Correlation Analysis of Surface Temperature and Physical feature in Mountainous Area using RS and GIS

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Abstract

Recently, in order to extract exact and detail information of surface, various spatial technology such as RS(Remote Sensing) and GIS(Geographic Information System) have used very efficiently. Especially, to extract the surface temperature environmental information in mountainous area, a field survey, AWS(Auto Weather Station) data, and low resolution satellite images have used for a while.

However, at point of time forest disasters such as frequent forest fires, dangerous landslides, and local downpours have threaten to human being, there are great needs to acquire very accurate local meteorology information.

In this paper, to observe the surface temperature in mountainous area high-resolution satellite images such as Landsat TM is used while previously NOAA and GMS, which has 1.1 ㎞ resolution, had used. Moreover, the correlation between surface temperature extracted from Landsat Tm and the physical environment characteristics such as topography, NDVI, landcover was done by integrating with GIS. Finally, the result of this study can help to minimize the damage from forest disasters and make infrastructure for domestic forest information.

Key Words : Surface temperature, RS(Remote Sensing), GIS(Geographic Information System), Mountains physical environment

. Introduction

In our country the forest is occupied in large area and forest is the major country's resource so that it is needed the development technique for extinction and prevention of forest fire. In case of foreign countries, Coweeta in America and Tasmania in Australia are promoting the long term's ecological study for the restoration technique development of ecosystem applying various techniques such as image composition, visualization of the three dimension, GIS and remote sensing in its damaged area by forest fire while domestic forest fire-related study has investigated forest fire diffusion simulation algorithm development (Kim Eung Sik, etc, 1995), and predicted forest fire using GIS (Shin Yeong Cheol, An Sang Hyeon, 2000).

In fact, there has been a great need not only to acquire complex spatial information and study the way to manage actual damaged area for the restoration activities but also to analyze between local metrology and natural environment in mountainous area using RS and GIS technology.

This study is to aim the construction ecological approach DB for the prevention of natural disaster such as forest fire and the correlation analysis between surface temperatures in mountainous area and physical environment such as topography and NDVI. For this, the construction of landscape

ecological GIS DB, the spatial analysis for the best forestation, and the preparation of various thematic maps considering landscape ecological are performed. Finally, the possibility to use spatial data is shown for the restoration of forest fire damaged area.

II. Research Method and Data

In this study, Landsat TM image and digital topographic map of 1:25,000 and 1:5,000 on the 30th, March, 1997 and 7th April 2000, before forest fire, and on the 16th October 2000 after forest fire on the surroundings of Mt. Gumbong, Imwon-Li, Wondeok-Eup, Samchuk area, in Gangwon province are used for the preparation of various GIS thematic maps in forest fire damaged area. Also, digital forest map and surveying data are used as additional data.

1. Landsat TM image processing

Utilizing a digital topographic map of 1:5,000, first, after the image on 7th, April was practiced geometry control through ERDAS Imagine 8.5 of appropriation soft ware of image. The image on 16th, October 2000 and 30th, March 1997 was practiced coordinates registration with image to image. The image was re-sampled Nearest Neighbor of the least change of pixel value.

In the grouping of land cover in object of the study, using numerical topographical map, paper topographical map of 1: 25.000, after selecting training area, by investigating the actual places, after identifying training area again, among the techniques of supervision classification with Maximum Likelihood Classification, six-classes were classified into the six regions of forest, cities, river system, farmland, low region and damaged forest fire.

Normalized Difference Vegetation Index (NDVI) was calculated for analysis of the vegetation level before and after forest fire days of study- object regions by using band 3 and band 4 of the image of Landsat TM. To analyze the surface temperature distribution characteristic in the area of the study object which is spatial-temporal by applying ERDAS Imagine 8.5, it extracted the surface temperature using the value of the radiance got from the value of DN(Digital Number) in Landsat TM band 6.

2. GIS digital thematic map and spatial analysis

In order to perform various spatial analysis functions grid data within 30m-cell size, which is equal to spatial resolution of satellite image used in this study, was acquired after generating TIN converted by coverage and point using ArcView 3.2.

On the basis of it, slope and aspect were calculated then reclassified for the aim of its analysis and NDVI and land cover classification extracted from satellite remote sensing were acquired for various GIS thematic maps.

. Extraction of surface temperature using Landsat TM images

In order to examine the distribution of surface temperature before and after forest fire in study area, the distribution map of surface temperature should be composed using on Landsat TM band 6 image. For this, radiation brightness was extracted based on NASA Model(Markham and Becker, 1986) after acquiring DN(Digital Number) from three time series Landsat TM images(1999. 3. 30, 2000. 4. 7, 2000. 10. 13).

Finally, the surface temperature depending on each area and each elevation could be detected based on the result of all above products and GIS digital thematic map. Extraction equation is as follows;

$$T = \frac{K_2}{\ln\left(\frac{K_1}{L_\lambda} + 1\right)}$$

Where, T = temperature in degrees Kelvin
Lë = spectral radiance in w· m-2· ster-1· mm-1
ln = natural logarithm
K2 = calibration constant 2 in degree Kelvin
K1 = calibration constant 1 in w· m-2· ster-1· mm-1

Generally the remaining snow still existed in mountainous area so that the study area was examined to have lower surface temperature distribution in 1973. The result of examining higher temperature area in the image on 30th, March 1997, 7th April 2000, 16th, October 2000, Ichon-li, Biwha-li, Nogok-li, Changryong-donf, where had had once a large sized forest fire, had over 20 high surface temperature distribution.

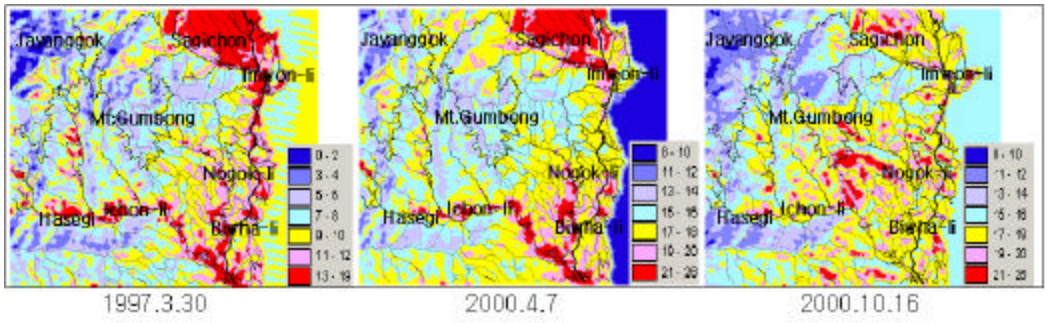


Fig. 2. Surface temperature distribution map using multi-temporal images

. Spatial distribution characteristic of physical surface feature using GIS DB

1. The spatial analysis for topographic characteristics

In order to analyze topographic characteristics, slope and aspect were first calculated on the basis of 30m grid cell data equaling with satellite image used in this study. Then forest fire damaged area corresponding to each elevation level, slope level and aspect level could be extracted through spatial analysis.

Table 1 shows the result of spatial topographic characteristic analysis in study area. Among the whole area, 75.2 „ surface having the elevation of 0-300m is distributed in 63.8%, 35.8 „. Examining aspect in study area, most area tends to lean to eastern and southern direction. The each direction of northeast, east, southeast and the direction of south, southwest are occupied in 44.5% (23.4 „) and 26%(19.5 „), respectively. Examining slope in study area, below 15ø and between 20 and 30ø are spread in 27% (20 „) and 39% (29.5 „), respectively.

Table 1. The topographic characteristics analysis in study area

Aspect	Area(㎢)	Percent(%)
flat	3.90	4.38
north	4.15	5.52
north	2.91	3.87
northeast	11.13	14.81
east	12.22	16.25
southeast	10.75	14.30
south	9.82	13.06
southwest	9.63	12.81
west	6.33	8.42
northwest	4.95	6.58

Slope(°)	Area(㎢)	Percent(%)
0-5	6.81	9.06
6-10	4.82	6.41
11-15	8.38	11.15
16-20	12.72	16.92
21-25	15.31	20.37
26-30	14.28	19.00
31-35	9.08	12.08
36-40	3.35	4.45
41-48	0.43	0.58

Elevation(m)	Area(㎢)	Percent(%)
0-10	4.08	5.42
10-20	1.23	1.65
21-30	1.32	1.76
31-40	1.47	1.95
41-50	1.52	2.02
51-100	9.90	13.17
101-150	8.79	11.70
151-200	7.43	9.89
201-250	6.18	8.22
251-300	5.96	7.93
301-350	5.45	7.25
351-400	4.22	5.61
401-450	3.50	4.66
451-500	3.05	4.06
501-600	4.84	6.44
601-700	3.50	4.65
701-800	2.37	3.15
801-900	0.37	0.50

2. spatial properties of Landcover and NDVI

As result of calculating forest fire damaged area, area around Mt. Gumbong showed the largest scaled forest fire damaged area. This result was extracted from land cover classification map by using Landsat TM images on on 30th, March 1997, 7th April 2000, 16th, October 2000. In study area most damaged tree were identified as a coniferous tree while a deciduous tree had 50% damaged of a coniferous tree.

According to the NDVI distribution in study area, the area around Mt. Gumbong presented lower NDVI values on a satellite image on 16th October 2000 even though considering that it was fall season while it had higher NDVI values on a satellite image on 30th, March 1997 and 7th, April 2000 before forest fire.

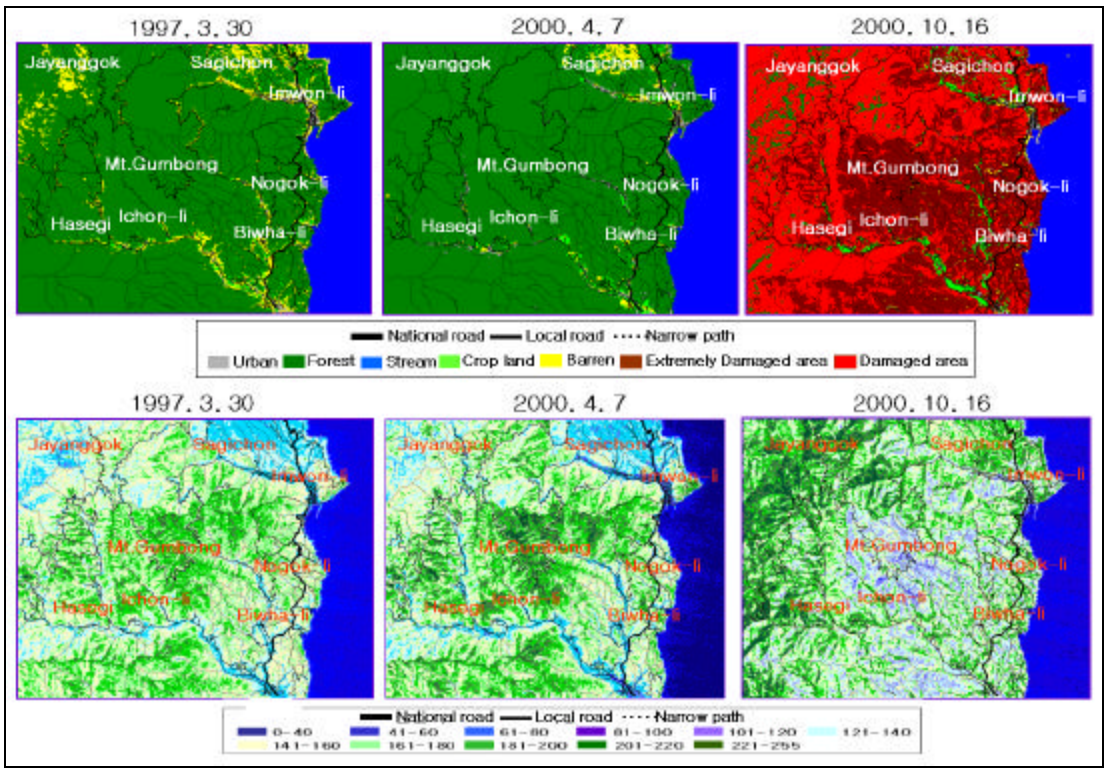
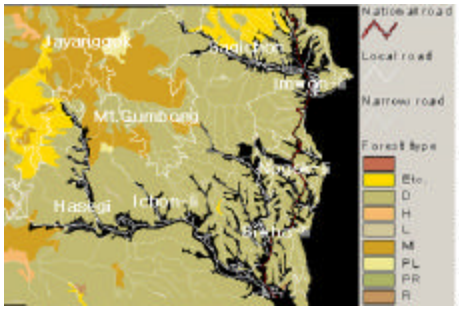


Fig. 3. Landcover and NDVI distribution map

3. The analysis of forest type properties

This study also showed the possibility to analyze correlation between the combustion of forest fire and the aspect, the slope, the forest types by calculating the distribution area of each forest type in study area. In the future, this result can be used to prove specific forest type may affect the diffusion of forest fire and helps to design “the right tree to right place”.



VALUE	Forest Type	Area(㎢)	Percent(%)
1	D(Pinus densiflora forest)	46.23	71.73
2	Etc.	5.09	7.90
3	M(Mixed forest)	11.50	17.85
4	L(Crop land)	0.48	0.74
5	R(Miscellaneous)	0.08	0.13
6	PR(Pinus rigida forest)	0.02	0.03
7	PL(Larix leptolepis forest)	0.48	0.74
8	H(Broad-leaved forest)	0.57	0.88
	Total	64.45	100.00

Fig. 4. Forest type and area distribution map in study area

. Correlation analysis between surface temperature and physical surface feature in mountainous area

In this paper spatial characteristic of surface temperature distribution is analyzed efficiently using RS and GIS. As shown in Table 2, area having higher temperature has lower NDVI and is located between 170 209m within slow elevation. Also, this area is identified in order forest fire damaged area, barren, and city where are generally spread in lower elevation. Examining forest type depending temperature level, a deciduous tree, mixed tree are planted in higher elevation while a needle-shaped leaf are planted in lower elevation.

Table 2. Spatial property analysis of forest type and surface temperature on multi-temporal images

<1997. 3. 30>

Temp(℃)	Area on each Temperature(㎢)	Average of NDVI	Average of Aspect	Average of Elevation(m)	Average of Slope(°)	Forest type
0~2	0.95	123.63	243.28	682.16	26.30	2.63
3~4	4.24	143.19	221.27	514.08	26.90	2.35
5~6	12.54	164.14	181.45	392.41	25.49	1.75
7~8	20.08	152.08	135.51	295.63	22.07	1.25
9~10	18.62	128.93	134.57	208.55	20.25	0.79
11~12	10.99	148.78	150.09	135.84	17.47	0.83
13~19	7.77	120.98	136.27	112.12	16.33	1.19

<2000. 4. 7>

Temp(℃)	Area on each Temperature(㎢)	Average of NDVI	Average of Aspect	Average of Elevation(m)	Average of Slope(°)	Forest type
8~10	2.61	37.13	10.34	29.83	1.11	0.04
11~12	2.03	114.86	176.12	401.45	19.10	1.73
13~14	9.58	160.05	206.96	433.63	26.07	1.98
15~16	21.44	172.93	155.23	333.32	24.10	1.48
17~18	25.79	162.07	143.60	217.74	21.06	1.19
19~20	8.08	143.58	148.19	121.11	16.89	0.81
21~25	5.65	114.96	138.56	121.38	16.37	1.28

<2000. 10. 16>

Temp(℃)	Area on each Temperature(㎢)	Average of NDVI	Average of Aspect	Average of Elevation(m)	Average of Slope(°)	Forest type
8~10	0.46	181.78	240.62	717.04	26.20	1.69
11~12	6.33	183.77	191.50	576.36	25.82	2.59
13~14	9.71	180.88	169.56	406.88	26.59	1.92
15~16	21.52	122.40	129.20	257.34	20.39	0.82
17~18	25.67	158.31	149.68	170.33	18.78	0.89
19~20	8.90	150.22	157.39	160.59	19.35	1.00
21~25	2.59	127.11	169.70	209.57	21.93	1.08

. Conclusion

This study is to aim the construction ecological approach DB for the prevention of natural disaster such as forest fire and the correlation analysis between surface temperatures in mountainous area and physical environment such as topography and NDVI. For this, the construction of landscape ecological GIS DB, the spatial analysis for the best forestation, and the preparation of various thematic maps considering landscape ecological are performed. Finally, the possibility to use spatial data is shown for the restoration of forest fire damaged area. Following description indicated the effect of our study.

1. The physical characteristic is examined based on elevation, slope, aspect, and area on elevation also the correlation between spatial characteristics of forest fire damaged area and spatial characteristics of mountainous area. All this study are performed on GRID analysis based on GIS and RS.
2. The study area is classified into 6 classes such as forest, city, stream, field barren, and forest fire damaged area using Landsat TM images. The result of spatial analysis considering digital forest type map and topography characteristic, a needle-shaped leaf was spread in most forest fire damaged area was while mixed leaf and a deciduous tree had half damaged of a needle-shaped leaf.

3. Examining correlation between landcover classification and NDVI(Normalized Difference Vegetation Index) using band 3 and band of Landsat TM images in study area, especially before forest fire and after forest fire and, there are remarkable difference of NDVI.

4. After carrying out GRID spatial analysis using digital forest type map and other thematic maps, the possibility to use spatial data is shown to analyze relation between forest fire and other physical environment such as elevation, slope, aspect, and forest type.

5. Examining forest type distribution on each temperature level by using band 6 of Landsat TM images, mixed tree and a deciduous tree tend to spread in high elevation within lower surface temperature while a pine tree is located in lower elevation within higher surface temperature.

As the result of this study, in order to arrange right tree to right place and study landscape ecological in forest fire damaged area more efficiently, RS and GIS technologies are proved as very useful. In the future, the more detailed data such as the characteristic of tree, topography and metrology mapping to GIS data possibly and the more spatial analysis technology such as adjacency, suit area, overlay, the more effective land ecological study carrying out.

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