Reliability of landslide isopleth maps

F. Bulut · S. Boynukalin · F. Tarhan · E. Ataoglu

Abstract Following very heavy rainfall on 19/20 July 1983, 109 landslides occurred in the east of Findikli, Rize, north-east Turkey. The movements took place in completely weathered andesitic, dacitic and granitic rocks as well as slope debris. They extended over an area of approximately 25 km^2. The paper discusses the contour (isopleth) map prepared using data from the 1983 landslides and discusses its value for landslide hazard zoning. It is concluded that on the basis of 12 years of field evidence, a contour map derived from a precise inventory map can be a useful tool.

Résumé À la suite des fortes pluies des 19 et 20 juillet 1983, 109 glissements eurent lieu dans la région de Findikli, Rize, dans le nord-est de la Turquie. Les mouvements de versant se réalisèrent dans des roches andésitiques, dacitiques ou granitiques très altérées ou dans des formations de pente, et concernèrent une région d'environ 25 km^2. L'article présente une carte d'isovaleur de densité de glissement préparée en utilisant les données des glissements de Findikli de 1983 et discute de son intérêt pour un zonage de l'aléa glissement de terrain. Sur une base de 12 années d'expérience, la conclusion est qu'une telle carte tirée d'une carte précise d'inventaire peut constituer un outil intéressant.

Key words Landslides · Isopleth maps · Turkey

Mots clés Glissements de terrain · Cartes d'isovaleurs · Turquie

Introduction

A landslide contour map was prepared by dividing the study area into specific units and drawing contour lines to indicate those unit areas where an equal percentage of the ground has suffered landslide disturbance (Wright and Nilsen 1974). In the majority of landslide studies, mapping is undertaken primarily to show an inventory of the areas where landslides have occurred in the past. They do not normally include numerical values; thus they are difficult to incorporate with other data obtained for slope stability studies. However, carefully prepared inventory maps may be modified using isopleth mapping techniques to provide numerical data and facilitate a comparison of the distribution of landslide areas. Combined with other numerical data, they can also form the basis of more detailed maps. For further information on the preparation and use of landslide isopleth maps, see for example Campbell (1973), Wright et al. (1974), Pomeroy (1978), de Graff and Canuti (1988), and Bulut et al. (1993).

This paper discusses the landslide isopleth map prepared on the basis of an inventory map of the 109 slides which occurred between 2300 and 0500 h on 19/20 July 1983 to the east of the town of Findikli, Rize. As can be seen from Fig. 1, the town is situated on the eastern part of the Black Sea, the most active landslide area in Turkey. The geology comprises completely weathered andesitic, dacitic and granitic rocks and slope debris. The landslide movements themselves occurred after a period of very heavy rainfall. Field observations continued at the site between 1983 and 1995, the records of which have been used to assess the reliability and usefulness of isopleth maps.

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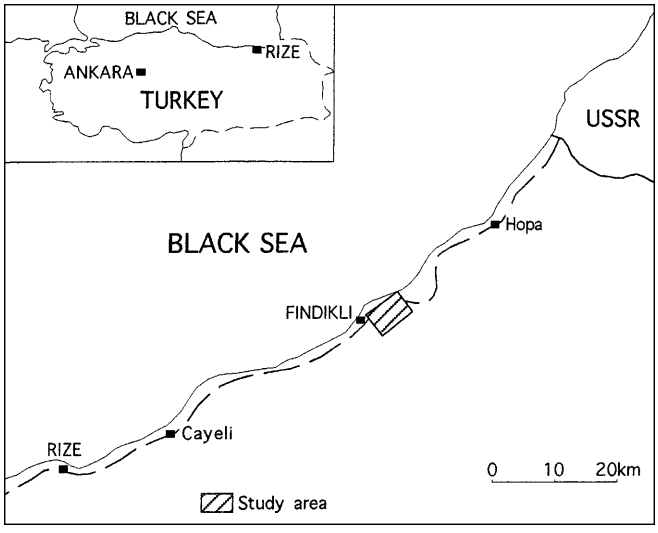

Fig. 1
Location of study area

Table 1
Areas of mappable landslides that occurred in the Findikli region on 19/20 July 1983

No.	Area (m^2)	No.	Area (m^2)	No.	Area (m^2)	No.	Area (m^2)	No.	Area (m^2)
1	1012	23	5645	45	1100	67	3280	89	1620
2	898	24	3862	45	264	68	406	90	3142
3	1555	25	2863	47	1740	69	555	91	2888
4	1081	26	2487	48	984	70	731	92	1710
5	990	27	6191	49	2508	71	1400	93	1520
6	507	28	9081	50	835	72	6175	94	840
7	1458	29	14625	51	1254	73	5074	95	594
8	1891	30	3615	52	480	74	2800	96	934
9	2544	21	945	53	260	75	1854	97	2040
10	1653	32	645	54	2321	76	4350	98	496
11	2079	33	200	55	1464	77	22400	99	312
12	1695	34	4314	56	827	78	1740	100	1890
13	2433	35	2800	57	792	79	1200	101	1300
14	2355	36	882	58	555	80	1769	102	555
15	2472	36	1760	58	286	81	2040	103	945
16	3168	38	2368	60	902	82	1300	104	1350
17	5787	39	1485	61	2592	83	1485	105	2100
18	4455	40	1050	62	555	84	1050	106	3402
19	3126	41	980	63	286	85	900	107	633
20	5664	42	1508	64	902	86	680	108	217
21	4848	43	735	65	200	87	630	109	1728
22	4660	44	6875	66	2479	88	392		

Preparation of isopleth maps

Details of the preparation of landslide isopleth maps are given by Campbell (1973) and Wright et al. (1974). In this study a modified version of the method presented by these authors has been used and is described below. A landslide inventory map was prepared by marking the landslides in the area of Findikli on a 1:25,000 topographic map. With a base map of this scale the actual dimensions of the small landslides could not be shown, hence they have been indicated by a symbol and given a reference number (Fig. 2). Scaled sketches were used to determine the area of the landslide (Table 1) which was recorded as a percentage of the total unit area using the following equation:

$$\%S = (S_1/S_2) \times 100$$

where %S is percentage landslide within the unit area; S_1 is landslide area determined from scaled sketches (m^2); and S_2 is unit area defined as the area of a circle having a 13-mm radius on a 1:25,000 topographic map. The calculated landslide areas were indicated on grid intersection points.

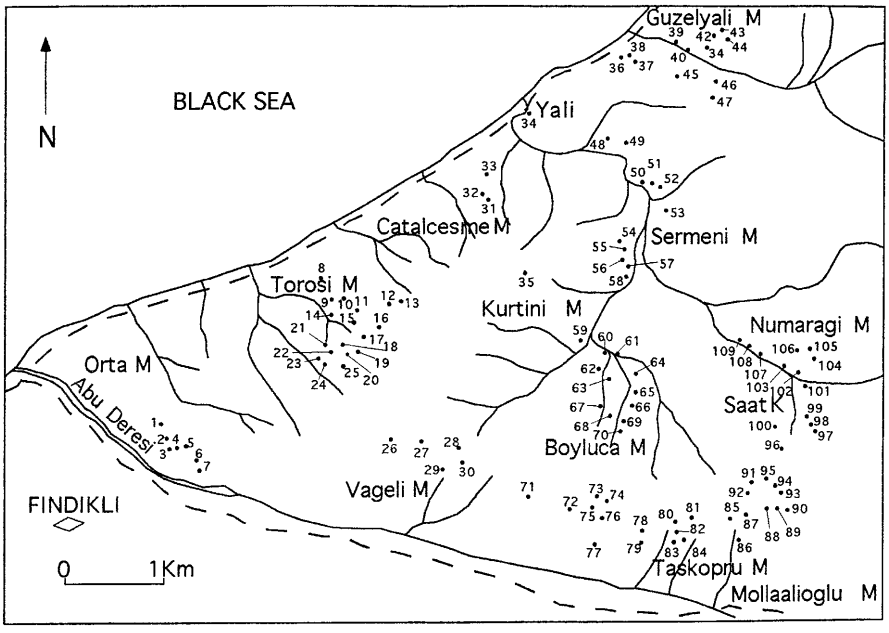

Fig. 2
Landslide inventory map of the Findikli area (prepared using 1983 landslide data)

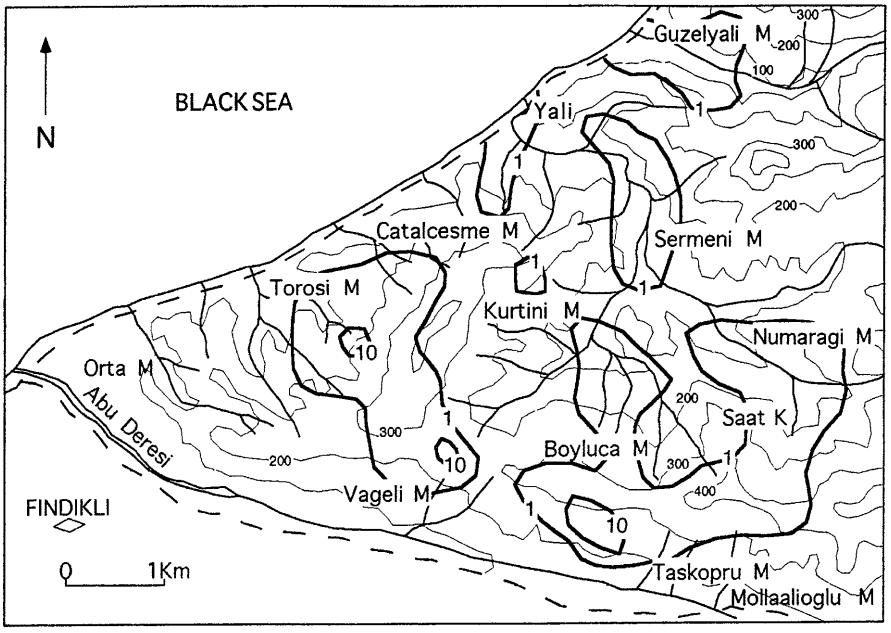

Fig. 3
Landslide isopleth map of the Findikli area (prepared using 1983 landslide data)

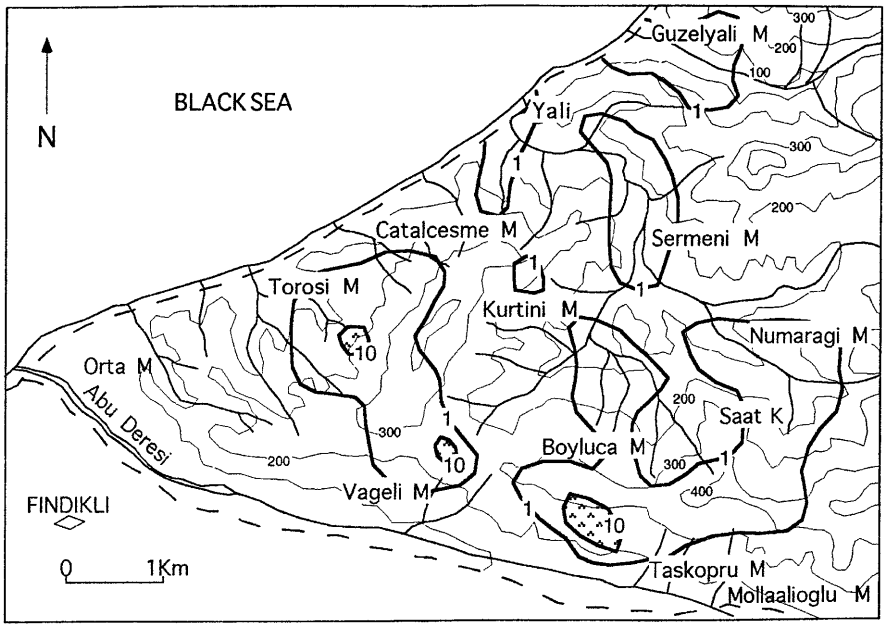

Fig. 4
Distribution of landslides that took place in the Findikli area between 1983 and 1995 shown on the landslide isopleth map

Contour lines were drawn through those points with an equal percentage of landslides.

Reliability of isopleth maps

On the basis of this isopleth map, three zones were identified for the area of Findikli (Fig. 3). Those with isopleth values less than 1% were assumed to be areas of minimal risk while those with isopleth values of more than 10% were considered likely to experience further landslides in the future. In order to test this hypothesis, the landslides in the Findikli area were observed regularly over the period of 12 years between 1983 and 1995 at all the landslides marked on the original contour map. As can be seen from Fig. 4, the new disturbances all took place within the zones where the isopleth values were more than 10%.

Conclusions

The preparation of a detailed landslide inventory map to be used as the basis for isopleth maps is both costly and time-consuming. This study has indicated that marking

landslides on a 1:25,000 topographic map can be a realistic alternative. Observations over a 12-year period have confirmed that isopleth maps prepared in this way can also be used to delineate general "hazard zones" to help identify areas most at risk from future landslide movement.

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