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Natural disasters due to climate change in India

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ABSTRACT : There is convincing evidence that changes in the earth's climate are taking place that cannot be explained without taking into account natural disasters. Trends in average conditions are much easier to identify than changes in extremes, largely because the latter are inherently episodic and rare. Precipitation events are getting more severe due to climate change. The study was conducted with an objective of analysing the trend in rainfall and temperature and death occurrence due to natural disasters in India. The present study was purely based on secondary data which was collected from Directorate of Economics and Statistics and National Crime Record Bureau, Ministry of Home Affairs from 1901 to 2012. The data was analysed using the Trend analysis (TCSI) and tabular analysis. Highest rainfall was during 1917(122.0mm)and lowest was during 2009(79.48mm). Highest Seasonal variation during April, May, June and July. Irregular variation ranges from 0.0085 to 0.01210 during the year 1917 to 1918, respectively. The minimum temperature in India was more during 1995(20.39^{o}C) and highest maximum temperature was recorded during 2009 (30.9^{o}C). In the year 2012 percentage death due to cold and exposure (14.8%), floods (420%), heat stroke (1247%), landslides (282%), lightening (2263%), torrential rains (203%) and heat waves (263 %) was more compare to previous year. Highest death was occurred due to lighting, earth quake and heat stroke and least was death was due to avalanche and epidemic.

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Key Words :
Avalanche, Flood, Land slide, Cyclone, Earthquake

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Evidence of climate change includes the instrumental temperature record, rising sea levels, and decreased snow cover in the Northern Hemisphere. According to the Intergovernmental Panel on Climate Change (IPCC), most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in human greenhouse gas concentrations. Further there is a direct influence of global warming on precipitation. Increased heating leads to greater evaporation and thus, surface drying, thereby increasing the intensity and duration of drought. However, the water holding capacity of air increases by about 7 per cent per 1°C warming, which leads to increased water vapor in the atmosphere. Hence, storms, whether individual thunderstorms, extra-tropical rain or snow storms, or tropical cyclones, supplied with increased moisture, produce more intense precipitation events.

The temperature increase is wide spread across the globe and is greater at higher northern latitudes. It is estimated that there is a 100-year linear trend of 0.74^{0}C increase. It is observed since 1961 that the average temperature of the global ocean has been taking up over 80 per cent of the heat being added to the climate system. Warming of the climate system induces increase in global average air and ocean temperatures,

widespread melting of snow and ice and rising global average sea level. In India, an increase in the surface air temperature has been observed in the past century. A warming trend is visible along the west coast, central India, interior peninsula and the North-Eastern India, but some cooling trends are also visible in the North-West India and parts of South-India. (NAPCC, 2008).

Indian monsoon rains are the backbone of Indian economy as most of our agricultural activities and replenishment of ground water sources have a direct dependence on monsoon rains. Monsoon rains are a manifestation of the complex interactions between land, ocean and atmosphere. Due to variability of climate natural disasters are increasing over the year and affecting the human lives. Keeping this all in view the present study was under taken with following objectives.

Specific objectives of study :

- To analyse the trend in rainfall and temperature in India
- To analyse the death occurrence due to natural disasters in India

EXPERIMENTAL METHODOLOGY

The study was based on secondary data collected. Data regarding rainfall and temperature in India was collected from Directorate of Economics and Statistics, Department of Agriculture and Co-operation from 1901 to 2012 *i.e.*, 112 years. Data related to Death due to natural disasters in India was collected from National Crime Record Bureau, Ministry of Home Affairs website from 2000-2012. Time Series analysis and Tabular analysis was used to compute the data.

EXPERIMENTAL FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Rainfall trends in India :

The trend was computed for pattern of rainfall in India and the results are presented in the Fig. 1, reveals that rainfall was fluctuated over the year *i.e.*, 1901 to 2012. There was highest rainfall was in the year 1917 with 122.0 mm followed by 1990 (116.78 mm), 1961(116.60 mm) and 1959 (114.73 mm) and lowest is during the year 2009 with 79.48mm followed by 1964 (78.94mm), 1972 (78.91 mm) and 2002(78 mm).

In order to ascertain the long term seasonal variation of rainfall pattern in India, the seasonal indices of monthly rainfall was calculated and presented in Table 1 and Fig 2. The table reveals that the rainfall showed a seasonal variation during April, May, June and July. In the month of July there was highest rainfall was observed with

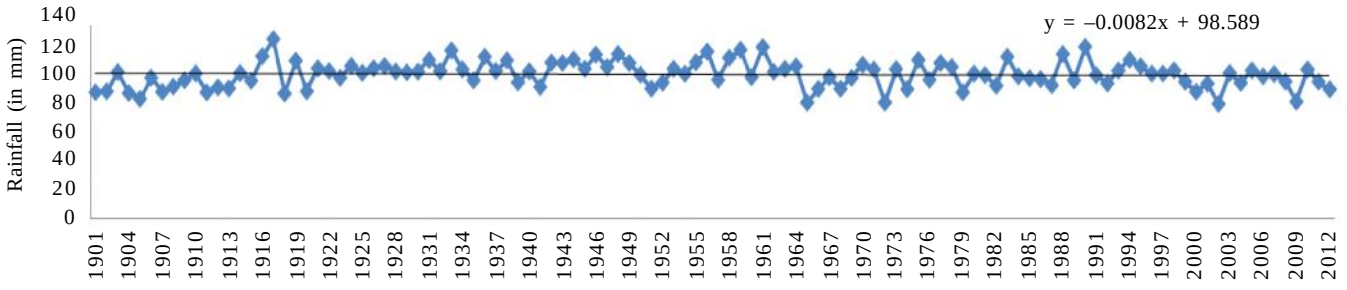

Fig. 1 : Rainfall trend in India during 1901 to 2012

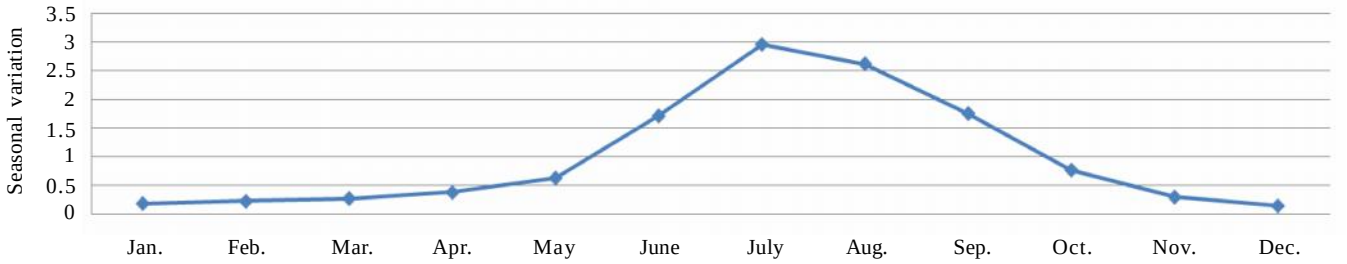

Fig. 2 : Seasonal variation of rainfall in India

variation of 2.95 followed by august (2.61), September (1.75) and June (1.71). And lowest seasonal variation in rainfall was observed during the month of December (0.1540) fallowed by December, January, February and March with variation of 0.153, 0.194, 0.231 and 0.238, respectively.

As shown in the Fig. 3 the cyclical variations in rainfall were analyzed in order to know the variation in rainfall occurrence over the years. In rainfall pattern, uneven cycles were observed. The numbers of cycles observed was 12 and they occurred on an average for every three and four years, respectively.

Irregular variations of rainfall in India were analyzed in order to know irregular variations. The irregular variation ranges from 0.0085 to 0.01210. Highest irregular variation was observed in 1918 and 1972 and lowest irregular variation was observed in 1919 (0.0086) and 1917 (0.0085)as shown in Fig 4. As shown in Fig. 5 the

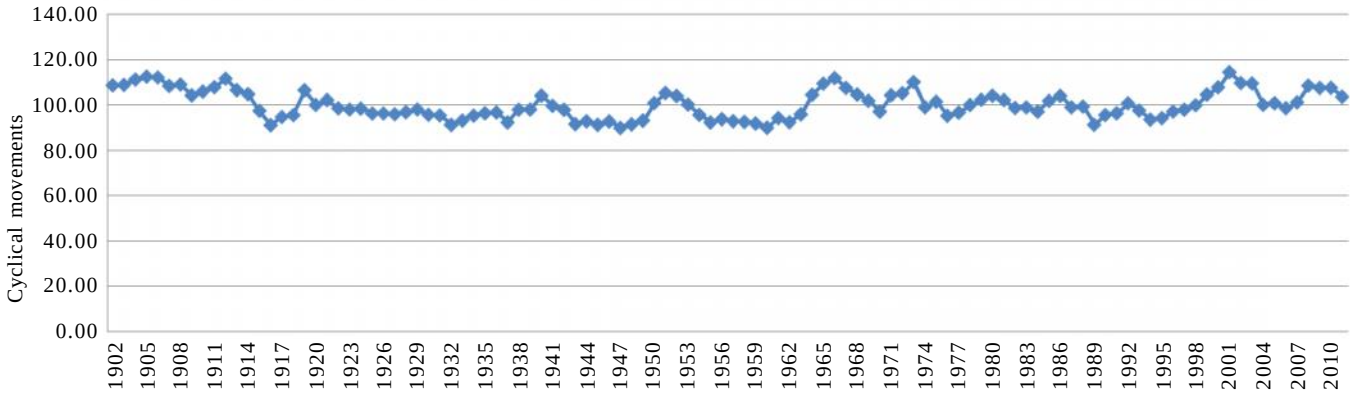

Fig. 3 : Cyclical movements of Rainfall in India

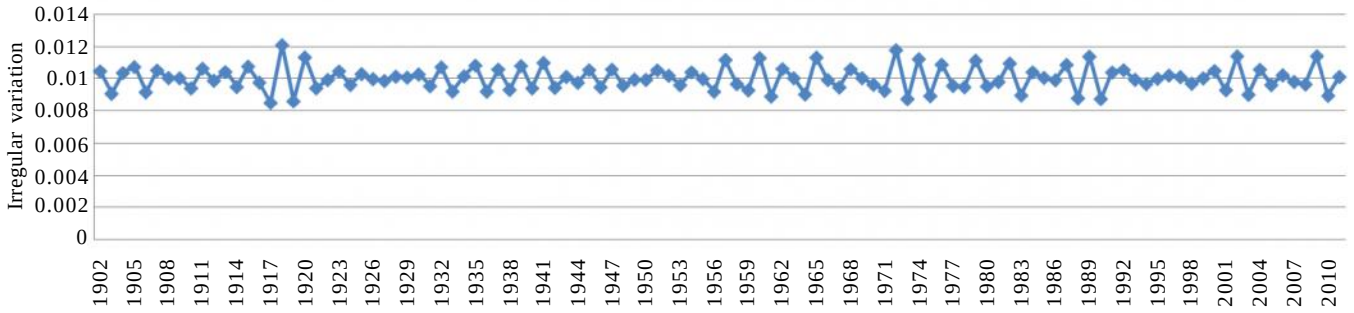

Fig. 4 : Irregular variations of rainfall in India

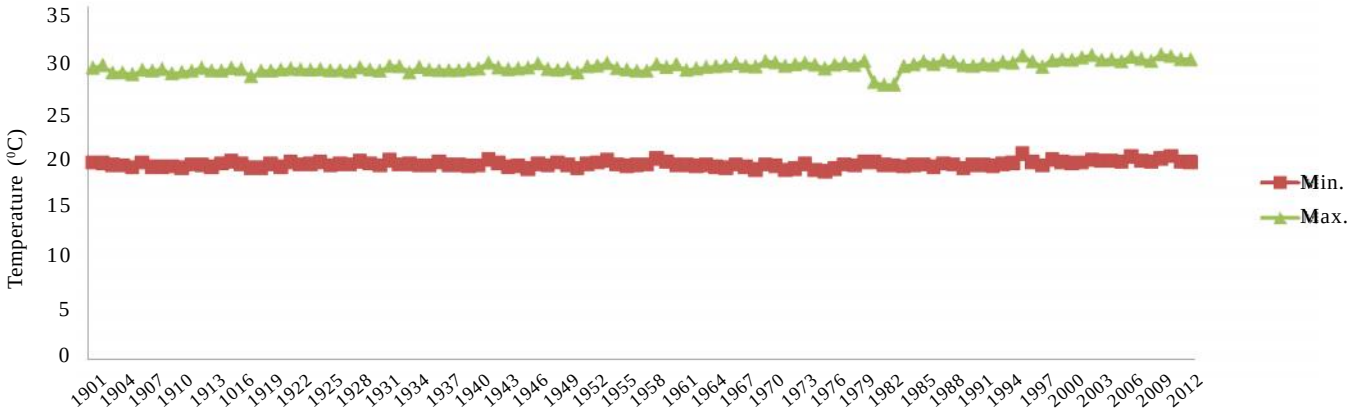

Fig. 5 : Annual temperature of India (1901- 2012)

Table 1 : Per cent change over previous year of death due to natural disasters in India

Year	Avalanche	% Change over previous year	Cold and exposure	% Change over previous year	Cyclone	% Change over previous year	Earth quake	% Change over previous year	Epidemic	% Change over previous year	Flood	% Change over previous year	Heat stroke	% Change over previous year	Landslide	% Change over previous year	lightening	% Change over previous year	Torrenial rains	% Change over previous year	Heat waves	% Change over previous year
2000	13		762		115		1		102		1863		534		264		1472		150		57	
2001	55	76.4	641	-18.9	93	-23.7	13702	100	103	1	399	-366.9	505	-5.7	254	-3.9	1507	2.3	114	-31.6	70	18.6
2002	47	-17	525	-22.1	62	-50	5	-273940	64	-60.9	484	17.5	720	29.9	235	-8.1	1383	-9	1296	91.2	806	91.3
2003	70	32.9	835	37.1	120	48.3	6	16.7	78	17.9	453	-6.8	807	10.8	334	29.6	1792	22.8	257	-404.3	1539	47.6
2004	9	-677.8	570	-46.5	1512	92.1	44	86.4	69	-13	754	39.9	756	-6.7	357	6.4	1842	2.7	133	-93.2	117	-1215.4
2005	238	96.2	646	11.8	1438	-5.1	724	93.9	103	33	785	3.9	1075	29.7	590	39.5	2064	10.8	557	76.1	587	80.1
2006	18	-1222.2	694	6.9	96	-1397.9	8	-8950	76	-35.5	1097	28.4	754	-42.6	274	-115.3	2387	13.5	259	-115.1	135	-334.8
2007	33	45.5	802	13.5	118	18.6	14	42.9	47	-61.7	1348	18.5	932	19.1	312	12.2	2790	14.4	100	-159	476	71.6
2008	47	29.8	836	4.1	99	-19.2	6	-133.3	73	35.6	861	-56.6	616	-51.3	340	8.2	2553	-9.3	148	32.4	294	-61.9
2009	22	-113.6	742	-12.7	128	22.7	2	-200	75	2.7	726	-18.6	1071	42.5	394	13.7	2113	-20.8	132	-12.1	320	8.1
2010	45	51.1	937	20.8	106	-20.8	8	75	57	-31.6	965	24.8	1274	15.9	347	-13.5	2622	19.4	123	-7.3	126	-154
2011	60	25	849	-10.4	117	9.4	69	88.4	127	55.1	585	-65	793	-60.7	302	-14.9	2550	-2.8	170	27.6	250	49.6
2012	40	-50	997	14.8	47		3	-2200			420		1247		282		2263		203		263	
Sum	697.00		9836.00		4051.00		14592.00		974.00		10740.00		11084.00		4285.00		27338.00		3642.00		5040.00	
Average	53.62		756.62		311.62		1122.46		81.17		826.15		852.62		329.62		2102.92		280.15		387.69	

minimum temperature in India was more during 1995 (20.39°C) fallowed by 2010 (20.15°C) and 2006 (20.07°C) and during the year 1975 (18.61°C),1974 (18.76°C) and 1971 (18.76°C) the minimum temperature was lowest. The highest maximum temperature was observed during 2009, 2002, 1995 with 30.9°C, 30.23°C, 30.18°C, respectively. The lowest maximum temperature was observed during 1981, 1982, 1980 with 27.24°C, 27.26°C, 27.51°C, respectively

As shown in Table 1 There was highest number of death due to aralanche in the year 2005 which was highest (96.2%) per cent change compared to the previous year. In the last twelve year there was least deaths due to aralanche (13 %) in the year 2000 and 2006 there was decline in the death due to aralanche to the extent of 1222.2 per cent over previous year. Due to cold and exposure there were 997 deaths in the year 2012 which was highest in the last twelve years. In the year 2003 there was 37 per cent increment in death due to cold and exposure to previous year which was highest among those years. Cyclone affected lives to the greatest extent in the year 2004. It caused 1512 deaths which was 92.1 per cent increment to previous year. The year 2012 experienced least number of death due to cyclone to the extent of 1397 per cent in the year and in 2001 there were 13702 deaths because of earthquake which was 100 per cent over previous year death. There were 127 deaths in the year 2011 due to epidemics which 55.1 per cent increment over previous year. There was severe flood in the year 2000 which has taken 1863 human lives followed by the year 2007 (1348 %). In the year 2010 there were 1274 deaths due to heat stroke. There were 590 deaths due to landslides in the year 2005 which was highest in twelve years. After 2009 there was decline in the death due to landslide. Because of lightening there were 2790 deaths in the year 2007 which was 14.4 per cent increment in death over previous year. There was considerable decline in deaths due to lightening by 20.8 per cent in the year 2009. There were 1296 deaths because of torrential rains in the year 2002 which was 91.2 per cent increment over previous year deaths because of it. In the year 2007 there was decline in the deaths due to torrential rains by 159 per cent over previous year. Heat waves have caused 1539 deaths in the year 2003 and there was highest increment in per cent over previous year by 80.1 per cent in the year 2005. Considering above table it is observed that earthquake has taken highest number of lives in the year 2001. Every year among all natural calamities because of lightening there were highest number of deaths in last twelve years. As shown in Table 2 in the year 2003 there was highest per cent (54.91%)of increment in the death due to loss of livestock over previous year deaths. In the year 2009 there was largest decline (-103%) in the death due to loss if livestock over the previous year. There was highest per cent increment in number of cattle lost to previous year in the year 2005 (88.83%). There was largest decline in number of cattle lost due to flood, cyclonic storm, landslide from the year 2006 to 2007. There was highest increment (45.14%) in death due to

Table 2 : Percentage change over previous year of damages caused due to flood, cyclonic storms, landslides etc.

Years	Livestock lost human (in no.)	% Change over previous year	Cattle lost	% Change over previous year	Houses damaged	% Change over previous year	Cropped area affected (in lakh ha)	% Change over previous year
2001	834	–	21269	–	346878	–	18.72	-
2002	898	7.126949	3729	-470.367	462700	25.03177	21	10.85714
2003	1992	54.91968	25393	85.31485	682209	32.17621	31.98	34.33396
2004	1995	0.150376	12389	-104.964	1603300	57.4497	32.53	1.690747
2005	2698	26.05634	110997	88.83844	2120012	24.37307	35.52	8.417793
2006	2402	-12.3231	455619	75.6382	1934680	-9.57947	70.87	49.88006
2007	3764	36.18491	119218	-282.173	3527041	45.14722	85.13	16.75085
2008	3405	-10.5433	53833	-121.459	1646905	-114.162	35.56	-139.398
2009	1677	-103.041	128452	58.09096	1359726	-21.1204	47.13	24.54912
2010	2310	27.4026	48778	-163.34	1338619	-1.57677	46.25	-1.9027
2011	2156	-7.14286	5021	-871.48	1346451	0.581677	52.01	11.07479
2012	2015	-6.99752	4698	-6.87527	1338549	-0.59034	50.36	-3.27641

Table 3 : Total per cent contribution towards death due to natural disasters in India

Year	Avalanche	% of contribution towards death	Cold and exposure	% of contribution towards death	Cyclone	% of contribution towards death	Earth quake	% of contribution towards death	Epidemic	% of contribution towards death	Flood	% of contribution towards death	Heat stroke	% of contribution towards death	Landslide	% of contribution towards death	lightening	% of contribution towards death	Torrential rains	% of contribution towards death	Heat waves	% of contribution towards death	Total
2000	13	0.18	762	10.39	115	1.57	1	0.01	102	1.39	1863	25.41	534	7.28	264	3.60	1472	20.07	150	2.05	57	0.78	7333
2001	55	0.28	641	3.30	93	0.48	13702	70.47	103	0.53	399	2.05	505	2.60	254	1.31	1507	7.75	114	0.59	70	0.36	19444
2002	47	0.62	525	6.88	62	0.81	5	0.07	64	0.84	484	6.34	720	9.44	235	3.08	1383	18.13	1296	16.99	806	10.56	7629
2003	70	0.84	835	10.07	120	1.45	6	0.07	78	0.94	453	5.46	807	9.73	334	4.03	1792	21.61	257	3.10	1539	18.56	8294
2004	9	0.11	570	6.98	1512	18.51	44	0.54	69	0.84	754	9.23	756	9.26	357	4.37	1842	22.55	133	1.63	117	1.43	8167
2005	238	2.20	646	5.97	1438	13.30	724	6.70	103	0.95	785	7.26	1075	9.94	593	5.46	2064	19.09	557	5.15	587	5.43	10812
2006	18	0.23	694	8.89	96	1.23	8	0.10	76	0.97	1097	14.06	754	9.66	274	3.51	2387	30.59	259	3.32	135	1.73	7804
2007	33	0.37	802	8.93	118	1.31	14	0.16	47	0.52	1348	15.01	932	10.38	312	3.47	2790	31.07	100	1.11	476	5.30	8979
2008	47	0.60	836	10.61	99	1.26	6	0.08	73	0.93	861	10.93	616	7.82	340	4.31	2553	32.39	148	1.88	294	3.73	7881
2009	22	0.28	742	9.59	128	1.66	2	0.03	75	0.97	726	9.39	1071	13.85	394	5.09	2113	27.32	132	1.71	320	4.14	7734
2010	45	0.52	937	10.87	106	1.23	8	0.09	57	0.66	965	11.19	1274	14.78	347	4.03	2622	30.42	123	1.43	126	1.46	8620
2011	60	0.76	849	10.77	117	1.48	69	0.88	127	1.61	585	7.42	793	10.06	302	3.83	2550	32.35	170	2.16	250	3.17	7883
2012	40	0.51	997	12.82	47	0.60	3	0.04		0.00	420	5.40	1247	16.03	282	3.63	2263	29.10	203	2.61	263	3.38	7777
Sum	697		9836		4051		14592		974		10740		11084		4285		27338		3642		5040		92279
Per cent of Contribution towards death	0.76		10.66		4.39		15.81		1.06		11.64		12.01		4.64		29.63		3.95		5.46		

house damage over previous year in the year 2007. Per cent change over previous year in death due to crop area affected by flood, cyclonic storm, landslide was highest in the year 2006 (49.88%).

As shown in Table 3 the Number of deaths due to alanche was highest and lowest in the year 2005 and 2004, respectively and its contribution to total death were highest (2.20%) in the year 2005. There were 697 deaths in the last twelve years. Its contribution towards total death was 0.76 per cent in the last twelve years. Number of death due to exposure to cold was 9836 in the last twelve years and it contributed 10.66 per cent towards total deaths in twelve years. Highest number of deaths recorded due to cold and exposure were in the year 2012 and its contribution towards total death was 12.8 per cent number of deaths due to cyclone was highest in the year 2004 and its contribution towards total death was 18.51 per cent. In the year 2001 earthquake has taken 13702 lives which was 70.47 per cent increment over previous year death due to it. It contributed 15.81 per cent of total deaths in the last twelve years and caused total of 14592 deaths. There was highest number of deaths because of epidemics in the year 2011. Epidemic contributed 1.06 per cent towards total deaths in the last twelve years. Flood has caused 1863 deaths in the year 2001 which was highest in twelve years. It contributed 11.64 per cent to total deaths in the last twelve years. Due to heat stroke there were highest number of deaths in the year 2012.Heatstroke has contributed 12.01 per cent towards total deaths in the last twelve years. Landslide has contributed 4.64 per cent towards total deaths in those years. Lightening has caused total of 27338 deaths which contributes 29.63 per cent towards total deaths in consider period. Torrential rains have caused total of 3642 death and contributed 3.95 per cent towards total deaths. Total deaths because of heat stroke were 5040 and contribute 5.46 per cent to total deaths in the last twelve years.

As shown in Table 4 the highest per cent of contribution towards total death because of livestock lost by human was in the year 2003 (0.281%) and the year 2006 experienced least per cent of total death. In the year 2007 and 2001 there was highest and least number of deaths due to loss of livestock by human. In the year 2006 and 2012 per cent of death due to cattle lost to total death because of flood, cyclonic storm, landslides etc recorded were highest (19.045) and least (0.35%), respectively in the year 2006 there was highest number of death due to cattle lost in the flood cyclonic storm and landslides. Deaths due to house damaged by flood cyclonic storm landslides were highest (3527041) and least (346878) in the year 2007 and 2001 which contributed 96.63 per cent and 94 per cent towards total death, respectively. Crop affected by flood, cyclonic storm, landslides etc also affected lives and number of deaths. In the year 2007 crop area affected was highest (85.13%). So we can say that house damage was primary cause for deaths in the last 12 years.

Table 4 : Total per cent contribution towards damage caused due to flood, cyclonic storms, landslides etc.

Year	livestock lost human (in no.)	% of contribution towards death	cattle lost	% of contribution towards death	houses damaged	% of contribution towards death	cropped area affected (in lakh ha)	% of contribution towards death	Total
2001	834	0.226	21269	5.76	346878	94.00	18.72	0.01	368999.7
2002	898	0.192	3729	0.80	462700	99.01	21	0.00	467348
2003	1992	0.281	25393	3.58	682209	96.14	31.98	0.00	709626
2004	1995	0.123	12389	0.77	1603300	99.11	32.53	0.00	1617717
2005	2698	0.121	110997	4.97	2120012	94.91	35.52	0.00	2233743
2006	2402	0.100	455619	19.04	1934680	80.86	70.87	0.00	2392772
2007	3764	0.103	119218	3.27	3527041	96.63	85.13	0.00	3650108
2008	3405	0.200	53833	3.16	1646905	96.64	35.56	0.00	1704179
2009	1677	0.113	128452	8.62	1359726	91.26	47.13	0.00	1489902
2010	2310	0.166	48778	3.51	1338619	96.32	46.25	0.00	1389753
2011	2156	0.159	5021	0.37	1346451	99.47	52.01	0.00	1353680
2012	2015	0.150	4698	0.35	1338549	99.50	50.36	0.00	1345312

Conclusion :

Due to climate change number of drought years and heat stroke are increasing. Warming of the climate system induces increase in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. In India, an increase in the surface air temperature has been observed in the past century. Climate change leads to many extreme events. It will affect the human habitat. This is reflected in the death of human being.

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