LANDSLIDE ASSESSMENT BY USING DIGITAL PHOTOGRAMMETRIC TECHNIQUES

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ABSTRACT:

Landslide is one of the most costly and damaging natural hazards of the world, and has direct and indirect influence on a number of human activities. The term landslide includes a wide range of mass movement, such as rock falls, deep failure of slopes and shallow debris flows. Aerial imagery is a very powerful tool for landslide monitoring because it offers a synoptic view of landslide that can be repeated at different time intervals. This study focuses on the application of landslide activity maps created by digital photogrammetric techniques for evaluating the mass movement hazard in selected areas of the Northern East Turkey: Rize and surrounding. The availability of multi-year aerial photo coverage helped to assess the morphological changes, which occurred in the last seven years. This information, integrated with historical data on slope instability and field checks, was used to produce landslide activity maps. The morphological changes have been revealed from aerial images that are belonging to 1996 and 2002 years. For the evaluation of the aerial images, stereo photogrammetric software by Z/I Imaging was used. From the images that are belonging to 1996 and 2002 years, digital terrain models and vector map, which are containing the landslides area, were determined by using mentioned software. The landslides have been occurred very wide areas in the study area at 2001 year. In this study, the parameters that landslides occurring have been determined and environmental impacts of the landslides have been fixed. In addition, threatening areas of landslides have been resolved with separately. As result, it is presented to have determined the landslides effects in combination with image data and geomorphological data.

1. INTRODUCTION

Landslides, as one of the major natural hazards, account each year for enormous property damage in terms of both direct and indirect costs. Landslides, defined as the movement of a mass rock, debris or earth down a slope (Cruden, 1991), can be triggered by a variety of external stimulus, such as intense rainfall, earthquake shaking, water level change, storm waves or rapid stream erosion that cause a rapid increase in shear stress or decrease in shear strength of slope-forming materials. In addition, as development expands into unstable hillslope areas under the pressures of increasing population and urbanization, human activities such as deforestation or excavation of slopes for road cuts and building sites, etc., have become important triggers for landslide occurrence (Dai et al., 2002).

Monitoring landslide activity is of paramount importance for landslide studies. In the landslide studies, remote sensing imagery is a very powerful tool for landslide monitoring because it offers a synoptic view of the landslide that can be repeated at different time intervals. Landslide monitoring is to light the way for new landslide and retrogressive failure in the old landslide. Landslide monitoring is generally accomplished by field-based geodetic, geotechnical and geophysical techniques complemented with aerial photo interpretation (Mikkelsen, 1996; Keaton and DeGraff, 1996). Most field techniques, however, only provide point-based measurements of the landslides. In addition, they do not give information on past movement episodes. Although ground-based techniques are necessary to acquire very precise information on displacement or deformation at very specific locations in active landslides, especially when they might affect residential areas or major infrastructure, they do not provide information on the displacement fields or surface changes due to landsliding in a wider area. Moreover, their application to preliminary investigations of unstable areas may sometimes not be cost effectives (Hervas et al., 2003).

Photogrammetry is a technique whereby information about the position, size and shape can be attained. Photogrammetric products refer almost exclusively to the object space (maps, surfaces (DEM's), orthophotos, points, profiles). Photogrammetry is an important contribution to many disciplines. Landslide studies can be effectively done using aerial photographs with photogrammetric tecniques (Kraus, 1993).

The importance of mapping, quantifying, and monitoring changes in the physical characteristics of landslide area has been determined in the study. Furthermore, changes in selected an landslide area was determined using dijital photogrammetric techniques. Landslide profiles was exctracted and analyzed by using the aerial images with dated 1996 and 2002 covering landslide area. The areas affected by landslide was determined by examining the formation of the changes.

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2. STUDY AREA

The study area is located 41°09′54″ ve 41°12′04″ east meridians and 40°57′17″ ve 41°06′39″ north parallels, and take part in Ardesen district, Rize (Figure 1).
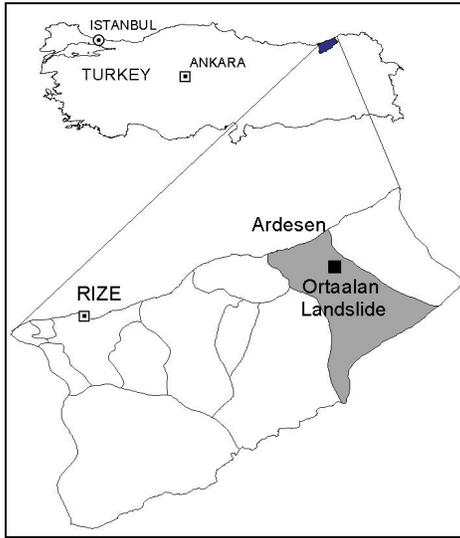
Figure 1. Location of study area

According to observations result 27 yearly in Ardesen region, the coldest month is January that its temperature average is 6.7 °C, the hottest month is July that its temperature average is 22.2 °C . Rize is the rainiest city in Turkey, its total precipitation is more than 2300 mm., and precipitation disperse every month symmetrical. Heavy rainfall is the triggering variables which shift the slope from a marginally stable to an unstable state and thereby initiating failure in an area of given susceptibility. So, landslides in the study area have been widely affected by heavy rainfall. At the same time, heavy rainfall has been increased to speed of weathering materials in the region. Thus, weathering has been considerably reducing materials' resistance for landslides susceptibility in the area. Observations result 27 yearly in Ardesen region has been evaluated and is shown the results in Figure 2 and 3.

Tea gardens have been great majority constituted land cover and tea farming has been widely made in the study area. But, the roots of tea tree are tightly set and have been obstructed surface flow. So, superficial water has been gotten into soil materials and its saturation increased. The soil materials that saturated have been showed higher stress- lower resistance. Thus, movements have been become easy. Also, distribute acidic manure over a tea garden have been increased weathering speed of soil materials and this event invest the situation with additional horrors for landslide.
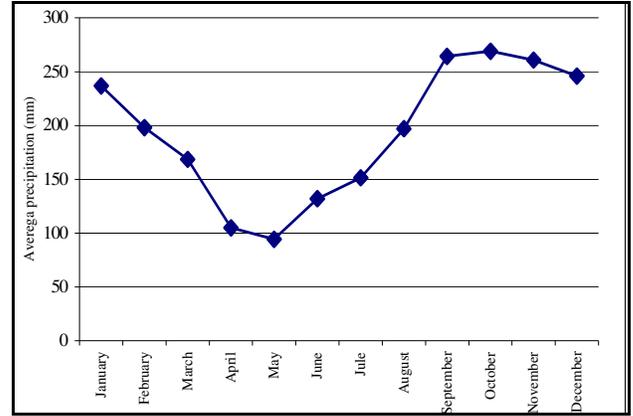
Figure 2. Average precipitation according to months
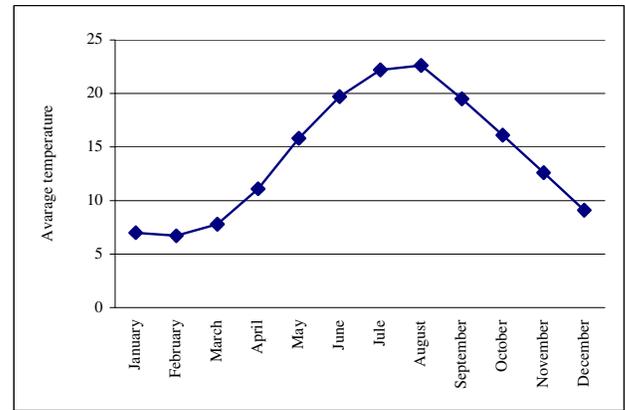
Figure 3. Average temperature according to months

3. METHODOLOGY

3.1 Geotechnical properties of landslide materials

The properties of soil materials have been investigated for the effects on landslides. For this aim, geotechnical properties have been outlined in the study area. Geotechnical investigations carried out after Ortaalan landslide (Figure 1) revealed that much of the topsoil in the study area, consisting of soil. Weathering in the region has presumably altered and broken down the upper part of the bedrock by chemical decomposition and physical disintegration. In decomposed rocks, inherent bonding in the parent rock has gradually deteriorated in the course of decomposition because cohesion due to bonding generally decreases as the material decomposes. Due to limited cohesion, local soils, if unprotected (i.e., subjected to saturation), are susceptible to erosion during heavy rainfall. The shear – strength characteristics of such soils are dependent on the material type, density, stress level, permeability, etc. For the effects of soil on the Ortaalan landslide, representative disturbed and undisturbed soil samples were collected for conducting laboratory investigations including consistency of clays, specific gravity, unit weight of soil and direct shear test.

Soils containing fines (silt and clay) display the properties of plasticity and cohesiveness where a lump of soil can have its shape changed or remoulded with out the soil changing in volume or breaking up. This property depends on the amount and mineralogy of the fines and the amount of water present, or moisture content. As the moisture content increases a clayey or silty soil will become softer and stickier until it can not retain its shape when it is described as being in a liquid state. If the moisture content is increased further than there is less and less interaction between the soil particles and slurry, and a suspension is formed. Typical moisture contents of soil are shown in Table 1.

Soil type	Moisture content
moist sand	5-15
'wet' sand	15-25
moist silt	10-20
'wet' silt	20-30
NC clay low plasticity	20-40
NC clay high plasticity	50-90
OC clay low plasticity	10-20
OC clay high plasticity	20-40

NC: Normally consolidated, OC: Overconsolidated

Table 1. Typical moisture contents of soil

For clays and silts the usual classification is derived from their engineering properties under varying conditions of moisture. The Atterberg limits are an empirically developed but widely used procedure for establishing and describing the consistency of cohesive soil. The Atterberg limits are of a somewhat empirical nature, but frequently these limits to provide useful information regarding soil strength, behavior, stability, type, and state of consolidation, or classification of a clay as organic or inorganic. Consistency limits of soil have been determined in the clays occurring as a result of weathering Upper Cretaceous aged andesitic rock and are given in Table 2. These samples have been defined normally consolidated high plasticity soil.

Rock Type	Consis. limits	Result
Completely weathered andesite	W_L (%)	69
	W_P (%)	42
	I_P (%)	27

Table 2. Consistency limits test results

The general definition for specific gravity is the ratio between the unit weights of a substance and the unit weights of pure water at 4 ^{0}C. The value commonly used for the specific gravity of soil particles is 2.7 gr/cm^3 (Cernica, 1995). Specific gravity value of the clay has been determined as 2.68 gr/cm^3.

3.2 Photogrammetric Evaluation of Landslide

In this contribution, stereo photogrammetric evaluation was performed by using aerial photographs of Ardeşen region (Ortaalan Village) in Rize. Digital Photogrammetric Workstation Zeiss SSK by Z/I Imaging was used for photogrammetric evaluation. After pre-processing, the different dated images scanned with 21 micron precision and covered the selected area was transferred to the system. To establish the relationship between object space and image space, the ground control points were selected in model area to be able to do all measurements in Natiaonal Coordinate System. These points coordinates were measured using GPS (Global Position System) technology. Then, inner, relative and absolute orientations were respectively performed (Figure 4). At the result of the absolute orientation, the accuracy was obtained 45 cm in planimetry (x, y), 50 cm in height (z).
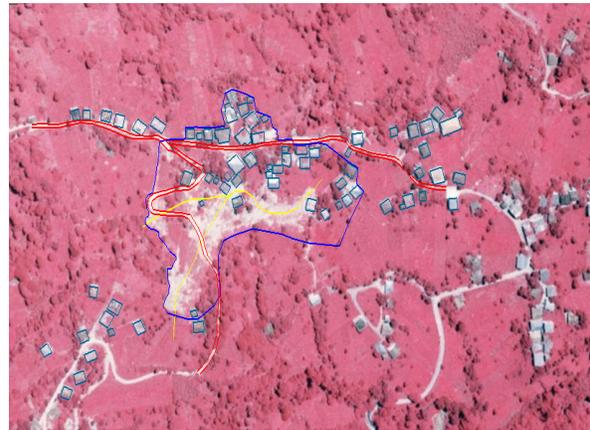
Figure 4. The aerial image of study area after landslide

The color aerial images were taken between 1996 and 2002 in scale of 1/16000 and covered the landslide area were used. The images were taken in 1996 before the landslide and the landslide was occurred in 2001. The vectorel maps were produced from determining the images using the existing buildings, roads and morphology before and after landslides. The morphological changes were investigated by taken the two different direction profiles covered the landslide area (Figure 5). In addition, the goemetrical boundries of the area affected by landslide was determined.

3. RESULT AND DISCUSSION

In this study, it is worked out that the geometrical changes in the landslide area are determined with using the photogrammetric techniques. It is seen that the desingnation landslide area with photogrammetric techniques can be determined easily, true and effectively according to classical methods. Espacially, the geomorphological characteristics of landslide area were obtained from the images taken before landslide. The quantity of the surfacial changes in the landslide area were investigated by taken the two different direction profiles (Figure 6, 7). Landslide aera was calculated as 3.2 hectar. Main scarp, swelling aera and toe area were easily determined from the profiles reflected the landslide characteristics features.
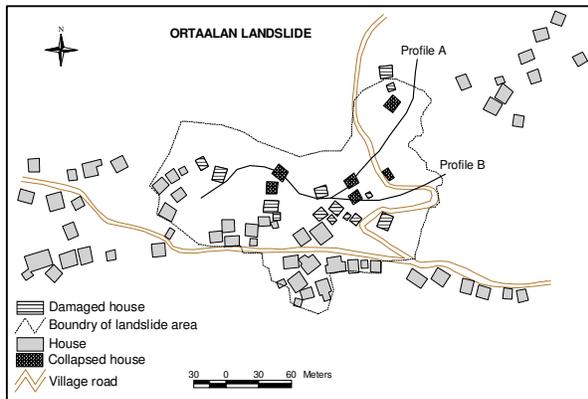
Figure 5. The vectorel map of landslide surrounding

In the study area, heavy rainfall is very important factor for landslide. Heavy rainfall was increased the saturation of soil materials, so increasing saturation of soil is one of the most important factor landslide occuring.
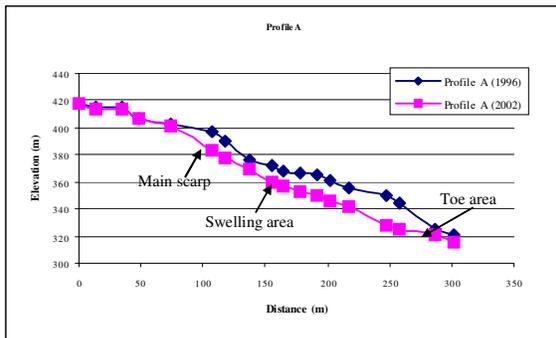
Figure 6. Profile A of Landslide
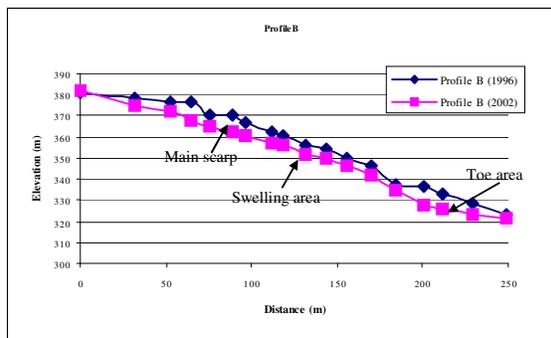
Figure 7. Profile B of Landslide

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