Predicting Losses from Landslide and Flood Events in Nepal: A Regression Analysis with Moving Averages Approach[1]

Pitri Bhakta Adhikari, Rachana Ghimere, & Nabaraj Khanal

Abstract

Nepal is highly vulnerable to disasters due to its geographical structure, significant temperature variability over short distances, and changing climate. This paper aims to evaluate historical trends and predict future disaster-related losses. The moving average method is used in this study for analysis. The study focuses on data and analysis of two frequently occurring disasters in Nepal. A straight regression line is applied to the number of incidents and various variables (total deaths, missing people, affected families, and injured people) to predict future losses. Since 1971, the number of incidents involving these two disasters, landslide and flood, has been rapidly increasing. A 5-year moving average is employed to analyze the data, revealing a sharp increase in all variables studied. The rapid rise in disaster incidents and associated losses could pose significant challenges for the country. To enhance public safety, information programs should be implemented, and areas should be ranked by their level of danger to mitigate losses.

***Keywords*:** Flood; Forecast of disaster; Landslide; Natural disaster

Introduction

Nepal is the country which has high geographical variability. Due to which Nepal is a hub for the natural disasters like flood and landslide. The hazard may be natural and manmade. There are several natural hazards. The destruction made by the hazards cannot

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be determined exactly but can be predicted with the help of previous data. Nepal has total area of 147181 square kilometers which is 0.3% of Asia and 0.03% of total land. It has average width of 193km and length of 885km has high geographical variability. In this range it contains terai region, hilly region and Himalaya region. It has low land of 59m and high land of 8848.86m which is the world's highest peak. Due to this geographical variability the Nepal is vulnerable to disasters [1,2]. In the hilly and terai region fire flood landslide is more vulnerable. And in Himalayas the avalanche is the most vulnerable disaster. But there are many more disasters which stuck the life of human as well as animals is in danger [3]. The climate change is the main cause of disasters like flood, landslide, thunderbolt, fire, etc. and there are numbers of defense and security threats caused by the natural hazard and climate change [4]. There are many cases of landslides and floods which take the life of humans away. Not only the loss of humans but high loss of property has been recorded. These two, landslides and flood, are the major disasters in Nepal which are frequent in the rainy season. Due to these types of disasters many people become homeless and many children become orphans. There are many families affected by these disasters annually [5, 6]. The major cause of the landslide and flood seems to be climate change. Although, drought, shorter rain fall season, higher temperature, etc. are major effects. The various results show the significant effects of education to prevent the higher [7, 8]. But overall, the number of incidents and human loses are increasing. These effects of landslides and floods can be reduced by using early warning systems and promotion of education level to people [5 - 8].As numerous articles indicate, temperatures are rising and climate change is impacting various sectors, such as agricultural patterns and efforts to maintain basic food security [9].

The forecasting of disasters can help to reduce the effect of disasters such as human losses, property losses, animal losses, etc. It helps to early decision-making regarding disaster and the future losses by disaster can also be predicted. For example, forecasts can estimate the future number of disaster incidents, the expected number of fatalities, and other related impacts for specific disasters. It also helps to find out, in what pattern the losses by disaster are increasing and decreasing. It helps to find out which disaster may cause more losses in upcoming year. By analyzing these facts, the losses of disaster can be reduced. The hydrological models are particularly effective in predicting droughts and flood, with the incorporation of climate forecasts into disaster management holding promise for reducing losses and enhancing adaptation to climate change [10, 11]. There are various articles which pursues the forecasting of different disasters but there are few papers which predict the losses of disasters. The forecasting is one of the critical issues which only predicts the chances of occurrence. The forecasting of losses by disaster helps to give early warnings. Which can help to control the losses and can be analyzed how the loss by disasters are occurring day by day [12 - 15]. The countries with high population density, rapid urbanization need comprehensive disaster preparedness and mitigation strategies to safeguard lives and resources. The countries which have a low economy and lack of basic services are at higher risk [16,17]. Landslides are frequent in the hilly region and floods are frequently seen in the Terai region. So, the effects of these disasters are seen everywhere in the world [18]. Stopping problems before they happen is way cheaper than fixing them afterward, not to mention the human lives saved. From 1951 to 2009, Italy spent a lot of money dealing with the damage from landslides and floods. This shows that putting money into preventing these disasters is a smarter move financially. It's more cost-effective to avoid problems in the first place than to deal with the mess and save lives later [19]. The landslides that moved quickly, such as rock falls, rockslides, rock avalanches, and debris flows, led to the highest number of fatalities [20]. Establishing clear rules, implementing warning systems, and promoting education are essential steps to minimize the impact of disasters [21].

Methodology

The data is taken from the Disaster Risk Reduction Portal, Minister of Home Affairs (DRR, portal, MoHA) from 1971 to 2022 AD. The data is divided into 5 year intervals and takes the moving average of average number of incidents, average total death, average missing people, average affected family, average injured peoples, etc. for flood and landslide. Then, the regression line is plotted for each of the variables for both disasters. The graph is plotted for each variable separately and according to its trend the regression equation in the form of $Y=a+bX$ is determined and the predicted line is drawn through Microsoft excel. For the error analysis, the different values of X are put in the regression equation to get the predicted Y. After that we plot the table for each variable, and the error is calculated. This data is analyzed by using Microsoft excel and Microsoft word in the form of regression graphs of each variable. Here the regression equation is in the form of straight-line $Y=mX+C$. Overall, this methodology involves comprehensive data analysis using statistical techniques and graphical representation to assess the trends and predict future occurrences of flood and landslide incidents in Nepal, based on historical data from the DRR portal/MoHA. The normal equations of this equation are

$\sum Y = m\sum X + nC$ ……………… (1)

$\sum XY = m\sum X^2 + C\sum X$ ……………… (2)

On solving these equations, we get, m= $= \frac{n\sum X \ -\sum X \sum Y}{n\sum X2 - m\sum X}$ and $C = \frac{\Sigma \ -m\sum X}{n}$

By putting these values from the tables below the regression equation for each graph is obtained.

Result and Discussion

Moving average is one of widely known technical indicators used to predict the future data in time series analysis. In the time series analysis, the simplest method is the simple moving average method. The time series analysis by moving average method gives the future trend by analyzing the past data. In this, the data is analyzed by using a simple moving average method in time series analysis by plotting a regression line. Here the moving average of the number of incidents, total death, affected family and injured people with a time interval of 5 years. The data is available from 1971 through the DRR portal, the data set from 1971 to 2013 is from DISINVANTER and from 2013 to 2022 the data is taken from MoHA. In the table below, the year 0 means 1971 to 1975, 1 for 1972 to 1976, 2 for 1973 to 1977 and so on. The moving average is calculated by adding five years data and the result is divided by 5 to get a moving average. In the tables below, the average NOI stands for average number of incidents people have. TD stands for average total death, average AF for the average affected family, average MP for average missing people and average INJ stands for average injured people. Overall, the manuscript utilizes the simple moving average method in time series analysis to analyze and predict the future trends of flood and landslide incidents based on historical data collected from the DRR portal. The tabular representation of moving average values facilitates easy understanding and interpretation of the data for further analysis and decision-making purposes. Here in this manuscript the data is of two disasters flood and landslide only.

Flood

The table 1 shows the different data set for different constraints. Here, the average means the moving average of the parameters within 5 years. In this, there are 5 different parameters under study. They are average NOI, average TD, average MP, average AF, and average INJ stands for average number of incidents, average number of total deaths, average numbers of missing peoples, average numbers of affected family and average number of injured people respectively.

Table 1

Average losses due to flood

Year	Average NOI	Average TD	Average MP	Average AF	Average INJ
0	27.2	29.6	2	6128.4	1.8
1	25.6	22.8	2.6	6146.4	1.6
2	23.6	25.2	2.6	6298	1.6
3	30.2	22.6	2.6	6866.6	2
4	23	11.4	2.4	14056	0.8
5	22.2	10	0.8	13093.8	0.8
6	28.6	35.8	40.2	21397.4	1.8
7	29.2	33	40.6	21308.6	1.8
8	25	40.4	41	19450.4	1.6
9	34.6	70.8	45.8	9607	1.8
10	38.2	76.2	47	9400	3.2
11	31.6	52	7	916.4	2.2
12	32.4	59	6.6	1202.4	2.8
13	37.4	51.6	6.6	1314.6	2.6
14	30.2	24.4	2.8	3276	2.6
15	30.4	27.8	4.2	3541.4	1.2
16	41.2	35.2	4.2	10475.4	1.2
17	37.8	28	4.4	10076.6	0.6
18	80.6	259.6	15	118670	4.4
19	78.2	255.2	14.4	116427	5.2
20	81	249.6	12	238510	9.4

21	76.4	255.2	25	306431.8	11
22	91.4	265.6	24.8	310783.8	12.2
23	63.6	58.2	14.2	295078.4	19
24	76.8	84.2	20.6	301505.6	22.2
25	104	95.2	23	181397.4	20.6
26	136.8	90.4	11	116019.4	23.6
27	206	106.2	18.4	185755.2	46
28	209.4	92.8	22.8	159486.4	38.8
29	228.4	80.4	23	204755.6	35.2
30	199.6	67.4	20.2	204615.8	32.8
31	168.6	68	19.8	195331	29
32	108.6	50.8	17	131863.2	15.6
33	135.2	63.4	17.6	100899.2	15.2
34	134.6	71.8	17.2	52696.4	22.6
35	184	96.2	22.2	77365.4	29.6
36	233.8	108.6	36.8	133145.2	37.2
37	229.8	121.4	35.2	212653.8	28.4
38	196.8	106.4	36.6	187311.8	25.6
39	173.2	108.4	56.6	190898.4	24.4
40	119.8	81.2	52.2	163984.6	18.4
41	106	78.6	44.2	109436.4	13.4
42	152.6	89.6	49.6	22331.4	19
43	145.6	82.6	43.4	11971.2	24
44	173.8	71.4	22.2	5283.4	20.8
45	190.4	79.8	29	5381.2	21.8
46	175.2	72.2	28.6	4012.4	21.2
47	118.6	42.8	23.2	1017.2	17.6

The graph of total number of incidents by the flood is represented by the blue dots. The straight line given in the graph represents predicted line for average number of incidents. The slope of the straight line is high that means the number of incidents due to flood is increasing rapidly. The observed data is increasing and scattered highly in latest years. The regression line for average number of incidents is shown in figure 1.This is the regression equation for average number of incidents, which is Y=5.94+4.12 X.

Figure 1

Regression line for average number of incidents

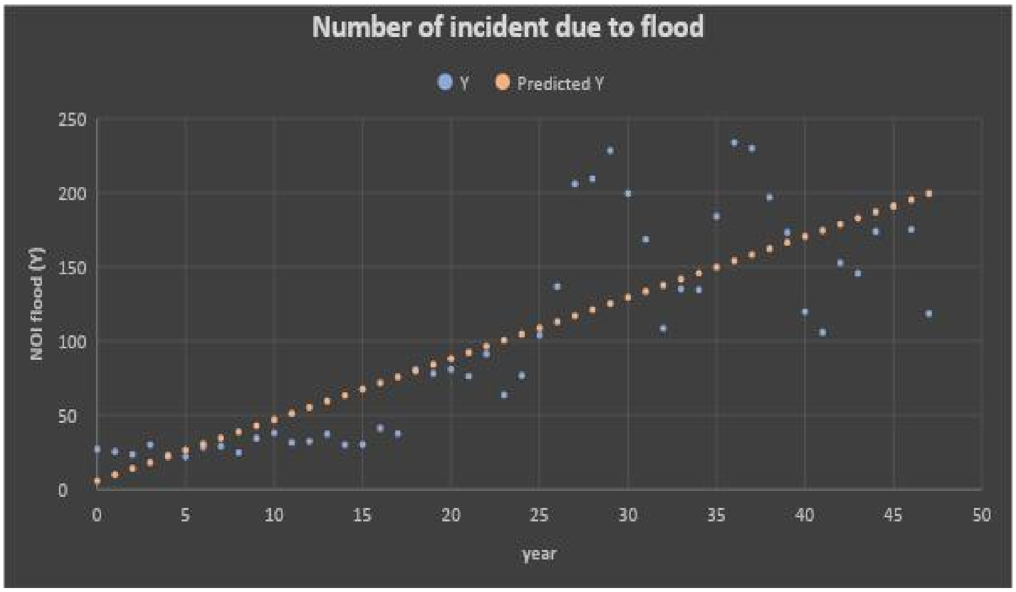


Table 2 represents the deviation in their estimated and the observed number of incident due to flood. The error in estimated and observed data can be calculated from this table.

Table 2

Estimated and predicted number of incidents for flood

Year (X)	Estimated Y=5.94+4.12X	Observed y	e=Y-y	e^2
0	5.94	27.2	-21.26	451.9876
5	26.54	22.2	4.34	18.8356
10	47.14	38.2	8.94	79.9236
15	67.74	30.4	37.34	1394.276
20	88.34	81	7.34	53.8756
25	108.94	104	4.94	24.4036

30	129.54	199.6	-70.06	4908.404
35	150.14	184	-33.86	1146.5
40	170.74	119.8	50.94	2594.884
45	191.34	190.4	0.94	0.8836
Total	986.4	996.8	-10.4	10673.9736

This is the graph of average of total death by the disaster flood from 1971 to 2022 AD. The straight line shown helps to predict future events based on previous trends. The dotted line in Figure 2 indicates the observed number of total deaths, showing that the total deaths due to floods were notably higher in the middle years compared to other years. The regression line for the average number of total deaths is illustrated in the Figure, representing the regression equation for the average of total deaths by flood as $Y=58.71+1.06X$.

Figure 2

Regression line for total death

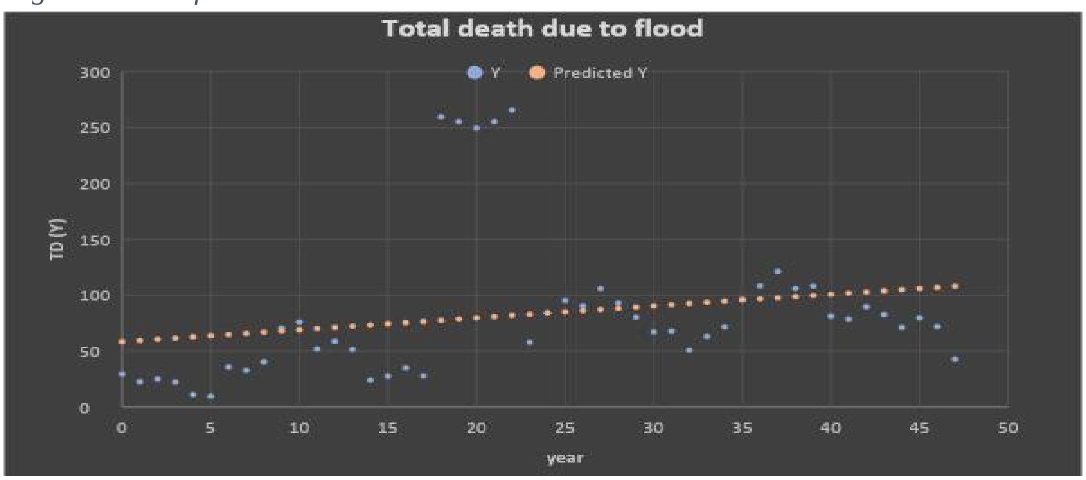


Table 3 represents the deviation between the estimated and observed number of total deaths. From this the error in the estimated and the observed value can be calculated.

Table 3

Estimated and predicted for total death due to flood

year	Y=58.71+1.06X	Observed y	e=Y-y	e^2

0	58.71	29.6	29.11	847.3921
5	64.01	10	54.01	2917.08
10	69.31	76.2	-6.89	47.4721
15	74.61	27.8	46.81	2191.176
20	79.91	249.6	-169.69	28794.7
25	85.21	95.2	-9.99	99.8001
30	90.51	67.4	23.11	534.0721
35	95.81	96.2	-0.39	0.1521
40	101.11	81.2	19.91	396.4081
45	106.41	79.8	26.61	708.0921
Total	825.6	813	12.6	36536.3447

The graph of average number of missing people represented by blue dots and the straight line represents the predicted line for the future events. The given equation below, represents the straight-line which can be used to calculate the future events. And the number of missing peoples due to flood is increasing in latest years as seen from figure 3. This is the regression equation for the average number of missing people by the flood, Y=8.88+0.56 X.

Figure 3

Regression line for missing people

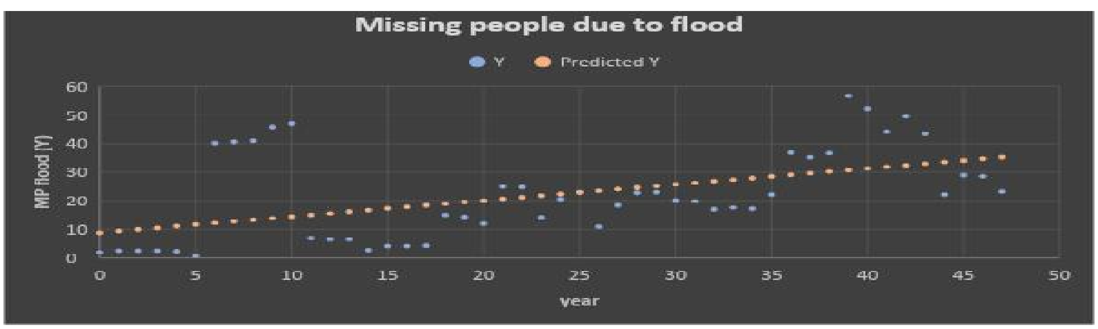


Table 4 gives the deviation of observed and the estimated number of missing peoples since 1971 AD, then the estimated error calculated.

Table 4

Estimated and predicted missing people due to flood

year	Y=8.88+0.56X	Observed y	e = Y - y	e^2
0	8.88	2	6.88	47.3344
5	11.68	0.8	10.88	118.3744
10	14.48	47	-32.52	1057.55
15	17.28	4.2	13.08	171.0864
20	20.08	12	8.08	65.2864
25	22.88	23	-0.12	0.0144
30	25.68	20.2	5.48	30.0304
35	28.48	22.2	6.28	39.4384
40	31.28	52.2	-20.92	437.6464
45	34.08	29	5.08	25.8064
Total	214.8	212.6	2.2	1992.5676

This graph of figure 4 displays the average number of people injured by floods, with the straight line representing the predicted trend based on past data. It is evident that this straight line is rising rapidly, indicating an increasing number of flood-related injuries. The blue dots on the graph show the observed data, which confirms the upward trend in injuries. This suggests that the number of people injured by floods has been increasing since 1971 AD, as shown in Figure 4. The regression equation for the average number of injured people is Y=0.92+0.66X. Table 5 presents the deviation between the estimated and observed numbers of injured people, allowing for the calculation of prediction error.

Figure 4

Regression line for injured people

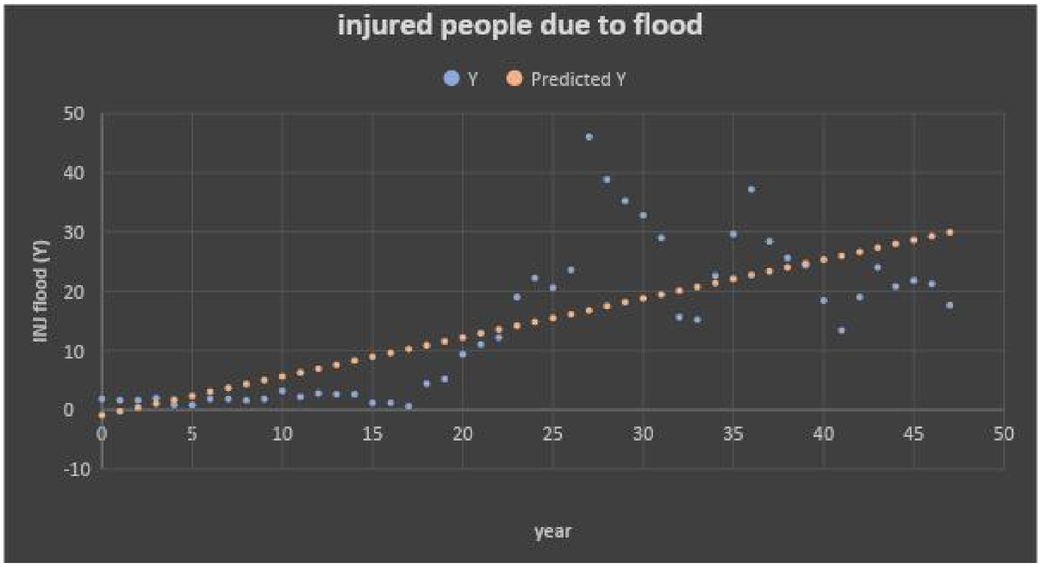


Table 5

\Estimated and predicted injured people due to flood

year	Y=-0.92+0.66X	Observed (y)	e=Y-y	e^2
0	-0.92	1.8	-2.72	7.3984
5	2.38	0.8	1.58	2.4964
10	5.68	3.2	2.48	6.1504
15	8.98	1.2	7.78	60.5284
20	12.28	9.4	2.88	8.2944
25	15.58	20.6	-5.02	25.2004
30	18.88	32.8	-13.92	193.7664
35	22.18	29.6	-7.42	55.0564
40	25.48	18.4	7.08	50.1264
45	28.78	21.8	6.98	48.7204
Total	139.3	139.6	-0.3	457.738

Landslide

Table 6 provides the moving averages for various metrics related to landslides since 1971 AD, including the average number of incidents, total deaths, missing persons, affected families, and injured individuals. In this table, NOI represents the number of incidents, TD stands for total deaths, AF stands for affected families, and INJ stands for the number of injured individuals. The graph depicting the average number of incidents is shown with blue dots, while the straight line indicates the predicted trend. This trend line helps forecast future events. The equation below Figure 5 corresponds to this straight line. The blue dots reflect the observed number of landslide incidents, which are seen to be increasing rapidly, as illustrated in Figure 5. The regression equation for the average number of incidents is $Y=-30.95+5.64X$.

Table 6

Average number of losses due to landslide.

Year	Average of NOI	Average of TD	Average of MP	Average of AF	Average of INJ
	15.8	45.2	5.6	99.2	21
1	18	61.8	10.6	528.6	26.4
2	17.4	54.4	10	928.6	11
3	16.8	57.6	8.2	891.8	9.2
4	15.8	58.6	8.2	1334.2	11.4
5	17.6	71.8	5.8	1775.8	17.6
6	15	49	0.8	1505.4	13.6
7	16.6	78.8	2.2	1279.6	15.4
8	17.6	92.2	4.8	1336.8	16.6
9	21.8	104.2	4.8	1143	18.4
10	21.4	92.2	4.8	842	14
11	21.2	102.4	4.8	965.2	12.8
12	19.4	67.2	2.6	1158.4	11.6
13	20.6	73.8	0	1198	14.2
14	18.6	82	0	1112	17.6
15	19.2	84	4.2	1022.2	18.4
16	23	72.2	4.2	870.2	19.6
17	23.2	72.4	16.2	502.8	20.2
18	49	94.4	19.6	12132	29.4
19	51.2	79.8	21.8	12481.6	27.6
20	59.8	110.8	22.4	24871	34.2
21	68.6	148.4	27	65031.8	47.8
22	73.2	150.2	15	66947.2	49.4
23	59.4	139.8	13.2	63048.2	46
24	70.6	154.6	12.4	66967.4	56.2
25	79.2	140.2	8	56420.2	57.8
26	141.2	151	16.4	19531.2	63.4
27	211.4	234	26	21896.4	84.4
28	216	239.2	33.8	15728	85.4
29	212.8	222.4	34.4	12365	74
30	195.4	202.2	35	10623.2	64.8
31	127	169.2	38	7299.4	45.6
32	66	95.8	29.2	3045.4	33.2
33	94.6	81.8	27	8286.2	40.4
34	103.6	95.2	30.4	11839.2	45.2
35	145.4	119.2	33	16048.2	69.4
36	181.2	125.6	18.2	19564.8	95

37	186.4	119.6	18.4	22401.2	90.8
38	155.6	110.2	14.8	16796	81
39	147	110	35.2	12247.2	90.8
40	113.6	110.2	34.2	7941.6	81.2
41	116.2	112.6	34.8	4644.4	82.6
42	127	115	36.8	1848.2	86.2
43	170.8	112	33.6	693.8	101.2
44	245.6	106.6	10	1206.4	100.6
45	331.8	139.6	20.2	1279.2	129
46	352.4	145.6	24.6	1102.4	127
47	385.2	151.4	25.4	1434	133.4

Figure 5

Regression line for number of incidents

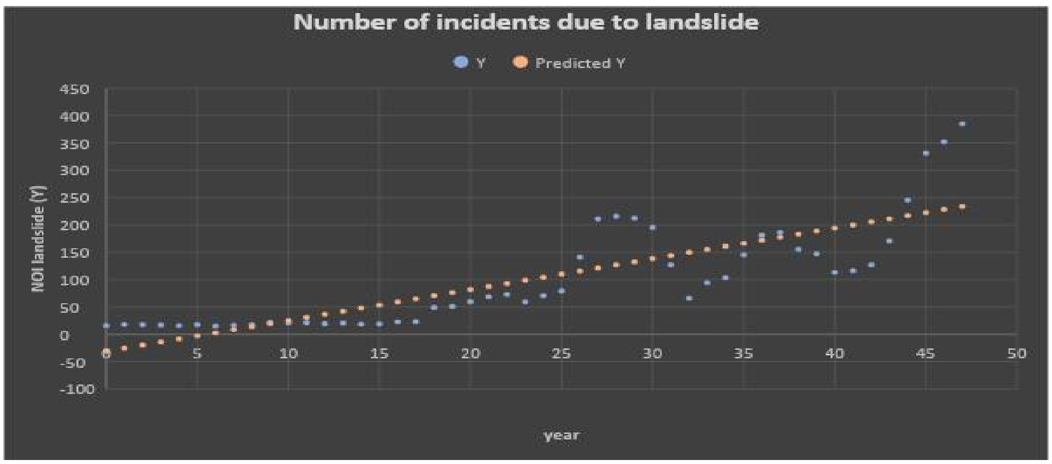


Table 7 is the table for estimated and the observed number of incidents due to landslides. This gives the deviation of estimated and observed data. And the error can be calculated.

Table 7

Estimated and predicted number of incident due to landslide

year	Estimated Y=-30.95+5.64 X	Observed y	e=Y-y	e^2
0	-30.95	15.8	-46.75	2185.563
5	-2.75	17.6	-20.35	414.1225

10	25.45	21.4	4.05	16.4025
15	53.65	19.2	34.45	1186.803
20	81.85	59.8	22.05	486.2025
25	110.05	79.2	30.85	951.7225
30	138.25	195.4	-57.15	3266.123
35	166.45	145.4	21.05	443.1025
40	194.65	113.6	81.05	6569.103
45	222.85	331.8	-108.95	11870.1
Total	959.5	999.2	-39.7	27389.2445

The graph of the average total deaths, represented by blue dots, shows an increase in the middle years followed by a decrease in recent years, as seen in Figure 6. The straight line on the graph is the regression line, which predicts future total deaths due to landslides. The regression equation for average total deaths is Y=71.68+1.74X, which can be used to forecast future fatalities from landslides. Table 8 shows the deviation between the estimated and observed number of total deaths due to landslides, and can also be used to calculate prediction errors.

Figure 6

Regression line for total death

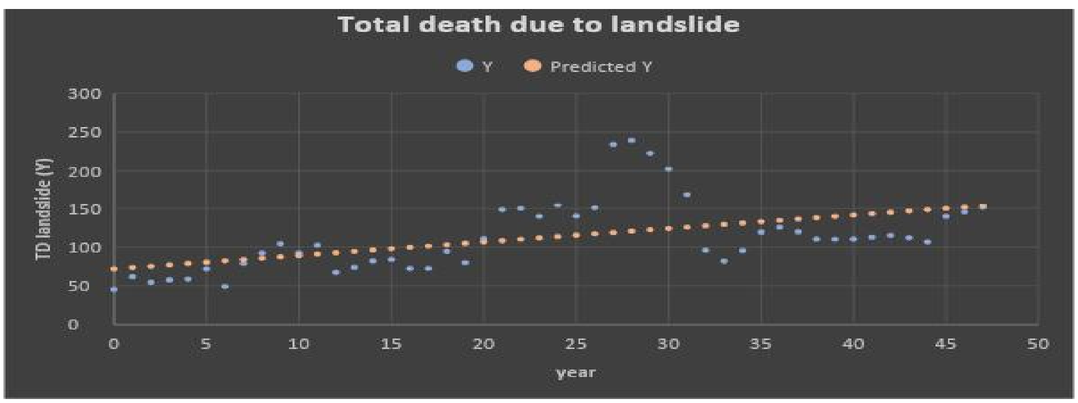


Table 8

Estimated and predicted total death due to landslide

year	estimated Y=71.68+1.74 X	Observed y	e=Y-y	e^2

0	71.68	45.2	26.48	701.1904
5	80.38	71.8	8.58	73.6164
10	89.08	92.2	-3.12	9.7344
15	97.78	84	13.78	189.8884
20	106.48	110.8	-4.32	18.6624
25	115.18	140.2	-25.02	626.0004
30	123.88	202.2	-78.32	6134.022
35	132.58	119.2	13.38	179.0244
40	141.28	110.2	31.08	965.9664
45	149.98	139.6	10.38	107.7444
Total	1108.3	1115.4	-7.1	9005.8496

The graph represented by the blue dots shows the average number of people missing due to landslides. The straight line is the predicted trend line, which forecasts future events. The high scatter of the blue dots indicates significant year-to-year variation in the number of missing people. In the early years, the number of missing people was low, but it has been increasing in recent years, as clearly shown in Figure 7. The regression equation for the average number of missing people is Y=2.79+0.63X.

Figure 7

Regression line for missing people

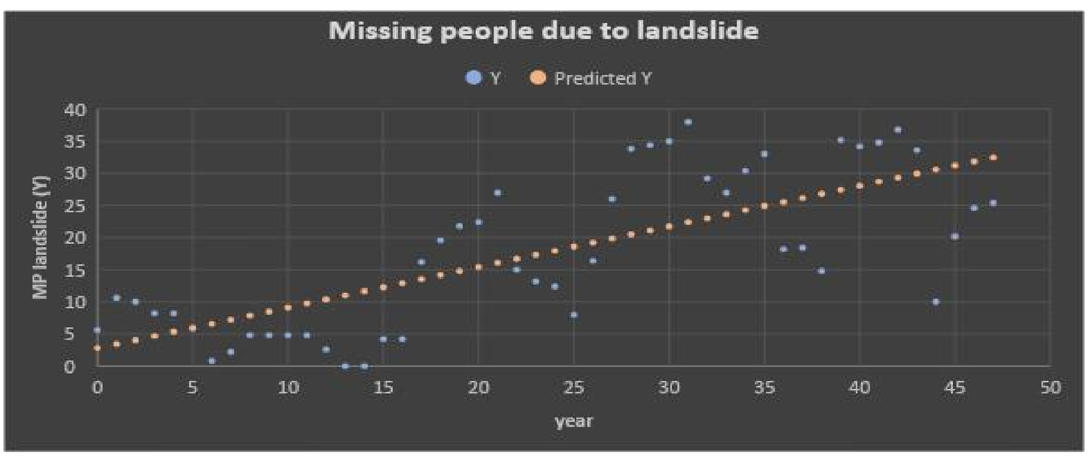


Table 9 is the table for the estimated and observed numbers of missing people due to landslides. The table 9 shows the deviation of estimated and the observed data. From this table the error can be calculated.

Table 9

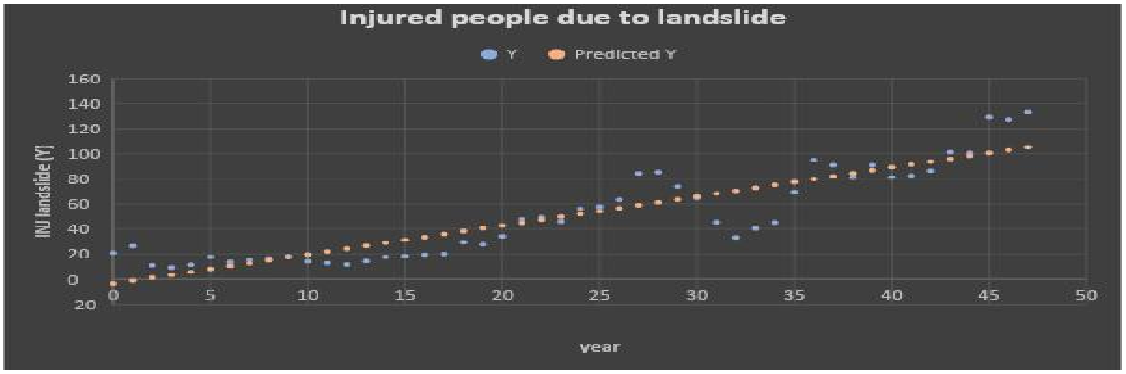
Estimated and predicted missing people due to landslide

year	estimated Y=2.79+0.63X	Observed y	e=Y-y	e^2
0	2.79	5.6	-2.81	7.8961
5	5.94	5.8	0.14	0.0196
10	9.09	4.8	4.29	18.4041
15	12.24	4.2	8.04	64.6416
20	15.39	22.4	-7.01	49.1401
25	18.54	8	10.54	111.0916
30	21.69	35	-13.31	177.1561
35	24.84	33	-8.16	66.5856
40	27.99	34.2	-6.21	38.5641
45	31.14	20.2	10.94	119.6836
Total	169.65	173.2	-3.55	653.1825

The graph of average number of injured people is represented by the blue dots and the straight line is the predicted line for future event drawn by the study of past events. The straight line helps to predict the future event is shown in the figure 8 below. The regression equation for number of injured people is, Y=-3.48+2.31 X.

Figure 8:

Regression line for injured people



The table 10 shows the deviation of estimated and observed number of injured peoples due to landslide. This can be used to calculate the error.

Table 10

Estimated and predicted injured people due to landslide

year	Estimated Y=-3.48+2.31X	Observed y	e=Y-y	e^2
0	-3.48	21	-24.48	599.2704
5	8.07	17.6	-9.53	90.8209
10	19.62	14	5.62	31.5844
15	31.17	18.4	12.77	163.0729
20	42.72	34.2	8.52	72.5904
25	54.27	57.8	-3.53	12.4609
30	65.82	64.8	1.02	1.0404
35	77.37	69.4	7.97	63.5209
40	88.92	81.2	7.72	59.5984
45	100.47	129	-28.53	813.9609
Total	484.95	507.4	-22.45	1907.9205

Conclusion

As the data indicates, the effects and losses due to disasters are increasing. According to the graphs, the impacts of disasters were less in previous years compared to recent years, possibly due to a lack of information about disaster effects. This analysis shows an upward trend in each case, though the number of families affected by landslides appears to remain constant. In the past, there was limited information available about these disasters, and fewer incidents were recorded compared to recent years. For both floods and landslides, equations have been developed to predict future losses from these disasters. These equations enable forecasts of the number of flood and landslide incidents and their impacts. By understanding these effects, it is possible to protect people and property from disasters. While the losses from natural disasters cannot be completely eliminated, they can be reduced by disseminating information about flood- and landslide-prone areas. Vulnerable zones can be categorized, and the public can be made aware of these risks.

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References

1. Information and Broadcasting Department, Nepal Government. (2022). *Nepal parichaya* (p. 1). http://www.doinepal.gov.np.
2. Adhikari, P. B. (2021). Death and injury of the people due to lightning in the Himalayan region, Nepal. *BIBECHANA*, 18(2), 116-128. https://doi.org/10.3126/bibechana.v18i2.29168.
3. Bhandari, D., Neupane, S., Hayes, P., Regmi, B., & Marker, P. (2020). *Disaster risk reduction and management in Nepal: Delineation of roles and responsibilities*. Oxford Policy Management Limited.
4. Tavares da Costa, R., &Krausmann, E. (2021). *Impacts of natural hazards and climate change on EU security and defence* (EUR 30839 EN). Publications Office of the European Union. https://doi.org/10.2760/244397.
5. Salvati, P., Bianchi, C., Rossi, M., & Guzzetti, F. (2010). Societal landslide and flood risk in Italy. *Natural Hazards and Earth System Sciences, 10*(1), 465-483. https://doi.org/10.5194/nhess-10-465-2010.

6. K.C., S. (2013). Community vulnerability to floods and landslides in Nepal. *Ecology and Society*, *18*(1). http://www.jstor.org/stable/26269258.
7. Gaire, S., Castro Delgado, R., & Arcos González, P. (2015). Disaster risk profile and existing legal framework of Nepal: Floods and landslides. *Risk Management and Healthcare Policy*, *8*, 139-149. https://doi.org/10.2147/RMHP.S90238.
8. Paudel, P. P., Omura, H., Kubota, T., & Morita, K. (2003). Landslide damage and disaster management system in Nepal. *Disaster Prevention and Management*, *12*(5), 413-419. https://doi.org/10.1108/09653560310507235.
9. Sudmeier-Rieux, K., et al. (2012). Climate change modeling for local adaptation in the Hindu Kush-Himalayas region community. *Emerald Group Publishing Limited*, *11*, 119-140. https://doi.org/10.1108/S2040-7262(2012)0000011013.
10. Rajabi, N., Rajabi, K., &Rajabi, F. (2023). Forecasting and management of disaster triggered by climate change. *ResearchGate*, *TechnischeUniversitat Dortmund*, 181-207. https://www.researchgate.net/publication/365584040_Forecasting_and_management_of_disasters_triggered_by_climate_change.
11. Majid, M. A., et al. (2021). River-flood forecasting methods: The context of the Kelantan River in Malaysia. *IOP Publishing Ltd*, *School of Mathematical Sciences*, *FST*, *UniversitiKebangsaan Malaysia*, *Dept. of Mathematics & Statistics*, *KFUPM*, Dhahran, Saudi Arabia. https://doi.org/10.1088/1755-1315/880/1/012021.
12. Jajarmizadeh, M., et al. (2016). Flood forecasting via time lag forward network; Kelantan, Malaysia. *IOP Publishing Ltd*, *Center for Sustainable Technology and Environment*, *College of Engineering*, *Universiti Tenaga Nasional*, *Jalan IKRAM-UNITEN*, *43000 Kajang*, *Selangor*, *Malaysia*, *32*(1). https://doi.org/10.1088/1755-1315/32/1/012043.
13. Rözer, V., Peche, A., Berkhahn, S., Feng, Y., Fuchs, L., Graf, T., et al. (2021). Impact-based forecasting for pluvial floods. *Earth's Future*, *9*, e2020EF001851. https://doi.org/10.1029/2020EF001851.
14. Rözer, V., Kreibich, H., Schröter, K., Müller, M., Sairam, N., Doss-Gollin, J., et al. (2019). Probabilistic models significantly reduce uncertainty in Hurricane Harvey pluvial flood loss estimates. *Earth's Future*, *7*, 384-394. https://doi.org/10.1029/2018EF001074.

15. Rözer, V., Müller, M., Bubeck, P., Kienzler, S., Thieken, A., Pech, I., et al. (2016). Coping with pluvial floods by private households. *Water, 8*(7), 304. https://doi.org/10.3390/w8070304.
16. Thattai, D. V., Sathyanathan, R., Dinesh, R., & Kumar, L. H. (2017). Natural disaster management in India with focus on floods and cyclones. *IOP Science, Department of Civil Engineering, SRM University, Chennai - 603203. India, 80*(1), 012054. https://doi.org/10.1088/1755-1315/80/1/012054.
17. Haque, A. N. (2021). Climate risk responses and the urban poor in the global south: The case of Dhaka's flood risk in the low-income settlements. *International Journal of Disaster Risk Reduction, 64*(4), 102534. https://doi.org/10.1016/j.ijdrr.2021.102534.
18. Salvati, P., Bianchi, C., Rossi, M., & Guzzetti, F. (2010). Societal landslide and flood risk in Italy. *Natural Hazards and Earth System Sciences, 10*(1), 465-483. https://doi.org/10.5194/nhess-10-465-2010.
19. Trezzini, F., Giannella, G., &Guida, T. (2013). Landslide and flood: Economic and social impacts in Italy. In C. Margottini, P. Canuti, & K. Sassa (Eds.), *Landslide science and practice* (pp. 303-318). Springer. https://doi.org/10.1007/978-3-642-31313-4_22.
20. Guzzetti, F., Stark, C. P., &Salvati, P. (2005). Evaluation of flood and landslide risk to the population of Italy. *Environmental Management, 36*, 15-36. https://doi.org/10.1007/s00267-003-0257-1.
21. Paudel, P. P., Omura, H., Kubota, T., & Morita, K. (2003). Landslide damage and disaster management system in Nepal. *Disaster Prevention and Management, 12*(5), 413-419. https://doi.org/10.1108/09653560310507235.