

Review Paper

Dichotomy of Rain: The Dilemma of Cloud Bursts in Uttarakhand (India) and Challenges to Disaster Management

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Abstract

The rain plays a crucial role in shaping the landscape and bringing nutrients to the creatures for survival, whether it is an ocean ecosystem or mountain eco systems such as in Indian Himalayan region. The geographical concepts of mountains acting as rain shadow and rain shedding natural structures are interlinked. In this way, rain not only enrich in variety of flora, fauna, human communities and cultural diversity but also important as a provider of life, offering water to a huge part of the Indian Himalayan subcontinent. But in recent past, continuing climate change and anthropogenic activities brings significant changes in the climate and precipitation pattern of the Himalayan area. As a result the, Uttarakhand state in Indian Himalayan Zone, is currently known for developing recurrence and power of common catastrophes like Cloud burst, downpour, overwhelming precipitation and ensuing avalanches. These frequencies result in the loss of people, agriculture lands, infrastructure, and further insecurity of mountain slants and ecosystems. As number of cloudburst accidents in Uttarakhand Himalaya area arising every year and hence, lots of discussions are going on how climate change is seeking revenge on mankind by endowing us with disasters! These cloudbursts in first look seem to mostly link with the occurrence of extreme event due to climate change. In this foundation, the main aim of this paper is to investigate and find the factors responsible for increased intensity of cloud burst and the extreme rainfall events experienced by the Uttarakhand through recent rainfall data. The paper likewise takes a gander at and examines different choices for disaster risk diminishments and reductions in the sensitive eco zone like Uttarakhand.

Keywords: Cloud Burst, Disaster Management, Downpour, Rain, Uttarakhand.

Introduction

Rain, the most important component of the planet earth, which is not only considered as “deliverer of life” but also consider as shaper of our civic establishments and landscape¹. The rain has charmed human being from establishment of human evolution. Many civilizations had adored rain as a divinity and religion adopts as the purifying agent². Hence, the peoples have made progress towards it, quite a while to imagine about that was dipping down on their heads from heaven and soon planned to examine its secret by building up an investigative way to deal with it. Numerous types of land-based life depend in light of fresh water, which originates from rain. This rain supplies the water that terrestrial living beings need, either specifically as rain that falls on soil where plants develop or in a circuitous way as lakes, streams and lakes where creatures can drink³. Be that as it may some rain meets with another destiny, i.e. gradually leaks its way into the ground and infiltrates permeable rock layers to end up groundwater⁴. Spring water from underground aquifers supplies streams and lakes, and people have utilized groundwater since time immemorial both for drinking and inundating crops^{4,5}. This groundwater is particularly critical for life amid dry seasons, since springs may be the only source of fresh water available during these times⁶. Rain in the form of

snow aggregates on mountain inclines amid the winter melts and nourishes streams and waterways in the summer⁷. In this way rain plays a crucial role in shaping the landscape and bringing nutrients to the creatures for survival, whether it is an ocean ecosystem or mountain eco systems such as in Indian Himalayan region. Rain and mountains speak to life structures and add to an agitating of life of 'a large number of years'⁸, therefore, the topographical ideas of mountains about as “Rain Shadow” and rain shedding natural structures are interweave the relationship between the mountain and the cloud⁹. It is evident from the rainfall from places like “Masinram”, India, Earth's wettest spots in southern Himalayas which has gotten 26.5 rainfall in one year and places like the “focal valleys of the Atacama desert”, the driest spots protected by encompassing mountains which can go for decades without rainfall¹⁰. In this way rain plays a crucial role in shaping the mountain ecosystem zone such as Uttarakhand, a fragile and sensitive ecosystem zone in Indian Himalayan region in which Himalaya, acting as rain shedding natural structures, brings nutrients to the creatures for survival in the form of rain and surface runoff. Hence, rain not only enrich in variety of flora, fauna, human communities and cultural diversity but also important as a provider of life, offering water to a huge part of the Uttarakhand Himalayan areas. These geodynamical young mountain ranges of

Himalaya, has been honoured by communities since the distant past and hence every year visited by a large number of pilgrims for paying tribute¹¹. But in recent past this area in which seers and saints, who found the Himalaya as the source of sacred thoughts and peace has been converted into arena of wreaked disaster. Persistent climate change is anticipated to prompt significant changes in the climate and precipitation pattern of the Himalayan area. As a result the, Uttarakhand is currently known for developing recurrence and power of common catastrophes like Cloud burst, downpour, and overwhelming precipitation. These disaster result in the loss of people, agriculture lands, infrastructure, and further insecurity of mountain slants and ecosystems. In the past, many of these climatic disruptions had occurred by natural phenomena, but from scientific studies it is evident that most climatic changes, like cloud burst, which mankind is witnessing is likely to result from anthropogenic activities.

Study Area

General State Profile: Uttarakhand is a land which is bestowed with natural grandeur at its best - picturesque locations, snow-capped Uttarakhand a hilly state of India, blessed with outstanding natural beauty like, snow-topped mountains, lavish green valleys, a cool atmosphere and affable people^{12,13}. It is situated between 30.0668° N Latitude and 79.0193° E Longitude, with aggregate geological zone of 53,483 sq. Km., out of which around 89% is hilly under which around 19% is under perpetual snow spread, icy masses and soak slants. Uttarakhand is a part of the North-Western Himalayas limited by Nepal in the East and Himachal Pradesh in the West, while northern limits goes up to *Tibet* while southern limit reaches out into Indo-Gangetic Plains. The aggregate geological territory it is fragmented into 13 regions inside two revenue divisions. As per the “*Census of India*”, 2011 report Uttarakhand's inhabitants is around 1.01 Crore with an expansion of 19.17 percent from the previous decade with significant spatial variety. Four of the 13 locale, to be specific *Dehradun*, *Haridwar*, *Udham Singh Nagar* and *Nainital* represent 61.5 % of the state's aggregate populace, which mirrors that the confederacy of population is very high in the mid and foothills when contrasted with the others six districts. Uttarakhand lies on the south incline of the powerful Himalaya range, and the atmosphere and vegetation change enormously with elevation, from icy masses at the most astounding heights to tropical backwoods at the lower rises called “*Tarai*”. Between 3000-3500, the Western Himalayan Alpine Shrub and Meadows ecoregion lies and prior to 5000 meters rise tundra along with alpine trees covers the most of the mountains. Just underneath the tree line, the Western Himalayan subalpine conifer backwoods comes at 3000-2600 meters also more inclined towards Western Himalayan broadleaf timberlands, which lie in a belt from 2,600 to 1,500 meters rise. Beneath 1500 meters rise lays western end of the drier *Tera-Duar* savanna and meadows belt, and the *Upper Gangetic Plains* clammy deciduous woods, therefore this belt is also called as *Bhabhar*. Hence elevation reflects and indicates

complete qualities of Himalayan atmosphere applying a calculable degree of impact on storm and precipitation. The atmosphere fluctuates inside the mountains as per the elevation of the spot. In the southern foothills, the normal summer temperatures change between 30°C to 18°C and winter is additionally tolerable and typical. In the zones of the Middle Himalayas, the midyear temperatures are around 15°C to 18°C; however winters temperature even drop underneath the point of solidification.

The higher heights of Himalayas (more than 15,000 feet) are cool consistently and now and again gotten to be difficult to reach because of overwhelming snowfall. The eastern edges of the Himalayan extents are liable to overwhelming precipitation while the western division is generally dry. However in Gangetic fields, summers are to a great degree hot and moist with temperature crossing the 40°C. In this way, the exceptional geographic, physiographic zones and climatic conditions depicted Himalayas as “*The Third Pole*”; and thus relevantly called as the “*Water Tower of Asia*”^{14,15}. The Geological Survey of India affirms that there are well more than 5,000-6,500 ice sheets in the Indian part of the Himalayas, out of which, in the state of Uttarakhand, the four sub-basin of *Ganga*, *Yamuna*, *Bhagirathi* and *Alaknanda* together constitute about 900 glaciers^{15,16}. *Gangotri*, *Yamunotri*, *Dokriani*, *Pindari* and *Milam glaciers* are few of them which structure imperative parts of the watershed¹⁷. Subsequently these glaciers shape River Basins and Sub Basins of Uttarakhand, with the stream of water through very much characterized channels, known as “*Drainage*” and the system of such channels is known as a “*drainage framework*”¹⁸⁻²⁰. The Major River Basins and Sub Basins have been congregated into six catchments which incorporate “*Yamuna Catchment*, *Bhagirathi Catchment*, *Alaknanda Catchment*, *Mandakini Catchment*, *Pindar Catchment* and *Kali Catchment*”. These Himalayan Rivers have a critical spot in Indian society and concord. Since the time of the *Puranas*, the antiquated Hindu sacred texts, this area is frequently called as the “*Land of Gods*”, as it is a spot favored with the excellence of paradise and the beauty of Gods.

Methodology and Research Objective

This research is based on interdisciplinary approach along with theoretical and integrated research review, in which the data and information has been synthesizes in the accumulated state of knowledge on similar or related data to the cloud burst and rainfall. Thus this article is based on study, involving compilation and analyses of information and data from official documents, research papers, reports, media reports and articles. Precipitation information and day by day precipitation information for all the accessible stations in and around the Uttarakhand area has been secured from the *National Data Centre (NDC)*, *National Informatics Centre (NIC)*, *India Metrological Department (IMD)*, Pune, for the time of 1901-2014. Recent precipitation data were gathered from “*Annual Climate Summary*” – 2015, developed by IMD Pune. The event

of cloud burst and the related casualties were sourced from National Disaster Management Authority (NDMA) reports, website and from various media reports. After the accumulation of information from various hotspots for more than 100 stations, every one of the information was orchestrated station wise. From the every month and for every year one most elevated worth was assessed for every station. Any exception was not considered. From this information yearly and occasional most astounding precipitation was acquired. With the available data, this article examines the phenomenon of frequent cloud burst in the Uttarakhand state, probable reasons, and suggests possible mitigation measures. It is expected that this research will provide a crystal clear view to cloud burst and answer to question "why life shaper property of rain changes into cloud burst in Uttarakhand?"

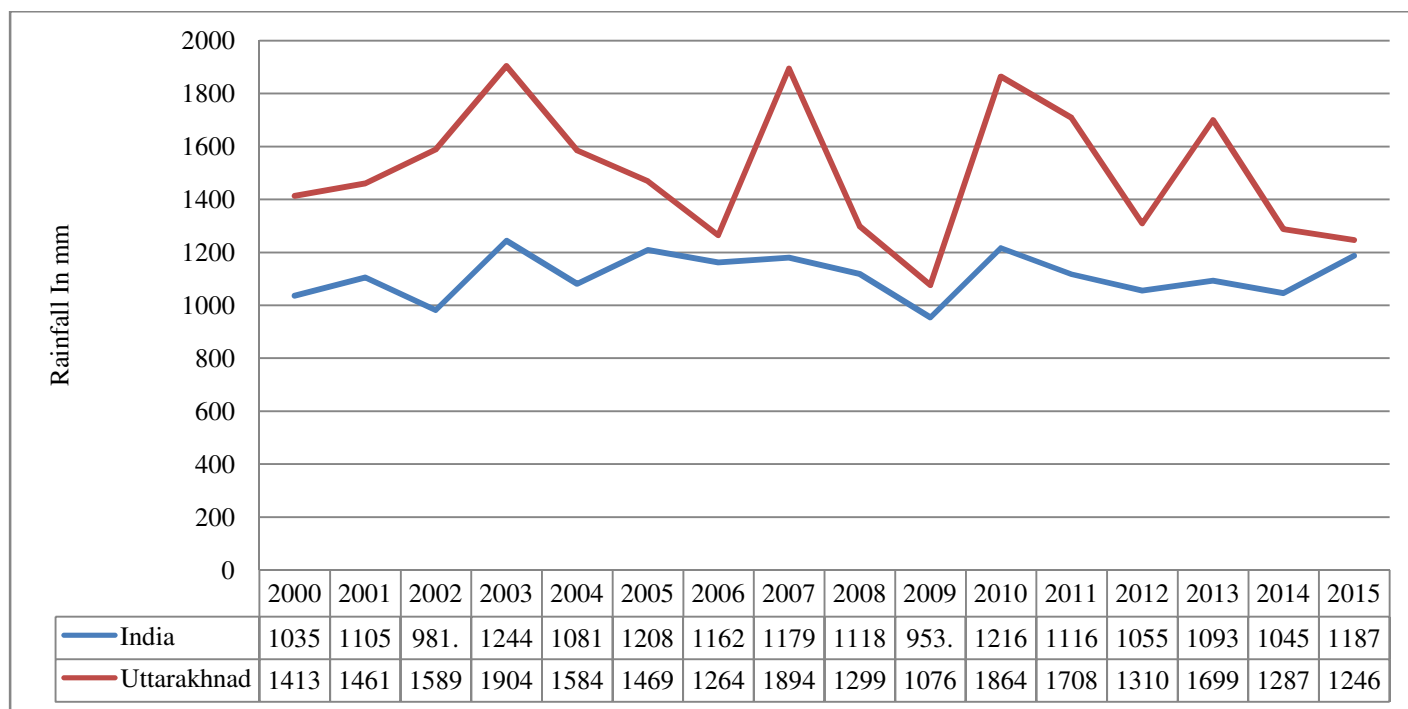
Dichotomy of Rain

In Uttarakhand, rain and mountains speak to life structures and add to an agitating of life of 'a large number of years. These mighty mountains peaks of Himalaya distinguish the stones that sparkle under sunshine, the cloud personally and have a reasonable notion of the approaching precipitation. The cloud by shedding their dampness on the unique mountain environment blessed its invigorating geographical topographies like, mountain peaks, waterfalls, glaciers, and thus portraits mountain villages and towns set amidst outstanding scenic beauty. Here rain changes the scene into watercolour mirages. The quiet surfaces of transitory lakes and puddles mirror the sky and states of structures, reinterpreting vertical lines of trees and design in their numerous level reiterations. Mist moves over roads and structures, making shadowy delusions and eye soothing.

The fragrance amid and quickly after rain numerous individuals find particularly wonderful or distinctive. Thus the streams going through the enormous shakes and twist going through expansive pine trees creates a characteristic song independent from anyone else. Hence, in Uttarakhand, rain and Mother Nature, together had formed pulchritudinous viewpoints of indomitable Himalayas comparing with other Himalayan destinations. Every one tends to like rain, apart from times when it rains dangerously too long. In recent past, the perception of rain is changing as rains are converting into the situation of cloud bursts. Such occasions are seen to be generally happening, even where total precipitation is diminishing: 'it never rains yet it pours! (Table-2 and Figure-1, 2 and 3). The recorded information mirrors that cloud bursts and heavy rainfall are not new episode in Himalaya region especially to Uttarakhand (Table-2, 3, 4 and Figure-3), anyhow with the start of new millennium, the power and amenableness of this event has been expanded. Almost every year this state encounters the deluge and associated catastrophe with cloud Burst (Table-1,2 and Figure-2). As of late in 2016 deluge was a one of the disastrous instance in human civilization²¹. Warmed by the sun's radiation, the sea and land surface evaporates water, which then moves

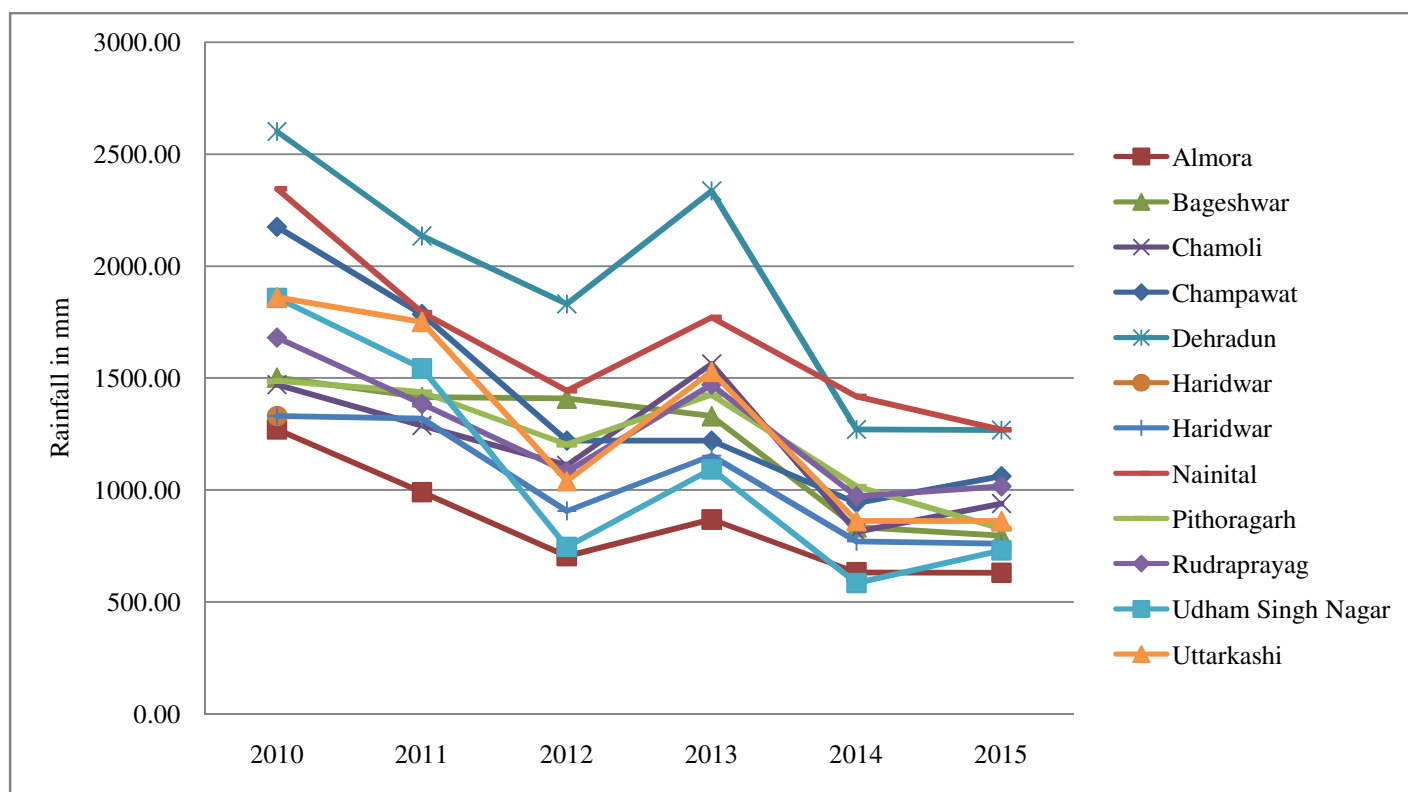
around with winds in the air, consolidates to shape cloud, and falls back to the Earth's surface as rain, just for some of it to stream to seas by means of rivers, thereby completing the worldwide hydrological (water) cycle²². Despite the fact that the component of cloud embodiment is surely knew by scientific communities but what precisely causes a cloud to deliver downpour remains a meteorological riddle²³. There are different meteorological models which use variables like wind velocity, air humidity etc, however the inward mechanics of clouds remain mysterious^{24,25}. As per the *India Meteorological Department (IMD)*, the cloudburst is a rainfall occasion in which overwhelming precipitation happens over a confined range with intensity of the order of 100 mm h⁻¹, accompanied by strong winds and lightning, as was seen in *Uttarkashi and Ukhimath* this year and in *Lehin*^{26,27}. It is trusted that they happen because of spontaneous lifting of the monsoon clouds, usually up to height of 15 km from the ground, as influenced by the sheer orography of the area. This uplifting of clouds brings the water droplets under "cumulonimbus convection condition", which further cause development of towering vertical thick clouds^{23,28}. As a result, under this situation the intermolecular strengths between the H₂O particles get stronger due to the quick diminishing in the temperature along with excess of electrostatic power in the clouds, bringing about the lighting to stay inside the cloud, which further trap the hyperactive energy inside the cloud. Therefore, the water particles get denser and denser and get solidified yet don't leave the cloud in light of excess of electrostatic powers. As the water concentration get ever more elevated thus the weigh gets heavier the water never again can keep up power with the cloud thus they fall. The lifting is typically dynamic and this causes thermodynamic fragility bringing about cloud bursts^{29,30}.

In Uttarakhand, rain has additionally been a boundless wellspring of motivation for artists and nature lovers. Not just would we be able to watch it in its characteristic environment, but also it is evident from various man-made structures alongside cultural and societal attitudes towards rains, which vary over the world. Be that as it may, now days, because of increment recurrence of rains, evoked different feelings, mostly negative which leads to dichotomy of rain. In spite of the fact that the conventional apprehension of rain in Uttarakhand culture is positive instead of adverse, but after 2010 onwards people do know that rain can also bring pain or blessed with soothing and aesthetic appeal. Hence, it is now open secret that cloudbursts bound people to believe that rain can have a discouraging impact by arousing their bitterness, despairing, dread, or a need to get away, which was prior be seen as sentimental, bringing out euphoria and persuading fun. Consequently the rain which regarded as a sheer matter of survival, which is the reason it is petitioned God for, welcomed with rapture and celebrated by moving when it in the long run comes, it is currently be seen as awful climate antagonistic to wellbeing and life as an outcome numerous individuals want to stay inside on stormy days, quietly imploring God by expecting that this rain remain rain not a cloud burst.



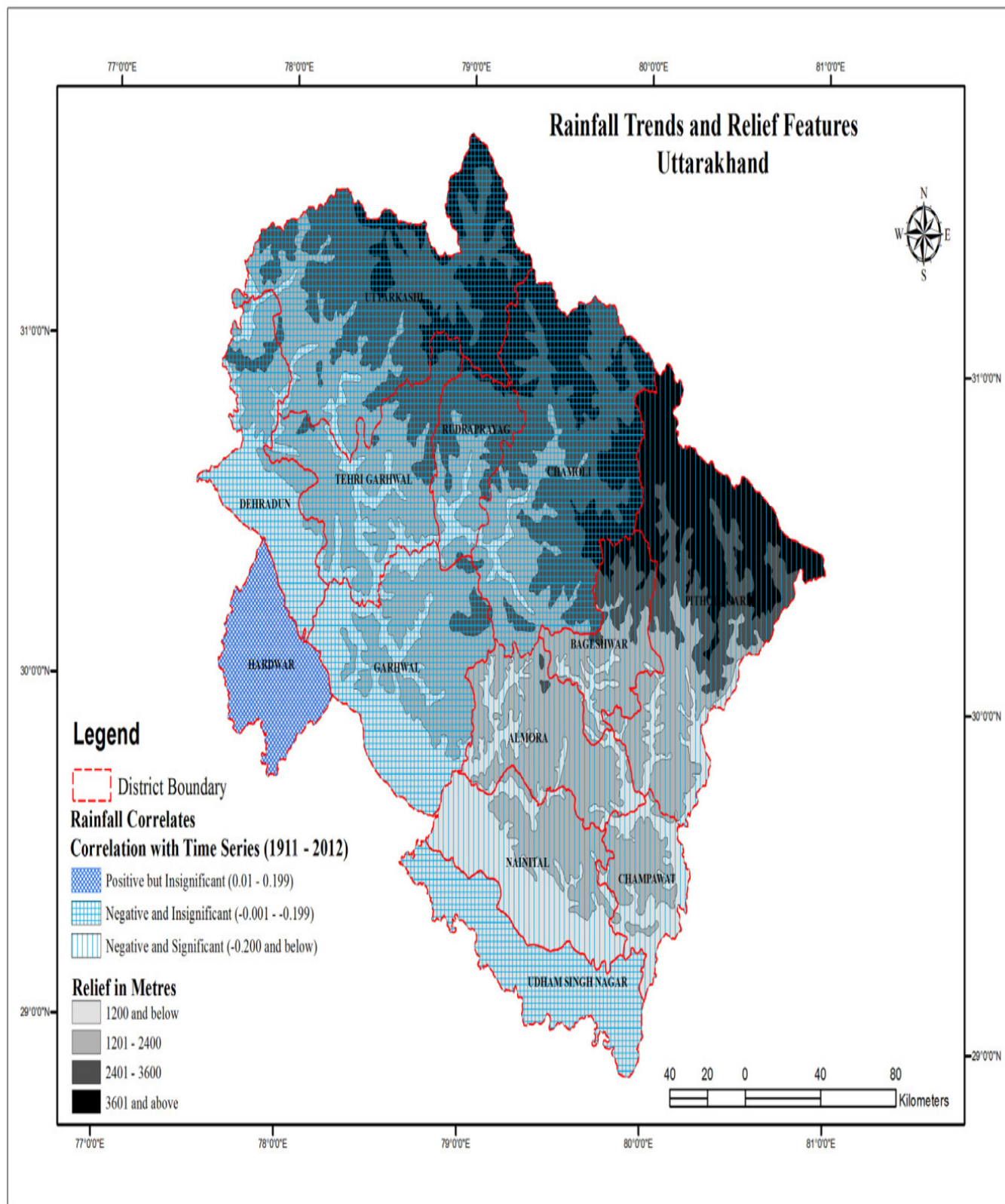
Source: IMD and National Informatics Centre (NIC), Ministry of Electronics and Information Technology, Government of India

Figure-1
Uttarakhand Rainfall Vs Annual rainfall of India



Source: IMD and National Informatics Centre (NIC), Ministry of Electronics and Information Technology, Government of India

Figure-2
Uttarakhand Major Districts Actual Rainfall June-September (in mm)



Source: IMD Pune

Figure-3
Uttarakhand Rainfall trends

Table-1
Cloud Bursts in Uttarakhand and related casualties

Affected Area	Year of Occurrence	Rate of Destruction
Pithoragarh, Uttarakhand, India	July 1, 2016	30 have been feared dead
Kothiara village in Uttarakha	May 28, 2016	damaging hundreds of houses in over half a dozen villages in Balganga valley and disrupting the Char Dhaam Yatra
Karnaprayag in Chamolidistrict	May 8, 2016	damaging hundreds of houses
Tehri, Uttarakhand	July 23, 2015	Two killed
Navthana village under the Ghansai sub-division of Uttarakhand's Tehri district.	July 31, 2014	Six killed and landslides at 25 places had blocked more than 150 key roads in Uttarakhand
Kapkot, Bageshwar	August 1, 2013	Various Landslides and disrupting the Char Dhaam Yatra
Kedarnath, Rudraprayag District	14-15 th June, 2013	10,000 were died and 7000 missing and several injured
Ukhimath, Rudraprayag District	September 13, 2012	39 were people died.
Bhatwari, Uttarkashi	August 2-8, 2012	34 persons died and 80 villages are totally cutoff for a month.
Almora district	September 14-15, 2010	1700 families were affected
Munisyari, Pithoragarh district	18th August, 2010	30 were died and 50 injured
Kapkotvillage, Bageshwar District	19th August, 2010	18-20 were died, more than 30 missing
Almora district	July 21, 2010	46 people were killed and 300 village affected badly
Nachni near Pithoragarh District	7th August, 2009	38 were people died.
Near Badrinath Shrine, Chamoli District	6th July, 2006	17 people died and 28 injured
Malpa, Kali Valley of Kumaun Division	17th August, 1998	250 were died including 60 Kailash Mansarrovat pilgrims
Khetgaon	2002	4 people died
Badrinath Shrine, Chamoli District	24 th July, 2004	17 were died and 18 missing
Alakananda river basin	July, 1970	15,000 were died and 80,000 houses were destroyed along the bank of Alakanada.

Source NDMA

Table-2
Magnitude of extreme one-day rainfall (mm) for stations in and around the Uttarakhand

Months / Season	Lowest	Highest
Jan	18.0	576.0
Feb	17.8	381.8
Mar	0.8	288.0
Apr	3.0	279.8
May	5.0	370.0
Jun	1.6	362.0
Jul	48.3	487.0
Aug	41.2	398.8
Sep	40.2	475.0
Oct	27.9	307.3
Nov	0.4	134.0

Source: IMD and National Informatics Centre (NIC), Ministry of Electronics and Information Technology Government of India

Table-3
Highest one-day rainfall (>400mm) recording stations inside the Uttarakhand (1901-2015)

No.	District	Station	Altitude (m)	Highest 1 day Rainfall (mm)	Date of Occurrence
1	Dehradun	Dehradun (O)	682	487.0	25/07/1966
2	Dehradun	Rajpur	975	440.4	25/08/1954
3	Uttar-Kashi	Kharsali(O)	2591	400.8	15/09/1963
4	Tehri-Garhwal	Mukhim	1981	450.0	05/09/1995
5	Pithoragarh	Askote	1372	450.0	05/09/1982
6	Pithoragarh	Berinag	1676	475.0	06/09/1965
7	Pithoragarh	Garbyang	3400	576.0	30/01/1968
8	Udham Singh Nagar	Bazpur	215	406.4	03/10/1934
9	Udham Singh Nagar	Khatima	203	405.6	13/09/1972
10	Nainital	Haldwani	348	413.0	11/07/1970
11	Nainital	kaladhungi	393	413.0	10/07/1970
12	Nainital	Nainital	2020	509.3	22/09/1958

Source: IMD and National Informatics Centre (NIC), Ministry of Electronics and Information Technology Government of India

Table-4
Month wise statistics of highest 1-day rainfall and their date of occurrence around the Uttarakhand

Month	Station	Altitude (m)	Highest 1- day Rainfall (mm)	Date of Occurrence
January	Khadrala	2957	762.0	28/01/1968
February	Khadrala	2957	482.6	16/02/1963
March	Chini (Kalpa)	2781	479.0	03/03/2002
April	Garbyang	3400	279.8	04/04/1969
May	Chini (Kalpa)	2781	378.0	04/05/1971 & 02/05/1989
June	Dhampur	235	400.0	25/06/1989
July	Dehradun (O)	682	487.0	25/07/1966
August	Dhampur	235	600.0	30/08/1991
	Thakurdwara	244	600.0	11/08/1991
September	Dhampur	235	772.2	18/09/1880
October	Simla (O)	2202	800.0	19/10/1899
November	Khadrala	2957	279.4	21/11/1967

Source: IMD and National Informatics Centre (NIC), Ministry of Electronics & Information Technology, Government of India

Why Uttarakhand is hub of cloudburst?

The major meteorological circumstance which provokes overwhelming precipitation over the Uttarakhand is:

Monsoon Depression: Throughout the summer monsoon season which includes June to September, the depressions arise in the North Bay of Bengal, few of them get twisted en route for the northeasterly part while proceeding to the central India, by making substantial overwhelming precipitation along the foothills of the Himalayas. A study from *Jin-Ho Yoon and Wan-Ru (Judy) Huang* on Indian Monsoon Depression: Climatology and Variability reflects that the higher the intensity of the depression, the greater the subsequent 24-hr rainfall, and the negative value suggests an inverse relationship. In last few year melancholies from the Arabian Sea had re-bends themselves after crossing the Gujarat and Maharashtra coast and strikes the “Garhwal-Kumaun” districts along with other districts of Uttarakhand by bringing on overwhelming downpours in the slopes and valleys of this region^{31,32}.

Break Monsoon Circumstances: In Indian Sub- Mainland, the monsoon is prevailing rainy juncture, usually experiences 30 to 40 days intra-occasional varieties which are known as break periods^{31,33}. But when this monsoon trough reshuffles towards the foot-slopes of the Himalayas from north Indian fields, which are meteorologically known as “setting in of 'break situation',

overwhelming precipitation happens in the eastern and focal Himalayas, bringing flooding in the streams of these regions³⁴. Break Monsoon circumstances generally happen amid the rainstorm months of July and August and at times in September³⁵.

Emanating from the Mediterranean and Caspian oceans, the extra tropical aggravations, commonly known as 'Western Disturbances' moves eastwards over Iran, Pakistan, Afghanistan and extreme northern parts of India. It brings on downpour and snow over the Himalayas, particularly, in the winter season³⁶. The recurrence of event of these Western Disturbances is about four to five every month amid the rainstorm season and six to seven every month amid the winter months.

Global Warming: a study from Ashok K. Singhvi and R. Krishnan shows that the debilitating and unpredicted pattern of the Indian Monsoon has been mainly due to the intensifying concentration of anthropogenic aerosol concentrates which includes sulphates, carbon black along with, soot and so forth. Their studies suggested that radiated impacts because of anthropogenic aerosols can alter the tropical climate-ocean coupled framework and cause unusual changes in the South Asian rainstorm flow, prompting a unpredicted rainfall patterns, sometime diminishing in precipitation or sometime substantial rainfall³⁶.

Have extreme rainfall and cloudbursts incidents increased over the years?

Massive studies have been completed on substantial precipitation and related surge at national and universal level along with Indian Monsoon trends. Rakhecha and Pisharoty on the ground of 80 years (1901-1980) precipitation information for 316 all around scattered stations over the India scrutinize the patterns and determination of substantial precipitation through standard statically tests. Their results displayed that the yearly great precipitation records of the vast majority of the stations are free from patterns and constancy. Similarly it is evident that there is an expansion in compelling storm downpour occasions in India over the span of 50 years from the 2009 report concluded by R. M. Khaladkar, P. N. Mahajan and J. R. Kulkarni of the *Indian Institute of Tropical Meteorology* detected thought extreme point rainfall event (EPRE). This study reports an alarming rise in EPRE after the 1980s, which is reflects that the intensity of rainfall increased by 40% to 370% after studying the 165 stations secured under the study. Furthermore, a 2009 study from S. D. Kotal, Soma Sen Roy and S. K. Roy Bhowmik brings out that due to vivacious association between mid-tropospheric trough in the westerlies and the rugged lower-tropospheric south-easterly rainstorm storm with monsoon low pressure framework over the North India, a lower tropospheric wind meeting zone created in and around Uttarakhand. As a result the westerly jet stream pumps in huge amount of moisture into the western Himalaya. Correspondingly a study by the *Indian Institute of Tropical Meteorology (IITM)* in 2015 speak to a fascinating elements and states that while there was a noteworthy rising pattern in the recurrence and magnitude of acute precipitation events, somewhere around 1951 and 2014, the event of moderate during the period was on a decline (Figure-3). But then, shockingly rainstorm precipitation over the previous century in India has stayed stable. How could that be? It is by virtue of decreasing trend of moderate events which is further rising the overwhelming precipitation events. The abstraction likewise sets up that there will be a hefty aggrandizement in perils identified with substantial rainfall over India later on. On the premise of it, researchers push the requirement for more nitty gritty appraisals all over India and recognize that the current downpour in northern India is a maximal rainfall event in conjunction with cloud bursts and that the nation will encounter a greater amount of such happenings later on. It is likewise obvious from these studies that the precipitation ought to be transiently and spatially disseminated inside 122 rainstorm days of the year, yet does that happen. As the whole measure of precipitation is pretty much the same over the 122 days, however the rainfall is not the same (Figure-2 and Table-2, 3 and 4). It might rain terrifically one day, as it did on 2013, 2014 and 2016 and afterward there is a chasm before it rains remarkably again. This situation is well known as protracted monsoon break and it is bad for humankind and environment. From these studies, it is clear that in acute events in Uttarakhand have been accelerated. Thus all these study gets and calls attention to that there may be sure

instabilities in the climatic model; however these acute events may have a connection with a worldwide temperature alteration and anthropogenic environmental change. The hike in surface temperatures, deforestation and huge reservoirs in river basin may bring about more evaporation and may likewise be expanding the moisture holding limit of the air, consequently prompting compelling downpours and cloudbursts.

Cloud burst tragedies of Uttarakhand: nature's wrath or man-made calamity

In Uttarakhand, natural catastrophes are as old as the Himalaya seems to be. A cloudburst which is considered as the foremost prime mover of numerous fiascos is not new to Uttarakhand. For the general population and Governments who contend that cloud bursts was the primary element behind the incident is not so true. There are numerous references to the past which demonstrate that such a substantial precipitation is not new and more than the precipitation this year, was recorded in the earlier years. Uttarakhand area saw such substantial rainfalls earlier, as the records demonstrate that Uttarakhand has recorded single-day precipitation in abundance of 400 mm multiple times, incorporating 450 mm in 1995 and 900 mm in 1965. Cloud Bursts, surges and flooding aren't extraordinary, but in a decades ago the human element have turned out to be more overwhelming and quickened. Consequently, the surge waters were stacked with thousands huge amounts of residue, stones and rubbish from dam development, found no outlet. The courses they took already, including valleys and streams, were blocked with sand and shakes. The waters deluged towns and regions, submerging various structures under a few feet of mud. A noteworthy number of the developments in the area are illegal and explorer motels that rose were out of penny's voracity since improvements depended on chaotic edge domains in which the tunneling is completely banned. The impromptu advancement is nullifying the nature of the mountains. In spite of number of Environmental Impact evaluation reports and natural laws, none of the laws are actualized in such delicate territories of Uttarakhand and the advancement is going unabated. The entire river basin in Uttarakhand has been converted into "engineer's playground"³⁷. There are total 427 dams are outlined for to be constructed on rivers and their development has altered the hydrological and different properties of river water³⁸. Each dams increased the surface area for evaporation as they are having big reservoir. For creating the reservoirs and dams, explosive impacts are required to shape the mountains, and on a Richter scale, such impacts are comparable to a quake of the greatness of 4.0, which is capable to exasperate avalanches, stifling drainage framework and in this way frame to counterfeit lakes^{39,40}. So also, mammoth development of streets and transport is getting the mountains Uttarakhand down. Massive pilgrims cause augmented increment in the number of vehicles⁴¹. As per official site of State transport of Uttarakhand, in 2005-06, there was only 83,000 vehicles enlisted in the state, which rose to almost 180,000 in 2012-13 and hopped to 19,00,962 vehicles in 2014-2015. Practically every ventures of

Uttarakhand, whether it is hydro power, street development, or township, include deforestation. In Uttarakhand, the forest spread in 1970 was 84.9% which got lessened to 75.4% in 2000 and further diminished to 71.05%. As per the report submitted by Forest Survey of India (FSI) in 2015, the forest cover of Uttarakhand has found to be decreased 268sqkm in last two years having total area of 24,240sqkm at present⁴². This deforestation directly increases the potential of erosion, landslides and floods since water now just runs off to the rivers, solid becomes exposed and without any binding that forests provided. It is an open mystery that impromptu urbanization, industrialization, and deceitful improvement arrangements are modifying the micro climatic states of Uttarakhand alongside worldwide environmental change, subsequently in charge of the vast majority of the human deaths and demolition of private and open property. As indicated by the Intergovernmental Panel on Climate Change (IPCC), "Glaciers in the Himalayas are retreating speedier than any other part of the world and if the present rate proceeds with, the probability of them vanishing by the year 2035 and maybe sooner is high, if the earth continues getting hotter at the present rate". This report likewise expresses that the collective territory of glaciers in the Himalaya will shrivel from 1930051 square miles to 38,000 square miles by 2035^{42,43}. The Himalayan area is a delicate zone, brimming with water bodies, timberlands and ice sheets and common judgment advocate that the provincial ecology be treated with responsibility and caution. The distraught insanity for energy has prompted damming of all water bodies. When unnecessary sand is expelled from the riverbeds, it hampers stream systems⁴⁴. Radical mining in the area are especially dangerous because the river beds and mines are rented out to those contractual workers, who usually cross the prescribed limits of mining regularly, and usually sorted out by plotting corrupt practice with administrators or legislators. Each action done for the sake of advancement wrecks trees and exasperates the environment. It has been continuing for quite a while and quickened in the previous decades after the purported monetary reforms and progression. The expanding convergence of religious voyagers and their exercises further disturbed the circumstance. However, accuse decisively falls for the shoulder of state organization that has no unmistakable coordinated and manageable improvement approach. They have additionally neglected to understand that in the environmentally delicate Himalayan area, nature is preeminent and all formative exercises must rotate around it. Doing anything contrarily will be a welcome to debacles, more so when the climate change impacts are debilitating individuals and society all over the place.

Challenges to Disaster management

The increase frequency of cloud Burst and flash floods along with number of deaths in Uttarakhand unequivocally demonstrated that there still nonappearance of precautionary and relief measure. It is without a doubt an unsettle situation that it happened in a state which had history of such debacles.

The post disaster balm feedback has been similarly poor and thus every such fiasco is asserting number of lives and bringing about colossal harm to economy alongside different social issues. This circumstance limits everyday citizens under general accord that the disaster administration power has neglected to do a large portion of its capacities which is an unequivocal truth. This demonstrates that individuals prepared just on papers to meet out file works and to finish departmental agenda. It reflects that disaster administration is not fully trained and prepared about what to do when the state sudden assaulted by cloud bursts, surges and avalanches that washed away ground transportation framework and harsh climate that slice off a real access to a few remote districts. It is no big surprise to witness the only response which they could cite on was to be animadversion the climate change and meteorological specialists. The number casualties and circumstance shows a sincere need to reinforce limits of all Stakeholders. Given the truth of India's administration, it appears to be astonishing that the execution of calamity arrangements is endowed with immaculate officials. From this present reality perspective, it seems more sensible the administrators ought to be kept to disaster administration strategy making and all the official viewpoints ought to be in the hands of individuals who have genuine experience of debacle taking care of, say defense work force and common society activists. Subsequently, aside from the strategy making bodies, all other catastrophe administration bodies must be run with individuals with calamity taking care of experience; maybe a couple civil servants can be put for purpose of managing other government bodies. Limited working of different partner gatherings is a standout amongst the most considerable difficulties in Uttarakhand which is confronting high hazard from numerous catastrophes.

Research, training, stakeholder acquaintanceship in a disaster administration must contact groups for fortifying disaster readiness, counteractive action, alleviation, crisis reaction, catastrophe resilient recreation and recuperation at local level. Further the disaster administration need to receive inventive frameworks, methods and advancements alongside group administration with appropriate coordination. Most modern countries have ratified creative frameworks, procedures and innovations to enhance the adequacy of disaster administration. The modern world technology like Information Technology, Information and Communication Technology for spread of early cautioning and ready messages, Remote Sensing, Scenario Analysis and Modeling, biometrics for family reunification in a debacles and complex philanthropic crises, early cautioning frameworks, Doppler radars, and so forth are by and large progressively utilized by numerous nations. In India, the Department of Information Technology's satellite-associated Common Service Centers (CSCs) can be used to spread fundamental lifesaving messages in close-by tongues and dialects to failure prejudiced gatherings as opposed to spending massive measure of money on TV openings for brief spots and securing substantial consumption on advertisements in every day papers and magazines. A wise blend of indigenous

conventional learning and cutting edge innovation is required to reach for more prominent public alertness on debacle danger and susceptibility in any case. Surprisingly several key equipment like Doppler Radars, which were affirmed by Government of India and Indian Meteorological Department were not introduced by the State Government. This was a direct result of absence of coordination between National Disaster Management Authority, India Meteorological Department and Uttarakhand government⁴⁵.

Conclusion

From this research it is evident that Cloud bursts in Uttarakhand are the results of intemperate human mediation in nature's scheme. It is apparent that anthropogenic exercises of infringing into nature delivered such awful cataclysms of extreme weather event in the form of cloud burst and high force downpours in the eco-delicate area, which has rumpled a large number of lives, and washed away various villages. The fragile development in the Uttarakhand hilly terrain, themselves has given path to various disasters to assault from decades. The rising imbalance, haphazard constructions, mushroomed hotel and motels, insatiable need of cheap electricity, radical mining and similar other factors crafted most exceedingly terrible years in last decade in the name of development. Hence, this moment is the perfect time to stop and time to learn from the past. This is not a discussion amongst progress, development and non-development. It is the preferential decision for sustainable development sphered by indigenous insight alongside benefit for local stakeholder by saying no to short term development, whose outcomes in inadvertent blow-back for all over the long haul. To be sure, Eco-delicate areas need lanes, streets, power, schools, recuperating offices and sustenance, however not at the expense of hopelessly abrogating their own establishments. But the mammoth question is are we planned and ready for scientific and sustainable development of Uttarakhand or in spite of everything, we want to test the patience of nature and people for more such fiascoes before we remove the unyielding U-turn from current purported development planning? Furthermore, given the climate change is the most puzzling and convoluted can of worms which humanity is facing and it will make such extreme weather disaster more regular, therefore it is time to preparedness and mitigate the impact of such event with sustainable adaptation strategy. If the present advancement model is not exchanged, the harm will be more extreme and more successive in years to come, and lead to dooms day. This is an ideal opportunity to take a break and plan for sustainable development for Uttarakhand. The increased frequency of cloud burst and extreme weather events triggers voices for a Himalayan policy for development. No doubt, rainfall and cloud bursts are natural phenomena; the catastrophe potential of such events directly depends on what we have done on ground over the years. Uttarakhand, by allowing indiscriminate buildings, roads and hydropower projects without basic assessments and participatory decision making processes, has increased the catastrophe potential of high intensity rainfall manifold.

Also in coming future due to global warming, the Bay of Bengal is going to witness more super storms and cyclones; surely the Uttarakhand is going to face more cloudbursts and heavy rainfall. If Uttarakhand states do not wake up, much bigger tragedy may await the region. Hence endowing the disaster management and administration authorities is at the need of great importance in Uttarakhand. There is dire requirement for use of modern technology with the assistance of meteorological departments and specialists on the pertinent matters which can help mitigate the circumstances. Development should not come at the cost of our environment. More construction activities does not mean more development, rather they should be people oriented. Redevelopment to micro scale industries like cottage industries should be apt and construction of small hydel power projects rather than big dams should be given priority. An environment friendly ecosystem should be given the noteworthy priority. If with the technical advancement, India can reach on the mars, can be a global leader in IT based solution; it can surely come up with such innovative technological solutions. It is also evident from the data used in this study that in coming time, the acute rainfalls intensity and frequency will arise, so it is quite necessary to feel safe by the people of Uttarakhand.

Therefore, we have to make versatile move against future great precipitation and gigantic deluges. No doubt disaster management is a continuous process and no framework or policy can ever ensure the Uttarakhand completely, yet we can set up this state, obviously better for the surges and cloud bursts than is the situation today. Hence the Uttarakhand needs a future oriented and dedicated cloudburst management plan with versatile activity and pooled exertion. Composed activity will make Uttarakhand a protected spot to live and to put resources into – for us and for future eras. If we do not move in that direction, we will keep on being spending scarce resources on providing post-disaster relief for damaged property, assets and infrastructure and continue to keep on taking ceaselessly assets from contending requirements like for provision of essential services like education, health care, power supply, water supply, sanitation, social welfare etc. for those segments of the society, which are deprived of these fundamental requirements for generations. “Sustainable Growth” can be achieved only if our planners, administrators and policy makers realize this harsh reality.

Recommendation and suggestions: The recent cloud burst events in Uttarakhand have showed and warned, like never before, that we require a development formula for the Himalayas that considers the vulnerability of the region and the prerequisite for environment protection. We have to consider a pan-Himalayan strategy so states can develop basic arrangements taking into account the locale's characteristic assets—timberlands, water, biodiversity, natural and forte nourishments, nature tourism – however without antagonistic impact to the environment. Following proposals and recommendation are suggested. i. Diminish scientific ambiguity: There is a serious information hole on a Himalayan in

comprehension the effect of climate change on the accessibility of water assets and water-incited dangers. There is a critical need to close this learning hole for water assets administration and catastrophe hazard diminishment. ii. Diminish threat from floods and flash floods: Water incited debacles, for example, riverine surges are the principle common cataclysms in the Himalayas, especially Uttarakhand waterway bowls territory. Diminishing the dangers from these debacles is central for poverty alleviation and sustainable development. Sharing of hydro meteorological data, collaboration for prosperous water management is crucial for the establishment of efficient early warning systems and for disaster preparedness. iii. Support community-led adaptation: Local communities such as the Himalayan mountain population and downstream flood plain inhabitants in Uttarakhand are the first to encounter the adverse effects of cloud burst and extreme weather related hazards. One way to deal with reducing vulnerability and strengthening local level adaptation is that of 'bottom-up' community-led processes. The attention ought to be on empowering groups to adjust to a changing atmosphere and environment in light of their own basic leadership forms and participatory innovation advancement with backing from pariahs. iv. Promote tourism but with safeguard: Adventure and nature tourism, along with religious pilgrimage are the major contributor to financial advancement in the Himalayan states. In any case, this must accompany with safe guard as the nature is very delicate. Some normal safeguard can be a provision of restricted area within 5-10km encompassing the pilgrim's site, similar to sanctuaries and national parks. Similarly strict preference to the neighborhood group and locals in all financial exercises may work fabulous. By make it required for the travelers to expel and reclaim all non-degradable things which can be executed through a security deposit and checks at the assigned entry points might be a decent alternative. Other Safeguards may include promotion of homestead tourism, instead of hotel/motel tourism, promotion of reuse and recycling of waste, energy efficiency and renewable energy sources at all hill tourist spots, restriction on the number of private vehicles in all fragile areas of the hill towns to reduce both pollution and congestion and use of floating solar power system to restrict the evaporation.

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