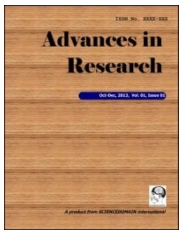

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Investigating Lunar Phases Impact on Natural Disasters over India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors contributed equally in data analyses and writing the manuscript and approving the final manuscript.

Short Communication

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ABSTRACT

The effect of lunar phases on natural disasters has been discussed from time to time. In the present work we have made an attempt to investigate the impact of lunar phases on the natural disasters viz. cyclone, earthquake, slides and floods. We have observed the increasing trend in the number of disasters over the last 100 years. The seasonal analysis of the above mentioned four disasters have shown their maximum occurrence in the monsoon season. Among all the four disasters, number of occurrences of the flood was highest in past years. It has been observed that during the first and last quarter we had more natural disasters compared to the new moon and full moon. However the Student *t-test* confirmed that statistically there is no difference between first quarter and last quarter and new moon and full moon phases at 0.05 level of significance.

Keywords: Lunar phases; natural disasters; India; student t test.

1. INTRODUCTION

The movement of the Earth around the Sun and movement of the Moon around the Earth are the basis of different seasons as well as changes in apparent shape of the Moon (lunar phases). These movements are causing ocean tides and in a similar way the mechanism is

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applied to lunar-solar tide [1], which is affecting the gravitational pull of the Earth. Researchers have tried to find the possible impact of these lunar tides on the various natural hazards. It has been proposed [2] that the atmospheric tides have an influence on hurricanes. After analysing the Atlantic hurricane data, [3] has shown the impact of new moon and full moon on the hurricane development activity. The study related to the connections between the lunar phases and the depressions formed in the Indian Ocean were attempted by [4] which may further develop into the cyclones and severe cyclones. Over the Atlantic Ocean, occurrence of hurricane was linked with the spring neap tide by [5].

There has always been a debate on the role of the lunar cycle in the occurrence of natural disasters. Many researchers (e.g. [6,7,8]) suggest the weak relationship between the lunar cycle and the occurrence of disasters. The new moon and full moon have been observed related to the cyclones over North Atlantic and Western Pacific Oceans by [9]. The occurrence of earthquake is also linked with the tidal forces and according to [10] a positive correlation exists between the earth tides and the seismicity. The significant triggering effect of tidal stress for earthquake has reported by [11] after studying the 142 earthquake cases worldwide. The seismicity datasets (1973-1991) for the Taiwan has been used by [12] to study the triggering effect of tidal forces of earthquakes. He finally concluded that the tidal forces mainly affect the small earthquakes, however the larger earthquakes are associated with the tectonic forces and the occurrence of micro earthquakes is neither associated with the tidal or tectonic forces. Triggering effect of tidal waves for earthquakes have been also studied by [1,13,14,15]. The natural hazard chain in China was studied by [16]. However in recent years, attempts to relate natural hazards with lunar cycle have not been found in literature.

The effect of lunar phase cycles on natural disasters has been studied by some researchers in previous years, but the relation between two was not quantified. It will be interesting to discover possible impact of lunar phases on disasters for the Indian region. India is a tropical country and receives higher amount of solar energy that is responsible for building intense thermal gradient between land and oceans [17]. Sometimes the heavy rainfall during monsoon is responsible for different slides and devastating flood [18]. We have used the data of natural disaster occurred over India for the past 100 years' period (1901-2000). The details of datasets have been given in section 2. The methodology, and results and discussion have been presented in subsequent sections, section 3 and 4 respectively.

2. STUDY AREA AND DATA SETS

We have focused our work only on the natural disasters that have occurred over India over the past 100 years (1901-2000). India is the seventh largest country in the world (~ 2.3% of the planet) and rich in biodiversity [19] as well as very vulnerable to natural disasters. India comes second in the world in terms of population, which makes this tropical country more susceptible to damage caused by natural hazards. The unique topography and landscape of India contributes to the high occurrence of natural disasters over the region [20]. On the north side, India is surrounded by Himalayan mountain range, while the coastline marks the territory of India in the south and western parts. The slight change in climate may lead to the major flood and major cyclones. The changing weather and monsoon pattern over Indian region is responsible for many natural disasters. Many low lying areas near the coast of India are facing the problem of submergence and some of them are already partially submerged [21]. This vulnerable nature of India for natural disaster makes this country a very good place to study about the natural disasters. The 100 years data (1901-2000) of natural disasters over India has been obtained from Asian Disasters Reduction Centre (ADRC) site

(http://www.adrc.asia/publications/databook/ORG/databook_20th/IND.pdf). The data comprises details of type of disasters, time and place of their occurrence (for few cases), and the impact of disasters has been also available in terms of injuries, death toll, and damaged property. The different types and their subtypes are given in Table 1.

Table 1. Different types of disasters and their subtypes

Disasters					
S. no.	**Types**	**Subtypes**	**S. no.**	**Types**	**Subtypes**
1.	Drought	Drought	5.	Famine (Natural)	Food Storage
2.	Earthquake	Earthquake	6.	Flood	Flood
3.	Epidemic	Arbovirus	7.	Insect infestation	Insect infestation
		Diarrhoeal/Enteric	8.	Slide	Land Slide
		Intestinal protozoal			Avalanche
		Leptospirosis	9.	Wave/Surge	Tidal wave
		Malaria	10.	Wild Fire	Forest
		Measles	11.	Wind Storms	Cyclone
		Meningitis			Storm
		Plague			Tornado
		Small Pox			Tropical storm
		Viral hepatitis			Typhoon
4.	Extreme temperature	Cold wave			
		Heat wave			

Based on the data there were total 448 cases of natural disasters, with mainly 11 types of disasters – drought, earthquake, epidemic, extreme temperature, famine (natural), flood, insect infestation, slide, wave/surge, wildfire, and wind storms. The major contribution in natural disasters was of flood that has the count of 156 followed by wind storms (119), epidemic (53), slide (35), extreme temperature (34), earthquake (27), drought (19) and rest were others natural disasters. In the given data sets the information about the day of occurrence is very limited and out of 448 disasters only 249 disasters have the information about the day of occurrence, whereas the information about the month is available for the 423 cases out of 448.

3. METHODOLOGY

The main objective of the present paper is to investigate the impact of lunar phase on the natural disasters over India. For this we have investigated the occurrence of disasters in different phases of lunar cycles. The lunar phase information for four main phases of moon i.e. New Moon (NM), First Quarter (FQ), Full Moon (FM), and Last Quarter (LQ) were taken from National Aeronautics and Space Administration (NASA) website for eclipse (http://eclipse.gsfc.nasa.gov/eclipse.html). For studying the disaster impact association with a particular phase of the moon, we required the actual date of the occurrence of disaster. As already mentioned in section 2, from the total 448 disasters only 249 disasters have the information about the date. Wind storm was the disaster where we had the highest number (107) of cases information with date of occurrence followed by flood (72), slide (26), earthquake (16), epidemic (16) and extreme temperature (10). Droughts (1), wave surge (1),

wild fire (0) and famine (natural) have one or none information about the date of disaster occurrence. We have used only those disaster types where the number of date information was at least 15 or more than 15. In the present study based on our condition out of 11 types of disasters only 4 disasters (wind storms, flood, slide and earthquake) has been considered for the analysis. The information of the day for the epidemic was also more than 15 but still we didn't consider it for our lunar phase impact analysis. In previous literatures researchers have not mentioned any direct relationship between epidemic and lunar phase cycle. Though, we may not neglect the possibility of relationship between the epidemic and lunar phase but that analysis is beyond the scope of this paper. Among the four disasters, two disasters (wind storm and slides) have their subtypes. The cyclone, storm, tornado, tropical storm, typhoon storm are the important subtypes of wind storm. The slides have only two subtypes- landslides and avalanche.

In section 4.1 combined trends of all the 11 different types of disasters have been explained. However in the section 4.2 variations of wind storms, flood, earthquake and slide disasters in pre-monsoon, monsoon, post monsoon and winter has been described. The occurrence of cyclones, earthquakes, floods and slides during different phases of lunar cycle has been dealt in section 4.3 (NM, FQ, FM, and LQ). The day for any disaster event is being counted in the lunar phase to which it is nearest. If any event is found to be equidistant from two phases, the event is not being considered in the present study. The occurrence of more cyclones in NM+FM (hereafter denoted as NF) has been supported by various researchers in the past for different study areas ([3,5,9]) compared to FQ+LQ (hereafter denoted as Q). This led us to divide our data in two groups NF and Q. We have used the Student t test in the present work. The Student t test is generally used to determine whether the two sets of data are significantly different from each other or not. In present work we have used the Student t test at 0.05 level of significance to differentiate NF and Q.

4. RESULTS AND DISCUSSION

4.1 Trends of Disasters for the Period of Study

Time series analysis of the number of natural disasters occurring each year has been done to see the annual trend and it is shown in Fig. 1. We have plotted the frequency of disasters over the 100 years (1901-2000). An increasing trend with slope = +0.19 (after fitting the linear line) has been observed in the frequency of disasters (Fig. 1) from 1901-2000. This increasing trend is worth to be noted because it could be the results of natural as well as anthropogenic activities that cause pressure on the ecosystem. The better time resolution of disasters after 1940 might be because of increasing communication facilities and increasing observational networks on the observation of the increase in disasters. However, we assume that data is representing complete set of disaster occurrence information over the region and the increasing trend reveals that total number of natural disasters/extreme events has been increasing with time as a result of climate change and global warming ([22,23]) for which unplanned human activities are chiefly responsible. Though, sometimes natural phenomena or events are also linked with these disasters (e.g. [1,4,5,9]). During 1980, we have observed the first peak in the natural disasters occurrence. We have observed the sudden drop in natural disasters during 1990, following which an increasing trend has been observed. This indicates that before 1980 the frequency of disaster was not only less but they have also shown the slow and steady increase. Though after 1980, we have observed more number of disasters as well as more variation within one decade.

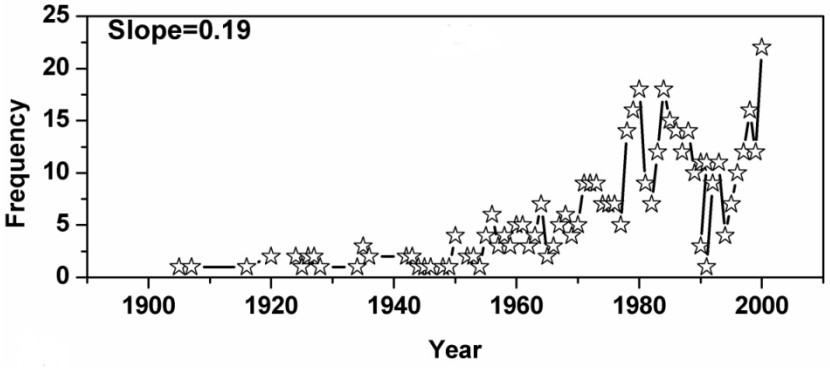

Fig. 1. The trend of frequency of disaster from 1901-2000

The increase in intra-decadal variation after 1980 has suggested that the cause of these disasters might be the climate change ([16,24]). Though, it needs a detail study to link between anthropogenic activities and natural disasters.

4.2 Seasonal Variation of Disasters

Fig. 2 shows the frequency of slides, earthquake, wind storm and flood over India for all the four seasons (pre-monsoon, monsoon, post monsoon and winter) during the period 1901-2000. Seasonal variation has been observed for the natural disasters. The total number of natural disasters in winter, pre-monsoon, monsoon and post-monsoon were 17, 40, 184 and 85, respectively. Overall in monsoon seasons we have seen the highest number of slides (28), earthquakes (11) and flood (122). Over India during monsoon high magnitude floods occur [25]. However wind storms have occurred mostly in the post monsoon months (54).

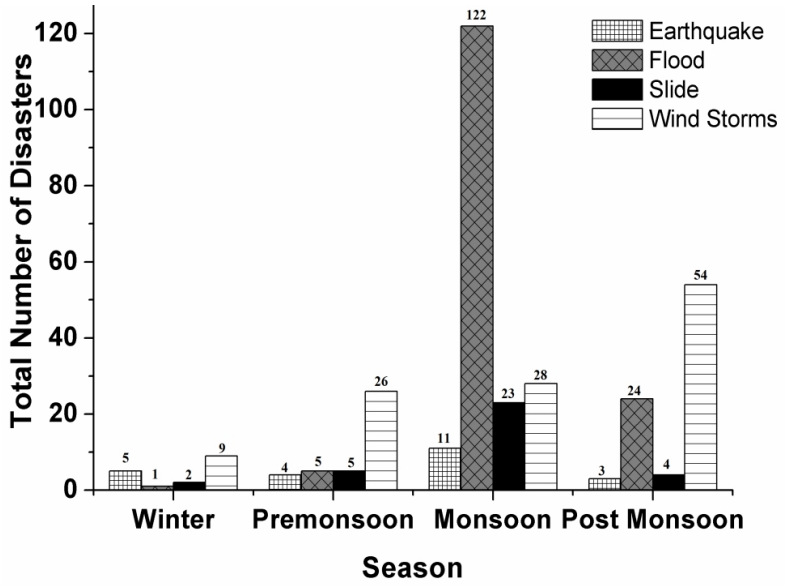

Fig. 2. The frequency of slides, earthquake, wind storms and floods in pre-monsoon, monsoon, post monsoon and winter (data taken from ADRC)

The percentage of total disasters is 5.21%, 12.27%, 56.44% and 26.08% in winter, pre monsoon, monsoon and post monsoon, respectively (Fig. 2). The winter season has least contribution in the amount of natural disasters. In the winter wind is calm and stability in the atmosphere is common that lead to the inversion phenomena, thus causing a very hostile condition for the diffusion of pollutant originating from the earth's surface [26]. Various episodes of pollution have occurred in the winter months. Out of the available data number of months for the different types of disasters monsoon was the only season when most of the disasters have occurred.

4.3 Occurrence of Disasters in Response to Lunar Phases

In Fig. 3, the occurrence of different disaster has been shown over different lunar phases. A peak can be observed at FQ for cyclones, earthquakes and slides. Cyclones are highest in numbers for each quarter of lunar phase, followed by floods, slides and earthquakes. Number of cyclone, earthquake and slides observed in Q (58, 10 and 14 respectively) are higher than NF (49, 6 and 12 respectively) (Table 2), which support that disasters have shown their affinity towards the Q phase of the lunar cycle. However, occurrence of flood incidents was equal (36) in both the phases (NF and Q) (Table 2).

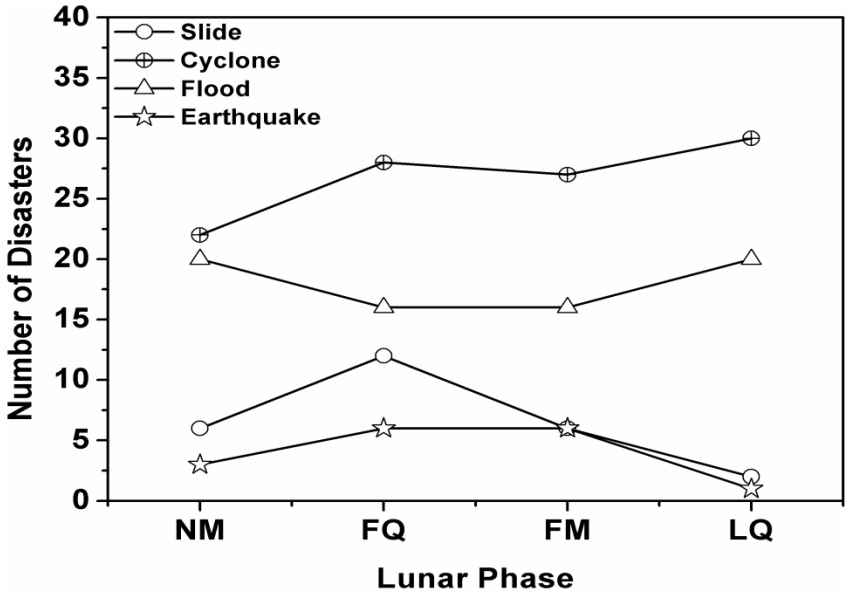

Fig. 3. The variation of disaster over different lunar phases: New Moon (NM), Full Quarter (FQ), Full Moon (FM) and Last Quarter (LQ)

The link of natural disasters with lunar phase in the present study has shown similarity with results of [4]. It has been mentioned in his work that the formations of depressions associated with lunar phases over the Indian Ocean region.

On the basis of these observations, we can propose that disasters: cyclone, earthquake, and slides associated with Q cycle are more devastating in nature rather than NF cycles, while flood occurred both NF and Q equally. To establish a clear relation, it is necessary to discuss the significance of Number(s) fluctuations in Fig. 3 and in Table 2 by standard statistical

methods. The two tailed Student t test has been performed to test the difference in NF and Q. We have found the difference in the NF and Q was not statistically significant at 0.05 level of significance. The p value for the t test was 0.89 and it was greater than the 0.05 so it indicates that there was no significant difference between the NF and Q phase. This further explains that both NF and Q have no effect on the natural disasters occurrence.

Table 2. The number statistics of disaster in different lunar phases along with its impact on people

Type of disaster	Lunar phase (number of events)	
Cyclone	NM (22)	NF (49)
	FM (27)	
	FQ (28)	Q (58)
	LQ (30)	
Flood	NM (20)	NF (36)
	FM (16)	
	FQ (16)	Q (36)
	LQ (20)	
Land Slide	NM (6)	NF (12)
	FM (6)	
	FQ (12)	Q (14)
	LQ (2)	
Earth Quake	NM (4)	NF (6)
	FM (2)	
	FQ (8)	Q (10)
	LQ (2)	

5. SUMMARY

The present study shows an increasing trend in the frequency of disaster from 1901-2000 accompanied by the increase in different types of disasters. The findings can be summarized as follows:

- The trend in natural disaster (1901-2000) has shown the pronounced increasing trend after 1980.
- Overall in monsoon seasons we have seen the highest number of slides (23), earthquakes (11) and flood (121). However, wind storms have occurred mostly in the post monsoon months (54).
- We have observed the higher number of cyclones, landslides and earthquake in Q phase but number of occurrence of flood was equal in both NF and Q.
- Based on the two tailed Student t test at 0.05 level of significance there is statistically no relationship between the NF and Q in terms of natural disaster occurrence.

The study suggests the need of more detailed analysis about the lunar phase and natural disaster to conclude anything about their relationship.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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