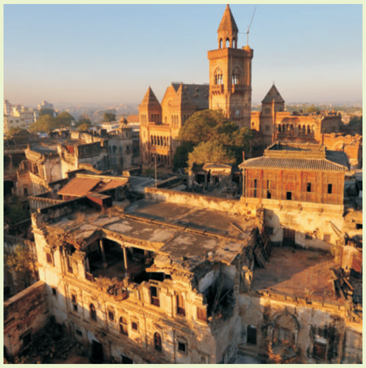
Geography (029) : Class-XI

OPEN TEXT MATERIAL

Open Text - Based Assessment

Annual Examination-March 2014






Themes **Page**

CENTRAL BOARD OF SECONDARY EDUCATION

Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi-110 092 India

OPEN TEXT MATERIAL

1. Theme – *Indian Summer Monsoon and The Himalayan Tsunami*

Abstract:

Indian summer monsoon has always remained vital for the economy and people of the country. The anomalies and variability in Indian summer monsoon is resulting in frequent disasters such as the fierce floods of Uttrakhand Himalayas. The recent flash floods in Uttrakhand have caused damages to calamitous proportions. Nature's fury has been magnified by mindless anthropogenic activities and irresponsible tourism. Cloud burst events combined with geophysical dynamics have become a serious threat for the region. Lack of proper understanding and knowledge about recent climatic events in the region and absence of efficient post-disaster response mechanism has increased the vulnerability of those living in such ecologically fragile areas.

The torrential rainfall in Uttrakhand Himalayas of June, 2013 resulted into huge death and destruction. It left hundreds dead; thousand marooned and washed away scores of villages, inundated the eight century *Kedarnath* temple. The famous *Manikarinika* temple on the banks of *Bhagirathi* was swept away by swirling waters of the river. Houses and small apartment blocks on the banks of *Bhagirathi*, *Alaknanda* and *Mandakini* have been toppled into the rushing, swollen waters and been swept away along with cars and trucks. The extent of damage due to flash floods in many parts of the seven districts of Uttrakhand ***(see table no. 1.1)*** is mind numbing. Single-storey houses simply disappeared, many double-storey houses crumbled due to the weakening of its foundation. Many people managed to flee to safety but animals got trapped under the silt. The area now stinks with rotten bodies. Drinking water has got contaminated; at many places electricity has not been stored and now there is fear of epidemics. The unusually early and immensely heavy rains in Uttrakhand devastated the hill state to such an extent that it will take months for the government to restore normal life. The disaster stuck when the *Chardham Yatra* was going on with a congregation of around 75,000 pilgrims from all over the country. The Central government, along with Indian Army, Indian Air Force (IAF), Indo-Tibetan Border Police (ITBP) and Border Roads Organisation (BRO) rescued around 33,000 stranded pilgrims. The flooding was so fierce and disastrous that people named it Himalayan Tsunami.

DISTRICT WISE STATUS OF THE IMPACT OF FLOOD DISASTER IN UTTRAKHAND							
Total Districts: 13			Affected Districts: 09				
	Rudraprayag	Chamoli	Uttarkashi	Tehri	Pithoragarh	Bageshwar	Almora
No. of Villages Affected	>60	39	28	15	10	08	08
No. of Persons Missing	>10,000 (including pilgrims)	>2,500 (including pilgrims)	-	-	Approx 100	-	-
No. of Houses Damaged	600-700	120-130	150-160	50-60	20-25	-	-
Source: Sphere India, 2013, New Delhi							

Table 1.1

Many environmentalists termed this event as a ***man-made disaster***. According to them human actions leading to environmental altercations have aggravated the problem and reduced the natural defense system. In the last three decades the region has witnessed demographic changes, deforestation, rapid urbanisation and expansion of roads. The environmentalists emphasised that mountains have a certain carrying capacity that should never be exceeded at any cost. Uttrakhand and Himachal Pradesh are the two Himalayan states that were worst hit by monsoonal flash floods in June 2013. Manmade factors compounded the scale of the disaster. Unabated expansion of hydroelectricity power projects and construction of roads to accommodate ever increasing tourism, specially religious tourism, are the main reasons of unprecedented devastation. The number of vehicles on roads is also rising in the entire state of Uttrakhand ***(see table no.1.2).*** According to many experts, the roads and transport, due to prevalence of excessive landslides, are bringing the mountains down. Mindless illegal construction of resorts, guest houses, roads has taken place in this ecologically fragile region to accommodate tourists. Buildings have been constructed over flood ways, old drains and streams blocking the natural pathway of the water. On June 15-16, 2013, the Alaknanda River and its tributary Mandakini occupied their flood ways and started flowing along the old courses where human habitation has come up with the passage of time.

Vehicle Registrations in Uttrakhand		
YEAR	**Private Vehicles**	**Tourist Vehicles**
2005-06	83,000	4,000
2012-13	1,80,000	40,000
Percent Increase	46 %	10 %
Source: Down To Earth, June 18, 2013		

Table 1.2

Figure 1.2 Kedarnath Temple, 1882[2]

Figure 1.3 New Changed Course of Alaknanda[3]

The Mandakini changed its course to the west. The sediment loaded river washed away shops, guest houses/lodges etc, killing people who were present at that time. *Kedarnath Dham*, a place of serenity and devotion, which was dotted by only few huts in 1882 ***(see figure no. 1.2)*** was mushroomed by haphazard illegal constructions of buildings, shops, hotels/lodges etc ***(see figure no. 1.4),*** blocking the natural flow of the Alaknanda river.

Figure 1.2 Kedarnath Temple, 1882[2]

Figure 1.3 New Changed Course of Alaknanda[3]

When the river shifted to a new natural course ***(see figure no.1.3),*** due to excessive rainfall and addition of water on account of lake burst and melting of glaciers perished all the construction ***(see figure no.1.5)*** along its new path very swiftly and quickly. The experts have pointed out that even in the narrow valleys of the Himalayas, the Alaknanda and Mandakani are the rivers that keep changing their course. Due to morphological settings of the area, the river has high sinuosity and hence, high level of erosive capacity, especially when it is loaded with sediments. It has been estimated that more than 300 multi story buildings, hotels, shops and other business establishments that had been built on ecologically sensitive areas close to Ganga and its tributaries like Alaknanda, Mandakani, Bhagirathi, Kali Ganga, Gauri Ganga, were swept away or excessively damaged due to flash floods.

Due to increased anthropogenic activities and terrain instability, Uttrakhand has always remained prone to landslides. Even during August and September 2010, Uttrakhand Himalayas witnessed large scale slope destabilization, particularly along the roads where widening of the roads work was in progress. The slope destabilization around Rudraprayag was caused due to the widening of NH 58. The Yellow dotted lines indicates ***(see figure no. 1.6)*** the recent movement on the slope. A house was damaged due to the disturbance of the slope during road widening. The catastrophic landslides are associated with floods that mainly occurred in July and August that claimed many human lives. Conventionally, major landslides in Himalayas are located in the transitional zone between lesser Himalayas and greater Himalayas. The reason

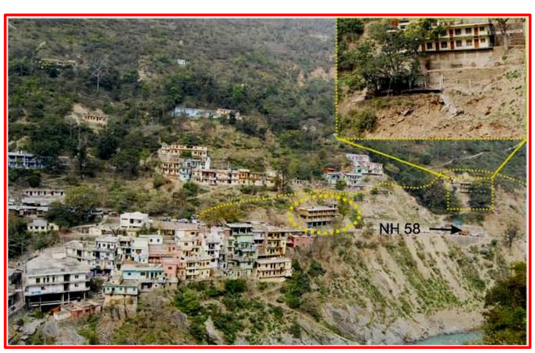
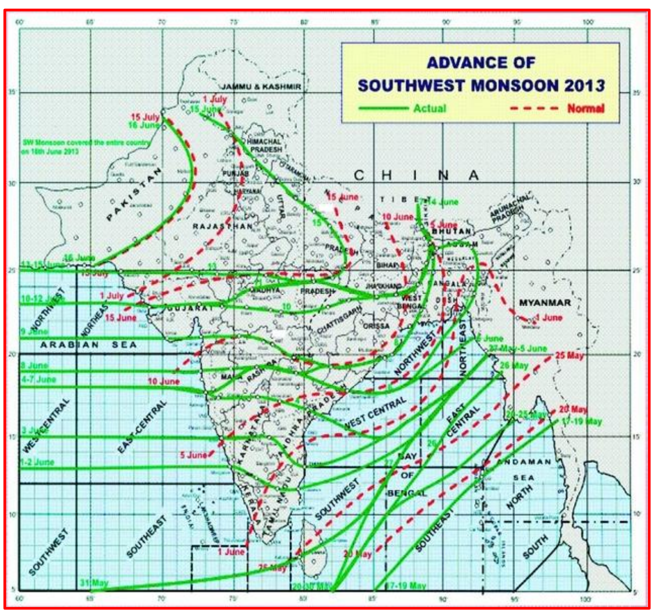


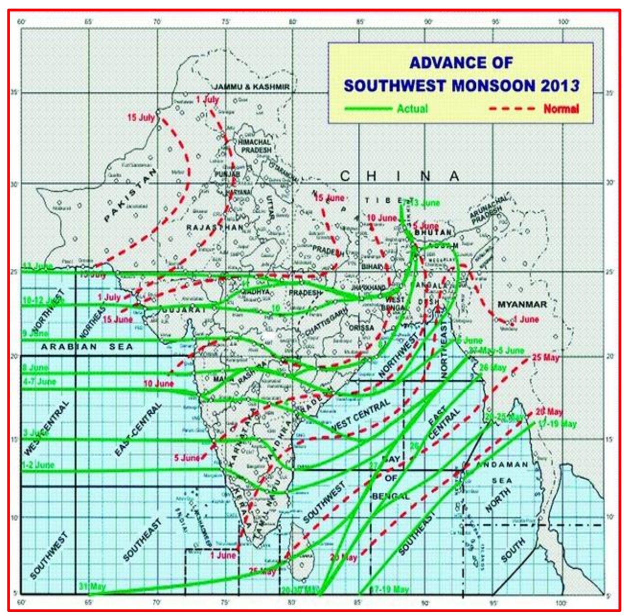
Figure 1.6 Landslide and slope movement in Rudraprayag [6]

being that, this zone is dominated by steep slopes, focused rainfall (cloud bursts) and frequent seismicity. Incessant rains also triggered many landslides in Uttrakhand this year at Uttarkashi and Chamoli, while 30 houses were damaged in Uttarkashi; four settlements were razed in Chamoli district. Landslide also killed six people in Nainital district ***(see figure no. 1.7)*** after heavy spell of rains in Bheemtal area. Flash floods due to water accumulation formation in Uttrakhand, has always been caused by landslides and accompanying debris. The June, 2013 Uttrakhand disaster, also known as Himalayan Tsunami was actually triggered by very heavy rainfall during June 16-18 and unusual behavior of monsoon this year in India. Rainfall measurement for June 16 and 17, 2013, at the Dehradun station was 220 millimeters and 370 millimeters respectively. It indicates the severity of the rainfall. Haridwar received 107 mm and 218 mm of rainfall in two days. Uttarkashi received 122 mm and 207 mm. While Mukteshwar (at the altitude of 2000 m) received 237 mm and 183 mm respectively on June 17 and 18, Nainital, on the same day, received 176 mm and 170 mm rainfall. What was peculiar about the monsoon this year was its advancement. On June 14, the monsoon front was located over eastern India. In fact it was sluggish compared with normal progress of the front. But within a day ***(see map no. 1.1 and 1.2)*** the front advanced right across Uttar Pradesh and western regions to cover the entire country by June 15, exactly a month ahead of its normal date of July 15.

Figure 1.7 Landslides in Nainital District July, 2013



Map 1.1 *Monsoon Progress on 14th June 2013*[8]



Map 1.2 *Monsoon Progress on 15th June 2013*[9]

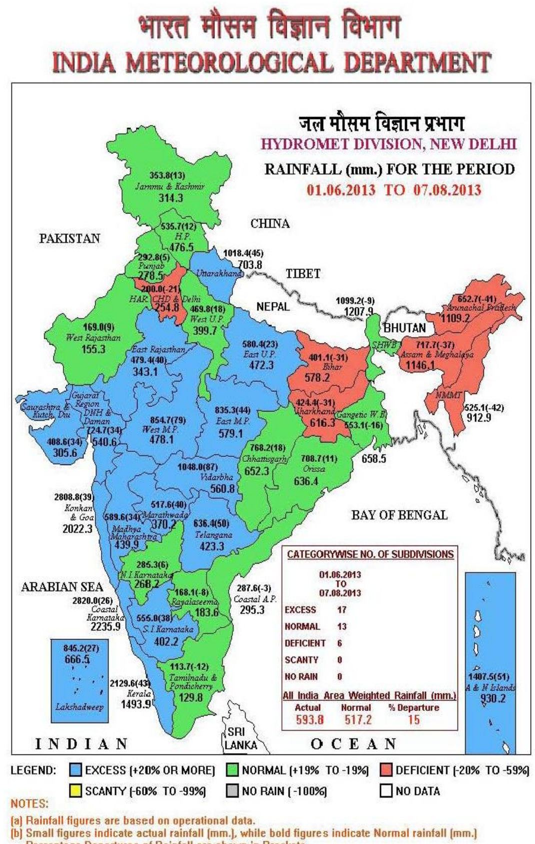
An analysis of the rainfall data for the past five years points to changes in rainfall trends in India, with a greater number of incidence of excess rainfall in Uttrakhand. The areas of Uttrakhand affected by recent floods, particularly Uttarkashi have experienced excess rainfall in June for the past several years. ***Table no. 1.3*** shows that in 2011, Uttarkashi received 146 per cent excess rainfall compared to the long period average (LPA). The corresponding figures for 2010, 2009 and 2008 are 26 per cent, 31 per cent and 98 per cent. Chamoli received 57 per cent excess rainfall in June 2011, 18 per cent in 2010 and 59 per cent in 2008. Rudraprayag received a deficit rainfall in 2008, 2009 but it received 70 per cent excess rainfall in 2011. The advance of the monsoon front right across to the west, just within a day was entirely unexpected. It was the interaction between the well-formed low pressure system of south-west monsoon, from east to west and upper air westerly trough running through north-west Rajasthan to east, that resulted in heavy rainfall over Uttrakhand. In fact, westerly system dragged the monsoon trough, which was present over Rajasthan and Central India until then, towards the north across Haryana. Its rapid movement northwards enabled the low pressure system that was in the eastern part of the country to quickly traverse and locate itself over north-west India. IMD (Indian Meteorological Department) is of the opinion that north-west India became the zone of an unusual confluence of two branches of the monsoon, the Arabian Sea and Bay of Bengal. The abnormally high amount of rain (more than 400 per cent) in Uttrakhand was caused by the fusion of westerlies with monsoonal cloud system. Heavy precipitation swelled rivers, both in the upstream and downstream areas. Besides the rain water, a huge quantity of water was probably released from melting of ice and glaciers due to high temperature during the month of May and June. The water not only filled up the lakes and

District-wise rainfall trends in Uttarakhand from 2008 to 2012

	Chamoli		Rudraprayag		Uttarkashi	
	R/F*	% departure from LPA#	R/F*	% departure from LPA#	R/F*	% departure from LPA#
2008	163.8	59	148.9	-30	298.3	98
2009	32.2	-69	17.8	-92	197.3	31
2010	121.8	18	166.6	-21	189.9	26
2011	170.5	57	369.6	70	363.7	146
2012	41.1	-62	95.4	-56	45.6	-69

*Rainfall
#Long Period Average

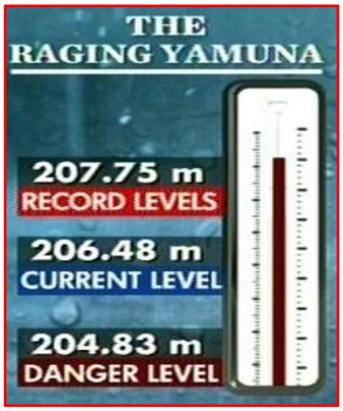
Table 1.3 [10]



Map. 1.3 [11]

rivers that over flooded but also may have caused breaching of moraine dammed lakes in the upper reaches of valley. The reasons cited by meteorologists and scientists raise our inquisitiveness about the possible cause and the role of Indian summer monsoon, which is generally considered as a blessing for the country and its economy in this entire event. There are many instances of years with flood (strong monsoon) or drought (weak monsoon) during which India as a whole receives excess or deficient seasonal rainfall, respectively. Even within a season, there is considerable variation, both in space and time, in the rainfall over India.

Most part of central and north India, including the state of Uttrakhand has received excess rainfall between the months of June and August, 2013 ***(see map no. 1.3).*** Due to excess rainfall this year, the river Ganga and its tributaries were flowing above or close to danger mark in the region, flooding many villages. In August, 2013, Ganga in Haridwar was flowing at 293.70 metres, whereas the danger mark is 294 metres. Similarly, Sharda River at Tanakpur in Champawat crossed the danger level, Alaknanda and Rudraprayag at Chamoli also reached close to the danger mark. Heavy rainfall in June 2013 at higher reaches also resulted in floods downstream. In that period Ganga was flowing near danger mark in Fatehgarh, Uttar Pradesh. Rapti was also near the danger mark at several places. Budhi Rapti was above the red mark at Kakrahi in Siddhartha Nagar. In Delhi, the Yamuna was also flowing near the danger mark, leading to closure of 145 year old railway bridge and evacuation of 2000 families along the river banks. The danger level for Yamuna River stands at 204.83 metres in Delhi, while the water level rose to 206.48 metres. The city was not witness to heavy rainfalls, otherwise there could have been a major disaster in the National Capital. Figure no. 1.8 shows the low lying areas which were submerged due to the swelling of the river and the areas which are prone and vulnerable to flood threat if the water level reaches 207 metres in the city.



Many scientists believe that the June 16, 2013 rainfall in Uttrakhand was a result of a cloud burst. Another cloud burst in Himachal Pradesh caused huge loss of property in Kinnaur district at the same time. A **cloudburst** is *an event in which heavy rainfall occurs over a localised area at a very fast rate*. The area typically doesn't exceed 20-30 sq/km, while the rainfall may reach the level of 100 mm per hour, resulting in flash-floods as was witnessed in Uttarkashi and Ukhimath this year and in Leh in 2010. Typically, a cloudburst in India occurs during the monsoon season over the Himalayan region, northeastern states and the Western Ghats. It can also occur over the plains, but such occurrences are rare. Cloudbursts become frequent during the monsoon season. It is believed that they occur because of rapid lifting of the monsoon clouds by the steep orography of the region. The June cloud bursts were far beyond

Figure 1.8 Floods Vulnerable Zones in Delhi [12]

anything recorded in the preceding years. Several major cloud bursts were reported from Uttrakhand in 2012 (see table no.1.4).

Details of Cloudburst in Uttarkhand, 2012

Date	State	District	Effected Villages
05/07/12	Uttarkhand	Uttarkashi	Assi ganga ghat, Charaghani, Andiyarakala, Phaniyarakala, Ravada
05/07/12	Uttarkhand	Chamoli district	Beriya area
04/08/12	Uttarkhand	Uttarkasi	Dayara bhugyal , Joshiyada, Gangori bridge
19/08/12	Uttarkhand	Uttarkasi	Nuranu village, Mori area
14/09/12	Uttarkhand	Rudraprayag	Timada, Sansari, Giriya, Chunniand, Mangali ,Premnagar and Juatok villages in Ukhimath area
14/09/12	Uttarkhand	Bageshwar district	Kapkot near Almorah

Table 1.4 [13]

Even though the cloud bursts have been increasing, many say that due to climate change, India does not have a system like the one for cyclones to predict a cloud burst, resulting in flash floods. On the basis of images from the remote sensing satellites of Indian Space Research Organsation (ISRO) and the U.S.

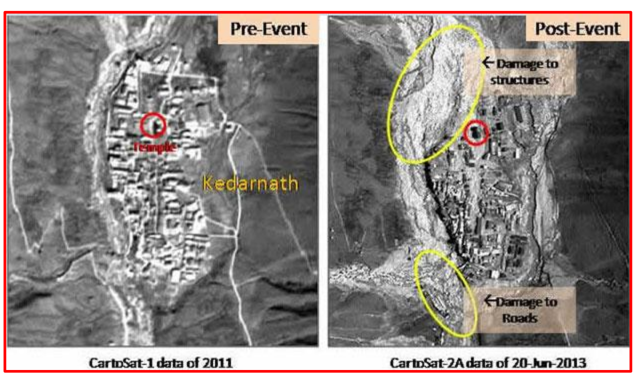


Figure 1.9 Kedarnath Satellite pictures Pre and Post Floods [14]

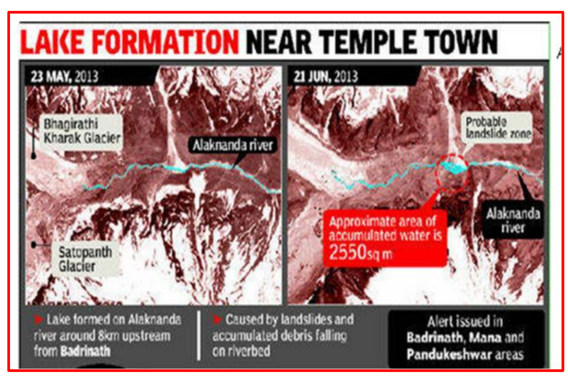


Figure 1.10 [15]

Landsat, it is evident from the post-event image of Cartosat-2 (see figure no. 1.9) that massive destruction was the result of large scale debris carried by huge volume of water from the upper reaches above the town. According to images released by NRSC, the landslides and subsequent lake formation occurred in the aftermath of the June 15-17 rains, that led to unprecedented devastation in the state. The bulge in the river just downstream of Alaknanda's source, is visible in the Indian Remote Sensing (IRS) image taken on June 21 ***(see figure no. 1.10)***. The spot was around 8 km from Badrinath. The approximate area of blocked river was 2,550 sq m. It led the government to issue an alert around Badrinath due to the partially blocked passage of water, leading to the formation of a 450 metre long lake that could have busted and flooded the river. Like other disasters, the only institution that managed to get most praise and credit is the Indian armed forces, trained in the idiom of action, organised in a way that is purposeful and acting without a trace of self-interest.

It was the army personnel who worked tirelessly and put their lives in danger to help and rescue stranded locals and pilgrims affected by flash floods. They provided people essential materials such as food, blankets and medicines. The Indian Airforce (IAF) put to use some of the best military skills to help people in flood ravaged zones of Uttrakhand and rescued hundreds of fatigued and exhausted, stranded pilgrims and locals. Operation 'Rahat' was the biggest ever helicopter based rescue operation in history. 45 choppers made sorties day in and day out despite bad weather and hazardous conditions. It mobilized the resources, evacuated people to relief and base camps and carried out extensive search and rescue operations creating a world record. The unusual advance of summer monsoon, combined with cloud bursts (still not confirmed) and geophysical dynamics (loose soil, landslides and lake bursts) had channeled huge devastation through massive flash flooding in Uttrakhand, which turned into a major disaster due to the combined impact of anthropogenic activities and breaching of the carrying capacity due to irresponsible tourism.

Figure 1.11 Indian Army Rescuing Flood affected people at Uttrakhand [16]

Figure 1.12 Operation Rahat of Indian Air Force (IAF) [17]

- ✰ It has now become essential for us to carry out some intensive and focused research on monsoon and its variability, since the exact dynamics between upper air westerly trough and the low pressure system of south-west monsoon have been recorded.

- ✰ It is also important to develop sophisticated meteorological monitoring and advance warning system with the help of remote sensing technologies and strengthen ground stations.
- ✰ It is necessary to upgrade the post-extreme event rescue and relief operation, keeping in mind the variability of monsoon and fragility of the region.

We, as students must strive to develop an understanding of this complex phenomenon, so that we may extend help and support to our family, relatives, friends and countrymen by taking informed decisions about visiting such areas and to make them aware the perils of indiscriminate use of natural resources and exploitation of mother earth. It is through the dissemination of the knowledge and understanding of the regional climatic conditions along with the establishment of effective disaster management mechanism only we can effectively save people, property and environment. The natural calamity happened in Kedarnath is only an eye opener to people and Government to call for an immediate action and sustainable Development in coherent with nature.

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Sample Questions

Q1. "Flooding in Uttrakhand Himalayas is a manmade-cum-natural disaster". Comment (5 Marks)

Q2. Imagine yourself as an army personal involved in a rescue mission at Uttrakhand. What possible challenges could you have faced in carrying out rescue operations? Discuss your own strategy to efficiently tackle such situations. (5 marks)

Marking Scheme

1. Answers containing following arguments need to be recommended
   - Environmentalists views on exploitation of natural resources and ignoring carrying capacity of the region.
   - Views of Meteorologists related to macro-level climatic changes and melting of glaciers.
   - Instances from Uttrakhand region and other parts of the country or the World.

   Explain in-detail

   (To be assessed as a whole)

2. For army personnel:

- ☆ Bad weather conditions
- ☆ Rugged Topography
- ☆ Lack of resources for rescue
- ☆ Measures to save them from Cloud Burst:
- ☆ Immediate Evacuation
- ☆ Taking refuge under shelter
- ☆ Store necessary items (medicines, food etc) Explain in-detail

(To be assessed as a whole)

OPEN TEXT MATERIAL

2. Theme – *Krakatau Volcano: Fear of East Indies*

Abstract:

Krakatau eruption is one of the most cataclysmic volcanic eruptions in the recorded history of mankind. It was so strong that it shook the entire world and generated calamitous Tsunami waves that devastated the Islands of Java and Sumatra. After a few years of the eruption, nature took its own course and a wide variety of flora and fauna flourished over the remnants of Krakatau Islands. The emergence of Anak Krakatau and its perpetual volcanic activity has further attracted attention of tourists and scientists in Krakatau, which has now become a brand in Indonesia to conserve biodiversity and promote eco-tourism.

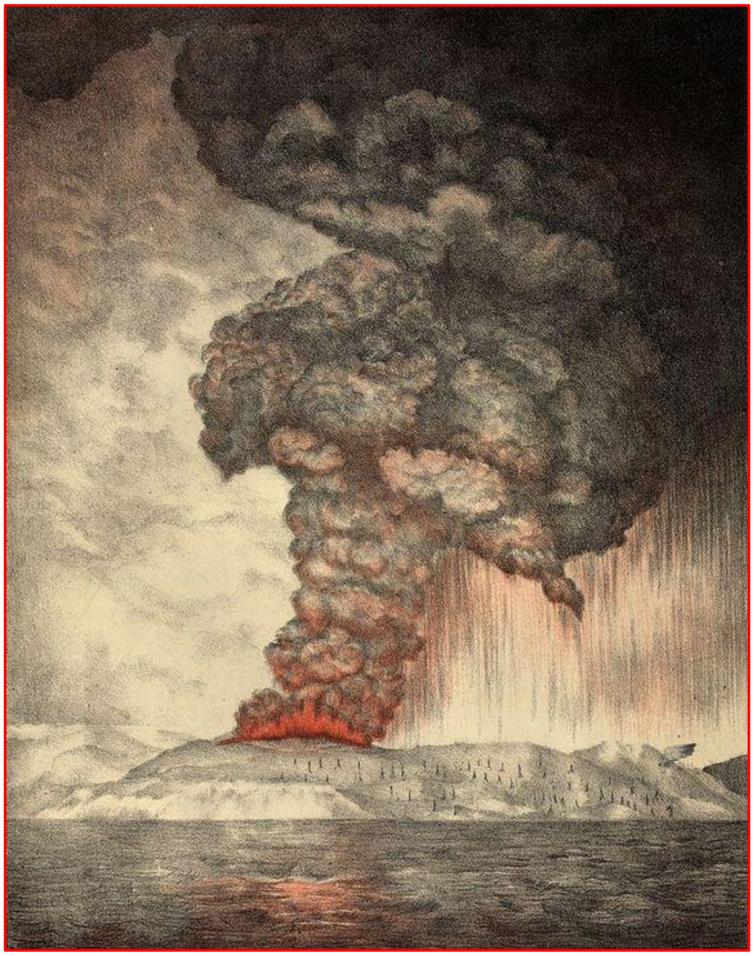

Figure 2.1: *A 1988 lithograph of 1883 Krakatau Eruption*[1]

On 20th May 1883 the German warship *'Elizabeth'* reported an 11 km high cloud of ash coming out of an uninhabited island of Krakatau between Java and Sumatra Islands of East Indies (Indonesia).

It was the first documentation of any volcanic eruption in Indonesia. Similar sights have been noted by crews on commercial vehicles and sightseers on charted ships for over two months. The sound of explosion and churning, the cloud of black ash and pumice, mesmerised local inhabitants and sightseers. It created a near festive environment. However, they failed to realise that these events are just a prelude to one of the largest volcanic eruptions of historic times. During that period no one lived on Krakatau because it was too small to attract settlers. It was a hiding place for pirates, who used the island as a base to rob trading ships. Krakatau volcanoes have been dormant for generations. The Dutch officials had examined the burned out craters earlier and thought the volcanoes were extinct.

Figure 2.2: *Krakatau Islands*[2]

Largest Explosive Eruptions of the 19th and 20th Centuries

Year	Volcano	First historical?	Deaths
1991	Cerro Hudson (Chile)	No	0
1991	Pinatubo (Philippines)	Yes	>740
1982	El Chichón (Mexico)	Yes	>2,000
1980	Mount St. Helens (USA)	No	57
1956	Bezymianny (Kamachatka)	Yes	0
1932	Cerro Azul/Quizapu (Chile)	No	0
1912	Novarupta/Katmai (Alaska)	Yes	2
1907	Ksudach (Kamchatka)	Yes	0
1902	Santa Maria (Guatemala)	Yes	>5,000
1886	Tarawera (New Zealand)	Yes	153
1883	Krakatau (Indonesia)	No	36,417
1875	Askja (Iceland)	Yes	0
1854	Shiveluch (Kamchatka)	Yes	0
1835	Cosiguina (Nicaragua)	No	5–10
1822	Galunggung (Indonesia)	Yes	4,011
1815	Tambora (Indonesia)	Yes	60,000

Table 2.1: *Largest Explosive Eruptions*[3]

A series of cataclysmic explosions began at mid-day on August 27 with a stupendous paroxysmal eruption. The first smaller eruptions had opened the middle of the volcano to the sea. It allowed the seepage of water into the volcano, that turned the water into steam and raised the pressure manifold. Due to this huge pressure the mountain blew up into pieces. Red hot rocks as big as a house were thrown high into the sky.

Thousands of people died immediately on Java and Sumatra islands as they came under the onslaught of burning rock and ash. It was the most violent explosion ever witnessed by humans. The noise produced by the eruption was heard almost 3000 miles away from Krakatau. The explosion was so powerful that the volcano collapsed into the sea. The undersea explosions produced huge ocean waves known as ***Tsunami.*** The Tsunami waves destroyed villages. About 34,000 people along the coast of Java and Su matra were drowned and more than 2000 people were burned to death. After the Tambora volcanic eruption the maximum number of deaths occurred in the Krakatau explosion of 1883 (see table no. 2.1).

Figure 2.3: *Volcanic ash coming out of Ejysfjallakokull volcano, Iceland, 2010*[4]

A volcano eruption is among a few spectacles in nature that are awesome and a delight to watch but violent eruptions such as the Krakatau eruption of 1883, could devastate the surrounding environment and completely change the nearby terrain. A ***Volcano*** has been defined as an opening in the crust of the earth out of which magma, ash, gases erupt, while *Volcanism* includes all the processes associated with the transfer of magma and volatiles from the interior of the earth to its surface. Magma beneath the crust remains under great pressure. Deep in the crust, faults and joints develop downward, reach the magma, and allow it to rise up and intrude into the crust. The magma then rises in conduits, forms bubbles and gives rise to volcanism. Eruptions may also vary in size and character. Krakatau eruption was an *explosive eruption,* in which pieces of molten and solid rock comes out violently into the air, while in *effusive eruptions* molten rock pours less violently into the surface as flowing streams. The variation in eruptive style is mainly the result of chemical and temperature differences in the magma beneath the surface. When basaltic magma is forced to the surface, the resultant eruption is effusive in nature. The cooler, more viscous silicic magma can produce explosive eruption. Molten material that solidify in-flight and solid lava fragments are termed as *Pyroclastic* materials, (also referred as *tephra*), that vary in size - from volcanic ash to gravel sized cinders (2-4mm), lapilli (4-64mm) and blocks (>64 mm). It may also include large sized *volcanic bombs* and clay and silt filled volcanic ash.

Table 2.2 Magnitude and Intensity of Famous Explosive Eruptions

Volcano	Country	Year	Total Magnitude (Kg)	Peak Eruption Plume Height (Km)
Tambora	Indonesia	A.D. 1815	$2X10^{14}$	43
Taupo	New Zealand	A.D. 180	$8X10^{13}$	51
Novarupta	U.S.A.	1912	$3X10^{13}$	25
Krakatau	Indonesia	1883	$3X10^{13}$	25
Vesuvius	Italy	A.D. 79	$6X10^{12}$	32

Source: Sigurdsson Haraldur (eds.) Encyclopedia of Volcanoes

In Krakatau explosion the superheated stream carried the pyroclastic flows up to 40 km at the speed of 100 kph. The eruption has been assigned a rating of 6 on the Volcanic Explosion Index and the magnitude of the explosion was $3x10^{13}$ (see table no 2.2) and is estimated to be equal to the explosive force of 200 megatons of TNT. Tephra and hot volcanic gasses took the lives of many victims. The peak eruption plume height was also among the top five volcanic eruptions. The explosions hurled an estimated 45 cubic kilometres of debris into the atmosphere and produced 442 Km of darkening skies. In the immediate vicinity, the dawn did not return for three days. The ash and gasses released by *Ejyafjallajokull* volcano of Iceland in April 2010 (see figure no. 2.3) had plumes that reached the height of 10 Km. It spewed over 9.5 billion cubic feet of ash over the course of several months that paralysed the air traffic and flights in Europe for many days.

Volcanic Tsunamis

Tsunamis (also called tidal waves) are sometimes thought to be produced only by large seismic events. However, about 5 per cent of all historic Tsunamis, including some of the most destructive tsunami waves ever seen on earth, were produced through volcanoes by eruptions or other volcanic processes. More than 90 Tsunamis of volcanic origin have been produced in the world oceans during the last 250 years. While relatively rare, volcanic Tsunamis are a great concern because they typically occur with little warning and can devastate populated coastal areas at…….considerable distances. Some of the most notable disasters are caused by volcanic Tsunamis (see table no. 2.3). The wave height produced by Krakatau eruption was around 35 metres and the waves travelled to the distance of around 800 km, making it the most catastrophic event in recent history.

Table 2.3 Major Volcanic Tsunamis

Volcano	Country	Year	Wave Height	Travel Distance (Km)
Unzen	Japan	A.D. 1782	10-55 m	20-50
Tambora	Indonesia	A.D. 1815	>10 m	>100
Krakatau	Indonesia	A.D.1883	5-35 m	800
St. Augustine	U.S.A.	A.D. 1883	7-9 m	> 100
Mt. St. Helens	U.S.A.	A.D. 1980	260 m	4

Source: Sigurdsson Haraldur (eds.) Encyclopedia of Volcanoes

Figure 2.4: *Volcanoes in and around Indonesia Fault Zone*[5]

Volcanic activity is inherently related to plate tectonics. Most of the volcanoes are found near divergent and convergent plate boundaries. The *subduction zones* of the world have the most number of explosive volcanoes. Subduction zones are characterised by deep oceanic trenches and chains of volcanoes. Indonesia contains over 130 active volcanoes, which is the highest concentration in the world. They comprise the axis of the Indonesia island arc system, which is generated by north eastern subduction of the Indo-Australian plate. The great majority of these volcanoes lie along the topographic crest of the arc's two largest islands Java and Sumatra. The islands are separated by the *Sunda Strait*, which is located at a distinct bend in the axis of the island arc volcanoes, from a nearly east-west orientation in Java to the northwest-southeast orientation in Sumatra. Krakatau is one of several volcanic islands in the Sunda Strait, located above an active north-northeast trending fault zone (see figure no. 2.4), an orientation quite distinct from the main island arc trend. Most of the world's best known volcanoes are *composite cones*, formed when formative eruptions are sometimes effusive and sometimes explosive. It is composed of a combination that represents a composite of lava and Pyroclastic materials.

Table 2.4 Major Composite Cone Volcanoes

Fujiyama	JAPAN
Cotopaxi	ECUADOR
Vesuvius	ITALY
Etna	ITALY
Mount Rainer	U.S.A.
Mt. St. Helena	U.S.A.
Krakatau	INDONESIA

Source: Sigurdsson Haraldur (eds.) Encyclopedia of Volcanoes

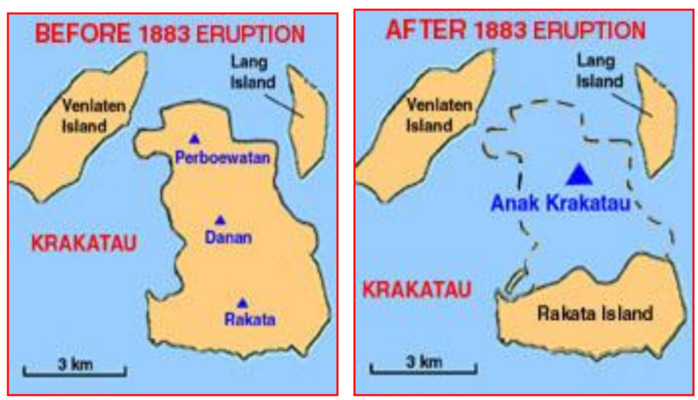

Figure 2.5: *Physiography before and after the explosion of 1883*[6]

The pre-eruption island of Krakatau was composed of three coalesced volcanoes aligned along north-northwest directions, parallel to the volcanoes of Sumatra. From north to south these were *Perboewatan, Danan* and *Rakata*. During the eruption, Perboewatan, Danan and north half of Rakata appears to have collapsed (see figure no. 2.5) into the vacating magma chamber, thus forming a submarine caldera and destroying the northern two third of the island. Eruptions since 1927 have built a new cone called Anak Krakatau in the centre of 1883 caldera.

Anak Krakatau

In 1927, Javanese fishermen reported steam and debris rising from the collapsed caldera of Krakatau. By August 12, 1930 the new volcano became a permanent island and was named Anak Krakatau "Child of Krakatau". By 1959 the crater rim reached a height of 152 m. The morphology of Anak Krakatau was significantly changed by the series of eruptions occurring in 1959-1963. Anak Krakatau was particularly active in November 1992 with the emplacement of two lava flows and 1000 and 4000 *strombolian* explosions per day. A phase of minor strombolian activity was observed for much of the 1990s until 2002, when Anak Krakatau entered a rest phase with only sporadic discharge of gas. October 2007 marked the onset of a new phase of activity with powerful strombolian (and possibly vulcanian) eruptions. Activity paused in early 2008 and by April the eruption resumed again.

For a hundred years since the enormous volcanic eruption rocked Krakatau and surrounding areas, the island has been left undisturbed and un-inhabitated. Currently, the island has been covered with lush green tropical rain forest, including a dense canopy of trees. The regeneration of rain forests was rapid. Beginning in 1884, a Dutch survey documented the re-introduction of the tropical flora and fauna, continuing through until the 1930s. A. Ernst in his work on the *New Flora of the Volcanic Island of Krakatau, on his* 1906 expedition to these islands, has mentioned the remarkable progress made by the vegetation. The whole south side from the beach to the summit and to the edge of the steep promontory was covered with green trees. They recognised numerous grey-green *Casuarina* trees. Isolated trees and shrubs were seen on the low lying ground. They also found several species of typical strand plants; it included *Ovate fruits* or *Cerbina Odollam,* strand palm or *Nipa Fruticans,* Pandamus, the large four sided fruits of *Barragtoria Speciosa* etc. In 1998 forty species of orchids were recorded in Krakatau.

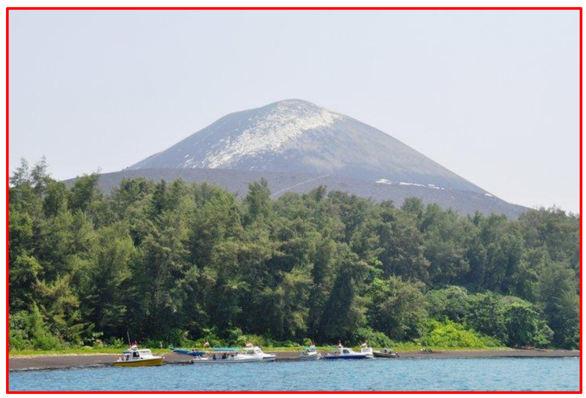

Figure 2.7: *Tropical rain forest in and around Krakatau Island*[8]

Figure 2.8: *Eco Travel Krakata*[9]

The Anak Krakatau wildlife is also very diverse, with 206 species of fungi, 13 of ferns and 25 species of plants, including pine trees, faunal life includes spiders, insects, rats, snakes and monitor lizards. But most of the rainforest of the island is dominated by vast stands of three tree species.

This suggests that rain forest is only in the early stages of succession, though it is over hundred year old. Krakatau islands now comprise of Rakata or Krakatau Besan (large Krakatau), Panjang or Krakatau Kecil (small Krakatau), Sertung and the Anak Krakatau. While the island of Rakata, Sertung and Panjang are remnants of the old Mount Krakatau, Anak Krakatau is an active volcano. The name Krakatau, once a synonym for terror for the local inhabitants for the fatalities associated with its explosion, is now becoming a famous tourist destination for domestic and international tourists. In 1991 UNESCO acknowledged Ujung Kulun National Park and Krakatau Island as an integrated Natural World Heritage site. The island's name has become a 'tourism brand' for Indonesia. Many tour operators are conducting eco-tourism to various destinations around Krakatau under the banner of Krakatau eco-tour. Travel to Anak Krakatau for watching active volcano is also catching up with domestic and international tourists. Anak Krakatau is providing an opportunity to the travelers to witness one of the most spectacular events produced by nature.

How to deal with a volcanic eruption

As students one should understand that volcanic activity is a part of the natural system or cycle that first leads to destruction and then paves the way for natural reconstruction and re-colonisation. So, it is important for all of us to stay alert and remain prepared to tackle any volcanic activity in our vicinity. Students can also do many things to protect themselves and their family from the dangers of volcanic eruptions. The best way to protect yourself and your family is to follow the advice of local officials. Local authorities will provide you with information on how to prepare for volcanic eruptions. **There are different ways in which you can protect yourself from volcanic eruptions in different scenarios.**

If the lava flow is headed towards you:

- Leave the area immediately.
- If available, take a vehicle to evacuate quickly.

Figure 2.9[10]

If you are indoors:

- Close all windows, doors and fireplace
- Turn off all electrical appliances, heating and air conditioning system.
- Bring pets to a closed shelter.

If you are outdoors:

- Seek shelter outdoors

- If caught in a rock fall, roll into a ball to protect your head.
- Seek care for burns immediately
- Move away from the area immediately

Figure 2.9[10]

Protect yourself from Ash-fall:

- Wear long sleeved shirts and long pants
- Use goggles to protect your eyes
- Use dust masks (see figure no. 2.10) or holds a damp cloth to cover your face to help breathing
- Keep car and truck engine off

The International Day for Disaster Reduction has been annually celebrated on 13th October, initiated by the United Nations International Strategy for Disaster Reduction Secretariat (ISDR). Every year, on that day, activities and events are organised worldwide, aiming at a global understanding of disasters, including natural disasters such as earthquake, floods, tsunamis, fires, volcanic eruptions etc. and for the sensitization towards preparedness mechanisms in order to minimize their disastrous effects.

***Figure 2.11:** Volcanism through Simulation*[12]

There is a need to carry out presentations and lectures in the school on volcanism and its impacts, since a guided tour is not possible in countries without active volcanoes. Students need to be trained through simulations of this complex cataclysmic natural phenomenon by breaking it down into sequenced simultaneous components and their effects, visualizing through dramatic simulations. Volcanism is a natural phenomenon which cannot be controlled, but its impact could be minimised through preparedness. It always reminds human beings not to interfere with the natural processes and systems of degeneration and regeneration, but to try and live in harmony with it as far as possible.

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Sample questions

Q1. "Volcanic eruptions are among the most spectacular events on earth" Comment (7)

Q2. "*The subduction zones of the world have the most number of explosive volcanoes. Subduction zones are characterised by deep oceanic trenches and chains of volcanoes*."

Explain the role of plate subduction in volcanic eruptions with reference to the world in general and Krakatau in particular. (5)

Evaluation Criteria: Sample Question

1. Answers containing following need to be recommended:
   - ✰ Description of plume heights during various volcanic eruptions around the world. (1 mark)
   - ✰ Description of Pyroclastic materials, tephra, magma, gasses, mud ect ejecting from volcanoes. (2 mark)
   - ✰ Explaining Strombolian activity near Anak Krakatau. (Explain in detail) (2 marks)
2. Answers containing following need to be recommended:
   - ✰ Discuss convergent plate boundaries of the world (outlining pacific ring of fire) (3 marks)
   - ✰ Explaining volcanoes in and around fault zone of Indonesia, including Krakatau

     (Explain in detail) (2 marks)