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GIS를 이용한 한국 동남부지역의 상대적 사면안정성 분류도 작성

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Relative Slope-stability Mapping in the Southeastern Part of Korea Using GIS

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요 약

연구대상 지역은 1 : 50,000 지형도 12매(김해, 부산, 밀양, 양산, 방어진, 동곡, 언양, 울산, 영천, 경주, 불국사 및 감포)를 포함하는 지역으로서 총 면적은 약 5,900㎢에 이른다.

본 연구서는 4개의 주제도, 즉 산사태 및 불안정사면 분포도, 경사분류도, 토양분류도 및 선구조밀도도의 작성을 다루고 있다. 작성한 4개의 주제도와 GIS를 이용하여 연구지역의 상대적 사면안정성 분류도(축척 1 : 100,000)를 작성하였는데, 본 도는 광역 토지이용계획에 활용될 수 있다.

ABSTRACT : The study region encompasses about 5,900㎢ including the topographic maps of Kimhae, Pusan, Miryang, Yangsan, Panguhjin, Tonggok, Uhnyang, Ulsan, Youngchon, Kyongju, Pulguksa, and Kampo, all at a scale of 1 : 50,000.

The paper discusses how to have prepared the four thematic maps, landslide and unstable slope distribution map, slope classification amp, soil classification map, and lineament density map. Using all the above maps and GIS, the relative slope-stability map for the study region was produced at a scale of 1 : 100,000 ; the map can be utilized for the regional land-use planning in the study region.

1. INTRODUCTION

This paper deals with a part of the research report titled Geological Hazards Investigation(Han et al, 1997).

For the purpose of environmental land-use planning, a mapping project on relative slope-stability was established in 1996, comprising 2-year-investigation for the area of approximately 5,900㎢. The area included the twelve topographic maps, Kimhae, Pusan, Miryang, Yangsan, Panguhjin, Tonggok, Uhnyang, Ulsan, Youngchon, Kyongju, Pulguksa, and Kampo, all at a scale of 1:50,000 (Fig. 1).

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Investigated in 1996 was the area (about 3,420㎢) covering the first seven of the topographic maps mentioned above, while the area of the rest was done in 1997.

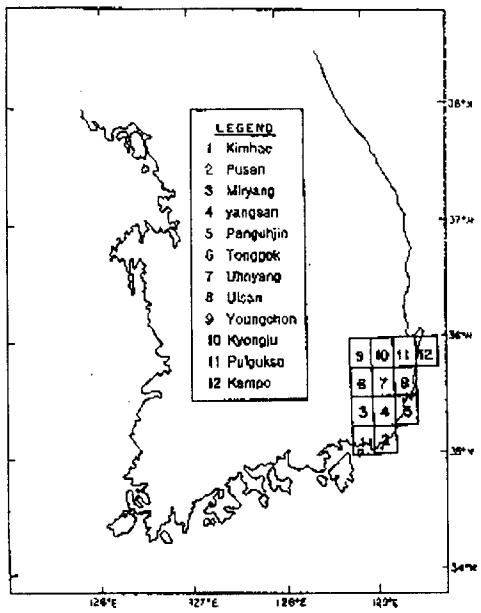

Fig.1 Map showing the study region composed of the 12 topographic maps (1:50,000).

2. THEMATIC MAPS

For the derivation of the relative slope-stability map for the study region, four thematic maps comprising landslide and unstable slope distribution map, slope classification map, soil classification map, and lineament density map were prepared and constructed as data base according to the process shown in Fig. 2.

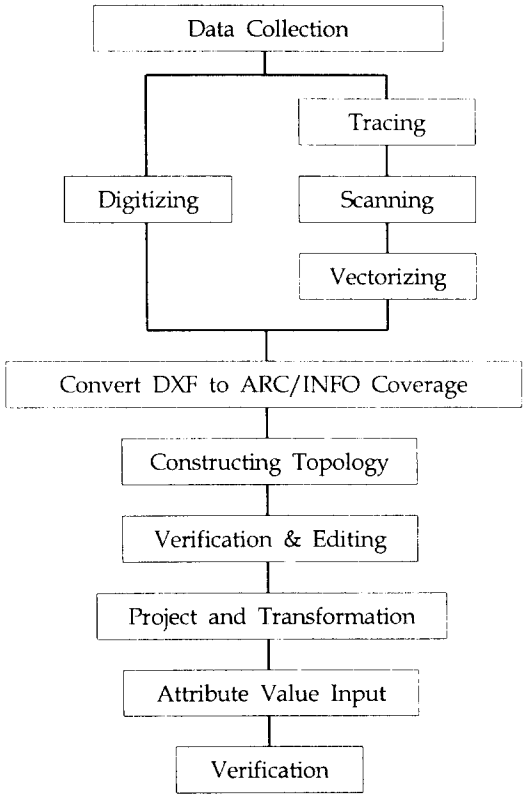

Fig.2 Process of data base construction.

2.1 LANDSLIDE AND UNSTABLE SLOPE DISTRIBUTION MAP

According to the records of the Forest Department of Kyongsangnamdo, Kyongsangbukdo, and Pusan, more than 200 landslides have occurred since 1973. Of them, the most common types were identified as the mud and debris flows which had been indued by the heavy rainfall during the months between June and September. Fig. 3 shows a typical example of mud flow. The mud flow occurred at Myongchonri, Sangbukmyon, Ulsan on 25th August, 1979 due to the intense rain by the typhoon Judy, killing 6 residents and

damaging 3 houses.

Field investigation was undertaken on 158 landslides and 4 unstable slopes, their locations being plotted as can be seen in Fig. 4(a).

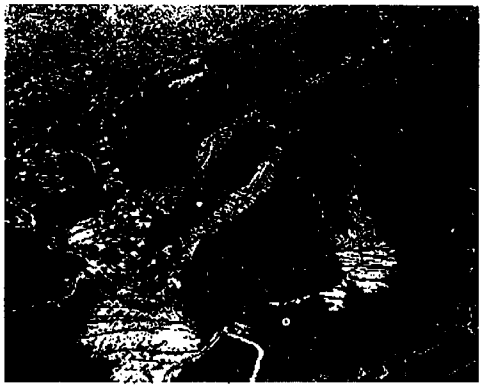

Fig.3 Photo showing the mud flow occurred at Myongchonri, Sangbukmyon, Ulsan on 25th August, 1979. (Photo courtesy of the Forest Dept. of Kyongsangnamdo).

2.2 SLOPE CLASSIFICATION MAP

The study region was divided into areas of four units, that is to say 0-5% (0-3°), 5-15% (3-9°), 15-30% (9-17°), and steeper than 30% (17°) slope. Fig. 4(b) shows the slope classification map for the study region. The general characteristics of the four units in Fig. 4(b) are presented in Table 1.

2.3 SOIL CLASSIFICATION MAP

The reconnaissance soil maps, which ware produced at a scale of 1:50,000 in 1971 by the Institute of Plant Environment, the Office of Rural Development, were significantly modified with the information acquired during the course of both field and laboratory investigation undertaken in 1996 to 1997 for engineering application. The modified map has seven units as shown in Fig. 4(c) ; the units are described in Table 2.

2.4 LINEAMENT DENSITY MAP

The lineament density map for the study region shown in Fig. 4(d) was derived from the lineaments which can be seen in the map. The procedure to construct the lineament density map is described below. After overlapping a net comprising 500m×500m squares and the lineaments, the lineament density value of all the squares was obtained by the following equation (1).

$$\text{Linea. density value} = \frac{\text{Linea. No./square}}{\text{Average of linea. No./square}} + \frac{\text{Total length of linea./square}}{\text{Average of total length of linea./square}} \quad \cdots\cdots (1)$$

The lineament density values, 0, 0-1, 1-2, 2-3, 3-4, and 4-11 were utilized to produce the lineament density map for the study region.

3. RELATIVE SLOPE-STABILITY MAP

The relative slope-stability map was produced at a scale of 1 : 100,000 using GIS and the four thematic maps described in the preceeding chapter.

The mapping procedure is described below. Firstly, the landslide frequency for all the

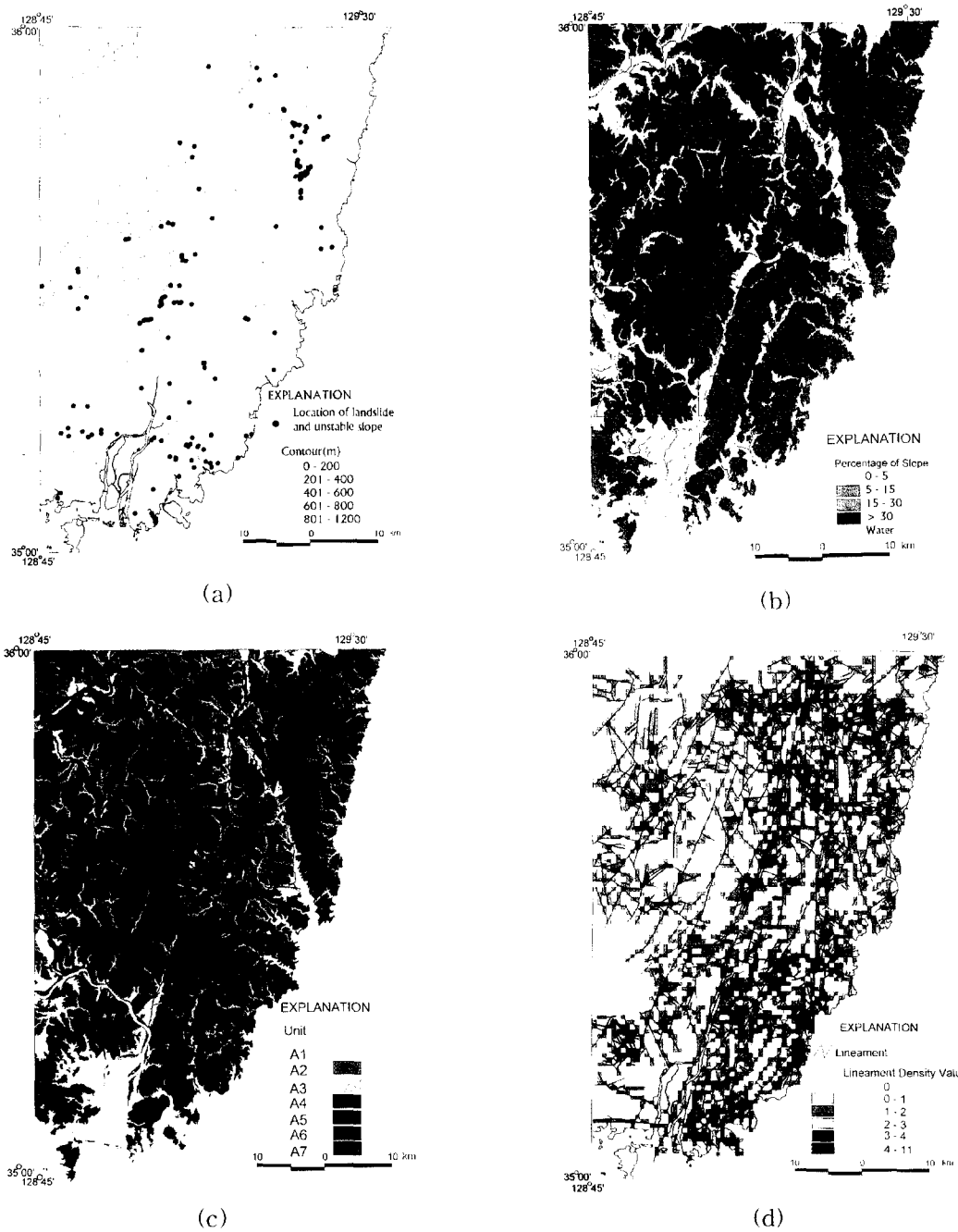

Fig.4 Thematic maps for the study region : (a) Landslide and unstable slope distribution map, (b) Slope classification map, (c) Soil classification map, and (d) Lineament density map.

Table 1. General characteristics of the slope categories in Fig. 4(b).

Slope category	Characteristics
0 to 5% (0-3o)	Almost flat. Rarely susceptible to landsliding. Partly susceptible to flooding. Suitable for urbanization and agricultural development.
5 to 15% (3-9o)	Gently sloping. Generally not susceptible to landsliding. Good for residential and agricultural development.
15 to 30% (9-17o)	Moderately steep slope. Erosion problems. Partly susceptible to landsliding. Partly suitable for dry farming and residential development.
Over 30% (Over 17o)	Steep slope. Partly susceptible to landsliding. Best restricted for forestry.

Table 2. Characteristics of the units shown in Fig. 4(c).

Unit	Topography	General geologic character	USCS*	Permeability
A1	Coastal and inland flat area	Coastal alluvial and flood plain deposits	SC, SC-SM, ML, CL, CL-ML	Low to very low
A2	Inland flat area	Alluvial and flood plain deposits	SP, SM, ML	Medium to low
A3	Area near valley	Alluvial and flood plain deposits	ML, CL-ML, SC, GC	High to very low
A4	Area near valley	Colluvial deposits	SM, GM	High to low
A5	Area at the foot and middle of mountain	Colluvial deposits	SC, SM, GC, GM, SC-SM, MH	Medium to impermeable
A6	Area generally near the top and middle of mountain	Colluvial deposits	SC, SM, GM, GC-GM	High to low
A7	Area generally near the top and middle of mountain	Rock exposure and residual soil	Residual soil: SC, SM, SM-SC, CL, ML	Low to very low

* Unified Soil Classification System.

units of the slope classification, soil classification, and lineament density map was obtained by overlapping each of the three maps and the landslide and unstable slope distribution map. The results are presented in Table 3.

Secondly, the units for each of the three maps were relatively rated on the basis of their own landslide frequency as presented in Tables 4, 5, and 6.

Table 3. Landslide frequency for the units of the slope classification, soil classification, and lineament density map.

Kind of map	Unit	Landslide frequency	Total
Slope classification map	0-5%	2	162
	5-15%	3	
	15-30%	89	
	>30%	68	
Soil classification map	A1	0	162
	A2	0	
	A3	4	
	A4	5	
	A5	24	
	A6	129	
	A7	0	
Lineament density map	Density value: 0	35	162
	Density value: >0.1	127	

Table 4. Rating for the slope classification map.

Unit (Slope percent)	1-5%	5-15%	15-30%	>30%
Rate	0	1	3	2

Table 5. Rating for the soil classification map.

Unit	A1, A2, A7	A3, A4	A5	A6
Rate	0	1	2	3

Table 6. Rating for the Lineament density map.

Unit (Density value)	0	>0.1
Rate	0	1

Finally, the rated maps were overlapped in order to obtain combined rates. Depending upon the combined rates, slope stability was classified into 4 categories, stable, generally stable, moderately unstable, and unstable, all of which were designated as the unit Nos. 1, 2, 3, and 4, respectively (Table 7). The general characteristics of the units are presented in Table 8. Consequently, the relative slope-stability map for the study region composed of the four stability categories was produced at a scale of 1:100,000. The map at a scale much smaller than the original one is shown in Fig. 5.

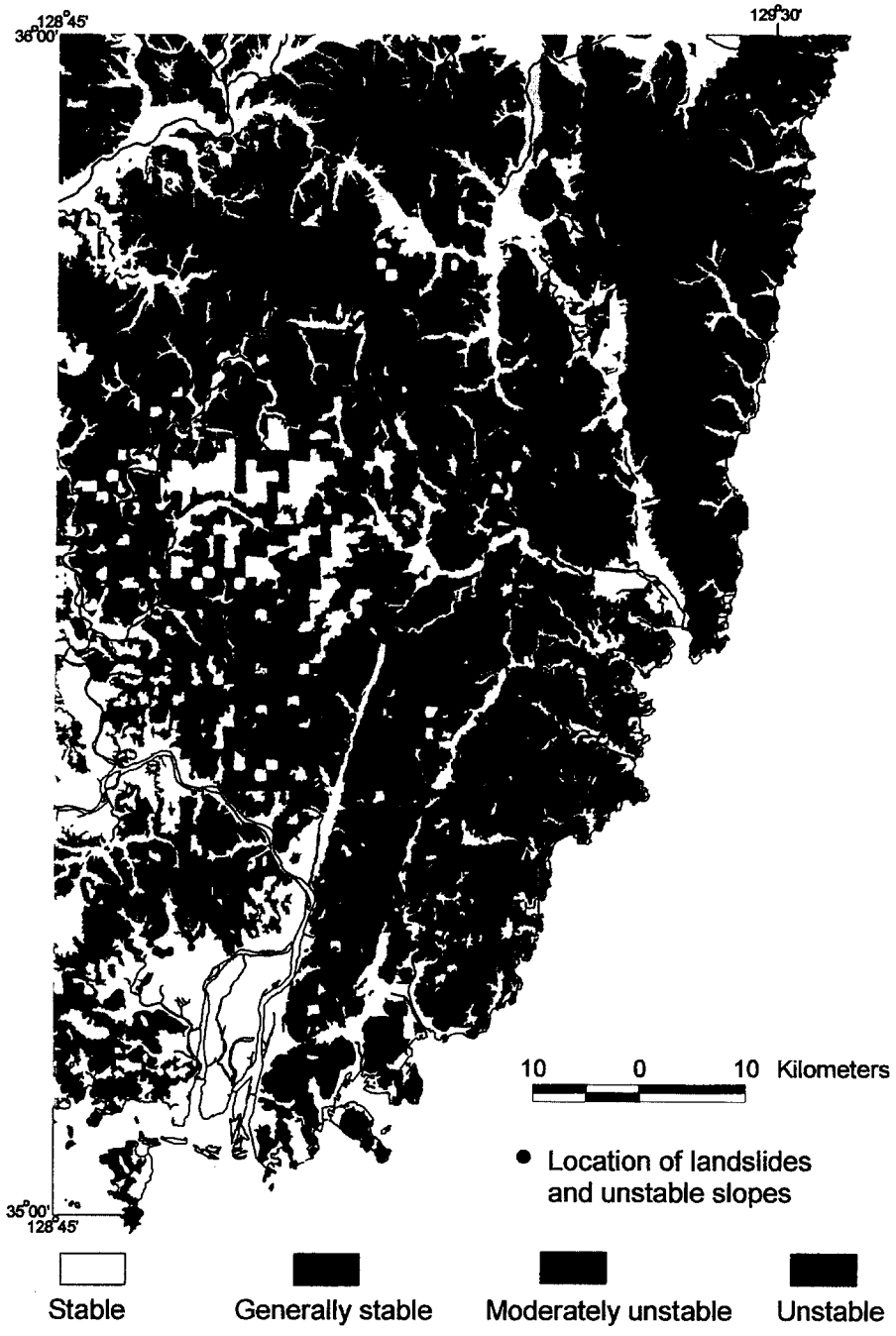

Fig.5 Relative slope-stability map for the study region.

Table 7. Relationship between the combined rates and the slope stability categories.

Unit	Combined rate	Slope stability	Remarks
1	0-3	Stable	All the areas of 0 to 5% slope were included.
2	4-5	Generally stable	
3	6	Moderately unstable	
4	7	unstable	All the areas of landslide and presently unstable slope belong to this unit.

Table 8. General characteristics for the units of the four stability categories.

Unit	General characteristics
1	Terrains of 0-5% slope that comprise coastal and inland flat areas. Their soils generally are classified as SP, SM, SC, ML, and CL according to the USCS and have medium to very low permeability.
2	Terrains of 5-15% slope that comprise areas near valley and at the foot of mountain. Their soils generally are classified as GM, GC, SM, SC, ML, and CL according to the USCS and have high to very low permeability.
3	Terrains of 15-30% and over 30% slope that comprise areas at the foot and middle of mountain and areas of rock exposure. Their soils generally are classified as GM, GC, SM, SC, ML, CL, and MH according to the USCS and have high to impermeable permeability.
4	Terrains of 15-30% slope that comprise areas at the foot and middle of mountain. Their soil characteristics are the same as those for the areas of the unit 3.

4. CONCLUSION

Based on the analysis of the landslide and unstable slope distribution map together with the slope classification map, about 55% and 42% of the landslides occurred at the terrains having a slope of 15-30% and over 30%, respectively. It also was analyzed that as much as 80% of the landslides occurred in the colluvium of the unit No. A6 of the soil classification map.

The relative slope-stability map, which was derived from the four thematic maps can be utilized for the regional land-use planning in the study region. The area percentage of its four units is as follows

Unit	Slope stability	Area, %
1	Stable	32.2
2	Generally stable	14.1
3	Moderately unstable	32.7
4	unstable	21.0

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