CHINESE GEOGRAPHICAL SCIENCE
Volume 4, Number 4, pp.371–382, 1994
Science Press, Beijing, China

DISASTERS AND REGIONAL RISKS OF DEBRIS FLOW IN ZHAOTONG PREFECTURE, YUNNAN PROVINCE, CHINA

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ABSTRACT: Zhaotong Prefecture has the area of 22,434km^2, where there are more than 330 debris flow ravines, with the average spatial density of 14.7 spots per 1,000km^2. According to the method of evaluation on the regional risk of debris flow, this study has come to the following conclusions: Qiaojia County–risk grade V; Yongshan, Yanjin, Ludian, Daguan, Weixin and Zhenxiong counties–risk grade III; Yiliang, Suijiang–Shuifu and Zhaotong City–risk grade II.Compared with the field investigation, the result is satisfied.

KEY WORDS: debris flow, disaster, regional risk

I. INTRODUCTION

Zhaotong Prefecture is situated in the northeast part of Yunnan Province, southwestern China. It ranges from 26°34′ to 28°41′ north latitude and 102°52′ to 105°19′ east longitude. Its width from east to west is 241km and its length from south to north is 234km. It has the area of 22,434km^2 and 96 percent of them are mountains.

There are one city (Zhaotong) and 10 counties (Ludian, Qiaojia, Yanjin, Daguan, Yongshan, Suijiang, Shuifu, Zhenxiong, Yiliang and Weixin) in Zhaotong Prefecture (Fig.1). Its total population are 389.15 million and 94 percent of them are agricultural population. The average density of population is 173 persons per sq.km.

In Zhaotong Prefecture, 13 rivers belong to the hydrographic net of the Jinsha River (Chinese designation for the upper Changjiang River). The main rivers are: the Jinsha River with the length of 458km and the average gradient of 0.093 percent; the Hengjiang River with the length of 306km and drainage area of 11,532km^2; the Baishui River with the length of 128km and the average gradient of 1.46 percent; the Luoze River with the length of 166km and the average gradient of 1.18 percent; the Niulan River with the length of 469km and the average gradient of 0.65 percent; the Chishui River with a drainage area of 1,903km^2 and the average gradient of 1.35 percent.

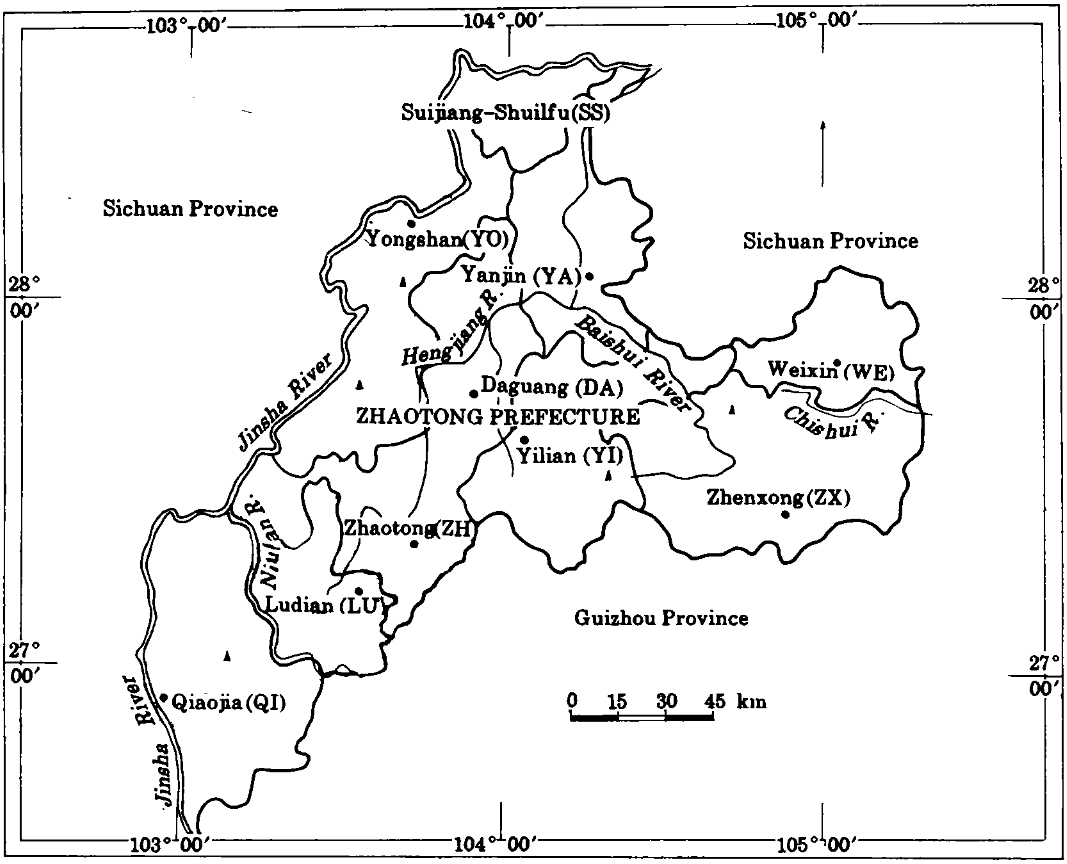

Fig.1 The location of Zhaotong Prefecture in China

There are 6 great soil groups in this area, including rice soil, yellow earth, violet soil, yellow brown earth, brown earth and dry red earth, mainly the group of red earth. The horizontal distributive law of the soils, on the whole, is from yellow earth and violet soil in northern humid region to red earth and dry red earth in southern semi–arid region. The vertical distributive law of the soils, from low to high, is dry red earth, red earth, yellow earth, yellow brown earth, and brown earth, dark brown earth, sub–alpine grassland soil, sub–alpine cold desert soil. The arable soil also has the corresponding changes. From low to high, it is sand soil, semi–sand soil, crude sand soil, yellow mud soil, grey steppe soil.

There are various types of forest and vegetation in this area. Along the Jinsha River there are scattered grasses and brushes. In the valleys of the rivers there are evergreen broad leaf forest (in the northern) and deciduous broad leaf forest (in the southern). In low mountains, there is the evergreen broad leaf forest (in the northern) or coniferous and broad leaf mixed forest(in the southern), In sub–alpine mountains there is mainly the brush forest, and in alpine mountains there are mainly brushes, bamboos and grasses.

In Zhaotong Prefecture, with the economic development, the intenseness of the human activities, and the destruction of the environment, the occurrence of debris flows is more and more frequent, and the debris flow disasters are more and more serious, which has become a major problem to hinder the economic development and the exploitation and utilization of the natural resources. This paper aims to analyse the formative factors of the debris flows and provide the regional risks of debris flow for local people and decision–makers to reduce the debris flow disasters and adjust the productive force layout.

II. DISTRIBUTION OF DEBRIS FLOWS

Zhaotong Prefecture has a vast distribution of debris flow ravines, which involves in all counties and city. According to the uncompleted statistics, it has more than 330 debris flow ravines, with the average spatial density of 14.7 spots per 1,000km^2, about 106 of them are key debris flows which have caused or probably cause large disasters (Table 1).

Table 1 Distribution of debris flow ravines in Zhaotong Prefecture

Item	ZH	LU	QI	YA	DA	YO	SS	ZX	YI	WE
Debris flow	47	14	80	12	10	71	13	53	20	10
Key debris flow ravines	10	14	16	7	3	26	10	4	11	5

Note: ZH:Zhaotong City, LU:Ludian, QI:Qiaojia, YA:Yanjin, Da:Daguan,YO:Yongshan, SS:Suijiang and Shuifu, ZX:Zhenxiong, YI:Yiliang, WE:Weixin.

The distribution of debris flows in Zhaotong Prefecture has the characteristics of more in the southwest and fewer in the northeast. It can be divided into 2 large regions. The southwestern region, including the counties of Qiaojia, Ludian, Yongshan, Yiliang and Zhaotong City, distributes 232 debris flow ravines and has the average spatial density of 18.7 spots per 1,000km^2. The northeastern region, including the counties of Yanjin, Daguang, Suijiang–Shuifu, Zhenxiong and Weixin, distributes 98 debris flow ravines and has the average spatial density of 6.8 spots per 1,000km^2.

III. DISASTERS OF DEBRIS FLOWS

Every year debris flows affect 20–30 townships, nearly 1,000 families in Zhaotong Prefecture. For example, in 1988, 22 townships including 39 villages and 1,068 families were influenced by debris flows and 645 families were forced to displace their houses. Debris flows also damage the cultivated land. From the early to the end of the 1980s, the damaged land has increased almost 7 times (Table 2).

Table 2 Cultivated land damaged by debris flows in Zhaotong Prefecture (ha)

Year	ZH	LU	QI	YA	DA	YO	SS	ZX	YI	WE
1982	200	133	167	459	79	167	–	474	134	67
1983	306	183	234	101	45	14	75	395	149	276
1984	817	166	244	209	117	–	231	435	324	556
1985	136	170	502	381	16	164	341	121	162	79
1986	193	171	424	282	125	44	125	217	194	–
1987	135	22	426	61	314	179	218	200	–	330
1988	1473	767	1207	216	803	845	40	2765	353	319

In addition, debris flows often dam rivers, destroy the water conservancy facilities, and stop transport. For example, on July 2, 1983, a large debris flow at Danquan ravine in Qiaojia County, dammed the Jinsha River. In the lower reaches, the water level fell down 3m, two ships were stranded, After 20 min., the water level suddenly went up 6m, and another ship was sank. The debris flow also destroyed several escape canals of water, damaged 585ha of arable land. On June 26, 1987, at Xintan ravine in Shuifu County, a large debris flow took place. 30min. later, debris flow blocked the bridge tunnels, and submerged the highway. A truck on the bridge was threw down·to the ravine and was rushed forward about 100m, another 3 trucks fully loaded chemical fertilizer were submerged. The debris flow also climbed on the right bank of the ravine and violently impacted buildings, 7 buildings were destroyed, and a gain warehouse was submerged resulting in the loss of rice of thousands of tons, and a simple film theater was destroyed and pushed into the Hengjiang River. On September 23, 1991, a large debris slide–debris flow occurred at Touzhai ravine, 30km from the north of Zhaotong City. 2.3 million cubic meters of debris fell down the Touzhai village situated outside the mouth of the ravine, 216 persons and 254 livestock were killed. In addition, 202 houses, 1.5 km of village highways, 300m of transmission lines and more than 20 hectares of arable land were destroyed.

Based on the statistics of the historical documents and the recent data of debris flow, from 1743 to 1989, Zhaotong Prefecture had total 49 large debris flow disasters (1 million yuan (RMB) damaged or more than 10 persons killed for each disaster), two of them in 18th century, four of them in 19th century, nine of them in the early half period of 20th century, sixteen of them in 1960–1979, eighteen of them in the current 10 years. It shows the intervals between the disasters are shorter and shorter (Table 3).

Table 3 Time and frequency of large debris flow disasters in Zhaotong Prefecture

Item	ZH	LU	QI	YA	DA	YO	SS	ZX	YI	WE
Duration (year)	247	81	237	71	85	167	39	71	59	72
Disaster (time)	8	3	15	2	4	7	3	3	2	3
Frequency (%)	3.2	3.7	6.3	2.8	4.7	4.2	7.7	4.2	4.0	2.8

IV. FORMATIVE CONDITIONS OF DEBRIS FLOWS

1. Geological Conditions

In Zhaotong Prefecture, the strata range from Quaternary to Mesozoic Age. Thickness and lithology of stratum differ with areas. The northern area is composed of mostly Jurassic and Triassic pelitic limestone with a little sandstone and shale; the middle area is mainly composed of Devonian and Silurian pelitic limestone, sand–shale, marl, and basalt; in the southern area, basalt, limestone, and dolomite are the main geological units; the eastern area is make up of basalt, Triassic and Cambrian limestone and Triassic purple–red sandstone. Because basalt contains a lot of Fe, Al and Mg, it is often weathered quickly and eroded easily. The soil formed by weathered basalt is viscous, and is deeper in the eastern than in the western. The weathered limestone mainly forms the zonal red and yellow earths, which have the properties of viscosity, thinness, acidity and dry. The regolith of sandstone is often the mother materials of the yellow sand soil, while the regolith of shale is always the mother materials of violet soil. Through the analysis of the relationship between geological factors and landslides and debris flows, the best advantageous rocks to the formation of landslide and debris flow are coal stratum and shale. The next rocks are basalt and sandstone, and the hard limestone is the much disadvantageous rock to the formation of landslides and debris flows in Zhaotong Prefecture[1].

The Xiaojiang fault running from south to north and other NE–SW faults represent the major geological structures in the prefecture. The NE–SW faults are the Yanjin–Qiaojia, the Daguan–Qiaojia, and the Yiliang–Qiaojia faults. All these formed prior the Cambrian, but are active. Since the Pliocene Epoch, this region was structurally dynamic and rapidly rising. Therefore earthquake and broken rocks are common.

2. Topographical Conditions

Zhaotong Prefecture belongs to the mountainous region. Its relative downcuttin depth of earth–surface is very large. The maximum relative relief is up to 3,773m. the area of plane land is only 1,267km^2, accounting for 5.6 percent in the total, and the area of the gentle sloping land with 15–25 degrees is 7,109km^2, accounting for 31.7 percent in the total, and the area of the steep sloping land with more than 25 degrees is 9,767km^2, accounting for 43.5 percent in the total. Based on the former researches[2], the proportion of the sloping land up or equal 25 degrees, accounting for the total has the closest relationship with the formation and development of debris flows.

3. Meteorological Conditions

The rainy weather systems in Zhaotong Prefecture are mainly low pressure trough and cold front. The vapour comes from the warm and humid air current of the southwestern Bangladesh Bay. When the deep and thick low pressure system in sky combines the cold front on earth–surface, it may cause the intensive rainfalls and rainstorms.

Zhaotong has the yearly precipitation of 730–1,230mm. The rainy season from May to October centralizes the precipitation of 75–95 percent of a year (Table 4). The coefficient of variation of monthly precipitation is large, usually 0.65–0.98. The rainstorms are chiefly distributed in the counties along the Jinsha River and the eastern high mountains. During the rainstorms, besides the slope and gully erosions, floods, debris flows and landslides frequently accompany with them.

Table 4 Average monthly precipitation in Zhaotong Prefecture (mm)

Month	ZH	LU	QI	YA	DA	YO	SS	ZX	YI	WE
Jan.	6.6	13.1	10.4	19.8	8.6	3.3	9.5	15.1	3.6	26.6
Feb.	6.4	13.6	8.9	24.7	10.5	6.3	13.2	17.0	4.0	26.7
March	10.1	14.4	7.8	35.8	16.2	11.3	23.5	22.1	9.7	40.4
April	36.0	43.1	22.1	65.1	46.2	44.8	53.1	53.0	34.3	67.9
May	72.1	90.2	81.4	95.3	85.1	68.4	97.3	106.4	64.0	113.9
June	154.7	190.6	186.6	178.1	147.2	118.9	140.7	164.4	141.4	152.4
July	143.4	181.0	129.6	237.7	204.6	127.7	206.7	163.4	170.6	162.9
Aug.	117.0	144.2	110.4	288.4	249.6	139.9	236.7	160.1	169.7	188.6
Sept.	105.8	118.8	119.8	132.4	128.3	86.9	114.2	112.3	112.8	113.3
Oct.	57.1	72.9	84.1	84.1	67.8	45.9	56.9	61.9	46.1	74.0
Nov.	18.0	25.3	24.2	42.0	25.4	13.6	23.4	30.9	13.7	46.1
Dec.	6.4	9.8	7.3	22.9	9.3	3.4	11.1	15.9	3.8	24.9

4. Impacts of human activities

The unreasonable agricultures greatly stimulate the los of water and soil, and the formation of debris flows and landslides. In Zhaotong Prefecture, there are 333,755 hectares of arable land with the slope more than 15 degrees, which accounts for 57 percent in the total, and 132,063 hectares of them are arable land with the slope more than 25 degrees, which accounts for 23 percent in the total. It shows the cultivation on steep slope is rather popular in the prefecture. This kind of hazardous agricultural activity is mainly caused by: (1) the primitive productive mode and the low grain yield; (2) frequent natural hazards and fast increase of population; (3) the conflict of land utilization between economic crops and grain crops. All above force the local people to cultivate on the steep sloping land.

To a certain extent, forest and vegetation may restrain the development of debris flows. However, since 1958, because of erroneous policies, several stages of deforestation have been resulted in. Currently, owing to the shortage of finance and lack of managerial experience, local people plant trees every year but the survival rate of the trees is fairly low. For example, in 1950–1958, the forest area in Zhaotong City was 70,742 hectares, and the forest coverage was 32.8 percent, and the stored woods was 3.9 million cubic meters with the average 18.6 cubic meters per person. In 1974, the forest area was 37,819 hectares, and the forest coverage was 17.5 percent, and the stored woods were 0.63 million cubic meters with the average 1.5 cubic meters per person. In 1980, the forest area decreased to 30,349 hectares, and the forest coverage was only 14.1 percent, and the stored woods was only 0.58 million cubic meters with the average only 1 cubic meters per person. During this 23 years, the forest area had decreased 40,687 hectares and the stored woods had decreased 3.3 million cubic meters. The diminution of forest resource is directly caused by the excessive fall of trees, which is closely related to the shortage of fuel in Zhaotong Prefecture.

Bad design and construction of roads are also favorable to the formation of debris flows. Because the limit of mountainous landform, most of the highway are zigzag. Blast and stone–picking results in the discarded earth to fall down along slopes and accumulate gradually, which takes sands and stones away from the original slope, and destroy the stability of natural slopes. The road surface of mountainous village highways is always broken. There is neither slope–protection, nor drainage, and nor tree–planting on the sides of the highways. Along most village highways, debris flows are very active, and the disasters are very serious, too.

V. REGIONAL RISKS OF DEBRIS FLOW

According to the requirement of the evaluation on the regional risk of debris flow[2], Zhaotong Prefecture is divided into 10 basic units. Here the basic units are the administrative counties. Because the prevention and relief of the debris flow disasters mainly depend on the various governments, we choose the integrated administrative regions as the basic units to evaluate the regional risk of debris flow[3].

The quantitative indexes used to evaluate the regional risk of debris flow are as follows.

X_1–the actual spatial density of debris flow ravines

It is the numbers of debris flow ravines per unit area (usually per 1,000km^2). it shows the active situation of debris flows and is the most important index. Therefore it is the leading index for the evaluation on the regional risk of debris flow.

X_2–the flood–hazard occurrence frequency

It is supposed that under the circumstance of the daily rainfall up or equal 50mm, or the continues rainfall of 3 days over 24–40 times of the average daily precipitation in a year (specific times must be designated by the local meteorological departments), the flood–hazard may possibly occur in the region.

Then within the certain statistical period, the proportion of the flood–hazard times in the possible total flood–hazard times is defined as the "flood–hazard occurrence frequency". We should pay attention to discriminate the "flood–hazard occurrence frequency" from the flood frequency. They are completely two different concepts. Because the debris flows often accompany with the floods, the flood–hazard occurrence frequency is a good implication of the active degree of debris flows.

X_3–the average weathered coefficient of rocks

It is the ratio of monoaxial compressive strength of weathered rocks to that of fresh rocks, marked with Ky $(0 < Ky < 1)$. It indicates the broken degree of rocks and the quantity of the loose solid materials provided for debris flows. Attentively, Ky should be the average value in the region (sample). In proportion to the leading index, we use its reciprocal as this index for the evaluation on the regional risk of debris flow.

X_4–the average coefficient of variation of monthly precipitation

In southwestern China, debris flows mainly occur in the rainy season from May to September in a year. The coefficient of variation, marked with Cv ($0<Cv<1$), suggests the centralized distributive situation of the yearly precipitation. There fore it also reflects the possibility of debris flow occurrence. That is, the larger Cv, the more concentrative the precipitation, and the higher the debris flow frequency. Cvmay be calculated by the formula:

$$Cv = \sqrt{\left[\sum_{i=1}^{12}(X_i - \bar{X})^2/12\right]} \Big/ \bar{X} \qquad (1)$$

where: X_i is the monthly precipitation, X is the average monthly precipitation, $i=1,2....,12$. Because Cv varies yearly, we had better average them more than 10 years.

X_5–the density of active faults It is the total length of active faults per unit area (usually 1,000km^2. The faults only count is those large, deep and active faults, because most of the debris flows often appear along the active fault zones.

X_6–the average annual days up or equal 25mm rainfall

Although the over 50mm daily rainstorms can ignite debris flows, the times of actual debris flows are usually more than the times of rainstorms. In fact, the average annual days up or equal 25mm rainfall has a closer relationship with the leading index than the average annual days up or equal 50 mm rainfall. Therefore, it is used as the index for the evaluation on the regional risk of debris flow.

X_7–the proportion of the cultivated land up or equal 25 degrees in the total cultivated land

It represents the intensity of human activities. Cultivation on the steep slope is the mankind's direct distraction to the natural environment, which easily results in the diminution of the coverage of forest and vegetation, the loss of water and soil, and the formation of debris flows and landslides.

X_8–the proportion of the sloping land up or equal 25 degrees in the total land

The sloping land up or equal 25 degrees belongs to the steep sloping land. Debris flows always take place there. Especially in the headwaters of debris flow ravine, slopes are even up to 60 degrees. In fact, it has close relationship with the leading index. Consequently it is used as the index for the evaluation on the regional risk of debris flow.

In order to make these indexes comparable, separative relativity the X_1–X_8 into relative value X'_1–X'_8 whose maximum is 1 and minimum is 0, and the rest are from 0 to 1. Relative indexes X_1–X_8 by the formula:

$$X'_{ij} = (X_j - X_j min) / (X_j max - X_j min) \tag{2}$$

where: i is the region (sample) number, i= 1,2,....,n. j is the index number, j= 1,2,...8. X'_{ij} is the relative value of the index j in the region i. X_{ij} is the absolute value (basic data) of the index j in the region i. $X_j min$ is the minimum of X_j, $X_j max$ is the maximum of X_j.

The functions of the 8 indexes are not equal in the evaluation on the regional risk of debris flow. Based on Liu's study[2], the weight numbers of the 8 indexes respectively are $W_1=1$, $W_2=0.7806$, $W_3=0.7621$, $W_4=0.7445$, $W_5=0.7384$, $W_6=0.7128$, $W_7=0.7126$, $W_8=0.7000$. The regional risk of debris flow can be calculated by the following formula:

$$P_i = X'_{i1} + 0.7806X'_{i2} + 0.7621X'_{i3} + 0.7445X'_{i4} + 0.7384X'_{i5} + 0.7123X'_{i6} + 0.7126X'_{i7} + 0.7000X'_{i8} \tag{3}$$

where: Ri is the regional risk of debris flow in the region i. The rest symbols are the same as before.

In line with this method of evaluation on the regional risk of debris flow[2] and the regional risk grades of debris flow in Table 5, the results of the regional risks of debris flow in Zhaotong Prefecture are shown in Table 6.

Table 5 Regional risk grades of debris flow

Regional risk of debris flow	Regional risk grade of debris flow	Suggestion of the countermeasure of debris flow
0–1.23	I	Continue to maintain the nice environment
1.24–2.46	II	Strengthen the conservation of water and soil, and prevent the new debris flows
2.47–3.69	III	Control the key debris flows and monitor their developmental trend
3.70–4.92	IV	Harness the main debris flows and predict the possible debris flow hazards
4.93–6.15	V	Strengthen the short-term prediction of debris flow, and reduce losses to the minimum

Note: From formula 3, we know that, when $X'_{i1} = X'_{i2} = ... X'_{i8} = 1$, the R_i is the maximum of 6.151, and when the $X'_{i1} = X'_{i2} = ... X'_{i8} = 0$, the R_i is the minimum of 0. Therefore, always $0 < R_i < 6.151$. The 5 grades in this table are made by this analysis.

Table 6 Results of the regional risks of debris flow in Zhaotong Prefecture

Index	ZH	LU	QI	YA	DA	YO	SS	ZX	YI	WE
X	21.1	9.4	25.0	5.9	5.8	25.6	11.2	14.3	7.1	7.2
X′	0.80	0.18	0.97	0.01	0.00	1.00	0.27	0.43	0.07	0.07
X	0.25	0.28	0.67	0.54	0.29	0.63	0.31	0.32	0.29	0.46
X′	0.00	0.08	1.00	0.70	0.10	0.90	0.14	0.17	0.10	0.49
X	1.86	1.99	2.02	1.85	2.01	1.96	1.70	1.89	1.92	1.83
X′	0.50	0.91	1.00	0.47	0.97	0.81	0.00	0.59	0.69	0.34
X	0.88	0.85	0.89	0.84	0.95	0.88	0.91	0.76	0.98	0.65
X′	0.70	0.61	0.73	0.58	0.91	0.70	0.79	0.33	1.00	0.00
X	46.8	74.7	120	72.4	86.1	46.6	47.7	60.4	55.1	87.2
X′	0.04	0.38	1.00	0.35	0.54	0.00	0.02	0.19	0.12	0.55
X	4.43	8.43	8.21	9.97	7.55	4.57	6.88	6.94	6.53	7.20
X′	0.00	0.72	0.68	1.00	0.56	0.03	0.44	0.45	0.38	0.50
X	0.09	0.08	0.33	0.25	0.08	0.15	0.29	0.30	0.21	0.39
X′	0.02	0.00	0.81	0.55	0.00	0.23	0.68	0.71	0.42	1.00
X	0.22	0.31	0.56	0.54	0.56	0.52	0.46	0.36	0.40	0.41
X′	0.00	0.26	1.00	0.94	0.99	0.89	0.71	0.40	0.51	0.57
Regional risk	1.77	3.08	5.56	3.37	2.99	3.65	2.28	2.51	2.43	2.59
Risk grade	II	III	V	III	III	III	II	III	II	III

VI. CONCLUSIONS AND SUGGESTIONS

In Zhaotong Prefecture, the debris flows are caused by manifold factors. Weathered and broken rock, complex and dense fault, steep sloping landform, heave rainstorm, unreasonable agriculture, excessive deforestation and a lot of road–building are all the advantageous conditions to the formation of debris flows. This paper through the theoretic and practical researches, concludes the regional risks of debris flow of Zhaotong Prefecture follows.

The regional risk grade V: Only Qiaojia County, has the area of 3,195km^2 accounting for 14 percent in Zhaotong Prefecture, and distributes 80 debris flow ravines with the average spatial density of about 25 spots per 1,000km^2. All the 8 indexes have the high values and are combined very well, and are extremely suitable for the occurrence of debris flows. At the present situation of finance and technique in the prefecture, to eliminate these favorable formative conditions of debris flow is fairly difficult. Therefore, the most important task we suggested is to predict the occurrence of debris flows, reduce the losses of properties, and protect the people's life.

The regional risk grade III: Including 6 counties of Yongshan, Yanjin, Ludian, Daguang, Weixin and Zhenxiong,have anarea of 13,100km^2, accounting for 59 percent in the prefecture, and distributes 170 debris flow ravines with the average spatial density of about 13 spots per 1,000km^2. Some of the 8 indexes have the high values but combine not very well. The developmental trend of the key debris flow ravines should be monitored closely, and the proper countermeasures should be implemented so as to reduce the debris flow disasters to the minimum.

The regional risk grade II: Including 3 counties of Yiliang, Suijiang–Shuifu and Zhaotong City, has an area of 6,138km^2, accounting for 27 percent in Zhaotong, and distributes 80 debris flow ravines with the average spatial density of about 12 spots per 1,000km^2. The values of the 8 indexes are relatively low and they are not combined well. In spite of this, a few key debris flows directly threatening mines, villages and main traffic lines should be controlled and highly paid attention to their active trends. Meanwhile, we should strengthen the conservation of water and soil, and prevent the formation of new debris flows.

This work was proposed by the government of Zhaotong Prefecture. According to its demand, we have done this research and provided this findings to identify which regions (counties) have and will have the serious risk of debris flow disaster, and which regions (counties) have and will have the light risk of debris flow disaster. The research results of the regional risks of debris flow are all relative, and only can be compared with each other in Zhaotong Prefecture.

ACKNOWLEDGEMENTS

Many thanks to Wang Shige, Yang Qingxi, Wang Yangchun, Zhao Xinbao and Chi Zongxin for their participation in the field investigation and the collection of the basic data. Also thanks to Dr. Pauline Ives and Prof. Li Tianchi for the comments and suggestions greatly assisting in the revision of this manuscript.

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