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APPLYING ENTERPRISE GIS TO DISASTER MANAGEMENT AT KANGWON PROVINCE

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要 旨

본 논문은 enterprise GIS 기반의 강원도 재해관리시스템 개발에 관해 기술하였다. 이 프로젝트는 "강원 종합 GIS 21 계획"의 일환으로 이루어졌다. 재해방재과에서는 2년 프로젝트로서 재해관리시스템을 개발하는 중이며, 산림, 문화, 환경, 관광 등의 측면에서 사업타당성을 분석하였다. GIS 구축 1단계에서는 반년이상을 재해관리의 필요성에 대해 초점을 두어 연구하였다.

계획과정에서 강원도 전체 지역에 대한 장기적인 정보가 필요하였다. 또한 평가와 응답단계에서는 기상청과 다른 기관으로부터의 실시간 자료가 요구되었다. 이런 모든 정보는 주의 깊게 분석되고 참조되었다.

ESRI의 새로운 GIS기술은 자연 재난/재해에서의 문제점을 해결해주었다. 예를 들어 위험물질의 이동경로는 도로망 분석을 통해 최소비용 경로를 찾는데 도움을 주었고, 물질을 운반하는 차량의 출발지와 도착지를 선택할 수 있었다. 또한 재해지역으로부터의 사람과 재산에 대한 최단시간내의 대피계획을 수립함으로써 재해문제의 전반적인 위험과 비용을 최소화할 수 있었다.

ABSTRACT

The purpose of this paper is to describe the Disaster Management System Development of Enterprise GIS at the Kangwon Province in Korea. This project is included into "the Kangwon Enterprise GIS 21 plan". The Division of Disaster Management is in the middle of the 2-year project of the Disaster Management System development, appropriate for business performed at the Departments of Forestry, Culture, Environment, Tourism, etc. At the 1st phase of GIS implementation, for more than half a year we focused on the necessity of management of disasters.

In the planning process, we needed long-term information on the whole area of Kangwon. In the assessment and response processes, we needed real-time data from Korean Meteorological Administration and other agencies. All the above information was carefully studied and referred to.

ESRI's new GIS technologies solve the natural hazard/disaster problems. For example, hazardous materials routing often needs to be found the least expensive path through a roadway network. In the circumstances given, we can choose the departure point and destination of the vehicle, which carries the materials. It's also possible to minimize overall risk and costs of disaster problems by making a plan of people and possessions evacuation from the disaster area in short time limits. We can meet all the above goals using the latest ESRI's technologies.

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1. INTRODUCTION

In Kangwon Province there are situated some of the country's most impressive mountain ranges and national parks. The mountainous terrain provides excellent slopes and vallies for ski resorts and rafting facilities. The east coast has many sandy beaches, hot, and mineral springs. To preserve these natural resources systematically, in 1998 the Administration of Kangwon Province decided to develop Geographic Information System as a supporting tool for decision-making and management operation.

In 1996 one of the largest fire disasters happened in Goseong, Kangwon Province. The fire broke out in almost the same area of Kangneung again in 1998 and burnt out more than 600 hectares of forest. After the second fire, the road in Goseong was blocked with trucks and tractors, cows and people escaping from the area like refugees. Many people lost their homes and the beautiful forest was almost completely destroyed by fire. Therefore, the Office of Forestry had decided to develop disaster prevention plans for every single big fire case by using the GIS technologies for Disaster Management System development.

2. Main scope of work

Main scope of this work consists of following 3 basic objectives.

1) Extending the basic system capabilities for GIS (H/W, S/W)
2) Development of applications for three applicati -on fields - forest fire, drought and flood building new dams
3) Building a GIS Database

3. The Disaster Management Project (2000.3~2001.1)

3.1. The basic system configuration for Kangwon Province (H/W, S/W)

- Server : Sun Enterprise450, Ultra10
- Input/Output peripherals : Calcomp Scanner /HP Plotter/GTCO Digitiger
- Software : Visual Basic+MapObjects (Client application), MapObjects IMS+InterDev (Web Application), ArcView+Spatial / 3D Analysts (Analysis Program) extensions, ArcInfo (Main Map Management Program)
- **DBMS**: Informix 7.0.3

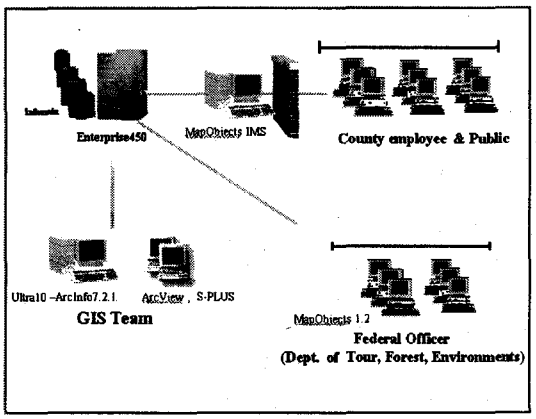

Figure 1. System configuration diagram

3.2. Applications for three fields

3.2.1. Fire

The Department of Forest management is responsible for wildfire protection on 16,873Km^2 of

private and national forest land. Normally, the forest fire employees check up the place of the fire origin on a paper map with the coordinates containing films created on OHP. It usually takes several hours to find the place since searching involves more than 1000 paper maps. In emergency situation, the fire-fighting helicopter has to wait until the fire forest employee notifies the pilot of the target coordinates. GIS analysis program helps them to find the place of the fire origin very quickly and supports various projections like UTM and TM only by clicking on some buttons. They can also make the fire prevention plan through the spider analysis showing the network relationship between the place of the fire origin and the lake which contains water to be used for fire extinguishment. After the system is developed, the technology for expected paradigm is gradually transferred to the employees.

In addition, solar fire monitoring camera towers were erected on the tops of some mountains in Kangwon, in order to detect fire and flames location. All information on the area around tower is transmitted from the camera to the control center in provincial office, where all the movements in GIS system are displayed on real time basis. This system can be helpful to the province of Kangwon for rebuilding the parts of the environment destroyed by fire. Moreover, it can be adopted as a management tool for provincial operations improvement.

※ Modeling Fire Behavior

The Fire Tracking program is used to model the fire behavior for the Kangwon Province. Fire tracking program is an ArcView GIS based application that generates fire behavior data for a given set of weather conditions and/ or moisture data inputs. The outputs are based on the fire behavior model. The outputs are GIS models of flame length, fire line intensity, the spreading speed, etc. The inputs required to run Fire Tracking program include slope steepness level, aspect level, elevation, and weather information. Slope steepness, aspect level and elevation derive from Digital Elevation Models (DEM's) and the weather information should be gathered from the Korea Meteorological Administration (KMA)'s weather service stations with the cooperation of the Administration of Kangwon Province.

The fire behavior modeling process begins with the development of Weather Influence Zones for the Province. The Weather Influence Zones are shaped on the basis of historical weather data of the Kangwon Province collected from the KMA and weather service stations of 18 counties. This weather data is used to develop the weather model (in percentage) for each Weather Influence Zone. The weather model is developed in four categories which include low, moderate, high and extreme points, input into Program. The fire risk level is determined according to the weather model and it can be input to model the fire behavior by using the Tracking Program. The model calculates fire behavior for every cell in raster representation of the landscape described by the input layers. Output values include flame length, heat per unit of area, fire line intensity, and the spreading speed. The output values for each cell show how the present fire will spread under assumed landscape, weather, and environmental conditions.

Outputs from the model combined with the Potential Fire Occurrence layer, (described above)

develop a GIS model of Wildfire Susceptibility for the Kangwon Province. The wildfire susceptibility analysis integrates the probability of the wildland fire behavior in the limits of expected fire size. This analysis calculates a Wildland Fire Susceptibility Index (WFSI) for each 25 X 25 meter cell in the study area. The analysis also includes the factors which limit the fire spreading by the containment by suppression resources and the presence of non-burnable surfaces, such as water or rock.

Calculating the Widland Fire Susceptibility Index

The formula used to calculate the WFSI is:

WFSI = (Expected meters burned in the FOA) / (Total Burnable meters in the FOA)

*Fire Occurrence Areas (FOA).

where,

"Expected meters burned in the FOA" = Final Fire Size (FFS)

* Number of Fires per Year in FOA

The "Total Burnable meters in the FOA" value is determined simply by subtracting the non-burnable meters in the FOA from the total meters in the FOA. To obtain a value for "Expected meters burned in the FOA" the spreading speed is calculated for each Weather Influence Zone for each cell in the FOA using Tracking Program.

Fire size is calculated for each spreading speed on the basis of formula for either contained fires or escaped fires or by using a maximum fire size.

The results of the calculation contain the fire size for each spreading rate per cell. The final fire size is then calculated as an average of the four fire sizes. The final fire size is multiplied by the number of fires per year in the FOA to obtain a value for "Expected Fire Size". This "Expected Fire Size" is divided by the "Total Burnable area in the FOA" in order to obtain the index value for the cell.

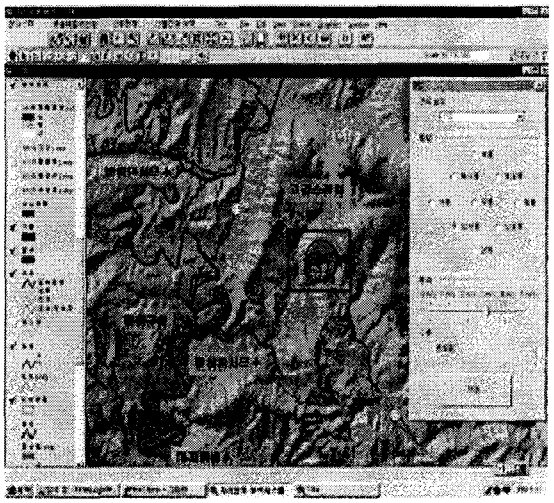

Figure 2. Simulation of fire

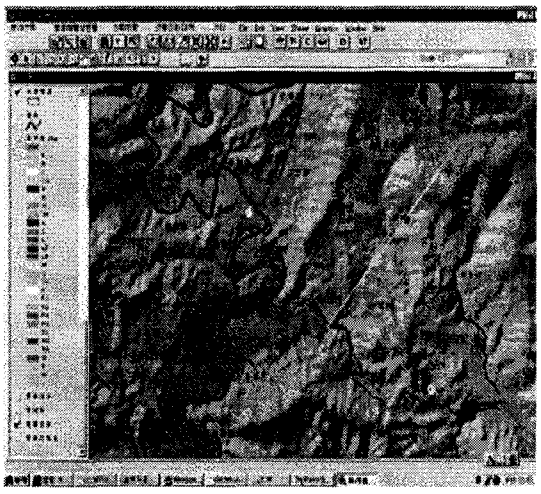

Figure 3. Spider Analysis: where is the water?

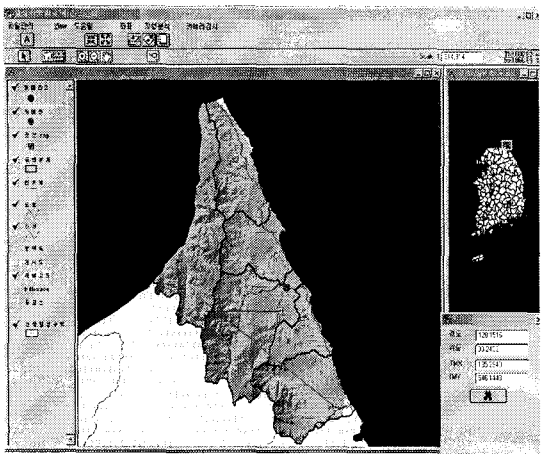

Figure 4 Displays the information from the camera to be applied into GIS System on real time basis

3.2.2. Drought

The worst drought in decades in Korea happened last spring. But that was nothing new. Kangwon Province is known for droughts. Whenever the nation suffered from a continuos drought, the central government provided local authorities with drought relief aid. Last spring the government decided to spend $90 million to relieve the damage caused by Korea's worst ever spring drought. Local Administration authorities of Kangwon were tasked to buy and send pumps to drought areas, but they didn't know which area was the worst, simply because of the lack of data and solution models. Even now they have to depend on the intuition and information from separate sources.

To analyze the drought, we applied "S-Plus plug-in" to our system. Using the time series analysis, we developed an analysis program based on the rainfall intensity in each county. The results predicted with the use of our system help to estimate operational costs. Through the DDE(Dynamic Data Exchange), we can surely display the predicted results in ArcView-Spatial Analysis-by using "Inverse Distance Weighting Method".

Basing on the research performed by the Univ. of Kangwon, the following formula was used in order to estimate the volume of water, needed to be provided to the ponds during the dry season :

$$WR = (P * 1.1) - (E * 1.3) - 80$$

This formula also calculates the balance level between precipitation and evaporation during the season.

where: WR = Water requirement.
P= mean monthly precipitation,
E = monthly potential evapo-transpiration

Correction factors:
Precipitation was multiplied by 1.1 to include the amount of rain that drains into the pond from the pond dikes.
Evaporation was multiplied by 1.3 to compensate for the higher evaporation from free surfaces such as small open ponds.
80 = seepage from ponds [mm].

Example syntax of the above formula:

```
Grid: waba = (afrain01gr * 1.1)
             - (etm1new * 1.3) - 80
```

where: afrain01gr = precipitation grid for the month of January,
etm1= evapo-transpiration grid for January.

The ArcView Scripts automates the procedures for all months with IDW method.

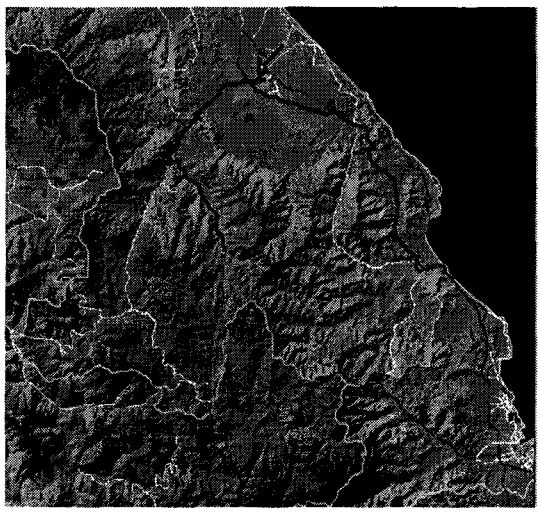

Figure 5. Network Analysis - where is the well?

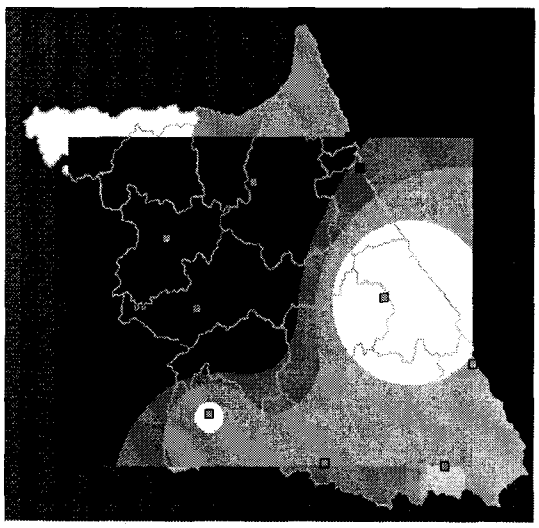

Figure 6. Spatial Analysis - rainfall in 18 county, Kangwon Province

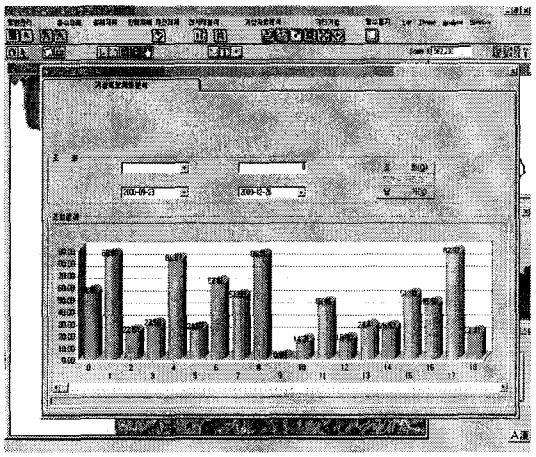

Figure 7. Statistical Analysis - where to be worst drought

3.2.3. Flood by building the new dams

In 1998, Ministry of Construction and Transportation promoted the plan of dam construction and drew up a budget to solve the water deficiency problem. It decided to construct the new dam for Yongwol County in Kangwon province. Many environment organizations had protested against issuing the license for the Tong River dams construction in Yongwol in Kangwon Province, because the they believe it will threaten the eco-system and lower the water quality of one of Kangwon's most important rivers. The parties couldn't come to a concession. The dispute was stopped through the president's decision to cancel the construction of the Tong river dam (1999 .11). There still are other plans of the new dams construction in Kangwon province made by the Ministry of Construction and Transportation. It put the Kangwon province employees related to the dam construction into awkward position. Local citizens, environmental organizations, members of

the local administration, congressmen, and even the governor of a province wanted to know which area will submerge, which schools and roads will disappear under the water. All their questions were answered by our analyses program built on ArcView. It can show the area to submerge through simulating the dam construction with watershed, grid analysis and the list of data presenting the area.

Figure 8. Estimated districts to submerge after construction of the new dam

4. FUTURE PROJECTS

According to the "Kangwon Enterprise GIS 21 plan", the next step deals with road transportation management system. The Province administration wishes to partly open the geographic data via internet to the people interested. The supporting policy decisions and assisting the plan by the municipal government is being considered in the project. To satisfy these needs, we'll upgrade Internet applications in order for them to be used through the Internet with ArcObjects of ArcInfo development tools.

5. CONCLUSION

The Administration of Kangwon Province considers various GIS technologies in the process of performing the Disaster Management Project. They continuously replace one method by the more sophisticated one which causes the large dissemination of the GIS technology within the Province's services. The GIS concept of coping with data of spatial nature by means of GIS functionalities has become common in the daily work. The implementation of the new-GIS based technology is now enthusiastically being proposed in almost all new projects. Therefore, it has become important to implement proper training which will be flexible, personalized, and appropriate. It is desirable that both instructors and trainees take part in the applying of GIS for solving the current operational problems.

6. Acknowledgement

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