Temporal Features of Shallow Landslides and its Topography in Upper Kurokawa Basin, Northern Part of Mt. Aso

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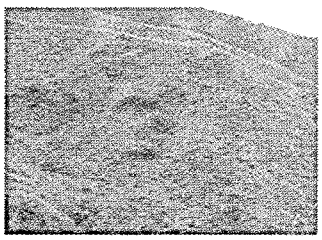
1. Introduction

The study of shallow landslide archives shows that over the period of about 45 years in between 1953 to 1998, the landscape in northern part of Mt. Aso has been denuded by recurrent shallow landslides occurred due to causal and triggering factors like precipitation, geology, rainfall and volcanic events. Majority of shallow landslides were developed into mudflow and debris flow. Owing to its impact infrastructures like road, bridges were damaged and human casualties were also reported. In this study, shallow landslides archives of years 1954, 1977, 1990 and 1998 are utilized to know landslides hazard of area. Different environmental conditions like volcanic events, intense rainfall in 1953 and 1990 and no volcanic activity with less intense rainfall in years 1977 and 1998 were observed. An attempt has been done to obtain information about past shallow land sliding events, topography and triggering rainfall characteristics in upper Kurokawa basin. To describe diversified topography, geology and slide features more specifically the entire basin is further sub divided into Sakurakigawa and Furuegawa sub-watersheds. The data analysis knowledge on past landslides, its topography and other associated factors might be useful to mitigate landslides hazard and to understand its causes and mechanics.

2. Study area and its Natural settings

Adjacent to each other, the two sub-watersheds are bounded in between 32°52'44" to 32°54'26" N latitudes and 131°6'18" to 131°9' 3" E longitudes in Northern part of caldera. The study areas in Furuegawa and Sakurakigawa sub-watersheds are about 4.52 km^2 and 1.08 km^2, respectively. The forest and grassland are the main land use types. The pyroclastic deposits are found in gentle hilly slope. The subsurface geology comprises pyroxene olivine andesite and basalt lava in upstream regions, while gravels, sand and mud deposits are common in down stream. The mean annual rainfall in between years 1953 to 1998 was 3270 mm. The old scars partly covered by grasses and remains of the partially deposited rock debris mass behind the check dams are shown in Photo 1.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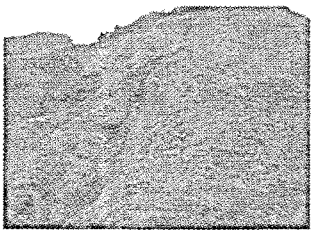
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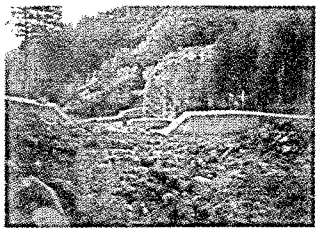
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Photo 1. Glimpse of the study area a, b: old scars partly covered by grasses, c: rock debris mass

3. Study items and Methodology

Broadly the study items consist of the compilation of the historical sliding events, rainfall characteristics, aerial photo view examination and map analysis. For historical shallow landslide information the records obtained from Sabo Engineering Company, Kumamoto prefecture is used. This comprises spatial distribution of shallow landslides and features. The monthly weather bulletin (Kisyo geppo) published by Kumamoto prefecture was used to know rainfall characteristics. The topographic features like slope

gradient, slope form, aspect and elevation are analyzed by Geographic Information System (GIS). The 20 m grid cell sized Digital Elevation Model (DEM) was prepared from topographic contour map. The subsurface geological map and soil map of scale 1: 50000 were used to know the sub surface geology and soil characteristics, respectively. The relationships are examined with overlay analysis.

4. Results and Discussion

The relief of Sakurakigawa and Furuegawa sub-watersheds is about 907 m and 720 m, respectively. The mean slope angles in both sub-watersheds are about 21°. The slope gradient changes remarkably from ca.1000 m altitude and becomes steeper as elevation rises. In the upstream regions the coefficient of variation for slope angles decreases (1.3 to 2.0) indicating consistent in steep slope angle values. The slides are abundantly distributed in between slope class 30 to 40 degrees. Geologically, in Sakurakigawa the major sliding areas are occupied by pyroxene olivine andesite lava and scoria cone originated from Takadake volcano and pyroclastic originated mainly from Washigamine volcano. While in Furuegawa the pyroxene andesite basalt lava and pyroclastics originated from Nekodake volcano is dominant. Relatively high moisture content black soil is commonly distributed in the concave valley slope. The results of the shallow landslide features recorded during different years are summarized in Table 1, which shows that the land sliding events in 1990 and 1953 are most disastrous comparing to the rest years. Because of, unlike in other years in both of these years the volcanic events were occurred in April and gradually intense heavy rainfall has started in succeeding months as shown in Table 2. In year 1953 monthly rainfall was increasing gradually after volcanic action, and heavy intense rainfall of June with maximum intensity of 49mm/hr. has hit the area. Similarly in 1990, after volcanic event the rainfall was increasing gradually. Starting from June 29 to July 2nd the prolonged rainfall had occurred. In a single day of 2nd July, the day of major sliding, a total of 338.5mm rainfall, with maximum intensity of 58.0mm/hr. had hit the area.

Table 1. Temporal features of shallow landslides

Landslide features	Sub w/s	Slides data recorded years			
		1954	1977	1990	1998
Slide (no.)	S	181	66	315	57
	F	375	17	546	38
Density (no./km^2)	S	167	61	291	52
	F	82	3	120	8
Area slided(km^2)	S	0.081	0.024	0.23	0.045
	F	0.157	0.006	0.365	0.025
Slided ratio (%)	S	22	6	60	12
	F	28	1	66	5

S: Sakurakigawa, F: Furuegawa, w/s: watershed

Table 2. Rainfall during major sliding years

Rainfall records	Years	Months			
		4	5	6	7
Monthly (mm)	1990	227	263	532	492
	1953	123	425	1552	527
Max. I (mm/hr.)	1990	16	18	39	58
	1953	-	-	49	-

recorded at Aso-san station

Max.: Maximum, I: Hourly intensity

5. Conclusion

The steep hilly topography in upstream parts of watersheds has been mainly subjected to recurrent slope failure. The mean slope angle and slides distribution in a particular area have shown strong relationship. The combined action of intense rainfall and volcanic activities were thought to be most responsible triggering factors. As this is initial step, and detail investigation is needed for more concrete conclusion.