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EXTREME WEATHER EVENTS IN HIMACHAL PRADESH WITH SPECIAL REFERENCE TO CLOUDBURST AND FLASHFLOOD IN LAST THREE DECADE

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ABSTRACT

Human induced climate change has contributed to the changing patterns of extreme weather events across the globe, from longer and hotter heat waves to heavier rains. While natural variability continues to play a key role in extreme weather. Climate change has shifted to the odds and changed the natural limited, making certain types of extreme weather more frequent and more intense. Extreme weather events are on the rise, and the indications are that it will continue to increase more in both predictable and unpredictable ways. Increase in temperature, rainfall, rainfall variables and intensities in the State may lead to accelerated summer flows which leading to situations like flash/flashfloods in north western regions of the State. Health risks also associated indirectly with extreme events in sub montane, low hills, and humid agro climatic zones of the State.

In Himachal Pradesh due to extreme weather events mainly cloudburst and flashflood in past three decades, there were so many losses of lives and damage to the properties, cloudburst formed flashflood and landslides in hilly areas. The main regions in Himachal Pradesh are like Kullu, Kinnaur and the high altitude regions of Himachal Pradesh. In this study Kullu, Kinnaur and Mandi district had highest number of cloudbursts and flashfloods.

Whereas in last 5 years this is estimated that total damage to the houses, crops and public properties lead to 4 % revenue loss of total estimated budget of Himachal Pradesh. It is also revealed that revenue losses are continuously reduced since 2014-15 i.e. 3.36%, 2015-16 i.e. 3.17%, 2016-17 i.e. 2.64% and in 2017-18 loss is only 2.55% that due to appropriate implementation state disaster management plan.

The present paper is based on the secondary data/information and aims at giving an account of various incidences of flashfloods and cloudburst in their multi-facet impacts on the Himachal

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Pradesh. The paper also tries to analyze the spatial similarities and differences in the flood prone areas to find out the policy imperatives for the sustainable development.

Keywords: extreme weather, rainfall, cloudburst, flashflood, Himachal Pradesh.

INTRODUCTION

Weather is the state of the atmosphere, describing for example the degree to which it is hot or cold, wet or dry, calm or stormy, clear or cloudy. Most weather phenomena occur in the lowest level of the atmosphere, the troposphere, just below the stratosphere. Weather refers to day-to-day temperature and precipitation activity, whereas climate is the term for the averaging of atmospheric conditions over longer periods of time. When used without qualification, "weather" is generally understood to mean the weather of Earth. Weather is driven by air pressure, temperature and moisture differences between one place and another. These differences can occur due to the sun's angle at any particular spot, which varies with latitude. The strong temperature contrast between polar and tropical air gives rise to the largest scale atmospheric circulations: the Hadley Cell, the Ferrel Cell, the Polar Cell, and the jet stream. Weather systems in the mid-latitudes, such as extra tropical cyclones, are caused by instabilities of the jet stream flow. Because the Earth's axis is tilted relative to its orbital plane, sunlight is incident at different angles at different times of the year. On Earth's surface, temperatures usually range ±40 °C (−40 °F to 100 °F) annually. Over thousands of years, changes in Earth's orbit can affect the amount and distribution of solar energy received by the Earth, thus influencing long-term climate and global climate change. Surface temperature differences in turn cause pressure differences. Higher altitudes are cooler than lower altitudes, as most atmospheric heating is due to contact with the Earth's surface while radiative losses to space are mostly constant. The Earth's weather system is a chaotic system; as a result, small changes to one part of the system can grow to have large effects on the system as a whole. Human attempts to control the weather have occurred throughout history, and there is evidence that human activities such as agriculture and industry have modified weather patterns.

Extreme Weather Events - Long term observations suggest that there has been an increase in the extreme weather events viz. drought, heavy rains, floods situation and heat waves over the globe. Heavy and widespread rains with heavy falls lead to flood situations, World meteorological organization (WMO), and Intergovernmental Panel on Climate Change (IPCC) point out for climate change and its effect on increasing extreme weather events

India is greatly influenced by such weather systems during southwest or summer monsoon season during June to September. Drought and flood situations over India occur mainly during this rainy season. Extreme weather due to cyclones occurs during pre and post monsoon seasons.

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Though, direct evidences of climate change effect on monsoon season are not recognized fully till date. But, large intra-seasonal and inter-annual variations of precipitation are observed associated with the large scale atmospheric flow patterns over different parts of the world, including India, during monsoon. Rainfall during four months June to September of monsoon is about 80% oftotal annual rains over India. Generally, parts of India suffer with drought (flooding situation) if significant less (widespread and excess or heavy) rainfall occurs in monsoon. About 60% livelihood of population of India depends on agriculture. Though, there has been continuous increase of irrigated agricultural land after independence. But, still about 60% agriculture is rain fed (WMO). Production of Kharif and Rabi crops depends on rainfall during summer monsoon and post monsoon or northeast monsoon (October to December). Rabi crops depend on temperature in winter season (January-February) apart from precipitation. As most of the annual rain occurs during monsoon season, it has great impact on electric power, economy, agriculture, ground water and all facets of humans live.

Due to extreme variation in elevation, great variation occurs in the climatic conditions of Himachal. The climate varies from hot and sub humid tropical in the southern tracts to, with more elevation, cold, alpine, and glacial in the northern and eastern mountain ranges. The state's winter capital, Dharamshala receives very heavy rainfall, while areas like Lahaul and Spiti are cold and almost rainless. Broadly, Himachal experiences three seasons: summer, winter, and rainy season. Summer lasts from mid-April till the end of June and most parts become very hot (except in the alpine zone which experiences a mild summer) with the average temperature ranging from 28 to 32 °C (82 to 90 °F). Winter lasts from late November till mid March. Snowfall is common in alpine tracts (generally above 2,200 metres (7,218 ft) i.e. in the higher and trans-Himalayan region). Cloudbursts are associated with convective clouds. Vertical Development of clouds in Himalayan region is associated with its topography and southwestern monsoon wind direction. Himalaya is arch shape mountain located in east-west direction in the northernmost part of India. Average elevation of Himalaya is about 6100 meters above mean sea level. Himalayan river valleys are open towards south and are closed in the north. Summer monsoon winds enter in the river valleys and are forced to rise vertically along the valley slopes. Vertical development of clouds can extend up to 15 kilometers above the earth surface. Sometimes a very heavy rainfall occurs of equal to or greater than 10 centimeters per hour which is called cloudbursts. Cloudbursts are usually associated with landslides and flash floods. There is need to analyze and study the extreme weather events viz. heavy rains & cloudburst cause flood and flash flood situation during a monsoon season over Himachal Pradesh. Following objectives are undertaken: To study the rainfall and associated atmospheric features, and to study the hot spot areas of extreme weather events in Himachal Pradesh.

STUDY AERA

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Himachal Pradesh is situated in the Western Himalayas latitude 30° 22' 40" N to 33° 12' 40" N and longitude 75°45' 55" E to 79° 04' 20" E covering an area of 55,673 kilometres Himachal Pradesh is a mountainous state with elevation ranging from about 350 metres (1,148 ft) to 6,000 metres (19,685 ft) above the sea level. The drainage system of Himachal is composed both of rivers and glaciers. Himalayan rivers criss-cross the entire mountain chain. In fact the rivers are older than the mountain system. Himachal Pradesh provides water to both the Indus and Ganges basins the drainage systems of the region are the Chandra Bhaga or the Chenab, the Ravi, the Beas, the Sutlej and the Yamuna. These rivers are perennial and are fed by snow and rainfall. They are protected by an extensive cover of natural vegetation. Climate of Himachal Pradesh There is great variation in the climatic conditions of Himachal due to extreme variation in elevation. The climate varies from hot and sub-humid tropical in the southern tracts to cold, alpine and glacial in the northern and eastern mountain ranges with more elevation. The state has areas like Dharamshala that receive very heavy rainfall, as well as those like Lahaul and Spiti that are cold and almost rainless. Broadly Himachal experience three seasons; hot weather season, cold weather season and rainy season. Summer lasts from mid April till the end of June and most parts become very hot (except in alpine zone which experience mild summer) with the average temperature ranging from 28 °C (82 °F) to 32 °C (90 °F). Winter lasts from late November till mid March. Snowfall is common in alpine tracts (generally above 2,200 metres (7,218 ft) i.e. in the Higher and Trans-Himalayan region.

RESULT AND DISCUSSION

Himachal Pradesh mostly lies in the hilly area. The most areas of the state are under the flashflood and cloudburst prone areas as shown in the table no.2 with the the district wise hazard vulnerability. Whereas the table no.1 shows the extreme weather events and the damage occurred with the given rainfall data. Kullu, Mandi and Kinnaur are more affected districts due to flashflood and cloudburst. Hundreds of people lose their lives due to these natural disasters. Every year hundreds crore damages (houses, agriculture and horticulture etc) occur due to flashflood, cloudburst and heavy rainfall.

The extreme weather events increase because of El-Niño and climate change. The rainfall pattern change and there are unexpected rainfall in time of pre monsoon season. Due to climate change in Himachal Pradesh temperature increases every year. Effect of climate change on weather increase population and industrialization with time over all part of the globe led to increase in green house gases. Recent reports speak about huge per capita annual emission of GHGs over all the parts of the world. These activities cause increase in carbon dioxide, methane and nitrous oxides by about 1.5% times to 2.5% times in year 2005 these in pre-industrial period (year 1750) over the globe, due to these the global temperature is observed to increase by 0.74%. More

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events of drought, heavy precipitation and heat waves over parts of world are consistent with global warming and increase in atmosphere water vapor.

The major cause that is responsible for flashfloods in the state of Himachal Pradesh are cloudburst in the catchments region of the rivers, heavy rainfall in the upper reaches of the river. Sudden breach or bursts of man-made dams or natural lakes, landslides leading to obstruction of flow and change in the river corse, tectonic movements leading to slope failure and landslides (earthquake) .

Flashflood and cloudburst these are the worst disasters in the state, that not only causes huge economic loss in the form of damage to houses, public utilities, agriculture and property but also many losses of human lives and cattle heads. In the monsoon season almost all rivers of the state carry heavy discharge in their catchments area. The problem of flood varies from one basin to another and the magnitude of flood also varies. The most flashflood and cloudburst prone area in the state are in the Satluj and Beas rivers.

Table no. 1: Extreme Weather Events last thirty years in Himachal Pradesh.

Extreme Weather Events	History of Damage Occurred	Rainfall in mm
1. Soldang village, Flash flood, 29th September 1988.	Cloudburst and flash flood along Soldang Khad in Satluj valley killed 32 people, 15 houses washed away.	67.9mm data recorded at Chini Kapla.
2. Soldang khad and nearby area, Cloud burst, 31st July 1991.	Damaged 1500m road section of NH 22 and wash away agriculture land.	Data not available
3. Tapri and nearby area, Cloudburst and flashflood, 4th & 5th September 1995.	32 people and 35 cattle lost their lives.	88.0mm
4. Kullu valley, Flash flood, 4th & 5th September 1995.	Flash flood in Kullu valley occurred which cause damage to the tune of Rs. 759.8 million.	4th September – 72.9mm
5. Kullu valley, 12th September 1995, Flood and landslide.	Flood and landslide along Beas river in Kullu valley killed 65 people.	Data not available
6. Andhra khad Pabbar valley, Flash flood, 11th August 1997.	Flash flood and landslide along Andhra khad in Pabbar valley killed 124 people, 456 cattle.	68.2mm
7. Satluj valley, Flash flood, 31st July & 1st August 2000.	135 people and 1673 cattle lost their lives.	Data not available

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8. Satluj valley Kullu, Cloudburst, 22 July 2001.	Two persons were washed away and 5 cattle perished.	75.8mm
9. Mandi District, Flood, 17th & 19th July 2001.	Excessive rains caused damage to 160 houses in Mandi and destroyed 11 cattle and one human life.	Data not available
10. Chhota Bhangal and Baijnath sub division, Flash flood, 29th &30th July 2001.	Caused widespread damage in the area. 12 deaths occurred due to flash floods and loss 150 cattle.	29th July – 122.0mm 30th July – 22.0mm
11. Ani sub division Kullu, Flash flood, 21st & 22nd August 2001.	9 people and 70 cattle lost their lives.	44.3mm
12. Sihunta and Tissa area of Chamba district, Flash flood, 12th and 13th August.	Washed away 9 hectare of fertile land, 2 small bridges causing a total loss to property of some Rs. 2 Crore.	13th August – 173.8mm
13. Gharsa valley district Kullu, Flash flood due to cloudburst, 16th July 2003.	Due to these flash floods 21 people lost their lives, 21 people suffered major injuries and 9 still missing.	61.0mm
14. Kangri Nalla near Solang Kullu, Flash flood, 7th August 2003.	30 people lost their lives and 19 people injured and 9 people are missing.	48.1mm
15. Parachoo lake in Tibetan catchment, Flash flood, 26th June 2005.	Extensive damage as a result of risen water level of Satluj river.	Data not available
16. Bhavi Village, Ghanvi Village, Shimla, Cloudburst and flashflood, 15th August 2007.	58 persons died; all roads leading to village cut off.	80.0mm
17. Dharampur, Mandi, Flash flood, 7th August 2009.	2 persons died.	104.7mm
18. Kharahal valley Kullu, flash flood, 12th September 2010.	Washed away several roads and bridges.	65.1mm
19. Pandoh in Mandi, Cloudburst, 6th August 2011.	10 domestic animals washed away.	95.0mm
20. Mandi, Flashflood, 12th August 2011.	Four person lost their lives.	177.4mm
21. Chamba, Heavy rainfall, 15th June 2014.	Two persons died in Chamba.	300.0mm
22. Sirmour, Cloudburst & flashflood, 6th August 2014.	Four persons washed away along with car due to cloudburst in Sirmour	237.0mm

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	district.	
23. Jahu Hamirpur, Flash flood, 13th & 14th 2014.	Three persons died in Jahu district Hamirpur.	163.8mm
24. Kullu valley, Cloudburst, 16th July 2015.	Three died in Kullu district due to cloudburst.	240.4mm
25. Dharampur District Mandi, Cloudburst, 8th August 2015.	Three persons buried alive.	138.0mm
26. Sunni Shimla, Cloudburst and flashflood,10th may 2016.	Five persons washed away along with car in Sunni due to cloudburst.	65.0mm
27. Sangla valley Kinnaur, Cloudburst,17th July 2016.	Property loss.	104.0mm
28. Rampur Shimla, Cloudburst, 25th &26th August 2016.	Five persons died due to cloudburst.	77.0mm
29. Baddi Solan, Flashflood, 6th June 2017.	Eight persons died.	45.0mm
30. Nirmand district Kullu, Cloudburst, 6th & 7th August 2017.	Two persons died due to cloudburst.	160.0mm
31. Mandi, Flashflood, 13th August 2017.	Forty six people died at Pathankot Mandi National Highway due to landslide.	Data not available

Data import from IMD & State of Environment Report Himachal Pradesh.

Table no. 1 show that extreme weather events (cloudburst and flashflood) in different districts of Himachal Pradesh, this table also show that damage and rainfall in mm because of extreme weather events.

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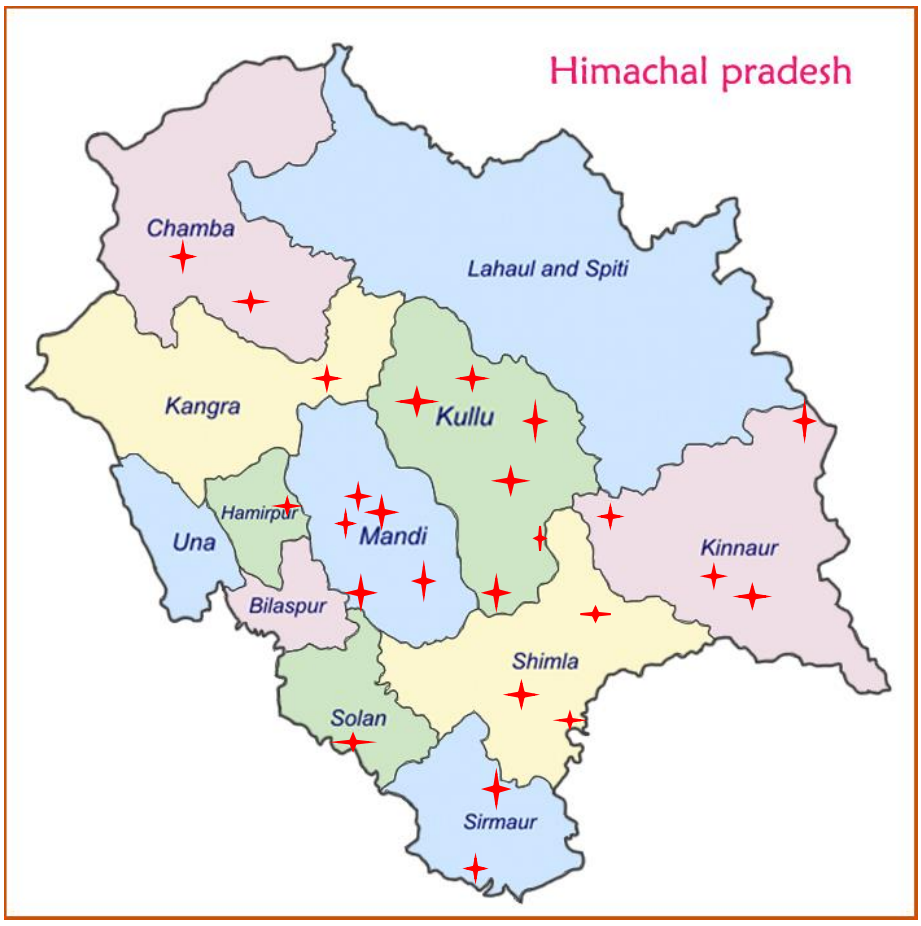

Map No. 1: Last thirty years main Extreme Weather Events Cloudburst and flashfloods.

This map show that hot spot areas of Himachal Pradesh in case of cloudburst and flashflood.

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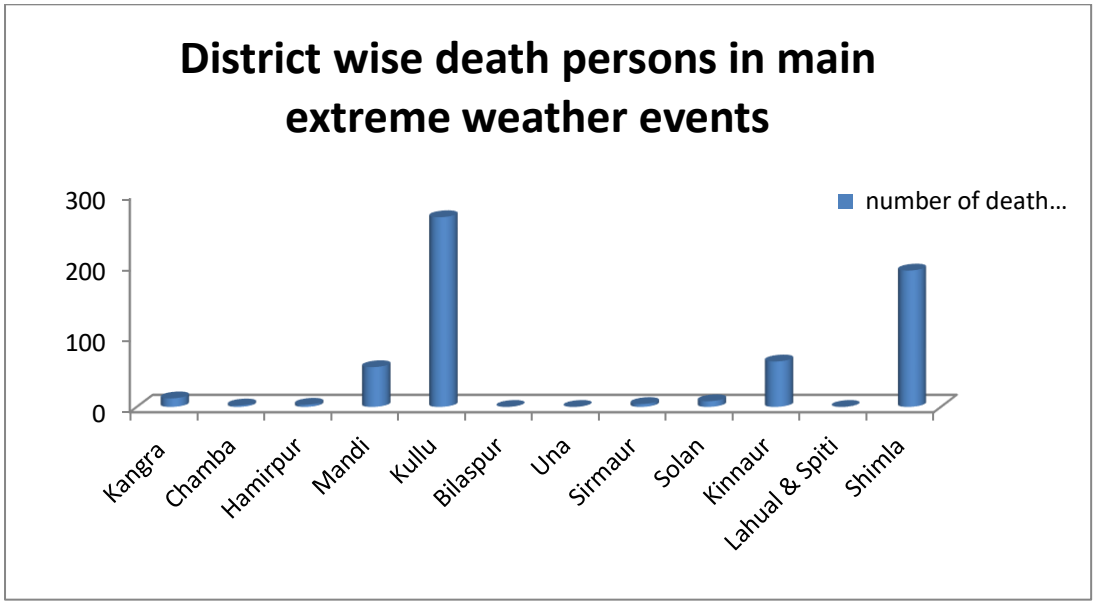

Figure No. 1: District wise loses in main extreme weather event in Himachal Pradesh (1988-2017).

Most of the districts of Himachal Pradesh face natural hazards but some of the districts face the brunt of such hazards more than other. In case of cloudburst Kullu and Kinnaur district more number of cases occurs.

Table no. 2: District wise hazard vulnerability.

S.N.	District	Flashflood	Cloudburst
1.	Kangra	Medium	Medium
2.	Chamba	High	High
3.	Hamirpur	Low	Low
4.	Mandi	High	High
5.	Kullu	High	Vary high
6.	Bilaspur	Low	Low
7.	Una	High	Low
8.	Sirmour	Low	Medium
9.	Solan	Low	Low
10.	Kinnaur	High	Vary high

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11.	Lahaul & Spiti	Medium	High
12.	Shimla	High	High

Source: Himachal Pradesh State Disaster Management Plan 2017.

In Himachal Pradesh flood mainly occur because of cloudburst and heavy rainfall in catchment areas of rivers. Every year in monsoon season hundreds of crore rupees damage because of flashflood and cloudburst. Table no. x show that area, population, crops, cattle lost and humanliveslost etc in during 2001-2011 in Himachal Pradesh.

Table no. 3: Flood Damages in Himachal Pradesh during 2000-2011.

YEAR	Areaaffected (m.ha.)	Population affected (million)	Damage to crops Area (m.ha.)	Damage to crops Value (Rs.Crore)	Damage to houses nos.	Damage to houses Value (Rs.Crore)	Cattlelost Nos.	Humanliveslost Nos.	Damageto publicutilities (Rs. Crore)	Totaldamage (Rs.Crores)
2000	0.420	0.87	0.031	46.8	3865	13.08	1411	35	1466.02	1525.9
2001	0.008	0.40	0.006	20.0	2683	4.223	915	45	113.981	138.2
2002	0.000	0.00	0.00	0.0	00.0	00.0	00.0	00.0	00.0	0.00
2003	0.033	0.30	0.016	17.7	2924	60.06	452	89	87.964	165.8
2004	0	0.02	0	0.67	524	0.864	103	8	29.236	30.7
2005	0.530	0.87	0.048	328.5	2024	9.147	3049	8	22.063	569.8
2006	0	0.00	0.094	245.4	4379	23.66	846	48	351.56	620
2007	0	0.00	0.180	239.1	10820	96.44	3087	98	933.34	1268.9
2008	0	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.000	0.00
2009	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.001	0.60	0.204	286.3	6666	7.978	5839	62	1750.710	2044.0
2011	0.030	0.60	0.157	417.3	8467	0.480	2372	51	618.600	1036.4

Source: State Disaster Management Plan 2012.

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Nature and period of calamity: Cloud Burst, Flash floods, Landslides during Monsoon 2014-2017.

The estimated budget of a state was 28552 crore in the years 2014-2015. Whereas it is estimated that total damage due to house, crops, and public properties was 961 crore, and it was 3.36% of state budget (Fig.3&4). In the year 2015-2016 state budget was 28339 crore and the calamity revenue loss was (901.00 crore) 3.17%of total state budget. Whereas the estimated budget of a state was 32593 crore in the 2016-2017 and revenue loss due to calamity was 826.37 crore (2.64%).The estimated budget of a state was 35780 crore in the 2017-2018. It is estimated that total damage due to house, crops, and public properties was 914.05 crore, it was of state budget 2.55% (Fig.3&4).It is reveled from above data that percentage of revenue losses are continues decreases year wise year, all due to state disaster management plan(figure no. 3).

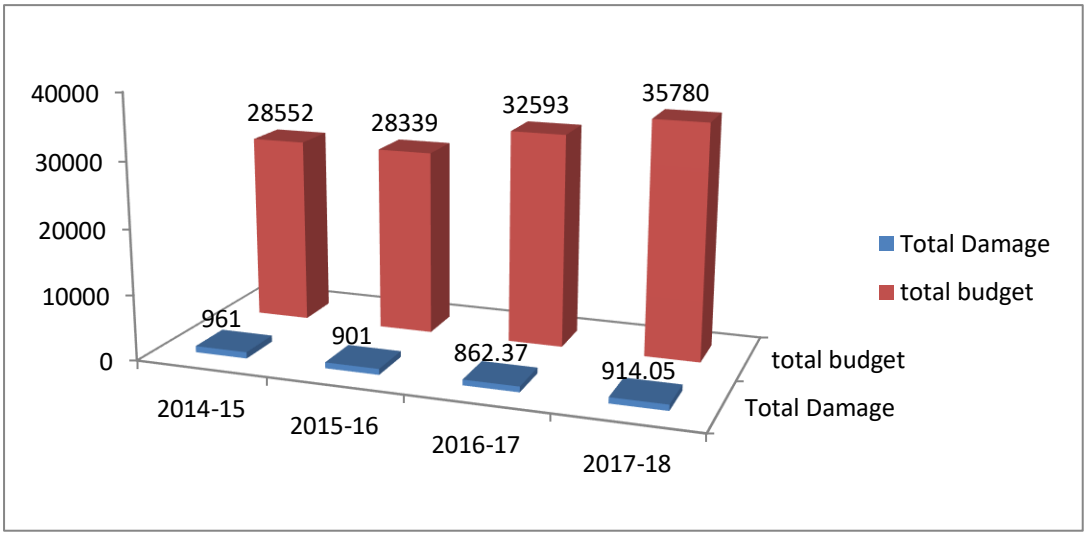

Figure No. 2: Showing difference in between total budget of Himachal Pradesh and total damage due to extreme weather events during 2014-2017.

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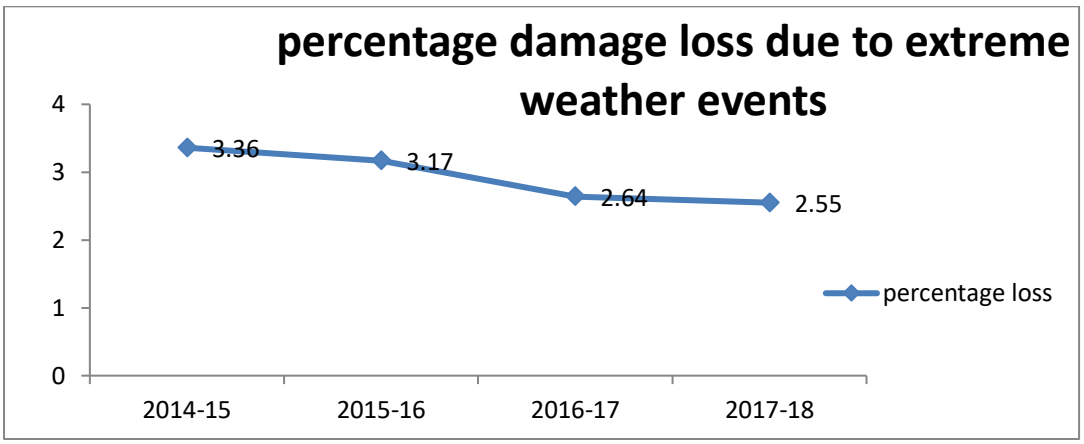

Figure No. 3: Showing percentage damage loss due to extreme weather events compare to annual budget of Himachal Pradesh.

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