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RIVER DYNAMISM AND QUASI - NATURAL DISASTER OF KEDERNATH AREA, UTTARAKHAND

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ABSTRACT:

The forgoing paper bespeak about the Geomorphologt and related hazards of Kedernath area, Uttarakhand. Development of morphological aspects is a result of the interaction of the hydraulics of flow and factors like velocity, discharge, roughness shear, channel configuration. The present paper is concerned with the detail study of the glacio-fluvio-geomorphological analysis about the development of glacier valleys of different ages with their particular depositions regarding the time and space. Mandakini originates from the Chorabari Glacier near Kedarnath in Uttarakhand, India. Mandakini is fed by Vasukiganga River at Sonprayag. Mandakini joins.Alaknanda at Rudraprayag. Alaknanda then proceeds towards Devaprayag where it joins with Bhagirathi River to form the Ganges River. The Intergovernmental Panel on Climate Change (IPCC) published a report in 2012 on Managing the Risks to Extreme Events and Disasters , which concluded that even without taking climate change into account, the risk of disasters will continue to increase as more people, infrastructure and businesses – are exposed to weather extremes. The morphology and development of valleys are controlled by some endogenetic and climate. Development of morphological aspects is a result of the interaction of the hydraulics of flow and factors like velocity, discharge, roughness shear, channel configuration. The special emphasis has been given through the paper is the detail analysis of glacier as well as fluvial valley formations with the expansion of time and space. The river has an magnificent litho-tectonic and fluvio-morphological journey from Kedernath to Rudraprayag with a typical landform evolution being considered as Glacier, Peri Glacier, Fluvio-Glacier and Fluvial. The incessant, heavy rainfall over three days, perhaps accompanied by a few cloudburst-type events (which cannot be confirmed), resulted in flash floods and associated landslides. On June 14, the monsoon front was located over eastern India. In fact it was a trifle sluggish compared with the normal progress of the front . But within a day , the front advanced right across Uttar Pradesh and the western regions to cover the entire country by June 15, exactly a month ahead of its normal date of July 15. While the IMD had forecast a rapid advance with the announcement that the monsoon would strike Delhi before the normal scheduled date of June 30, its advance right across to the west just within a day was entirely unexpected. With the advancement of the monsoon, and heavy rainfall was beyond the capacity of water holding capacity of Chorabaru lake which had leads to the devastating flood of Kedernath area. There are two different but reinforcing events that caused the disaster were landslide-induced debris that came from the glaciated area in the north-east and a glacial-related flow that originated from the north-west glacier. From the images, one can distinctly identify the two flows. The damage caused to the Kedarnath region and downstream villages by the natural destruction resulting from unusual meteorological and geophysical processes was undoubtedly greatly enhanced because of the general environmental degradation caused by the massive and unregulated influx of pilgrims year after year, the haphazard development fuelled by tourist traffic, and the unplanned and poor construction of buildings and roads. Given the vulnerability of the region, the town itself has come up in a very dangerous location, points out Petley. Therefore, how much of the destruction in this event was actually man-made is a moot question.

KEYWORDS: DYNAMISN , GEOMORPHOLOGY AND DISASTER

PROLOGUE:

Kedernath,the one of the most important secret sources of river Ganga situated on 3583 m up of the Himalay and give an ample scope for studying the Glacio-fluvial aspects and development of magnificent Glacier terraces being deposited in different Glacier stages in both bank of river Mandakini. It is a detail study on the aspects of valley formations, both by the action of glacier and fluvial under the litho-tectonic and climatic interferences. The special emphasis has been given through the paper is the detail analysis of detail analysis of recent calamity, occurred by both physio-anthropogenic causes. The prefix "mand" (Sanskrit) means "calm" and "unhurried", and Mandakini thus signifies "she who flows calmly". Mandakini (Hindi: Məŋdâkini]) is a tributary of the Alaknanda River. Mandakini originates from the Chorabari Glacier near Kedarnath in Uttarakhand, India. Mandakini is fed by Vasuki Ganga River at Sonprayag. Mandakini joins.Alaknanda at Rudraprayag. Alaknanda then proceeds towards Devaprayag where it joins with Bhagirathi River to form the Ganges River. Kedarnath falls within the regime of Chorabari Glacier. With the specter of global warming looming large, the glaciers have become a centre of attraction. It was this fact that drew R. K. Chaujar of Wadia

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Institute of Himalayan Geology, Dehradun to Kedarnath area. Being a Lichenometrist he used lichens as his source material for studying the advance and retreat of glaciers in the past. The Study area is under the upper part of Mandakini Basin being controlled and conjugated by Glacier and fluvial geomorphological aspects. IT is now a well-established fact that the glaciers are receding by and large worldwide. Warmer climate in the future may cause increased melting of glaciers, which will lead to a rise in sea level. Change in climatic trends is clearly reflected in mass and temperature changes of glaciers and permafrost. The present study deals mainly with climatic change and its impact on the Himalayan glaciers based on the study of landforms by the Chorabari glacier in the Kedarnath temple area, Garhwal Himalaya, and dating of various cycles of its advance and retreat by lichenometry. On the basis of detail mapping of glacial moraines, we have identified four glacial stages. These are termed as Rambara Glacial Stage (Glacial Stage I,Rgs); Ghanurpani Glacial Stage (Glacial Stage Ii,Ghgs); Garuriya Glacial Stage (Glacial Stage Iii,Ggs) Kedarnath Glacial Stage (Glacial Stageiv, Kgs). These are located at different altitudeRanges of 4800 m asl above the snout of Chorabariglacier and down valley to 2800 m asl near Rambara and a series of four well-developed lateral Moraines are noticed at heights 3160, 3320, 3440and 3640 m al.Under this Geomorphic condition the great nature hazards of the last decay occurred due to the cloudburst and flooding of the Chorabari tal leads to the devastating flash flood on 17 th June morning. The primary trigger for the Uttarakhand disaster following the very heavy rain during June 16-18 was the extremely unusual behavior of the monsoon this year over north India. The incessant, heavy rainfall over three days, perhaps accompanied by a few cloudburst-type events (which cannot be confirmed), resulted in flash floods and associated landslides. The devastation all round in their wake has been huge but the largest impact has been at the temple town of Kedarnath, which was in the midst of the annual pilgrimage season, with tens of thousands of people thronging the town and the downstream region along the Mandakini river. Rainfall measurements for June 16 and 17 at the Dehradun station, of 220 millimetres and 370 mm respectively, indicate the severity of the rain during these days in the region. Haridwar received 107 mm and 218 mm of rainfall on the two days. Uttarkashi received 122 mm and 207 mm. While Mukteshwar (altitude over 2,000 metres) received 237 mm and 183 mm respectively on June 17 and 18, Nainital on the same days received 176 mm and 170 mm. Though rainfall over a 24-hour period in different parts of Uttarakhand has greatly exceeded these figures in the past (on many occasions above 450-500 mm and once even 900 mm at Rajpur near Dehradun), prolonged heavy rainfall for nearly three days over a large area is perhaps unprecedented, and the cumulative effect, compounded by geophysical, meteorological and environmental factors, may be the reason for the enormity of the disaster. More pertinently, these numbers do not give the actual quantitative picture of the very heavy rainfall in the higher reaches of the Himalayas (above 3,000 m) in Uttarakhand, where Kedarnath, Gangotri and Badrinath are located and where the impact has been most severe. This is because the rain gauge stations of the India Meteorological Department (IMD) are all located largely in the lower Himalayan reaches (below 2,000 m) and there are no stations in the higher reaches (above 3000 m). This is probably because snowfall data is regarded as more important than detailed rainfall data in these regions. As a result, there is no proper estimate of the rainfall in the affected regions.

AREA AND LOCATION

In the Mandakini basin the Kedernath area lies between 30°42' N to 30° 70' N and longitude 79° 5 'E to 79° 09' E. The entire area is under the Rudraprayag district if Uttrakhand.

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OBJECTIVES:

The primary objective of the research work is the detail study of the River Morphology And Development of River Valleys of Mandakini Basin, Uttrakhand.To fulfill the objectives the present research work includes the following teams.

(i) To evaluate the development of the valley and to examine the multi-cyclic landscape under the Glacio- fluvial morphology.
(ii) A detailed study of related natural hazards ;its cause and geomorphic changes .

METHODS:

To fulfill the aforesaid objectives this worker has adopted the modern methodology including the Remote Sensing and GIS, employing appropriately the relevant data, information and evidences and intensive field work with particular environmental and geomorphological interest. This dynamic interfluve area seismotectonically known as active zone of complex neotectonic framework. Most of the analysis of the study is based on intensive field work, data collection and empirical observations in terms of- (i) pre-field, (ii) field and (iii) post field methods with an application of advanced techniques of measurement and analysis. Due weightage has also been given on the level of socio-economic well being. The first phase includes the collection of data, preparation of maps like hydrological, pedological, drainage and data base maps concerning primary and secondary sources.

CLIMATE AND SOIL:

The climate varies from Sub-tropical monsoon type (mild inter, hot summer) to tropical upland type (mild winter, dry winter, short warm summer). The northern, northwestern, northeastern and western part of the district is perennially under snow cover, here the climate is sub-arctic type as the area is represented by lofty Himalayan Range. Severe winter and comparatively higher rainfall are the characteristic features of the northern part. The year may be divided into four seasons viz. the cold winter season, (December to February), the hot weather season (March to May), southwest monsoon season (June to September) followed by post monsoon season (October to November). Larger part of the district is situated on the southern slopes of the outer Himalayas, monsoon currents can penetrate through trenched valleys, the rainfall reaches its maximal in the monsoon season that spans betweens June to September. Rainfall, spatially, is highly variable depending upon the altitude. In the Lesser Himalayan Zone (1000-3000m amsl) maximum rainfall occurs about 70 to 80% in southern half. August is the rainiest month. Rainfall rapidly decreases after September and it is the least in November. About 55 to 65% rainfall occurs in the northern half in Central Himalayan Zone. About 17% of the annual precipitation occurs in winter season. The winter precipitation is in association with the passage of the western disturbances and is mostly in the form of snowfall, particularly at higher elevations. The Kedernah area is under the Frigid and cold zone

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having the climatic type like Caw and Da. Glacio-fluvial valleys are dominantly occupied with very shallow to moderately shallow excessively drained, sandy-skeletal to loamy-skeletal, neutral to slightly acidic with low available water capacity soils. They have been classified as Lithic/Typic Cryorthents. These soils are in general under sparse vegetation. The Lesser Himalayan range is mainly composed of highly compressed and altered rocks like granite, phyllites, quartzite etc. and a major part of it is under forest. Intermittent sparse patchy terraced cultivation is also practiced on fairly steep hill slopes whereas dry and wet cultivation are prevalent on the uplands and low-lying valleys respectively. The broader valley slopes dominantly have deep, well drained, fine-loamy, moderately acidic and slightly stony.

GEOMORPHIC EVOLUSION OF KEDERNATH AREA:

Regarding the slope variation and long profile of river Mandakini are two break of slope have been identified which has help to regionalize the major units of the basin. There are three geomorphic zones in the basin as Glacieted zone, Glacio- fluvial and fluvial zone .The Kedernath area is under the Glacier zone which is well manifested and sculptured by the Glacier activities from the past since now. The development of Geomorphology is well related with the origin of the Temple as it give some evidences of of Glacier retreat and depositions of moraines with the development of glacier terraces during the different glacier stages.The Kedernath Temple is actually situated on the medial morains of river Mndakini. The exact date of the Kedarnath temple is not mentioned any literature. A minimum age of about 3000 years can be considered for the temple. The location of temple within the receded area of the glacier suggests three possibilities:(a) There was no glacier in the region at the time of construction of the temple – minimum of 3000 years ago.(b) There was a glacier but beyond the present location of the temple.(c) There was a glacier and the temple was constructed after cutting through the ice of the glacier at that particular position. Siddharth11, in his studies on the basis of astronomical And literary references supported by archaeological evidences Concluded, ‘events described in the great epic of Mahabharata could have occurred around 1350 BC. If we consider the evidences as the poems written in the walls of the temple, there are two times are considered, AD650 and AD850.There was no wards written about snow/ice in AD850 but in AD650,the poem describe snow flow/ ice accumulation. It is meanly due to the advancement of Chorabari glacier in little ice age which was continued till around ad1748(calculated by isometric dating. This was further supported by striation, found in the wall of the temple. In 2000 BC, Adi Shankaracharya came to Kedarnath with 4 of his disciples. However he preferred to go the final 14 kilometers alone to Kedarnath temple from Gauri Kund hot springs On the basis of detail mapping of glacial moraines, we have identified four glacial stages. These are termed as ,Rambara Glacial Stage (Glacial Stage I,Rgs); Ghanurpani Glacial Stage (Glacial Stage Ii,Ghgs); Garuriya Glacial Stage (Glacial Stage Iii,Ggs) ;Kedarnath Glacial Stage (Glacial Stageiv, Kgs).

.RAMBARA GLACIAL STAGE (GLACIAL STAGE I,RGS); In the field, the emergent point of this glacial stage moraines is located at 4420 m and the moraine continued till Rambara where it terminates at around 2790 m asl .From the valley floor, themoraine ridge runs at an elevation of ~400 m. Around Kedarnath temple, this stage is represented by a moraine that comprises a large

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mass of angular and sub-angular rock fragments of heterogeneous composition with clast varying in shape and size.

GHANURPANI (GLACIAL STAGE II,GHGS); GhGS moraines are represented by a paired lateral moraine preserved along both banks of the Mandakini River valley and can be traced from the present snout (3865 m asl) to Ghanurpani at 3010 m asl (figure 5b). The morainic ridges run at an elevation of ~300 m above the valley floor.

GARURIYA GLACIAL STAGE:GGS landforms are represented by two lateral moraines and several hummocky or recessional moraines. They are observed between the altitude of ~4880 and ~3360 m. These moraine ridges are~2.5 km long and located ~100 m above the valley floor. The moraines comprises till with angular and sub-angular, pebbles and boulders of granitic gneiss, augen gneiss, calcsilicate, etc.

KEDARNATH GLACIAL STAGE: The KGS moraines are the youngest glacieradvance in the Chorabari glacial valley.These moraines remerge from an elevation of 4800 m asl and terminate at around 3520 masl near Kedarnath temple.Chorabari is a valley glacier which has two snouts, one in its left margin and other in the right margin. The right snout, which is presently the main supplier of water to the Mandakini River, is situated at an altitude of 3865 m asl and the left snout is at an altitude of 3835 m asl. In other words, the origin of the Mandakini is mainly from the right snout of the glacier.

The study in the upper part of Mandakini, deals mainly with climatic change and its impact on the valley formation based on the dating of lichens, developed on loops of moraines formed due to various stages of advance and retreat of the glacier. Here it has been shown that the date of the largest lichen on the loop of moraine that indicates the position of maximum advance of the glacier is 258 years. It shows the period when the Chorabari glacier started receding from the point of its maximum advancement in this part of the Himalaya. Earlier work in the Dokriani Bamak (glacier) has shown that the period of retreat in the respective part of the Himalaya is around314 years. Melt-out water from the left snout also feeds the water of the Mandakini and merges with the main channel, which is about 100 m northwest of the Kedarnath temple . It appears that this is part of a single glacier has been divided into two and separated by its medial moraine before receding to the present position .Originally there was only one glacier when it was in its advancing stage. Receding in due course of time has melted the glacier to such an extent that it could not disturb its own medial moraine and has been divided into two parts, thus forming the two Chorabari snouts. The left snout is in a stage of thinning faster than the right one. In the active zone, the main medial moraine now plays a major role in the glacier activities. It acts as the left lateral moraine of the main glacier and right lateral moraine of the tributary glacier, though the tributary glacier has a common accumulation zone as that of the main glacier. This suggests that the glacier has undergone vast amount of receding due to which its own medial moraine has separated its tributary glacier from the main glacier. There was a re-advancement of the glacier before the final stage of retreat , which was indicated by the presence of a new lateral moraine (the present one) near the snout, within the earlier lateral moraine. This advancement was smaller in size compared to the earlier glacier before retreat. The glacier valley formation is also accompanied with the retreat of glacier and deposition of sub-glacier and en-glacier morains including intermediate morains. It is also associated with carring materials of

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melt water and kem terraces which are viewed as the remnants of melt water stream beds that have formed along the Kedernath Valley wall at an ice margin.

Area vacated by the Chorabari glacier after receding. L1– L4 are lateral moraines forming parts of loops of stages I–IV of glacial advance and retreat at a height of 3160, 3320, 3440 and 3640 m as respectively represents location of the Kedarnath temple. 1–4 are locations of largest lichens of the respective loops. MELM= Maximum elevation of lateral moraine. 'Sc' is accumulation area and 'Sa' is ablation area 'Ah' is head of the glacier And 'At' is terminus of the glacier.

The second method of dating is the lichen analysis which evident as the evolutions of Kedernath Valley.The most common lichen growing on the morainic boulders is *Rhizocarpon geographicum.It belongs*to yellow–green section of *Rhizocarpon most frequently*used in lichenometry. The longest axis of all the lichens of the species growingon the upper faces of selected boulders were measured with a flexible tape and digital caliper, with measurements estimated to nearest 1 mm; about 185 lichens in the region were measured on different moraines and their size distribution was plotted to display relative dating.

TABLE NO.1 SHOWING DIFFERENT STAGES OF LICHEN DEVELOPMENT

STAGE(LOCATION)	LARGE LICHEN(mm)	SMALL LICHEN(mm)
RAMBARA GLACIAL STAGE (GLACIAL STAGE I,RGS);	192	18
GHANURPANI GLACIAL STAGE	157	28
GRURIA STAGE	89	17
KEDERNET STAGE	75	19

SOURCE: WADIA INSTITUTE OF INDIA AND FIELD WORK

(2009-2010)

LAND FORMS AND HAZARDS:

Under the glaco- fluvial activities the morain based valley is characterized by different depositional and erosial landforms.But it is very pain full when this beauty of nature and ancient

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Kedernath Temple has affected by the flash floods in last 16th and 17 th June,2013.The huge amount of rainfall added extra water in Chorabari tal and This lake would have had a depth of about 15 m, and the event was not exactly a glacial lake outburst flood (GLOF), which occurs when a dam or moraine wall is breached because of the sheer pressure exerted by the stagnant glacial water and ice that it encloses. This was a case of lake flooding because of excessive rainfall and consequent overtopping of the moraine wall, which eventually breached. There are four reasons as--

1.WEATHER CHOROLOGY-THE primary trigger for the Uttarakhand disaster following the very heavy rain during June 16-18 was the extremely unusual behaviour of the monsoon this year over north India. The incessant, heavy rainfall over three days, perhaps accompanied by a few cloudburst-type events (which cannot be confirmed), resulted in flash floods and associated landslides. The devastation all round in their wake has been huge but the largest impact has been at the temple town of Kedarnath, which was in the midst of the annual pilgrimage season, with tens of thousands of people thronging the town and the downstream region along the Mandakini river .

2. UNEXPECTED ADVANCEMENT OF MONSOON AND FORMATION OF HIGH ALTITUDE CLOUDS-What was peculiar about the monsoon this year? On June 14, the monsoon front was located over eastern India. In fact it was a trifle sluggish compared with the normal progress of the front . But within a day, the front advanced right across Uttar Pradesh and the western regions to cover the entire country by June 15, exactly a month ahead of its normal date of July 15. While the IMD had forecast a rapid advance with the announcement that the monsoon would strike Delhi before the normal scheduled date of June 30, its advance right across to the west just within a day was entirely unexpected. A system of westerly winds from the Arabian Sea had also been active during the same period and had covered Pakistan. It was a strong westerly system, “North-west India became the zone of an unusual confluence of the two branches of the monsoon—the Arabian Sea branch and the Bay of Bengal branch. It was the interaction between the well-formed low-pressure system of the south-west monsoon from east to west and the upper air westerly trough running from north-west Rajasthan to the east that resulted in the heavy rainfall over Uttarakhand.

3.GEOPHYSICALDYNAMICS-The peculiarity of the monsoon apart, the other interesting question is what geophysical dynamics channelled the major part of devastation along the Kedarnath valley and downstream of Kedarnath on the Mandakini. The region around Kedarnath is known to geologists to be prone to landslides. This is also clear from an early 1882 Geological Survey of India photograph of Kedarnath ,which shows that the temple site is located not far away from the snouts of two mountain glaciers.

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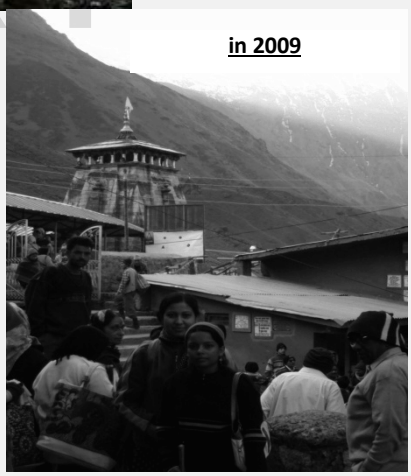
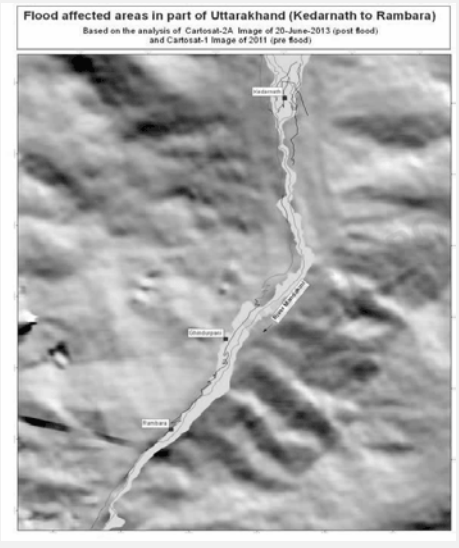
4. DOUBLE FLOW OF WATER WITH DEBRISE-

The two different but reinforcing events that caused the disaster were landslide-induced debris that came from the glaciated area in the north-east and a glacial-related flow that originated from the north-west glacier. From the images, one can distinctly identify the two flows.There are two stages of devastation-Firstly the eastern part was affected by landslides and huge amount of big sized boulders come down, deposited over the backside of the temple.2. In the second stage the huge amount of cloud and lake out burst water came down in high velocity. Actually in 150 years ago there were two flows of Mandakini,one was flowing along the western side of the temple and another in the eastern side.But as the eastern part is landslide prone, due to this the channel was blocked near source and that was flowing as small streamlet crossing which people use to reach Varivnath. With time space the past channel sides have been filled up by constructing Ashrams, Hotels etc and during last 10 years it has increased in high rate.





CONCLUSION: The deathly sludge that entombed most of Kedarnath town in just 24 hours on the evening of June 16 and on June 17 morning may have just changed life in the Indian Himalayas forever. Survivors say they witnessed tones of waterborne debris flattening almost anything that stood in the way. Screaming pilgrims, their voices drowned out, did not stand a chance in the face of the ferocious flood that unbelievably tossed around boulders, several meters across, like paper balls. Under the Glacio-Fluvial landscape ,the Kedernath Temple and adjacent areas have developed on a loose

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morains deposits which is never can strainthen the base of the constrictions. Along this reason the global warming help to create such lakes over the Himalaya and The sheer scale of the calamity that devastated the temple town and pretty much anything it encountered nearly 40 km downstream is now stirring scientists to the reality of a long-ignored but potentially catastrophic threat posed by the rapidly melting Himalayan glaciers-Glacial Lake Outburst Floods (GLOFS) triggered without warning by extreme rainfall, unpredictable seismic events or increased glacial melting.

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