

EXAMINING THE RELATIONSHIP BETWEEN ROADBLOCK CLEARANCE TIME AND FAILURE EVENT TYPES

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1. Introduction

The importance of road connectivity in a landlocked country like Bhutan is immense. Nearly around 48,500 numbers of vehicles are commuting daily across the national highway (2850 km) which are closely related to the daily functioning of various important sectors and industrial activities. Thus, disruption due to roadblocks caused by failure events such as landslide, debris flow, rockfall, etc. can cause a huge impact on the overall livelihood of the people as well as on the social-economic development of the country. Furthermore, the situation can get worst if the clearance of such blocks gets hampered and the essence of sharing Real Time Information (RTI) to the road users gets compromised due to several factors such as incessant rainfall, availability of machinery, type of failure events, etc. Thus, examining relationship patterns between the roadblock clearance time and the factors they depend on is important to accurately forecast the RTI for immediate response and in the long run, it would be beneficial for the agencies to prepare mitigation and risk reduction responses. Therefore, this paper studied the relationship between clearance time and the failure event types incorporating the factors affecting the clearance time by utilizing the multivariate regression model analysis.

2. Methodology

2.1. Data Collection

Relevant data were collected from various agencies in Bhutan especially the Department of Roads. The collected data consisted of records of roadblock that was reported in the year 2020, rainfall data, machinery allocation database, traffic count, geospatial data of town points and regional boundaries, etc.

2.2. Data Preparation.

Adopting Varnes' classification of slope movement [1], the failure types in the database concerning roadblock information were classified into seven different categories namely Landslide, Debris flow, Rockfall, Flooding, Subsidence, Scouring, and Snowfall. Further, the failure types were classified into single types and multi types depending upon the number of different failure occurrences at a given time and location.

Data from 20 rainfall gauging stations were exported to the GIS platform to integrate with the roadblock

database. A Thiessen Polygon Method was adopted to obtain the amount of rainfall that most likely occurred at the block point at the date and time of the failure event. Furthermore, the distance value between the roadblock points and the town point was obtained using the "v.distance" tool in GIS.

Finally, to obtain the relationship pattern, multivariate regression model analysis for different failure event types was carried out where the roadblock clearance time was set as dependent and the factors governing the clearance time as independent variables.

3. Results & discussion

3.1. Descriptive statistics of roadblocks.

Statistical results for the dataset after considering the failure types with the frequency of occurrence more than 10 times to be more significant which is approximately 96.7% are shown in Table 1. The results illustrate that on average it took 17.9 hours to clear those blocks with the maximum and minimum time taken values as 360.2 hours and 0.2 hours respectively.

Table 1 Descriptive statistics of the clearance time for different failure types

Failure Events	Frequency	Clearance time (hr.)		
		Average	Max	Min
Landslide	416	13.3	322.6	0.2
Debris flow	95	4.6	20.3	0.5
Rock fall	31	17.6	315.6	0.7
Flooding	28	21.4	105.5	1.0
Subsidence	16	67.3	360.2	2.7
Landslide/Debris flow	90	4.8	27.6	0.5
Landslide/Rock fall	17	6.0	24.0	1.0
Debris flow/Rock fall	15	8.2	32.1	0.2
All Data	708	17.9	360.2	0.2

The results show that on average, failure types concerning subsidence took a longer time to clear though they occurred less frequently when compared to other types such as landslides and debris flow. This indicates that the clearance time depends on the scale of destruction to the road infrastructure. For instance, failure types concerning subsidence and flooding are usually of greater

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scale where the entire road formation width gets washed out or submerged by the adjoining river or stream, thus requiring additional resources and time for its restoration.

3.2. Multivariate regression model for top three frequently occurring failure types.

Three different models were generated. Table 2 shows the results of failure type concerning landslide, debris flow, and a combination of both respectively.

Table 2. Multivariate regression model for different failure types

Failure Type : Landslide	R ² : 0.16	Significance F : 2.2E-11
Independent variables	Coeff	P-value
Machineries	0.3511	0.9183
Accumulated Rainfall	0.1362	0.0000
Distance from Town Point	0.0003	0.1570
Traffic(Nos) per day	-0.0005	0.9429
Road Category	-12.8282	0.0008

Failure Type : Debris flow	R ² : 0.144	Significance F : 0.021
Independent variables	Coeff	P-value
Machineries	-1.0995	0.2921
Accumulated Rainfall	0.0129	0.0827
Distance from Town Point	-0.0001	0.4882
Traffic(Nos) per day	-0.0058	0.0048
Road Category	2.3446	0.0490

Failure Type : Landslide/Debris flow	R ² : 0.16	Significance F : 0.021
Independent variables	Coeff	P-value
Machineries	-11.7759	0.3896
Accumulated Rainfall	0.0953	0.0030
Distance from Town Point	0.0004	0.0754
Traffic(Nos) per day	0.0081	0.6641
Road Category	3.3960	0.1189

Overall, the accumulated rainfall intensity during the clearance period is found to be one of the major factors that govern the clearance time with its p-values as 1.076E-09, 0.083, and 0.003 for the regression models concerning landslide, debris flow, and landslide/debris flow types of failure events respectively. Furthermore, at an individual comparison, the regression models concerning landslide and debris flow shows that road category had a significant influence on the clearance time of the road ($p < 0.05$) with coefficient values of -12.83 and 2.34 respectively. This result indicates that the clearance time for the roadblocks caused by landslides along higher categories of the road was lesser than compared to other road categories, whereas the roadblock caused by debris flow in the higher category took longer time to be cleared, however, the clearance time was shorter if the traffic volume along that section of road was higher. Thus, clearance of roadblocks due to debris

flow was shorter if the traffic volume was higher though the road was in a lower category or vice versa.

This could be because since the scale of debris flow destruction to the road assets are usually huge and larger in magnitude, the factors such as road category didn't have much impact as they did on the failure types concerning landslide alone.

Furthermore, Table 3 shows a similar multivariate regression model combining the three earlier described models where the types of failure were considered to be one of the independent variables. The model has an R-square value of 0.16 with a significance F value:8.9E-16.

Table 3. The combined multivariate regression model

Independent variables	Coeff	P-value
Landslide	0.8522	0.7817
Debris flow	-7.2931	0.0032
Machineries	-0.7448	0.7651
Accumulated Rainfall	0.1176	0.0000
Distance from Town Point	0.0003	0.0613
Traffic(Nos) per day	-0.0032	0.4830
Road Category	-6.9835	0.0041

The model as a whole show that the factors such as road category, accumulated rainfall, and debris flow failure types have a significant influence on the clearance time of the roadblock ($p < 0.05$). The roadblock clearance time is more likely to be shorter if the block points are located along the higher categorial road and with lesser rainfall intensity during the clearance period with coefficient values as -6.98 and 0.12 respectively. Furthermore, for the failure types concerning debris flow, due to a negative coefficient value of -7.29, the dependent variable of the model i.e., the clearance time of the block will also decrease substantially.

4. Conclusion

The results here are expected to assist in achieving the overall objective of the comprehensive research, i.e., to help the relevant agencies in understanding the relationship patterns which will enable them to better plan and prepare for future mitigation and risk reduction responses as well as predict the RTI more precisely so that the commuters are well aware of the situation.

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References

- [1] Varnes, D. (1978). Slope Movement Types and Processes. Special Report, 176, 11–33.