

## Seasonal variations of disasters in Nepal

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### Abstract

*Among natural disasters, landslides, floods, thunderstorms, and fires are major destructive disasters. Fires, which frequently occur in the spring and winter seasons, are the main cause of death for people in every season. Landslides seem to be very destructive in the summer season, floods also occur in the summer season, and thunderbolts frequently occur in the spring and summer seasons (pre-monsoon period). Different disasters occur frequently in different seasons and have a significant effect on humans, and animals, and result in huge property loss. Due to the geographical structure of our scenario, the destruction seems to be high in Nepal. Hence, the disasters cannot be stopped, but their impact can be reduced. Awareness programs should be conducted to mitigate their effects.*

### Keywords

Different disasters; seasonal variations; effects of disaster; awareness program.

### Article information

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## 1 Introduction

Nepal is situated at 28.3949 degrees north and 84.1240 degrees east. It has an area of 147,181 square kilometers and an average width of approximately 193 kilometers with a length of 885 kilometers. It is a landlocked country, comprising only 0.3 percent of Asia's total area. Due to its geographical structure, Nepal experiences many disasters, which can be classified into two main types: natural and manmade [1]. Nepal has vast geographical variability, ranging from low-lying areas of 59 meters to the highest peak of Mount Everest at 8,848.86 meters,

within an average range of 160 kilometers. The climate and severe weather conditions vary due to the difference in altitude and temperature across the country's geographical structure. For example, the temperature in the Terai region can reach up to 42 degrees Celsius, while at the top of Mount Everest, it can drop to as low as minus 55 degrees Celsius. This unique behavior of variability of temperature and geographical structure leads to the occurrence of various disasters [2]. Most of Nepal's cities are situated along riverbanks, and the country can be divided into three main regions: the Himalayas, hilly region, and Terai region. In the Terai region,

major disasters include floods, fires, thunderbolts, droughts, hailstorms, animal incidents, and snake bites. In the hilly region, major disasters include landslides, fires, floods, thunderbolts, hailstorms, etc., and in the Himalayan region, the main disasters are avalanches, landslides, thunderbolts, and snowstorms [3]. Earthquakes are a common natural disaster in Nepal, as the country is located between two tectonic plates - the Indian section of the Indo-Australian Plate and the Eurasian Plate. Nepal is considered the 11th most seismically-prone country in the world. The most recent devastating earthquake occurred in 2015, which resulted in a significant loss of life and property [4,5].

There are eight mountains whose heights are more than 8000 meters: Mount Everest, Kanchenjunga, Lhotse, Makalu, Cho Oyu, Dhaulagiri, Manaslu, and Annapurna. Besides the three main rivers, Karnali, Koshi, and Gandaki, several other rivers cause floods in different regions of Nepal [6,7]. The primary causes of disasters are unplanned urbanization, climate change, and variation in geography. In the Himalayan region, avalanches cause the most destruction, resulting in several losses such as loss of lives and property. In the Terai region, floods and fires cause the most destruction [7,8]. The main cause of snow melting is global warming, which results in glacial lakes swelling and consequently bursting. Many glacial lakes have burst, and as the snow melts, the area of the glacial lakes increases, resulting in the burst of lakes that cause the loss of human lives and property. Global warming has increased the area of Tsho-Rolpa glacial lake from around 0.23 square kilometers to 1.7 square kilometers [9]. The complex geological structure also plays an important role in landslides in Nepal. The weak rock and soil covering steep and hilly regions cause landslides. Several flash floods have occurred due to the complex geology. On June 15, 2021, the flash flood from Melamchi and Indrawati rivers caused huge destruction in Melamchi Bazaar, which made a huge impact on the Melamchi water supply project too [10].

Similarly, other disasters such as fires, thunderbolts, epidemics, animal attacks, snake bites, hailstorms, droughts, etc., have also occurred in various parts of the country due to its complex geological and geographical structure. Nepal is known as a natural hazard hotspot, experiencing frequent occurrences of natural disasters. This paper aims to explore the most frequently occurring disasters in Nepal during each of the four seasons and propose strategies to control these major incidents that cause significant destruction. Providing advance information about upcoming disasters like floods and landslides in endangered cities or villages can help minimize destruction. Additionally, conduct-

ing awareness programs for the general population regarding disasters like fires, thunderbolts, and hailstorms can also contribute to reducing destruction. Through an awareness campaign and timely information about impending disasters in high-risk areas, the loss of human lives, animals, and property can be mitigated.

## 2 Methodology

The data source is the DRR portal/MoHA (<http://drportal.gov.np/>). Many papers have been published that describe the annual destruction caused by specific disasters. However, this paper explains which disasters cause more destruction in different seasons and how they can be controlled. The paper includes the major four disasters: fire, landslide, thunderbolt, and flood, which seem to cause more destruction. The data for these four disasters in different years was noted, and the number of incidents, total deaths, and the number of injured people were taken from the DRR portal/MoHA. However, the data may not include full information because of the lack of information about all incidents. The annual data for different disasters from 2011 to 2022 AD was taken, and the number of incidents, deaths, and injuries due to the different disasters in different seasons (winter- S1, spring- S2, summer- S3, and autumn- S4) was observed, noted, and analyzed. Bar diagrams for different disasters during this time period were plotted, both annually and seasonally, and analyzed using the Microsoft Excel 2016 tool. The compiled file was created using Microsoft Word 2016.

## 3 Results and Discussion

### 3.1 Flood

Nepal is vulnerable to disasters, including various natural and man-made hazards. In this study, we focus on interpreting the data related to the destruction caused by natural disasters, such as human deaths, the number of injured people, loss of wealth and property, and more. The disaster data is collected both annually and seasonally, covering the period from 2011 to 2022 AD. The collected data includes the number of incidents, total deaths, injured people, affected families, estimated losses, missing people, fully damaged private houses, and partially damaged private houses. Table 1 presents the data related to the impacts of floods, Table 2 focuses on landslides, Table 3 presents data on thunderbolt incidents, and Table 4 provides information on fire-related incidents. Each table is organized separately to present the specific data observed and the impacts caused by these disasters.

Table 1: Incident, deaths, injuries, and damages due to flood in Nepal annually

Years	No. of incidents	Total deaths	No. of injured	No. of affected families	Estimated loss (lakhs)	No. of missing people	Private houses fully damaged	Private houses partially damaged
2011	259	126	19	400	5121.00	93	723	448
2012	45	9	3	139	213.76	7	139	309
2013	266	131	5	892	203.27	133	263	108
2014	65	129	36	36514	149176.14	133	8622	24447
2015	15	0	6	23	165.85	3	14	4
2016	230	101	17	7123	307.12	36	583	180
2017	338	166	35	15118	264.14	42	264	13886
2018	80	17	26	1078	345.31	3	22	538
2019	206	73	20	3075	10634.95	27	452	1907
2020	98	42	11	512	494.11	37	166	48
2021	154	63	14	279	1153.92	34	481	172
2022	55	19	17	142	145.88	15	58	13
Total	1811	876	209	65295	168225.48	563563	11787	42060

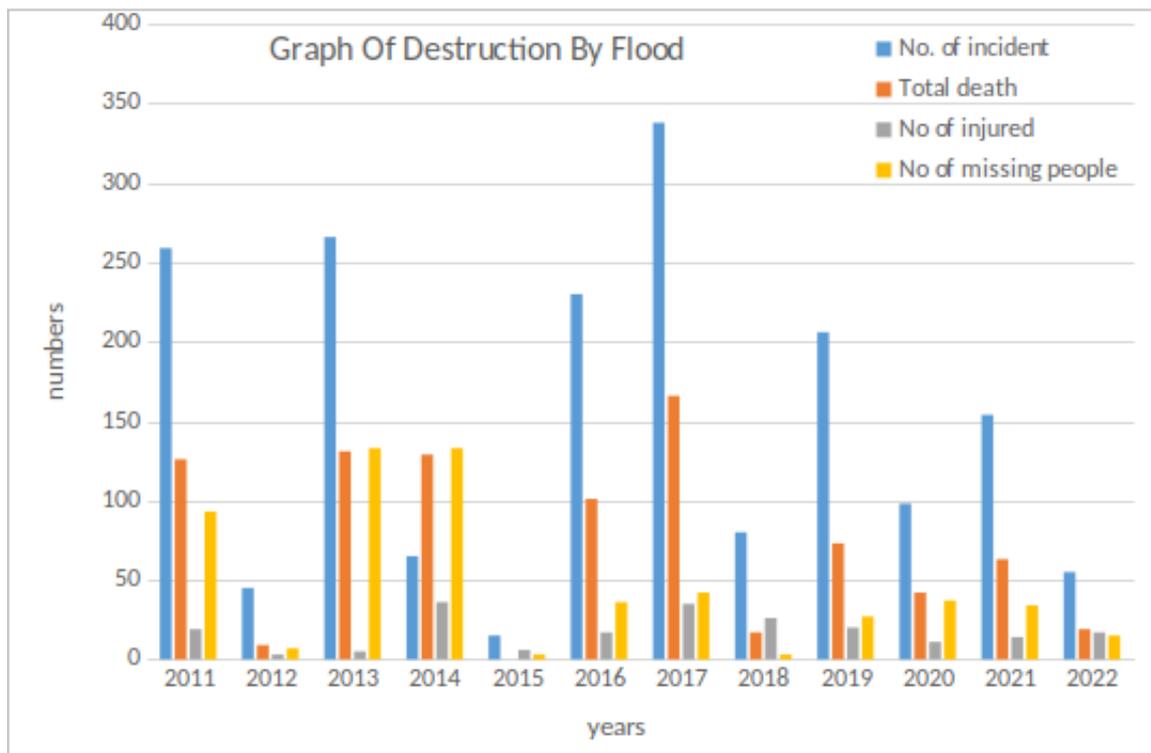


Figure 1: Graph of disaster due to flood in Nepal.

From Table 1, it is evident that between 2011 and 2022 AD, there were 1811 flood-related incidents, resulting in 876 deaths and 209 injuries. Additionally, 65295 families were affected, 563 people were reported missing, 11787 private houses were fully damaged, and 42060 private houses were partially damaged, leading to a loss of approximately Rs. 168225.48 lakhs, as reported by MoHA. The complete data from the source is presented in Table 1. The above data has been represented in the form

of a bar diagram. In Figure 1, the graph represents only four parameters: the number of incidents, the total number of deaths, the number of injured, and the number of missing individuals. The estimated loss and the number of private houses fully and partially damaged have been excluded from the figure as their presence may not be well-analyzed due to the high variability in the data numbers.

The graph in Figure 1 depicts the number of incidents, total deaths, injured individuals, and

missing persons. It is evident that the number of incidents remains consistently high throughout the years, while the number of missing individuals remains relatively low. Notably, the destruction caused by the flood was comparatively less in 2015 compared to other years. In 2014, there was a high number of affected families, partially damaged private houses, and a significant increase in total deaths compared to other years. However, in 2015, the overall destruction caused by the flood appears to be reduced. This can be attributed to the occurrence of an earthquake that year, which affected a large number of people. As a result, people were more aware of the potential destruction caused by natural disasters, leading to a decreased impact of the flood. It is worth mentioning that in 2014, a loss of approximately Rs. 149176.14 lakhs was incurred due to the flood.

### 3.2 Landslide

According to the data from the DRR portal, the table below presents information on disasters. Between 2011 and 2022, nearly 2785 landslide incidents occurred, resulting in 1483 deaths, 1218 injuries, 10161 affected families, 347 missing persons, 3890 fully damaged private houses, 3655 partially damaged private houses, and a loss of approximately Rs. 18407.78 lakhs. The estimated loss is quite high. Table 2 shows that the maximum loss

due to landslides occurred in 2016, with approximately Rs. 8104.42 lakhs lost.

In Figure 2, the graph shows the number of incidents, total deaths, number of injuries, and number of missing people due to landslides. The parameters for estimated loss, partially and fully damaged private houses, and the number of affected families were not included due to high variability in data numbers, making it difficult to analyze them in the figure. Figure 2 demonstrates the variability in the number of incidents, total deaths, number of injuries, and number of missing people. The number of incidents is high compared to the number of injured people, total deaths, and missing people. In 2020, the number of incidents is high with a high number of deaths. It seems that the number of incidents has been increasing since 2018 compared to previous years.

### 3.3 Thunderbolt

In the DRR portal, the information regarding missing persons and the destruction of private houses is not mentioned. Therefore, Table 3 only includes four parameters: the number of incidents, total number of deaths, number of injured people, and estimated loss. According to the available data, a total of 2666 incidents occurred, resulting in 1137 deaths. Additionally, 3073 people were injured, and 2784 families were affected.

Table 2: Incidents, deaths, and injuries due to landslide in Nepal

Years	No. of incidents	Total deaths	No. of injured	No. of affected families	Estimated loss (lakhs)	No. of missing people	Private houses fully damaged	Private houses partially damaged
2011	126	110	81	32	457.27	24	100	6
2012	102	60	33	65	205.98	8	65	74
2013	97	87	57	174	1691.27	22	135	60
2014	75	113	96	491	236.66	129	143	37
2015	62	138	84	407	6.42	13	121	96
2016	234	148	144	1488	8104.42	9	358	440
2017	163	70	56	334	615.42	15	140	40
2018	320	91	126	749	1301.19	2	188	109
2019	449	86	93	3054	4051.86	11	1132	1590
2020	493	303	226	771	509.65	64	383	68
2021	337	178	134	604	346.35	31	261	118
2022	327	99	88	1992	881.29	19	864	1017
Total	2785	1483	1218	10161	18407.78	347	3890	3655

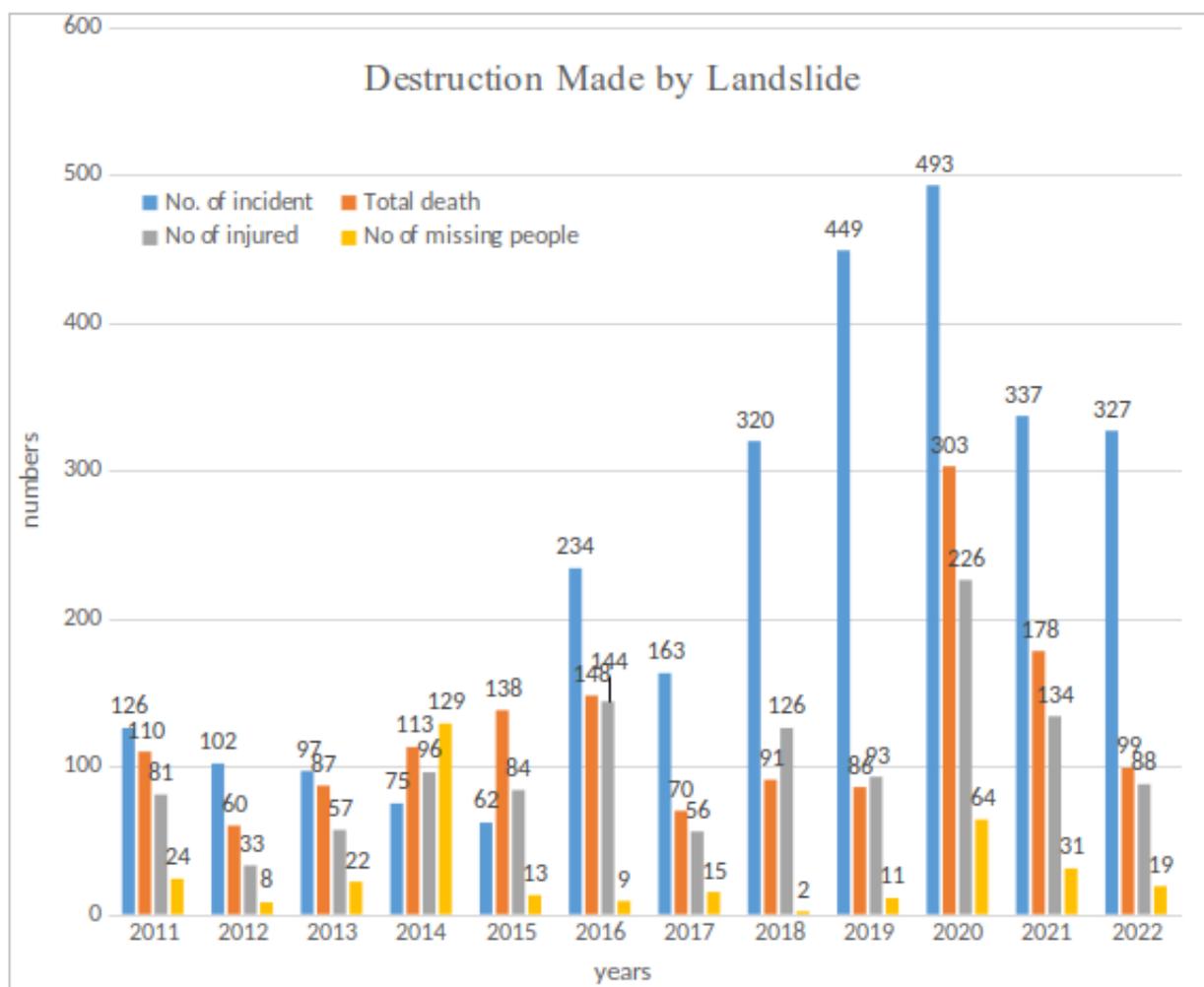


Figure 2: Graph of destruction due to landslide.

Table 3: Incidents, deaths, and injuries due to thunderbolt in Nepal

Years	No. of incidents	Total deaths	No. of injured people	Estimated loss (lakhs)
2011	120	76	138	35.30
2012	210	118	267	40.70
2013	213	147	286	28.12
2014	177	97	227	104.46
2015	148	103	187	10.00
2016	206	118	240	33.21
2017	188	85	251	91.25
2018	244	75	300	55.62
2019	383	94	451	122.08
2020	305	82	310	91.58
2021	208	55	193	177.78
2022	264	87	223	87.69
Total	2666	1137	3073	877.79

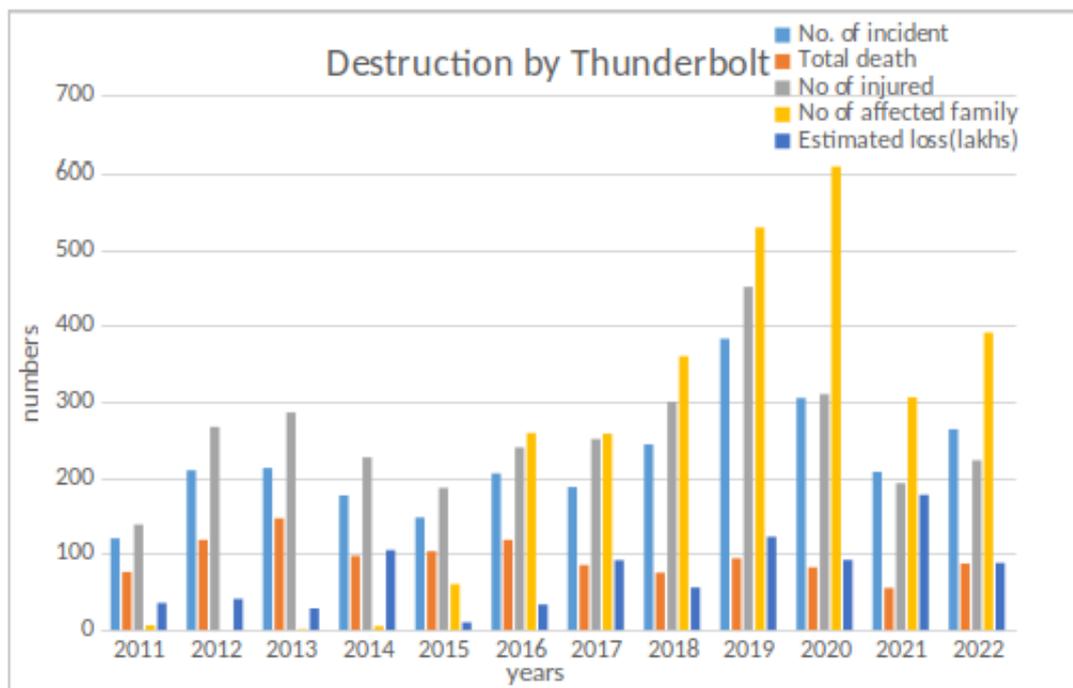


Figure 3: Graph of disaster due to thunderbolt in Nepal.

The table displays the average number of destruction caused by thunderbolts each year, along with the estimated loss of approximately Rs 877.79 lakhs during this time period. It is noteworthy that thunderbolts did not result in any missing individuals or fully or partially damaged private houses. From Figure 3, it can be observed that the number of affected families was highest in the years 2019 and 2020, coinciding with a high number of incidents. The graph indicates that as the number of incidents increases, the number of injuries and deaths also tend to rise. Additionally, there is a consistent trend of significant destruction caused by thunderbolts on average. However, the estimated loss attributed to thunderbolts is comparatively lower than that of landslides, floods, and fires.

### 3.4 Fire

The data presented in this analysis is derived from the DRR PROTAL/MOHA and covers the period from 2011 to 2022 AD. During this time frame, a total of 19,921 fire incidents were recorded, resulting

in 850 fatalities and affecting 27,073 families. The highest estimated loss due to fire occurred in 2015, amounting to approximately Rs 40,573.93 lakhs. Although the number of missing individuals and government house destruction were also recorded, they are not included in the analysis due to their relatively low occurrence.

In Figure 4, it can be observed that the number of incidents and the number of affected families were high in the interval from 2011 to 2017 AD. However, in the year 2018, the destruction decreased, but the number of private houses fully damaged by this disaster has been continuously increasing from the interval of 2018 to 2021 AD. The destruction seems to be less in the year 2022 AD. The total human loss and incidents caused by different disasters were mentioned annually in the above tables individually, and they are also presented in bar diagrams. Throughout the period from 2011 to 2022, the total loss due to fire is represented in Table 5 and shown in a bar diagram in Figure 5. In comparison to other disasters, the maximum number of incidents occurred due to fire.

Table 4: Incidents, deaths, and injuries due to fire in Nepal

Years	No. of incidents	Total deaths	No. of injured	No. of affected families	Estimated loss (lakhs)	Private houses fully damaged	Private houses partially damaged
2011	2595	106	369	3022	25775.42	844	723
2012	2693	99	362	3424	22308.66	1038	834
2013	2115	56	313	2679	15524.39	880	526
2014	2852	78	345	3777	30652.52	1623	333
2015	2459	85	336	3600	40573.93	1853	287
2016	1486	63	216	2392	22942.09	1374	258
2017	1521	63	244	3460	19240.96	2276	440
2018	623	74	67	309	9200.97	664	166
2019	950	65	98	194	16795.08	1254	171
2020	1018	59	108	1554	18540.73	1958	149
2021	1118	77	133	2512	12075.28	3785	223
2022	491	25	67	150	3980.04	574	189
Total	19921	850	2658	27073	237610.03	18123	4299

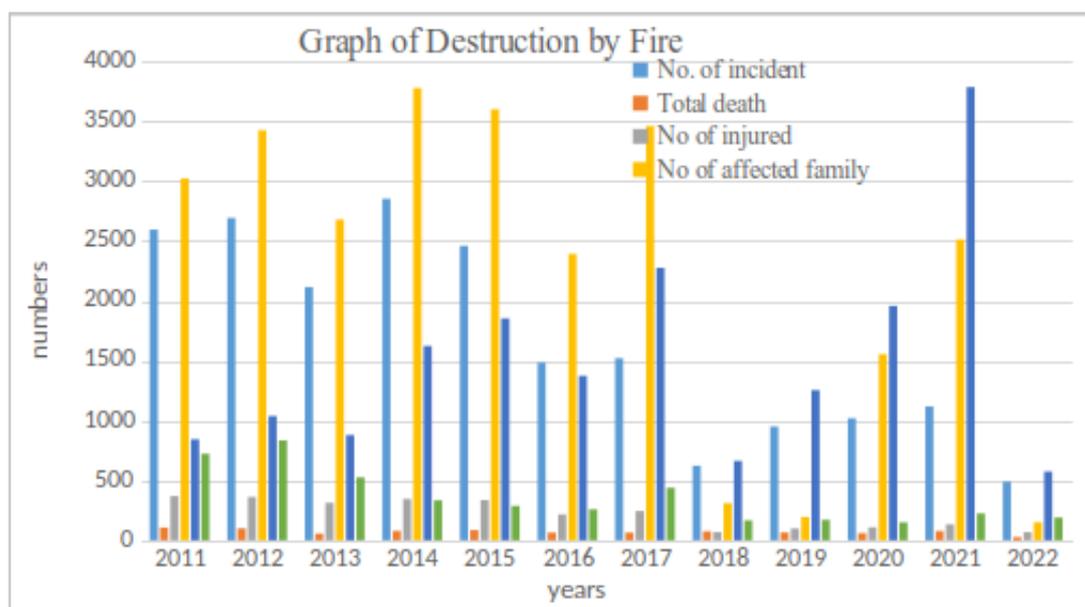


Figure 4: Graph of human and property loss due to fire.

**Number of incidents, human loss due to flood, landslide, thunderbolt and fire**

In Table 5, the number of incidents, total deaths, and number of injured people are recorded. Other parameters were not included due to their higher variability, which would make it difficult to interpret in a bar diagram and analyze. From Table 5, it can be seen that the maximum number of incidents, 19,921, occurred due to fire, followed by landslide, thunderbolt, and flood. The highest number of fatalities was caused by landslides, followed by thunderbolt, flood, and fire. Additionally, a significant number of people lost their lives due to

other disasters, totaling 10,196, which includes the 2015 earthquake. During the earthquake, approximately 9,000 lives were lost, and there was extensive damage and destruction of property.

From Figure 5, it is evident that the highest number of people were injured by thunderbolts during this time interval, followed by injuries caused by fire, landslides, and floods. Among the different disasters, floods affected the maximum number of families, surpassing the impact of other disasters. More than half of the total affected families were affected by floods. Regarding the damage to private houses, the earthquake caused the most significant destruction during this period. In 2015 alone,

more than 700,000 private houses were fully damaged and over 200,000 private houses were partially damaged. The next disaster resulting in significant house destruction is flood. In terms of estimated

losses, fire caused the highest financial impact, followed by flood, earthquake, landslide, and thunderbolt.

Table 5: Variation of disasters to human loss and number of incidents during the period 2011-2022

Disasters	Number of incidents	Number of deaths	Number of injured people
Flood	1811	876	209
Landslide	2785	1483	1218
Thunderbolt	2666	1137	3073
Fire	19921	850	2658
Other disasters	4823	10196	28158
Total	32006	14542	35316

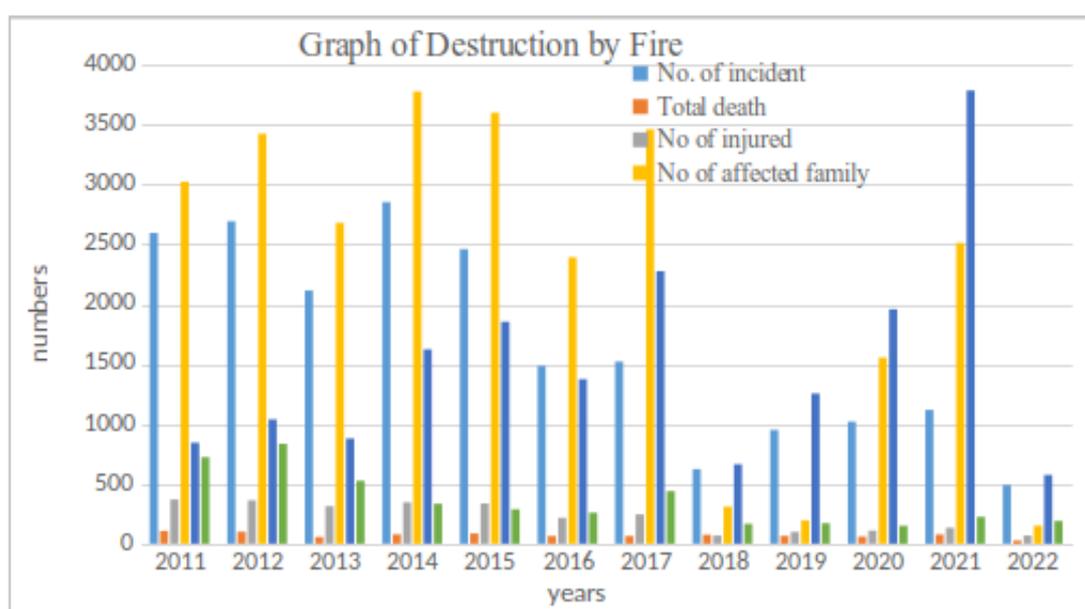


Figure 5: Variation of disasters to incidents, human loss and injuries in twelve years.

**The human loss and incidents by different disasters in different seasons**

The different seasons, winter represented by S1, spring by S2, summer by S3, and autumn by S4, are presented here. Winter includes December, January, and February; spring includes March, April, and May; summer includes June, July, and August; and autumn includes September, October, and November. The four main disasters in Nepal, which account for more than half of the total incidents, are very dangerous in different seasons and can claim lives and cause injuries. These are presented in table 6, and their representations in bar diagrams of different seasons and disasters are given in figure 6, with the different disasters in different seasons shown in figure 7. From figure 6, it can be seen clearly that the most number of incidents

were caused by fire in the winter and spring seasons. The maximum number of incidents occurred in spring (7223) and winter (6737), and the minimum in summer (2623) during the mentioned period. Hence, awareness programs should be conducted during the winter and spring seasons about fire, and people should be made familiar with its harmful effects. Similarly, during spring (1155) and summer (932), incidents occur due to thunderbolt, and awareness programs should be conducted during the pre-monsoon period. The landslide is most dangerous in summer among the four seasons, in which the maximum number of incidents and people were killed. In the summer season, the highest number of flood incidents were observed from the above figures, with 1408 incidents, 686 people losing their lives, and 176 people being injured.

Among the 32006 incidents of disasters, around

87 percent were caused by the four main disasters: landslides, floods, fires, and thunderbolts. These four disasters caused about 80 percent of the total deaths, which amounts to 4370 people, whereas the earthquake in 2015 caused around 9000 deaths. Although the main disasters caused the maximum number of incidents, the number of human losses is comparatively lower than the earthquake. Fire

caused the highest number of incidents, while flood and landslide caused comparatively fewer incidents. The table 5 shows that the number of injuries incurred in thunderbolts is about three times higher than the number of deaths, and similarly, the number of injuries in fires is more than three times higher than the number of deaths.

Table 6: Seasonal Variation of Disasters during the period 2011-2022.  
(A) Seasons in different Disaster

Disasters	Seasons	Number of incidents	Number of deaths	Number of injured
Flood	Winter	2	123	1408
	Spring	1	29	686
	Summer	0	14	176
	Autumn	0	0	0
Landslide	Winter	39	15	21
	Spring	107	66	57
	Summer	2066	1006	844
	Autumn	558	392	293
Thunderbolt	Winter	205	65	268
	Spring	1155	455	1472
	Summer	932	447	916
	Autumn	359	159	351
Fire	Winter	6737	433	1027
	Spring	7223	264	723
	Summer	2623	61	418
	Autumn	4000	133	602
Total		27803	4370	7208

(B) Disasters in Different Season

Seasons	Disasters	Number of incidents	Number of death	Number of injured
Winter (S1)	Flood	2	1	0
	Landslide	39	15	21
	Thunderbolt	205	65	268
	Fire	6737	433	1027
Spring (S2)	Flood	123	29	14
	Landslide	107	66	57
	Thunderbolt	1155	455	1472
	Fire	7223	264	723
Summer (S3)	Flood	1408	686	176
	Landslide	2066	1006	844
	Thunderbolt	932	447	916
	Fire	2623	61	418
Autumn (S4)	Flood	266	158	26
	Landslide	558	392	293
	Thunderbolt	359	159	251
	Fire	4000	133	602

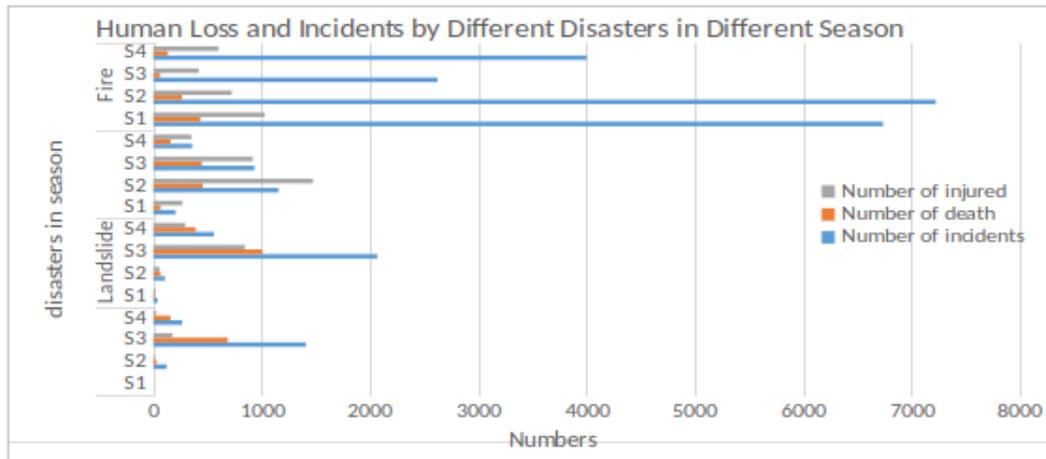


Figure 6: Human Loss and Incidents by different Disasters in different Season during the period 2011 – 2022.

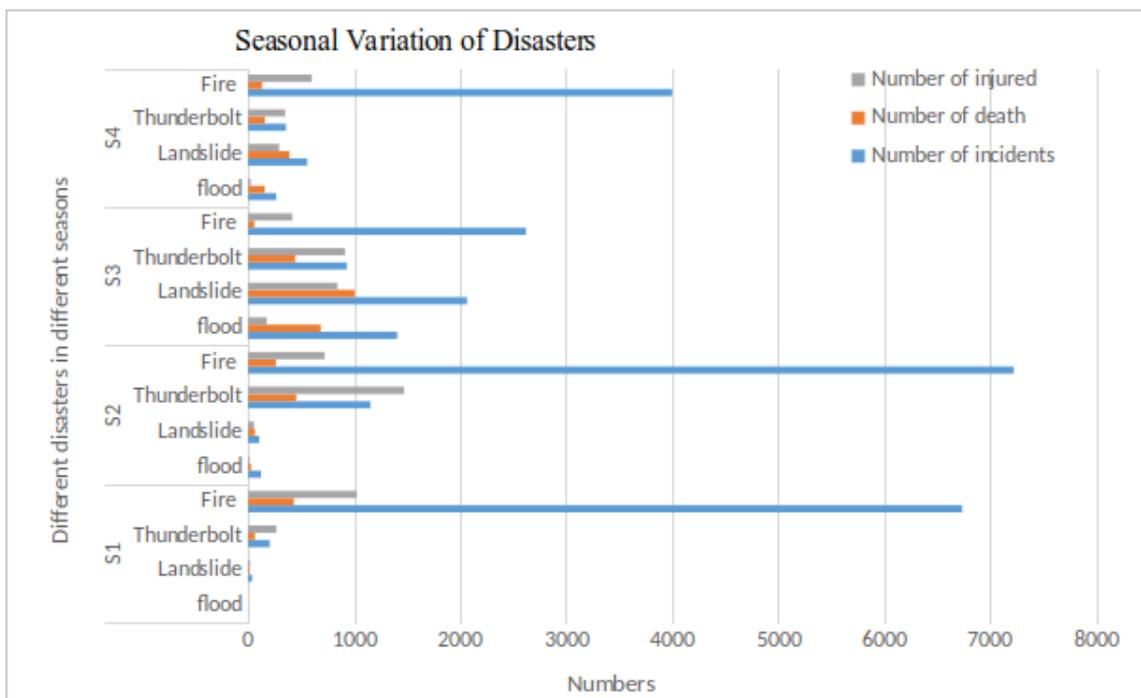


Figure 7: Seasonal Variation of Disasters.

#### 4 Conclusion

The maximum number of fire incidents occurred more frequently compared to other disasters. Fire is the primary cause of deaths in every season. The highest number of fire incidents took place during spring and winter, while the minimum occurred during summer throughout the mentioned period. Similarly, thunderbolts occur frequently during spring and summer, also known as the pre-monsoon period. To effectively address all types of disasters, awareness programs should be conducted based on the seasons. For example, awareness campaigns about thunderbolts should be focused on the

pre-monsoon period, while floods and landslides are more prevalent during the rainy (summer) season and have a greater impact. Landslides are particularly destructive during the summer season and moderately destructive during autumn, whereas winter and spring experience less destruction. A similar pattern is observed for floods, with the maximum destruction occurring in the summer season, moderate destruction in autumn, and significantly fewer incidents during winter. These disasters are primarily influenced by the geographical structure of the region, resulting in higher levels of destruction in Nepal. Therefore, it is crucial to conduct awareness programs in the prone zone areas during

these specific periods.

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