable rural water resources systems.

Rural water resources systems here have an integrated meaning which include both rural water supply systems such as reservoirs, wells, pumping stations and rural water demand systems such as municipal water for improving settlement environment, irrigation water for paddy rice, upland crops, fruit tree, industrial water for the opportunity of increasing agricultural income, livestock water, inland fisheries water, environmental water for conservation rural areas.

Field investigation and collection of statistical data for the subject areas are essential for planning rural water resources systems. The investigators collect their opinions and then plan new reservoir sites, hydraulic facilities, land use with their own experiences. The effort of preparation and handling data in the planning process are very extensive. The supporting data are usually difficult to keep and change in map form. Also, the ideas of investigator have a risk whether it is reasonable or not.

A Geographic Information System (GIS) will solve the above problems. The vast topographic data can be maintained and managed efficiently and the planned data such as farm land consolidation area, hydraulic facility and

water demand sites will be provided and updated easily for each purposes. Also, the GIS can be utilized for many planning purposes such as proper land use classification, proper decision of reservoir sites, and route alignment of irrigation or drainage channels.

CONSTRUCTION OF GIS

GIS is briefly described as a computer system capable of holding and using catographic data describing places on the earth's surface. It should be designed to efficiently capture, store, update, manipulate, analyse and display all forms of geographically referenced information.

In the 1980s, with the cumulated experiences of GIS and the advanced hardware and software techniques, the topologic relation can be loaded to a vector data. The function of geographic entity relation improved network analysis, searching of optimal traffic path and map overlay computation.

Fundamental factors of GIS are data, hardware, software. The data, main structure of RWRIS (Rural Water Resources Information Systems), were constructed by 4 layers of base map related to topographical data and 11 layers of thematic map with the investigated planning data of rural water resources systems. The layers of base map are contour, administration boundary, stream and road. The layers of thematic map are constituted by rural water demand boundary, reservoir watershed boundary, irrigation area, farmland consolidation area, drainage improvement area, site of reservoirs, diversions, pumping stations, pumping wells, pipelines of municipal water supply, livestock farms, industrial parks, inland fish farms. Table 1 shows the content of each layer and Table 2 shows the attribute code of each layers respectively.

Each layer was classified to maintain efficiently and update easily by the following criteria :

1. similar attribute data,
2. unique position,
3. protection of layer removal by the change of attribute data,
4. feasibility of attribute data conversion,
5. accomplishment of map data into polygon, line or point.

Hardware system was constructed as shown in Fig. 1. and software, ARC/INFO was used. Data input process used was shown in Fig. 2. Line and polygon data were obtained by vectorization and point data were obtained by digitization.

Table 1 The structure of RWRIS layers

Layer no.	Layer description	Feature class
1	contour	line
2	administration boundary	polygon
3	stream	line
4	road	line
5	rural water demand (district) boundary	polygon
6	reservoir watershed boundary	polygon
7	irrigation area	polygon
8	farmland consolidation area	polygon
9	drainage improvement area	polygon
10	reservoir sites (constructed, planned, reinforced, feasible)	point
11	pumping stations (constructed, planned, reinforced, feasible)	point
12	diversions (constructed, planned, reinforced, feasible)	point
13	pumping wells (constructed, planned, reinforced, feasible)	point
14	pipelines of municipal water supply	line
15	complex (livestock farms, inland fish farms, industrial complex, wastewater treatment treatment plants	point

Table 2 Attribute code of each layers

Layer description	Items	Description
contour	level	contour elevation (vertically 20 m space)
administration boundary	acode	administration code (polygon centroid)
	linec	boundary type — 1 : provincial boundary; 2 : city, county boundary; 3 : local adm. boundary; 4 : sub-local adm. boundary; 5 : coast line. If the boundaries are overlaped, high level of the boundary has the priority.
stream	name	stream name
	order	stream order
	main	code for generating longitudinal section of stream
road	road_no	road identification number
	pave	pavement status
	track	track number
district boundary	region_id	district identification number
reservoir watershed boundary	resr_id	reservoir serial number in district
	old_new	option for developement — 1. constructed; 2. planned; 3. reinforced; 4. feasible
	linec	same with the old_new item. If the line attributes are overlaped, high level of the line attribute has the priority.
irrigation area	old_new	same with old_new item of reservoir watershed.
	class	paddy (1) and upland (2)
	linec	same with linec item of reservoir watershed.
farmland consol-idation area	old_new	same with old_new item of reservoir watershed.
	linec	same with linec item of reservoir watershed.
drainage improvement area		same with all items of farmland consolidation area
reservoir site		except for linec, all items are same with farmland consolidation area.
pumping station	pump_id	pumping station serial number in distict
	old_new	same with old_new item of reservoir watershed.
diversion	ddam_id	diversion serial number in district
	old_new	same with old_new item of reservoir watershed.
pumping well	well_id	well serial number in district
	old_new	same with old_new item of reservoir watershed.
water supply pipeline	old_new	same with old_new item of reservoir watershed.
complex	old_new	same with old_new item of reservoir watershed.
	class	complex type — 1. inland fish farm; 2. livestock farm; 3. existing industrial complex; 4. planned industrial complex; 5. wastewater treatment plant

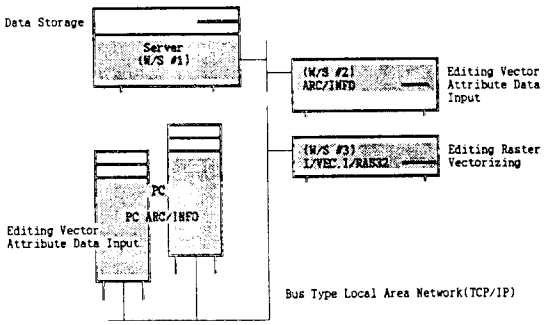

Fig. 1 RWRIS system configuration

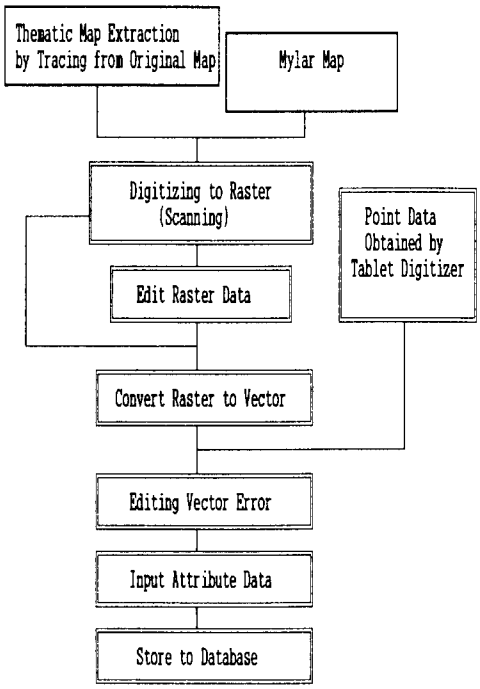

Fig. 2 Data processing procedure

EXAMPLE APPLICATION

Coverage Generation for Planning Rural Water Resources Systems

Coverage is a newly generated thematic map by manipulating base maps and thematic maps. The spatial analysis, data search, creation and update of a new coverage can be accomplished to split, mapjoin, append, seperate or overlay the coverages.

The manipulation procedures for generating a new coverage must be decided previously to obtain a useful planning data. Such standard procedures will raise the efficiency of GIS and be friendly to the users. Table 3 shows an example coverage creation for a certain planning purposes.

Table 3 An example coverage creation

Coverage	Query and results
administration boundary + irrigation area	cultivating area of paddy rice and upland crops, existing, planned, reinforced irrigation area within the administration boundary
administration boundary + hydraulic facilities	existing, planned hydraulic facilities (reservoir, diversion, pumping wells, pumping station) within the administration boundary
road + irrigation area	the pavement status and track number of road within the area investigation of adjacent area to road by buffering

Applicability of Three-dimensional Data

A GIS function which exhibits three dimensional data is known as an efficient tool in acquiring the spatial data such as slopeness, inclined plane of an area and longitudinal profile of river.

Three dimensional data may be constructed by digital elevation model (DEM), contour or level-surveying data. Among these, contour data can be easily obtained from the published map and it can be converted to grid data or

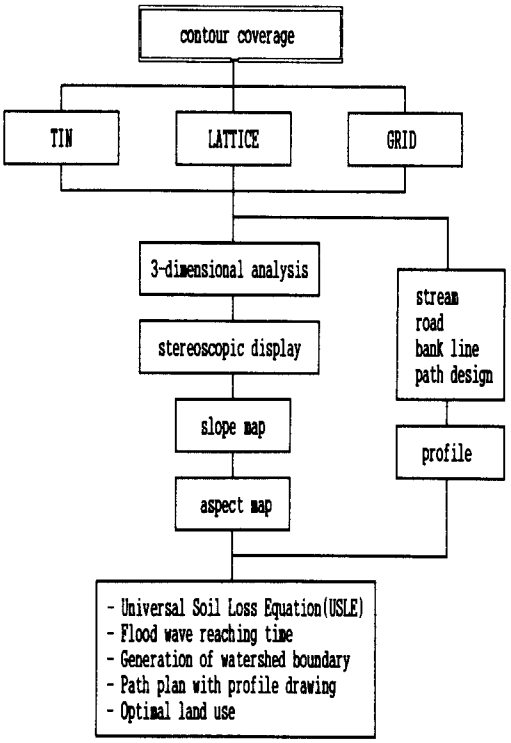

Fig. 3 Three-dimensional data processing

tringular irregulated network data. Fig. 3 shows a data processing procedures of three dimensional data.

The slope map can be used as a supporting data to find a watershed boundary, to estimate the time of concentration in a rainfall-runoff hydrologic model or to calculate the amount of soil erosion. The aspect map can be used to select a proper reservoir site or an arable land for crop. The longitudinal profile of river can be used to plan a watercourse route for municipal water supply or irrigation.

Planning Rural Water Demands

Forecasting future water demands within rural area is an essential task to plan a rural water resources systems.

It is usually approached by a mathematical or physical modeling based on the forecasting techniques. At the beginning of this project, the forecasting method of each rural water demands was established considering the obtainable statistical data and the investigated data, and the models were developed with Fortran 77 language. Among the input data of the models, some data can be obtained easily and reasonably from the RWRIS and these data are summarised in Table 4.

Table 4 Extractable data in RWRIS

Water demand programs	Extractable data in RWRIS
life	settlement site, present population
irrigation	present status of land use, area
industry	industrial complex site, area
livestock	livestock farm site, breeding size
inland fish	inland fish farm site, production
environment	river configuration, site of point pollution

CONCLUSION

The Geographic Information System for planning rural water resources systems is the beginning stage in the Republic of Korea. In this paper, a GIS was constructed and proved to be an efficient tool for the purpose of planning rural water resources systems.

Further research needs are focused on land use planning for irrigation land, the analysis of human settlement analysis, the abstraction of diverse parameters to support application models such as watershed model, water quality model, irrigation network model, and the design of irrigation and drainage channel routes.

REFERENCES

Ripple,W.J., 1989, Fundamentals of GIS: A Compendium, American Society for

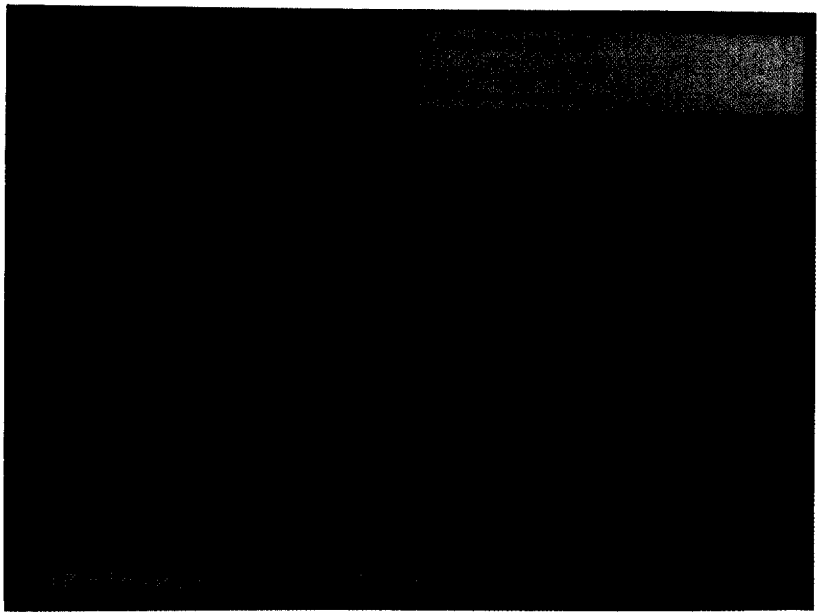

Fig. 4 Wartershed boundary extraction from DEM

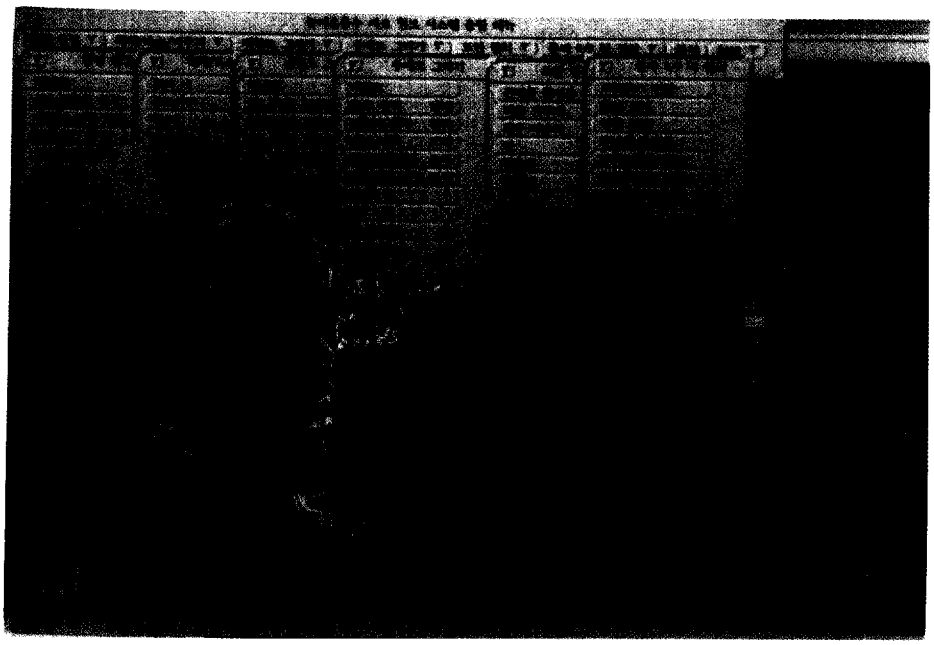

Fig. 5 User interface of the system and data display

photogrammetry and Remote Sensing and American Congress on Surveying and Mapping.

Park,B.T., 1992, A Study on Planning Methodology for Rural Area, Seoul National University, Republic of Korea, M.S. Thesis.

Koh,J.K., 1991-1993, Data Base Systems for Reasonable Planning of Rural Water Resources, MAFF, Republic of Korea.

Dent,F.J., 1978, Land Suitability Classification, International Rice Research Institute, pp. 273~293.

Chung,H.W., 1988, A Study on Development Technology for the Mountainous District, MAFF, Republic of Korea.