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'The Himalayan Tsunami'- Cloudburst, Flash Flood & Death Toll: A Geographical Postmortem

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Abstract: *People of Grarhwal in Uttarakhand state of India and several pilgrims, those who were present there would never forget the four days of June 2013. This part of India is very famous for several high altitude pilgrimages and mass tourism. For its spiritual importance this region is commonly known as 'Dev Bhumi'- Land of Gods. From May to October this entire region always remains busy with the 'Char Dham Yatra and tourism activities. Like every year, June of 2013 was no different, pilgrimages and tourist spots were crowded with thousands of people. They were totally unknown what was going to hell their life after the cloudburst on and from 14th June to 17th June. After the Multi days cloudburst and heavy rainfall, the entire region especially the Kedarnath area faced devastating flash flood and associating landslide. Rudraprayag, Uttarkashi, Chamoli, Pithoragarh districts were badly affected. The death toll is reached up to10, 000 and 3000 persons were missing and several hundreds were injured. The flash flood was so treating and massive that it was called 'The Himalayan Tsunami'.*

This paper explores the geographical causes of the Uttakhand-flood and issues related with this great disaster with possible mitigation.

Key Words: *Char Dham Yatra, Cloudburst, Flashflood, Landslide, Uttarakhand,*

I. Introduction

Uttarakhand, is commonly known as the 'Dev Bhumi' or Land of the Gods for its' spiritual identity. The Indian culture, society and economy are very much depended on the river system of Ganges. The Ganges and its several tributaries have developed one of the most fertile and prosperous plain of the World i.e. the North Indian Plain. From the historical past the River Ganges is a symbol of Indian vibrant culture and tradition. This River is so important for Indian that Indians always recognize it as 'Mother of Indian Civilization'. The Garhwal region of Uttarakhand is the catchment area of Ganga and Yamuna rivers. Several Hindu pilgrimage centers are spreading in this region. Most of these were invented and glorified by Adi Sankaracharya (early 8th century A.D), a Hindu spiritual reformer. Among all the pilgrimages of Uttarakhand,, the Chardham (four holy pilgrimages); Kedarnath. Badrinath, Gangotri and Yamunetri are famous not only for spiritual identity but also their panoramic beauty. In every summer this part of the state always remains crowded with pilgrims and tourists. Initially the economy of the state was traditionally depended on agriculture and religious tourism. After the separation from Uttar Pradesh (9th November 2000), the State Authorities started to emphases on industrialization, mining and mass tourism. Once, the spiritual land of India has been started to transform into the land of dams and jungle of concretes. Due to the urge of rapid infrastructural and economic development, the environment of Uttarakhand has been degraded up to extreme limit. The purity and spirituality of this holy land has been polluted with ruthless economic desire. As the Newtonian third laws; the nature has reacted with cloudburst and associating flash flood, landslide on and from 14.06.2013 to 17.06.2013 as the adverse effects of the so called development activities. This short of hazard is natural phenomenon. However, excessive human interference to the natural environment of this hilly tract leads it to not only a quasi-natural hazard but also a remarkable disaster of human history.

Main purpose of this paper is to identify the reasons of the Uttarakhand disaster. But it also deals with the Geography of the Uttarakhand state, nature of the disaster and possible management of this type of disasters. Tables, figures are used to discuss the facts scientifically with the help of authentic sources. Provided maps will help to understand the Geographical scenario of Uttarakhand and satellite images show the actual situation of the disaster.

II. Geography of Uttarakhand

2.1 Location

The northern state of Uttarakhand lies between 28.44' to 31.28' N latitude to 77.35' to 81.01' E longitude. It was evolved after the separation of the Uttar Pradesh. Actually the hilly tract of former Uttar Pradesh is now the present state of Uttarakhand. Total area of this hilly state is 53,483square Km constituting 1.63% of landmass of the India [1]. The state is consists of 13 districts and 95 development blocks. This state

has two divisions; western part is Garhwal and Eastern part is known as Kumaun. The state capital is Dehradun, located in Garhwal division. Uttarakhand shares its boundary with Tibet of China in North, Nepal in East, Himachal Pradesh in North-West, Haryana in South and- West and Uttar Pradesh in East.

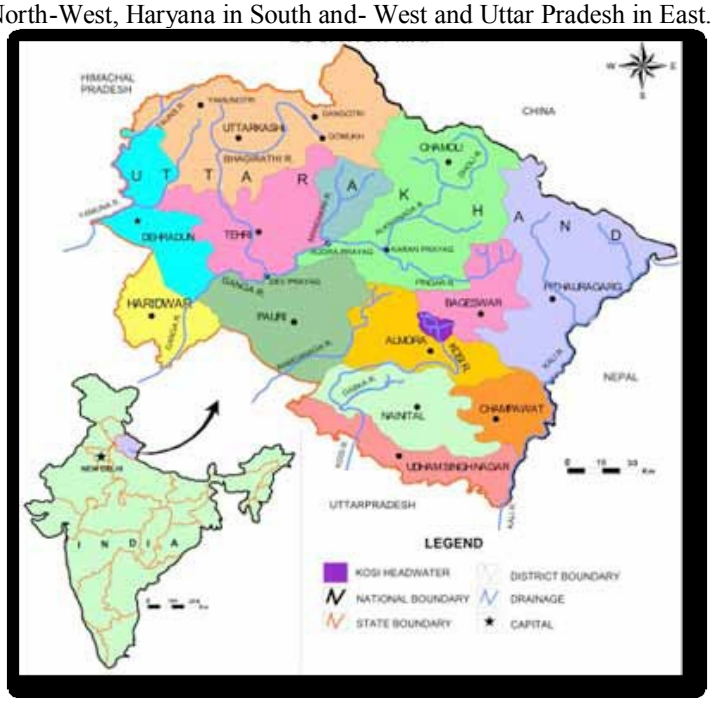

Fig: 1 Location Map

Source: Prakash Tiwari and Bhagwati Joshi (2012)

2.2 Geology

The entire state falls into three stratigraphical zones;

Table: 1 **Stratigraphical Zone**

Name of the Straigraphical Zones	Location	Lithological Composition
Outer or Sub-Himalaya (Siwaliks)	South of Main Boundary Fault and north of great plain.	Sediments of Tertiary age, commonly known as Siwalik sediments, clays, shale and conglomerates.
Central or Lower Himalaya	North of Main Boundary Fault and Main Central Thrust of Himalaya.	Limestone, Dolomite ,Granite, other metamorphic crystalline rocks such as quartzite, Gneiss
Higher Himalaya	North of Main Central Thrust	Quartzite, migmatites, gneiss, garnet-schist, diortic amphibolites etc

Source: R.L.Sing India A- Regional Geography

2.3 Physiographic Features:

Maximum portion of the Uttrakhand state is under hilly tract with rugged topography consists of snow clad mountain peaks; scatter crests, deep valleys, rapids, cascades cirques and glaciers etc. Topography of Garwal division is comparatively rugged and inhospitable than the Kumaun. The main mountain ranges are aligned in Northwest to Southeast direction [2]. The entire region is divided into three broad physiographic Regions;

Table: 2 **Physiographic Regions**

Major Physiographic Regions	Sub-Regions
Siwaliks (Sub Himalayan tract)	i) Siwalik ranges ii) Duns
Himachal (Lower Himalaya)	i) Himachal ranges and hills ii) Himachal valleys and Basins
Himadri (Greater Himalaya)	i) Himadri Ranges ii) Himachal Valleys

Source: India- A Regional Geography, R.L Sing

Siwalik Range is separated from the main range by the Main Boundary Thrust. Average altitude of this range is 750m to 1200 m. Southern slope is steeper and northern is gentle, stretched towards a structural valley, commonly known as Duns.

Himachal Range is a 75 km width massive mountainous tract, separated by Duns by the Main Boundary Thrust. The average altitude of this range is 1500m-2700m.Actually the whole range is a series of ridges, divided from each other by deep valleys of rivers. There are several lakes in Kumaon area, mainly structural basin. These lakes are commonly known as Tal.

Highest range of Himalaya is Himadri, width 50 km and average height varies from 4800m to 6000m. There are four prominent groups of mountain ranges. These are; a) Bandar Punch (6315 m); b) Gangotri (6614 m),Kedarnath (6940m), Chaukhamba (7138);c) Kamet (7756 m);d) Dunagiri (7066 m), Trishul (712 m), Nnda Kot (6861 m). These four groups of peaks are separated with each other by deep valleys of Bhagirathi, Alokenanda, and the Dhauli Ganga.

2.4 Drainage

This region is birth place of several perennial rivers of the Northern Great Plane of India. The entire State is dominated by three river systems;

The Ganga System: Maximum part of the Garwal region is being drained out by the Ganga river system expects the northwestern part of the Uttar Kashi district. In the river system of Ganga, there are two mighty rivers commonly known as Bhagirati-Alakananda. The Bhagirathi and Alakananda both are originated from opposite direction of Chukhamba peak (7138 m). The source of Bhagirati is Gamukh (3892 m) at the bottom foot of Gangotri glacier and the source of Alakananda is the bottom foot of the Satopanth and Bhgirath Kharak glacier [2]. After meeting with each other at Dev Prayag the name of the common channel is the Ganga. Though Bhagirathi is considered as Main River in religious faith of Hinduism but Hydrologically Alakananda is main stream due to its amount of discharge and length.

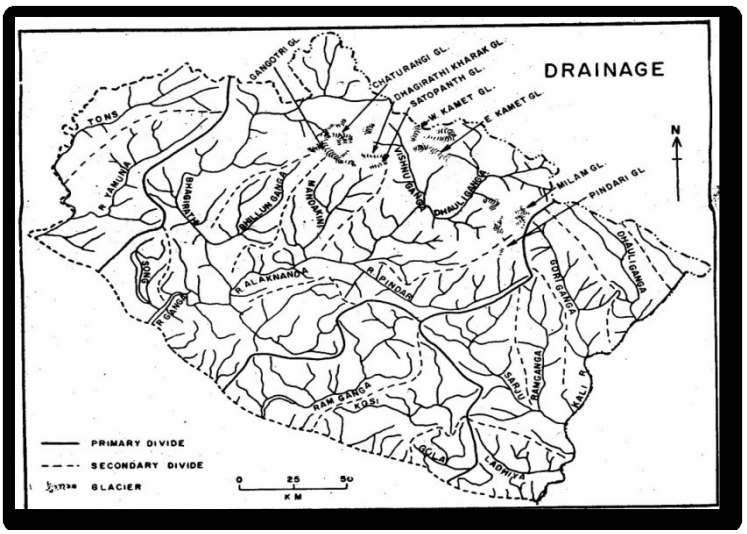

Fig: 2 Drainage Map of Uttarakhand

Source: India- A Regional Geography, R.L Sing

Yamuna-Tons River System: Yamuna, the major tributary of Ganges, is evolved from the Yamunotri glacier, lying on the southwestern peak of Bandar Punch Peak (6387m) [2]. Tons is the main tributary of the Yamuna which is originated from the northern slope of Bandar Punch Peak and flowing northwest of Yamuna and meets with it at Kalsi near Dheradun.

Kali River system: Kali is the main river system of the Kumaun Division of the Utatrakhand state, mainly the entire Pithoragarh district and eastern part of the Nainital, Almora districts. Kali has two headwaters, Kalapani (3600 m) is the eastern headwater and Kuti-yankti is the western headwater originated from snow-fields of Himadri range [2]. The tributaries of Kali are Pancheswar,Lohawati and Ladhiya.

2.5 Climate

Climatic condition is markedly different in high altitudinal areas and the lower basins in Uttarakhand. Temperature is varied not in different seasons but also with the altitude. For example, in summer the valleys experience hot steamy tropical climate, while at a distance of about 75 km, the great range bears one of the highest snow-field of the world. Normally January is the coldest month [2]. Snowfall and chilly cold is a common phenomenon in high altitudes and lower plane experience mild temperature during winter. Snow fall for seven to eight days in each three months January to March is a regular event due to western disturbance. July is the hottest month of northern part of the state with average temperature near about 7◦C, where as May is the

hottest month in southern part with average temperature 35◦c. According to altitude the entire state is divided into 7 micro climatic regions, these are;

Table: 3 **Climatic Zones**

Climatic zones	Altitude in meter	Temperature in Degree Centigrade		
		Annual	June	January
Tropical Zone	300-900	21.1	29.4	13.3
Warm Temperate Zone	901-1800	18.9	27.2	11.1
Cool Temperate zone	1801-2400	13.9	21.1	6.1
Cold Zone	2401-3000	1.3	17.2	2.8
Alpine zone	3001-4000	4.5	13.3	Below zero for 6 months, snow melts in July & August
Glacial zone	4001-4800	Ten months below zero two month between 2.2-3.9		
Perpetually frozen zone	Above 4800	Cold desert no vegetation		

(Source- R.L Sing, India A Regional Geography)

The Monsoon arrives in end of the June and retreats normally in middle of September. Nowadays, cloud bust during the Monsoon and pre-Monsoon is a regular matter in high altitude area of the Himalayas as well as in Northern part of Uttarakhand.

III. Brief Description of Himalayan Tsunami

It was a multiday cloudburst over the northern part of the Uttarakhand and adjourning Himachal Pradesh that caused sudden massive flash flood associating landslide and earth flow. From 14 to 17 June 2013, this area received heavy rainfall (370 mm In Dehra Dun 16th -17th June), which was about 375 percent more than the benchmark rainfall during normal Monsoon. [3] Main affected area was Kedarnath. After cloud burst, the Chorabari Lake (3800 meters) was collapsed resulting flash flood in Mandakini River. Millions tons of debris and boulder were carried by flash flood downwards areas such as Gobindghat, Rambara , Sonprayag and Rudraprayag town and several other part of the Rudraprayag district [4]. Excessive rainfall due to the cloud bust in catchment area of Mandakini, had increased the water level which created adverse flood condition in bottom areas and whole River system of Ganga in Uttarakhand. Several roads, buildings and other structure were washed away by rapid water flow and associating landslide. All the 13 districts in Uttarakhand have been affected by the floods of which four districts are the worst affected. These are: Uttarkashi, Rudraprayag, Chamoli and Pithoragarh districts. Both local inhabitants in the remote villages and pilgrims are affected. The Chief Minister of Utterkhand, Vijay Bhauguna stated (TOI June 30th 2013) that estimated death toll is more than 10,000 and still 3000 persons were missing and several hundred people were trapped in various high trained pilgrimages such as Keranath, Badrinath, Hemkund etc. Near about 70000 people were evacuated with death of 20 rescue worker and distraction of one Mi17choper [6].However the actual casualty is much more than the official statement. The flash flood of three rivers; Alaknanda,Mandakini and Bhagirati were so treating and massive that with the Chief Minister of Uttarakhand several main stream news agencies has quoted it as 'The Himalayan Tsunami'

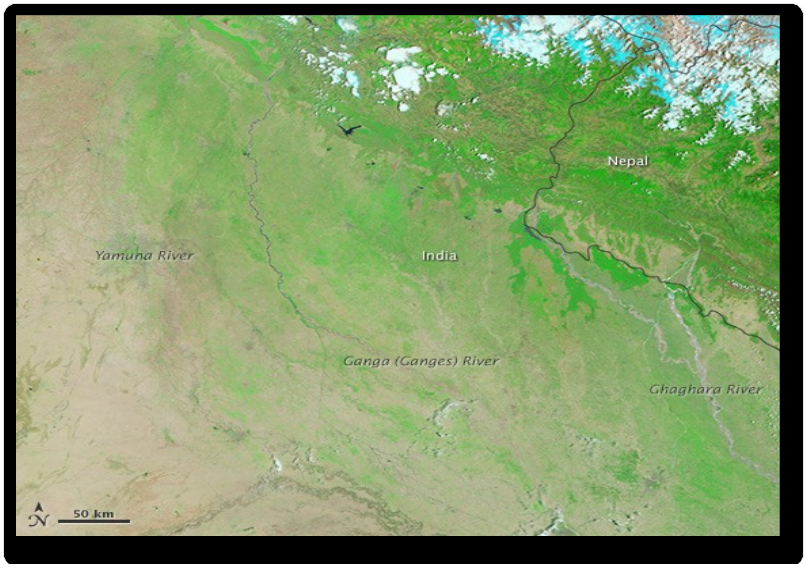

Fig: 3 Satellite Image of North India in May, 2013 (pre- flood)
Source: NASA's Earth Observatory

Fig: 4 Satellite Image of North India in last week of June, 2013 (post flood)
Source: NASA's Earth Observatory

IV. Geographical Postmortem of Flash Flood

Flood is normal activity of river as its course forming process. Actually flood occurs in a river when the flow rate exceeds the capacity of the river channel. Water flow can be increased in rivers due to several reasons such as sudden excessive rainfall, melting of glacier, increase of river load, landslide etc. In plain land flood is occurred comparatively slowly but in high altitude it happened suddenly. This short of sudden flood is known as Flash Flood which associated with landslide and earth flow. Though, initially flood is a natural hazard but due to excessive human interference in river courses such as deforestation, divert of river course, construction of bridge, dams and hydro projects, transforming it to a quasi natural hazard. The Flash Flood of Uttarakahnd in 2013 is the best example of it. The reasons of the 2013 flood are;

4.1 Cloud Burst, Excessive Rainfall and Associating Flash Flood- Land Slide

Initially the main cause of the disaster was Cloud Bust and excessive rainfall. Cloud bust is an extreme amount of precipitation over a smaller area within a shorter period. Sometime hail and thunderstorm are associated with it and can create flood or flash flood conditions causing loss of life and properties. It is observed that during the Cloud Bust the rate of rainfall can be reached up to 10 cm/hr [7]. It is a localized phenomenon affecting an area not more than 20-30 square km but some time it may be 50 square km. Like the other meso scale weather structures such as tempest, tornado cloud burst has also shorter life span and very difficult to predict.

Western Himalaya is a suitable place for cloud burst. Cloudburst is mainly occurred here in Monsoon. When Monsoon clouds are obstructed in main Himalayan range, the clouds rose upwards (sometime up to 15 km), formed dense Cumulonimbus with wider base. It is happened due to moist thermodynamic instability and rapid dynamic lifting of cloud by step topography. Cloudbursts can't occur only in the Monsoon period but also during the March to May as pre Monsoon Showers. Nowadays, intensity and destruction of cloudburst are being increased. Himalayas is warming at least twice as fast as the globe [8]. There are 389 high altitudinal glacial lakes in Uttarakhand (118) and Himachal Pradesh (271) [9].It is now being observed that these high altitudinal lakes are being melt faster than past. This glacier melt water come direct contact with clouds due to higher altitude. The temperatures of the glacial lakes are normally below or near the frizzing temperature. The saturation vapour pressure over super-cooled water remains high so the evaporated water of the lake immediately is being condensed over the cloud and volume of the cloud is increased with time. After formation of this type of clouds they become heavier, when they move downwards become instable due to adiabatic heating and can be collapsed with in a valley. When these short of clouds are trapped in a valley, the rate of destruction is become extreme. Moreover the situation can be more critical with the presence of extra tropical depression.

Before the 2013 disaster there was an active extra tropical depression (arrived from Black sea-Caspian Sea region) over the Uttarakhand and adjourning areas, just before the arrival of South Western Monsoon. In 2013, Monsoon arrived before the normal time. This extra tropical depression pulled the Monsoon towards western Himalaya. Due to collusion between two air-masses, the formation of cumulonimbus cloud generated rapidly. More over the faster rate of evaporation of glacial lakes in Uttarakhand especially the Chorabari tal (Gandhi Lake) increased the volume of the cloud. The concentrations of the clouds were so high that there was a multiday cloud burst in Kedar Dome and surrounding areas.

Kedarnath and surrounding areas are extremely affected by the several exogenetic processes such as physical weathering of kindreded shattering; debris slide- slump and earth flow etc. But most important is fluvio-glacial erosion. Kedarnath is located on the paleo-channel or in a narrow immature flood plain in between Mandakini and Saraswati Rivers; both are originated from Chorabari Lake. Height of the flood plain from the channels is very less. Kedarnath village and the surrounding areas are surrounded with debris of boulders, pebbles, talus and saturated silt- clay with glacial melt water. Moreover the area has poor lithologic structure due to excessive weathering process and vulnerably slide porn.

Fig: 5 NASA satellite imagery of Northern India on 17 June

Source: Wikipedia

During the multiday cloud burst (14th June to 17th June) million tons of debris, boulders have been carried down with the collapsed water of Chorabari Lake through Mandakini-Saraswati Rivers as flash-flood. Continues downpour also increased the rate of landslides in fragile mountains and the road linkage totally ruined with collapse of saturated debris in several pockets. After the cloud burst event water level in several channels of Alakananda, Bhagirathi river systems were rapidly increased and the settlements along the rivers side were affected vulnerably. Downwards flow of the water full of debris and boulder flooded several localities one after one up to Rishikesh.

4.2 Anthropogenic Regions of the Flood

After the disaster, it was clear to all that the reason of the flood cannot be Natural only. The Mother Nature has reacted on the ruthless development process that should be regulated by someone and nature took the responsibility. The anthropogenic issues of the facts are;

4.2.1 Constructions of Various Dams and Reservoir for Hydro Projects:

After the separation from Uttar Pradesh (9th November 2000), the state authority has emphasized on hydro power sector to boost the state economy. Uttarakhand has enough water wealth, the state is perfectly endowed with glacier melt water and seasonal Monsoon Rainfall.All Rivers are perennial in nature. Uttarakhand is the main catchment area of Ganga. This state has an estimated hydro potential of 27191.89 M.W and so far 3598.665. M.W has been harnessed up to 11th plane period, it is only 16% of its hydro potentiality [10] .In a recent report in 2011 the World Bank stated that Hydropower potential is one of the most important strategic assets of the state of Uttarakhand for its economic development. Therefore, the state authority plans to increase the production of Hydro power to be self sufficient and export to NCR and other part of the country. To achieve its hydro potentiality a large number of projects are already in advance stage of planning or execution and many more projects are being proposed in Bhagirathi and Alakananda basin.

The below table shows basin wise all type of Hydro projects (Large, Small, Mini-micro) with their installed capacities. Uttarakhand government has plans to have total of 336 hydropower projects with total capacity of 27191.89 MW. Largest numbers (122) of such projects are in Alaknanda basin, the largest capacity is proposed to be in Sharda basin at 12450.905 M.W [10].

Table: 4 **Basin wise total capacities for large, small and mini HEPs in Uttarakhand (up to 2011)**

	Large Hydro projects (above 25 MW)		Small Hydro projects (1-25 MW)		Mini-micro hydro projects (<1 MW)		Total Hydro projects	
	No of projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW
Alaknanda	35	6419	61	524.65	26	3.67	122	**6947.32**
Bhagirathi	10	3469	28	266.7	10	2.05	48	**3737.75**
Ganga Sub basin	1	144	3	31.2	2	0.35	6	**175.55**
Ramganga	7	512	14	105.3	11	2.05	32	**619.35**
Sharda	29	12335.6	20	109.65	35	5.155	84	**12450.405**
Yamuna	22	3144.75	14	113.3	8	1.135	44	**3259.185**
TOTAL	**104**	**26024.35**	**140**	**1150.8**	**92**	**14.41**	**336**	**27189.56**

Source: SANDRP 10th July 2013

The table, below shows basin wise figures of existing, under construction and proposed hydro power projects of all sizes in Uttarakhand

Table: 5 **Overview of all Hydropower projects in Uttarakhand (up to2011)**

Basin	Existing Hydro projects		Under construction projects		Proposed hydropower projects		Total Hydro projects	
	No of projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW
Alaknanda	32	456.97	16	1291.1	74	5199.25	122	**6947.32**
Bhagirathi	13	1851.5	13	1084.75	22	801.9	48	**3737.75**
Ganga Sub basin	4	173.8	2	1.75	-	-	6	**175.55**
Ramganga	12	210.8	-	-	20	408.5	32	**619.35**
Sharda	28	427.75	8	0.375	48	12022.28	84	**12450.405**
Yamuna	9	478.195	2	0.14	33	2780.85	44	**3259.185**
TOTAL	**98**	**3598.665**	**41**	**2378.115**	**197**	**21212.78**	**336**	**27189.56**

Source: SANDRP 10th July 2013

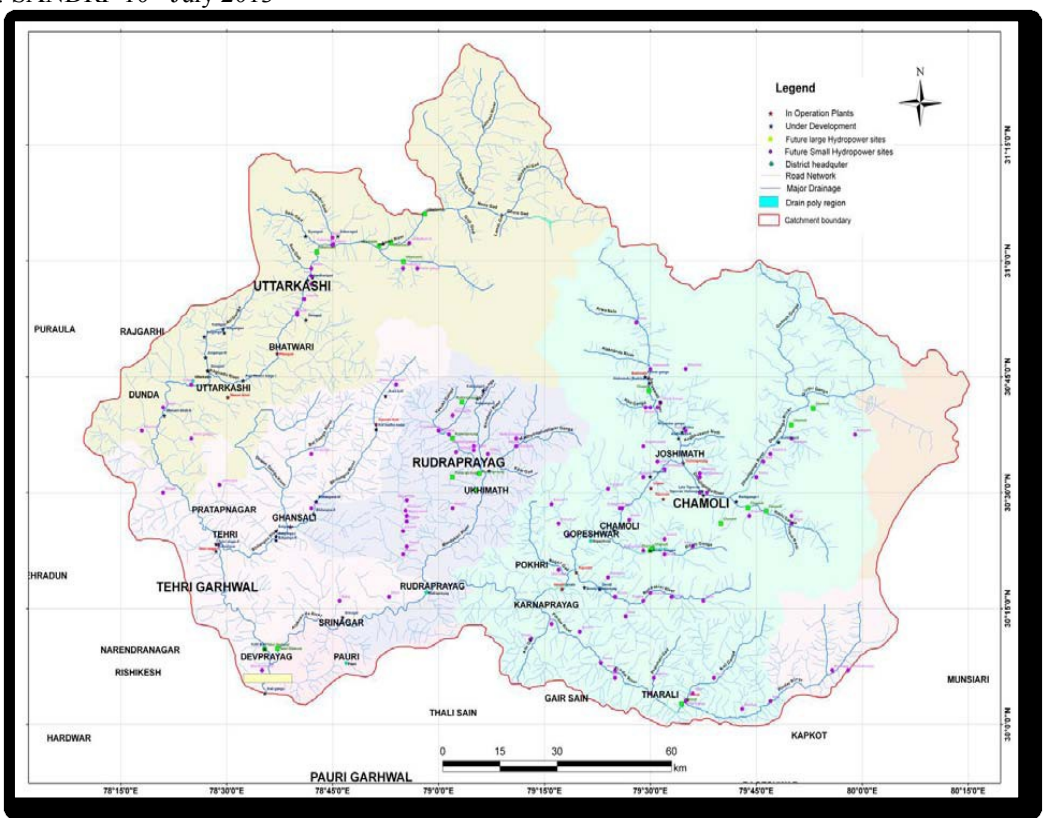

Fig: 6 Distribution Maps of Hydro Projects in Uttarakhand

Source: AHEC, 2010

From the above tables it is clear that there are 98 existing hydro projects in Uttarakhand, among them 32.65% are over the Alakanada basin, 13.26% over the Bhagirathi basin and rest are in Ganga sub basin, Ramganga, Sharda and Yamuna. The state Government, Central Government and private sectors are also developing 41 hydro projects mainly over the Alakananda (39.2%) and Bhagirathi (31.7%). The natural courses of the rivers and their flows are being interrupted by the bumper to bumper dam projects. Already the natural courses of the rivers are being diverted or shifted by various tunnels in many parts and if the entire proposed dams would be constructed, the river courses could be disappear. The depth and capacity of river channels are being reduced alarmingly due to lack of discharge from the dams. Intensity and possibilities of flash flood is also being increased simultaneously. Moreover, the hydro projects involve with drilling of huge tunnels, installation of heavy equipments that produce enough debris to block the rivers. Cutting down forest for tunnels, township, roads, other infrastructures and transmission lines are increasing the landslides over the river channels. Some dams are being developed on the same river within a minimum interval that there would no such space for natural course of the rivers. For example Kotlibhel1A, 1B and 2 hydro projects over Alakananda [11].So, no doubt the hydro projects of the state played an important role in concentration the disaster (flashflood) of 2013 summer.

4.2.2 Mass Tourism and Environmental Degradation:

Uttarakhand is very famous among the tourists for its panoramic beauty; similarly it is famous for several high altitude pilgrimages. Tourism is the backbone of Uttarakhand's economy, but it is now clear that visitors and pilgrims number too many: According to Official website of Uttarakhand Tourism Department, in 2012 total 28433000 tourist visited the state, among them 28292000 (99.50%) were domestic and rest 141000 (0.5%) were foreigner[12]. This total numbers of tourist are expected to double by 2017, with the state gearing up to welcome 77.7 million domestic travelers and nearly 400,000 foreigners [13].Actually now pilgrims are becoming Tourists. The Char Dhams are all not only high altitudinal areas but also eco-sensitive area. In spite of these a huge amount pilgrims visit these Dhams every year. Even, people were staying at Kedarnath before the catastrophic disaster. But until a few decades, the Kedarnath yatra was enough tough for people and they used to scare to halt there. In 2012, 573040 pilgrims or tourists visited the Kedarnath, but actual figure many more than the official data. With the advancement of communication, the Chardham Yatra has become so pleasure that in 2012 total 2223691 people visited the four places within a year.

Table: 6 **Tourists Flow in Char Dham Yatra (2010-2012)**

Name of Dhams	2010			2011			2012		
	Dom.	For.	Total	Dom.	For.	Total	Dom.	For.	Total
Badrinath	921250	276	921526	935680	492	936172	94077	322	94192
Kedarnath	40243	268	400511	569863	738	571601	572442	598	573040
Gangotri	310255	306	310561	484826	311	485137	372436	322	372768
Yamunotri	309452	182	309634	448751	194	448945	336543	248	336791
Total	1941200	1032	1942232	2439120	1735	2441855	2222191	1500	2223691

Source: official website of Uttarakhand Tourism Department.

The state authority has emphasized on tourism to boost the state economy and they are promoting the various pockets of the state for mass tourism. After 2000, there was a rapid influx in number of tourists in Uttarakhand up to 2010 and in 2011 the number of tourists was slide less due to recess. Over all the numbers of tourists are too much and it has crossed the total population of the state i.e. 1.01 crores [14] (near about 10 millions).

Fig: 7 Tourists Flow in Uttarakhand (2000-2012)
Data Source: Official Website of Uttarakhand Tourism.

With the influx of tourists, the tourism infrastructures such as hotels, lodge, dharashala, shops, dhabas, mobile phone tower, roads etc are also Mushrooming. According to the state tourism department, in 2006 there were 2312 recognized accommodation units (excluding Dharmashala) 27899 rooms and 185373 beds and 802 Dharmashala in major tourist destination [13]. But the actual figure was far more than that. Presently more than five thousand hotels and resorts have been constructed on Garwal division. The accommodation facilities are not enough yet. The hotels, lodges, Dharmashala, shops and restaurants are being constructed very close to river channel even with in active flood plains, to access roads that are mainly along the rivers. Construction of different buildings on deforested unstable slope causes landslide and road blockage.

Huge amount of tourists and their careless activities are also questionable. Eco-sensitive zones such as Gangotri glacier, Yamunetri,Valley of Flowers, Kedar Dom, Hemkund Shaib, Nagtibba, Binser, Chandrashila etc are famous to pilgrims and trackers. These areas are now being over exposed. Ecological balance and durability of the glaciers are being threatened due to emulsion of green house gases from vehicles, cooking stoves, generators etc. Moreover, the catchment areas are being polluted by tourists with huge amount of plastics and other non degradable elements that are enough responsible for landslides and flashflood.

4.2.3 Unplanned Urbanization:

During recent years the growth of urban population in Uttarakhand has rapidly increased mainly in Dhradun, Haridwar, Nainital and Udham Sing Nagar districts. Expansion of road network, development in tourism, improvement of market, growth of rural service centres etc are the important factors of the urban growth. There were a few old urban centres in the state, Dehradun, Nainital, Mussoorie, Sirinagar etc. Presently there are 86 urban units in the state, among them 1 Municipal corporation, 31 Nagar Palika Parisad, 9 Cantonment Boards, 12 census town and 2 industrial township.[15] In 2011 Census the percentage of urban population is 30.55% , very close to National average i.e.31.16%.[14] The urban population percentage of the state in 1971(as hilly part of U.P) was only 16.36%.[16] Within five decades it is near to double. But, rapid growth recorded mainly within 2001-2011, after separation from U.P.

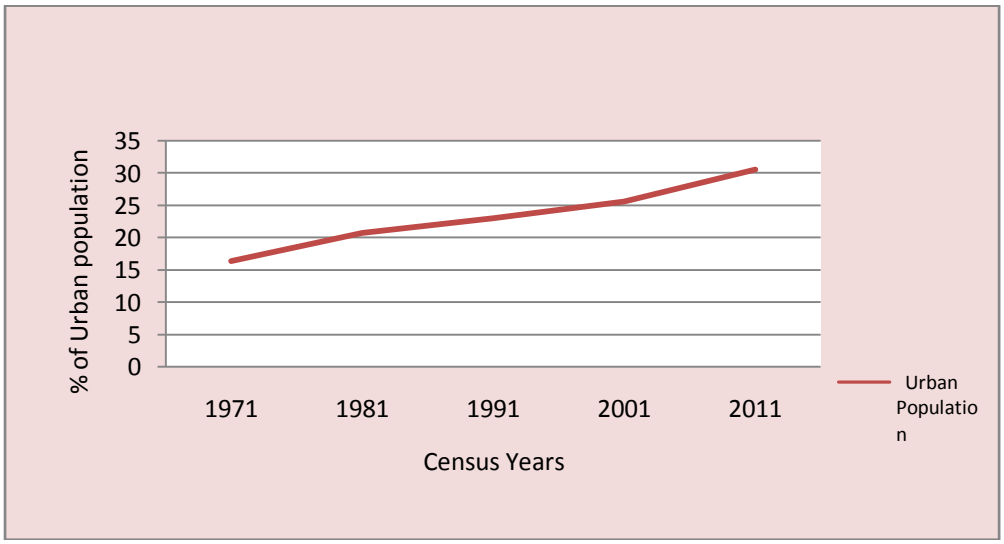

Fig:8 Growth of Urban Population in Uttarakhand
Data source: Tewari and Joshi 2012 & http://ndiafacts.in/india-census-2011/urban-rural-population-o-i

The urban centers like Devprayag, Sonprayag, Rishikesh, Bardinath, Rudraprayag, Gopeshwar Rudrapur etc have been developed as stoppage centre of Chardham Yatra. Seasonal economic activities gave them opportunity to develop as small or medium towns. Later on these small and medium towns have been converted to big town or cities. After 2000, the populations of these towns and cities have been rapidly increased due to mass tourism, related job opportunities. In this way a large numbers of the unplanned urban bodies were evolved without basic civic amenities and infrastructures. These unplanned urban bodies are major threat to the whole river system of the state. Non degradable solid wastes and several pollutants are being dump in rivers that hampering hydrological cycle, river ecology and morphology. Holy lakes and confluence that have spiritual values as well as environmental importance are polluted by uncontrolled discharge of waste water and solid waste. The jungles of concrete are putting extra pressure on weak lithology of hill slopes, causes more landslides than past.

4.2.4 Faster growth of Road Communication and Number of Vehicles:

Huge expansion of road and transport are un-stabilizing the mountain and hill slopes. As a young fold mountain, this part of Himalaya has poor lithologic structure full of fragment, fault and weak zones. Blasting of dynamites for road construction creates enough vibration to landslide and associating hazards. Moreover, trucks, buses and other heavy duty vehicles also produce vibration that increase higher incidence of landslide in Monsoon. The numbers of roads are increasing so fast that very soon there will be no such hills without roads and vehicle. Presently, as of 31.3.2012, the total length of all roads in Uttarakhand is 30530.68 km and that was only 19440.2 km in 2000. [17] In 2012-13 on road total numbers of Vehicles were 1521925. So, within 1 km distance 50 Vehicles move around. More surprisingly, the total number of all kinds vehicle registration are doubled within 10 years, in 2002-03 total number of vehicle registration was 51560 and in 2012-13 it is become 176674[18].

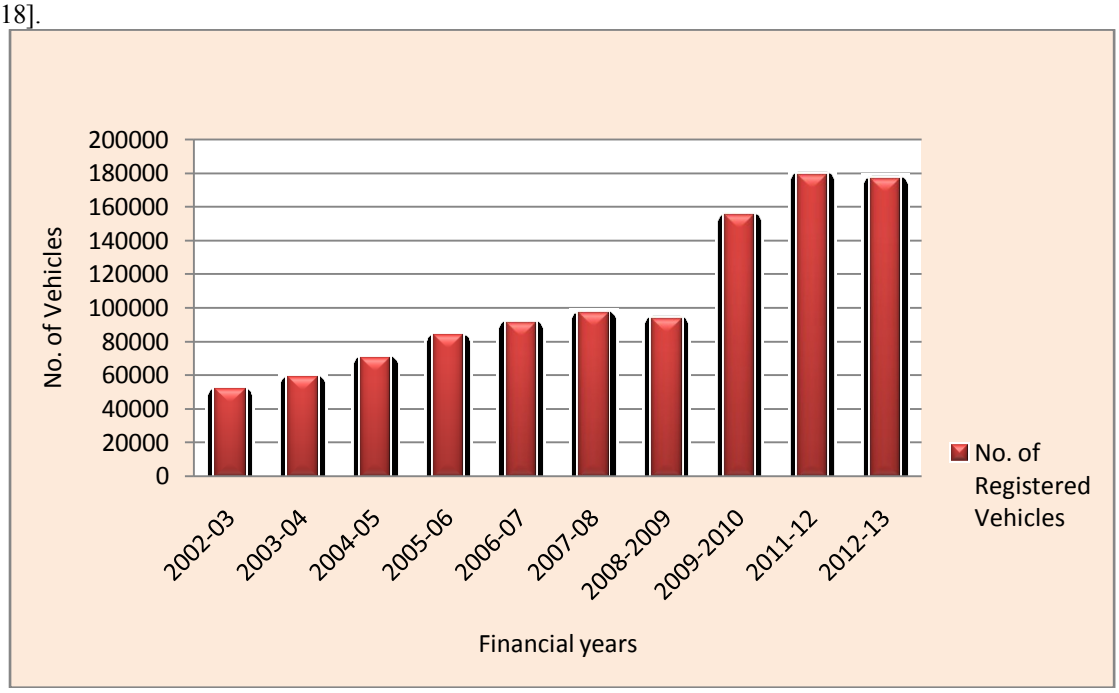

Fig: 9 Growths of Registered Vehicles in Uttarakhand (2002-03 to 2012-13)

Data source: http:// transport.uk.gov.in/pages/display/62-satistical-data

Constructions of roads and rapid increase of vehicles are not only responsible for landslide but also increasing the temperature in Eco-sensitive zones resulting faster rate of glacial destruction and flashflood.

4.2.5 Deforestation and Miss-Guided Forestation Policy

` The recorded forest area of Uttarakhand is 3.47 million hectors that is 65% its' geographic area [19]. The state is enriched with tropical, temperate and alpine forest. The forest further can be classified into Reserved Forest (68.74%), protected forest (0.36%) and Un-classed open forest (30.9%). [19] The open forests have been altered for several hydro projects and other infrastructural development. It is observed that hilly slopes near the construction sites are become very steeper and unstable with dynamite blast. These areas face landslide on steeper slopes regularly. Due to this phenomenon larger parts of the valley slopes are become barren, without any vegetation covers and that causing again landslide. Actually a cycle of landslide and deforestation is functioning very rapidly and that is one of the major reasons for the catastrophic disaster of 2013.

Govt. Uttarakhand is running forestation programme with different schemes. But the places which were once covered with oak trees are now being replaced by the pine. It is simply because of versatile use of pine. The wood, resin of pine have economic values, so pine is much more profitable than oak. But what is profitable to man it does not matter to nature. Oak is a unique plat, member of Quercus genus that lives for a long time. Oak lives create a layer of black subsoil which nourishes the scrubs and bushes with the organic matters that is very much effective against soil erosion and landslide. But pine does not grow leaves, but the needles are acidic in nature that creates a smooth dry bed that does not soak water [20]. This condition prevents the soil to grow under brushes. Some of the worst scenario of the flash flood was fallen down of trees, washing down with the rivers and knocking the settlements. [20] It can be said that the absence of oak and bushes in mountain slopes had accelerated the vulnerability of the flashflood.

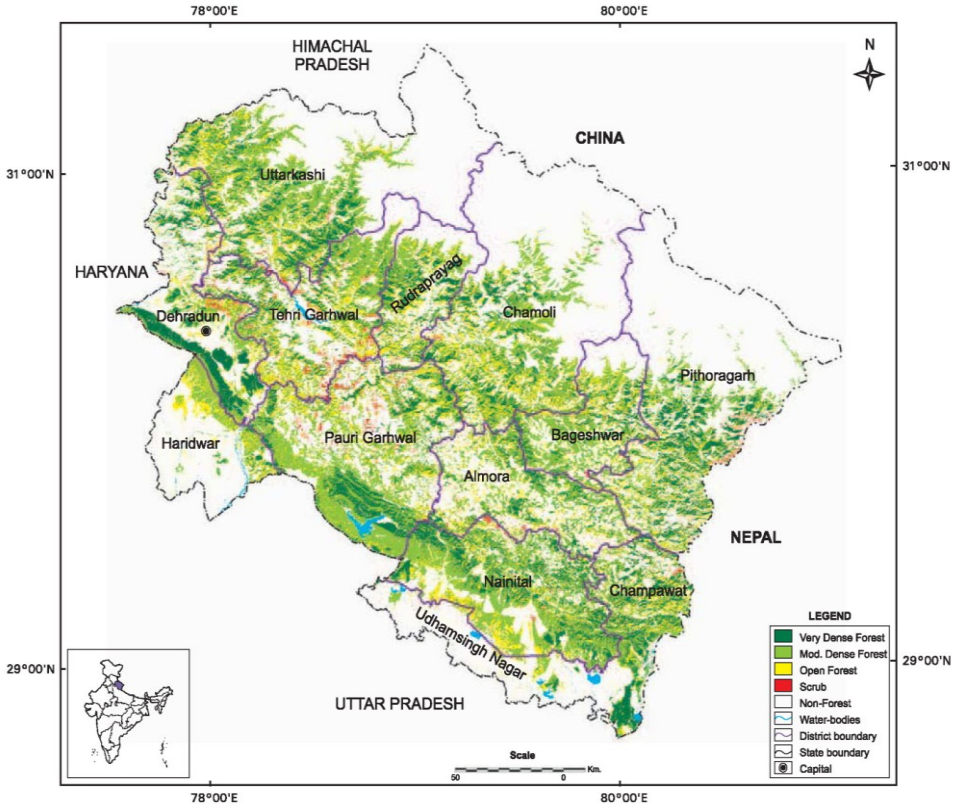

Fig: 10 Forest Map of Uttarakhand
Source: FSI 2009

V. Conclusion and suggestion:

Flashflood of Uttarakhand in 2013 is one of the devastating disasters in Himalaya as well as world history. There should not be any doubt that ruthless human desire for rapid development has increased and accelerated the impact of the disaster. Mother Nature has given a lesson to all those who are in rat race to control nature for their profit. After the death toll and long suffers, everybody is asking for the remedies. Actually, no one can prevent this short of catastrophic event; it is truly an '**Act of God'.** But we can minimize the impact of such disaster keeping in mind –"Prevention is better than cure". If we follow these matters, situation won't be so worst in future -

i) It is difficult to forecast a mesoscale weather phenomenon especially cloudburst. But to some extend now it is possible. But it requires high-resolution numerical models and mesoscale observation equipments such as of high performance computer, Doppler Weather Rader (DWR), Automatic Weather Station (AWS), Radiosonde / Rawinsond (RS/RW) etc [21]. These observation equipments can be installed in every sub divisional towns for high resolution measurement (>10 km) of vertical profiles and parameters of atmosphere. This entire model works in NOWCAST mode only i.e. few hours in advance. So, education and tanning of the local administration should be incorporated for preparation within short notice that helps mitigation of the disaster.

ii) With the early warning system, effective evacuation plans and responsive disaster management group should be prepared with the proper guidance and assistance with National Disaster Management Authority (NDMA). These groups can be deployed block wise with active Participation of local inhabitants.

iii) Construction of Big dams on highly seismic areas like Uttarakhand (major portions of the state fall in seismic zone v) is a vulnerable task. Though technically it is possible but negative impact should be kept in mind. Before construct these big dams the proper investigation is very much needed through Environmental impact Assessment (EIA).For a proper EIA report, a multi disciplinary (with the collaboration of social scientist ,engineer, environmentalist and civil society) task force is needed to investigates the socio-environmental challenges associate with the proposed projects. But it is a matter of regret that there are great difference in between EIA report of Govt. agencies and independent expert committees. For example, in April 2010, an independent expert committee of non-official members and expert of National Ganga River Basin Authority or NGRBA made a socio-environmental study of the

under construction Hydro projects such as Koteshswar on Bhagirati; Singoli Bhatwari and Phata-Byung on Mandakini and Srinagar, Vishnugangad, Pipalkoti on Alaknanda. After the study they have suggested to stop these projects immediately because this projects are vulnerable for natural river courses [11].

iv) Before construction of all the proposed dams in the state, the state and Central agencies must ensure that these projects won't submerge the important holy confluences. Otherwise the river morphology and ecology will be disturbed. For example, the projects of Devsari on Pinder River and other three projects Kotlibhel will submerge the confluence of Dev Prayag [11]. So, these projects should be cancelled immediately.

v) We should avoid the vulnerable areas (high terrain with slope factors and weak lithology) for big dams. Instead of big dams we can construct small dams (like check dams) in upper catchment areas according to the stream order and distribution of contours. Size and the height of these dams must be increased according to their stream order. It is also very important to maintain enough distance between two dams so that the natural flow of the rivers won't be interrupted. In this way an ascending order of dams in the catchment areas can be delayed the flood and provides relatively much more time to evacuate the people from lower areas. This type of dams can also play a vital role in village electrification generating the hydro power as well as can provide irrigational water.

vi) Hazard maps of landslide should be prepare in Digital Elevation Model (DEM) with airborne or stationary LiDAR, GPS, GIS and associating instruments. LiDAR technology is very much effective to identify the fault and weak zones in rock strata. [22] Geosynthetic or Geotextile can be used experimentally to reduce landslide. More over protection wall can be made in slide porn areas.

vii) The best way to prevent landslide in high mountain areas is to return back of Oak trees. It has proven that oak has the capability to compaction the lithology with organic matters than pine or other gymnosperms .Forestation of oak can be accelerated with social forestry with the cooperation local governing bodies and participation of local inhabitants.

viii) There should be strict restriction on mass tourism in Eco-sensitive zones especially in Char Dhams, Valley of Flowers and several glaciers and snouts areas. Annual quota of tourists or pilgrims should be introduced in these areas like Kailash –Manasarovar Yatra. Environmental Tax must be collected from the tourists and vehicles to regulate the influx vehicular movement in high terrain areas. Heavy Duty vehicles should be prohibited in slide porn areas and regular monitoring should go on.

ix) Construction of buildings and structures on unstable hill slopes and young flood pains must be restricted. Multi storied buildings on high terrain area should not be developed, this type of structures put excessive load on lithology that causes landslide.

x) Urban sanitation and sewerage systems should be modernized with water treatment plants and proper solid waste management. Using of plastic poly bags should be prohibited with strong monitoring.

References

Books:

[1]. India A Regional Geography-Edited by Sing. R.L, National Geographical Society of India, Varanashi-5, UBS Publishers' Distributers Pvt. Ltd, Reprinted in 2008, ISBN: 978-81-85273-18-1

[2]. National Wetland Atlas: High Altitude Lakes Of India, Sponsored by Ministry of Environment and Forests, Government of India Space Applications Centre, ISRO, Government of India, Ahmadabad – 380 015 September 2012, ISBN:978-93-82760-00-9

Academic papers:

[3]. Woolley Ralfer – Cloudburst Floods in Uttah 1850-1938, United States Government Printing Office, Washington: 1946

[4]. Tiwari Prakash C and Joshi Bhagwati , Urban growth in Himalaya Environmental Impacts and Developmental Opportunities, Mountain Research Initiative Newsletter no. 7, 2012

[5]. Das Someshwar,1 Ashrit Raghavendra 1 and Moncrieff M.W 2, Simulation of a Himalayan cloudburst event, National Center for Medium Range $_{Weather}$ Forecasting, Noida 201 307, India1. National Center for Atmospheric Research, Boulder CO 80301, USA

[6]. Takagi Masatak and Inada Ryo, Method of Landslide Measurement by Ground Based LiDAR Kochi University of Technology, Internationals Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, Volume XXXVIII, Part 8, Kyoto Japan 2010

Articles:

[7]. Varsney Vibha, Kedarnath temple in Uttarakhand survives glacier, floods,Down To Earth Jun,2013

[8]. Mathur Swati & Jha Durgesh Nandan, Uttarakhand floods: 744 villages are still marooned ,TNN Jun 30, 2013, 02.47AM IST

[9]. Uttarakhand: Existing, under construction and proposed Hydropower Projects: How do they add to the state's disaster potential? Posted on July 10, 2013 by sandrp
[10]. Scrap All Dams and Hydropower Projects on Ganga, Mainstream Vol XLVIII,No 25 June 2012
[11]. Siddharth Gautam, Restoring the Himalayas, Times of India ,03 July 2013, 10:24 PM IST

News Reports

[12]. Uttarakhand: Rescue efforts in full swing; 102 dead, 72000 stranded- India News". CNN-IBN Live18 June 2013. Retrieved 22 June 2013
[13]. *Uttarakhand Flash Floods:Situation update – 2nd July 2013By United Way of India*
[14]. Lessons from Uttarakhand: When 'development' is destruction rediff.com: June 28, 2013 11:38 IST

Government Reports

[15]. Uttarakhand Tourism Development Master Plan 2007 – 2022, published in April 2008

Websites

[1] http://www.nainitaltourism.com/Uttarakhand_Uttaranchal.html
[12] http://uttarakhandtourism.gov.in/files/Tourist%20Statistics%20of%20Year%202000-2012.pdf
[14] http://www.census2011.co.in/census/state/uttarakhand.html
[15] http://www.uusdip.org/urban-growth.php
[17] http://pwd.uk.gov.in/pages/display/2-about-us
[18] http:// transport.uk.gov.in/pages/display/62-satistical-data
[19] http://www.fsi.nic.in/sfr_2009/uttarakhand.pdf

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