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Land Subsidence Causes and Consequences with Special Reference of Joshimath Town

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Abstract: *Natural disaster or devastating incidence generated by the effects of natural, rather than human-driven, phenomena that produces great loss of human being or damage of the natural environment, private property or public infrastructure. A natural disaster may be caused by weather and climate events or by earthquakes, landslides, and other occurrences that originate at Earth's surface or within the planet itself. No place on Earth is protected from a natural disaster; however, certain types of disasters are often limited to or occur more frequently.*

The costs of individual natural disasters frequently reach the tens of billions of dollars. Such costs may be associated with damage to crops, buildings. Land subsidence generally occurs when groundwater is mined in an unplanned way. The impact is more evident in rocks made of fine-grained sediments. Decline of groundwater table causes a vertical compression of sediments bearing the water. Sometimes, lateral compression may also take place along with this vertical compression. Lowering of the pore water pressure in a layer results in an increase of the effective stress in the soil, resulting in consolidation of the soil which manifests as land subsidence.

The effects can be settlement of upper clay layer leading to damage of infrastructure (roads, bridges) and flooding due to ineffective drainage systems of the town and its surrounded areas.

Keywords: *Land subsidence, fine-grained, compression, consolidation infrastructure*

1. Introduction

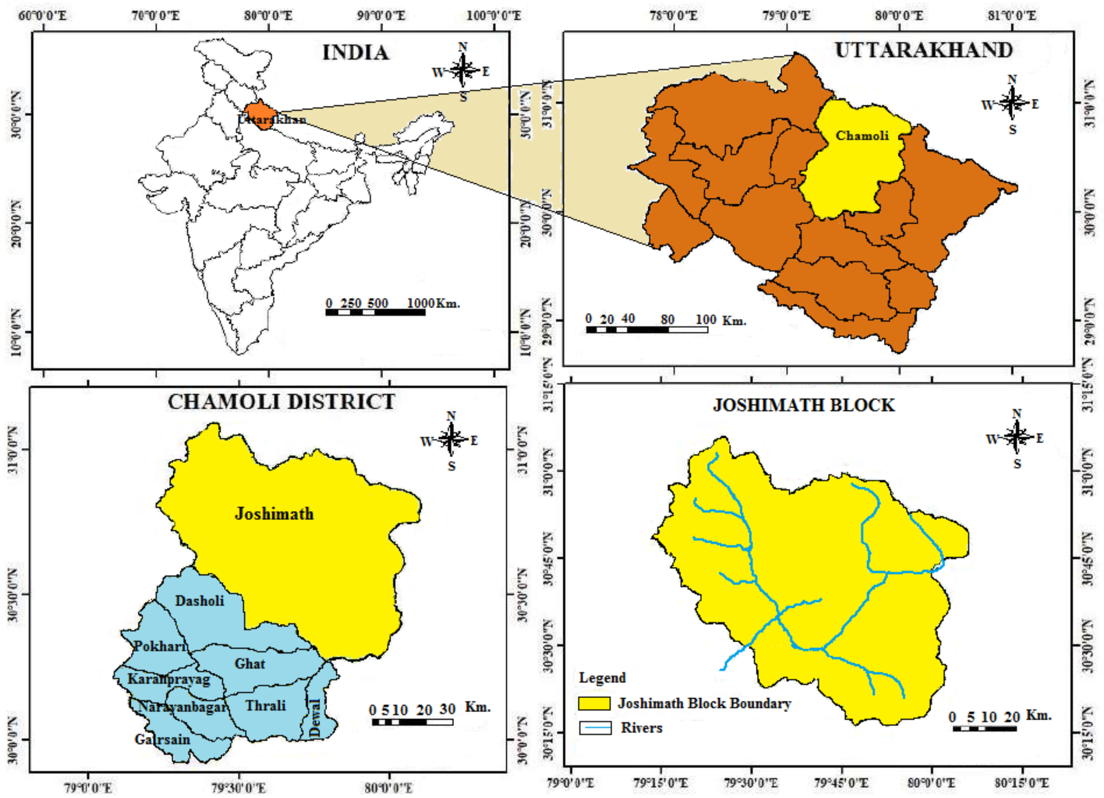
Natural hazards have caused a huge deal of trouble for mankind throughout history, and their outcome on national economies and society has also been well-known. Natural hazards viz. landslides, avalanches, cloudbursts, earthquakes and floods all are of frequent occurrence in the fragile Himalayan region. Owing to highly variable landscape, unstable steep slopes with inadequate soil cover, extreme climatic conditions and seismic activity this area is more vulnerable than the others. Developmental activities in such disaster prone area are resulting in loss of life, property damage, and environmental degradation.

Joshimath is a renowned hiking and pilgrimage destination. It is located at an elevation of over 6,000 feet (1,830 meters) in the northern part of border district Chamoli in Uttarakhand between 30º 17′ and 31º 07′ north latitude and 79º 13′ and 80º 06′ east longitude. The Joshimath region, which spans 2.5 square kilometers, is home to some 3,900 residences and 400 commercial structures. The town has a population of about 25,000.

The township is built on a fragile mountain slope dipping towards almost north. The slope is composed of ancient landslide material of glacial origin. Boulders as large as a two story building are frequently visible all along the slope. Some of the buildings are constructed over these boulders or with these boulders. Dip direction of the slope and that of underlying rocks are similar (20^0 due N and NNE to *45°* towards N) making it more unstable. The length of the region from S to N is 8-10 kilometers, the width up to 3 kilometers. The average thickness being estimated at 150 meters, the volume would be about 2.3 cubic kilometers (Heim and Gansser, 1936). The region that is already proven prone to landslides has undergone unplanned construction, drastic road widening and hydropower projects that have ignored multiple warnings. Now, the ground is sinking from under the town caused by multiple factors natural as well as anthropogenic.

Inhabitants of the ancient pilgrim town have had to flee their homes in the freezing January weather. Walls had cracked open, while foundations were tilting and sinking in a quarter of the approximately 2,500 buildings in the town.. Ground realities itself shows that it was a disaster waiting to happen because the authorities overlooked multiple warnings over decades about the way roads and hydropower projects were being built.

LOCATION MAP OF THE STUDY AREA



2. Objectives

To know the causes of land subsidence sliding in the entire Joshimath region. There are three main objectives:

1. To assess the effect of land subsidence/sliding on people's socio-economic conditions.
2. To investigate land subsidence /sliding effects on the, agriculture, employment, education, business, infrastructure and pilgrimage.
3. To provide appropriate preventive measures for present crisis and safety of the people and environment.

3. Methodology

The study is carried out in Joshimath town and its surrounded wards including Ravi Gram and Sunil and Manohar bagh area. An Intensive Survey of Manohar bagh area has been carried out, which was worst affected part of the town. The study is based on categorical (qualitative) and computable (quantitative) data. The qualitative data is collected through in-depth interviews with local people during the land subsidence/sliding crisis, and the quantitative data is collected through field survey methods. The following topics were covered in the survey: demographics detail of people, livelihood patterns and landslide effect on agriculture, employment, education, infrastructure, and pilgrimage. Primary data was collected in this study by speaking directly with interviewees in order to obtain very credible and accurate information. The use of secondary data is done by collecting the images of infrastructure damage and information provided by district administration of Chamoli district.

4. CAUSES OF THE JOSHIMATH DISASTER

The Reason behind the Land Subsidence

The possibility of such an incident happening in the region was first highlighted around 50 years ago when the M.C. Mishra committee report was published and it cautioned against "unplanned development in this area, and identified the natural vulnerabilities."

(a) Natural Reason

1. Dip of the slope material and that of underlying rocks are almost parallel this relationship makes slope material unstable.
2. Ground water movement- as the slope material is unconsolidated ground water play a significant role in stability of slope.
3. As the region fall in the Seismic zone V, a mild tremor may destabilize the slope.

(b) Anthropogenic Reason

1. Construction of multistory buildings up to seven stories is beyond the carrying capacity of the slope material.
2. Unplanned and unauthorized construction has led to the blocking of the natural flow of water.
3. The road-widening construction work to Badrinath highway.
4. Lack of a proper drainage system might have also contributed to the sinking of the area.
5. Besides gradual weathering of fine material between the rocks of debris, water percolation has decreased the cohesive strength of the rocks over the time.
6. Climate change as a force multiplier.

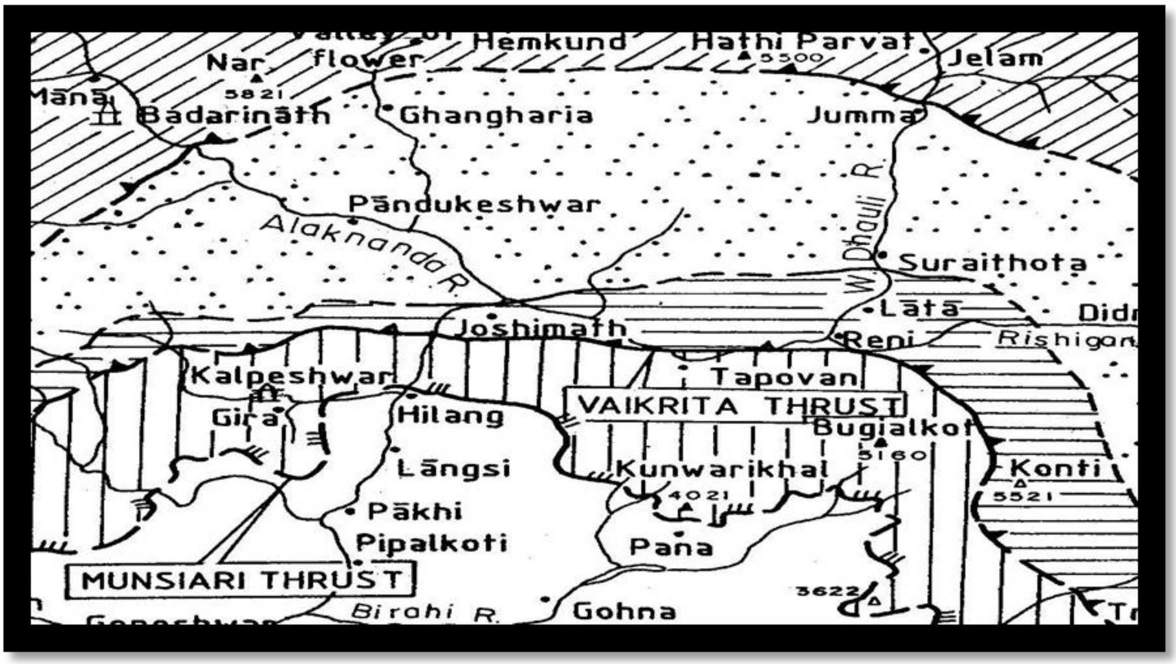
5. GEOLOGY OF THE STUDY AREA

Geological conditions play an important role to analyze stability conditions of any region. The geological and structural setup of the Himalayan region will help us to understand the sensitivity of the region.

The longitudinal stretch of the Himalaya is divided in five structural zones running parallel to the mountain arc (Gansser, 1964) (Table 1). These structural unit forms thrust sheets over each other bringing older Precambrian rocks over younger meta sediments.

Table1. *The broad tectono-formational zones of Himalaya from south to north.*

North	
Trans Himalaya	Tibetan Facies
---------- ***Indus Suture*** --------	
Tethys Himalaya	Tethyan Sedimentary Sequence
----------- ***Trans Himadri Fault*** ----------	
Central Himalaya	Intrusive Granite, Central Crystalline granitic-gneisses, schists, quartz granulites and migmatites.
-------- ***Main Central Thrust*** -------	
Lesser Himalaya	Metasedimentary, carbonate sequence with basic volcanic
---------- ***Main Boundary Thrust*** ---------	
Outer Himalaya	Siwaliks, Tertiary molasic sediments and recent deposits
South	



(Geological map of Joshimath Area, After: K. S. Valdiya, 1999).

6. Geological Formations

Geologically the area is occupied by the highly metamorphosed Central Crystallines. Central Crystallines is divisible into two major litho units the lower one Munsiari Formation and Upper one Vaikrita Group. Munsiari Formation and Vaikrita Group forms a thrust sheet over the Lesser Himalayan meta sedimentaries and is overlain by the Tethyan Sedimentary cover separated from the Vaikrita group by a series of normal faults (Valdiya, 1999).

The crystalline rocks are generally considered to be the basement of the Tethys sediments. Gansser (1964) correlated them with the Archaean System of the Peninsular India. However, there is a general agreement that the crystalline rocks as well as lower part of the Tethys sediments were subjected to intense regional metamorphism during Tertiary period (Powell and Conaghan, 1973; LeFort, 1975).

6.1. Munsiari Formation

Munsiari Formation is bounded at the bottom by Munsiari Thrust (MT), which overrides the Lesser Himalayan sediments. The Munsiari Formation is essentially made up of garnet bearing mica schists, deformed amphibolites, calc-silicate lenses, quartzites, mylonitic biotite rich fine grained gneisses and augen gneisses and phyllonites. On the whole deformed gneisses dominate over the other rock types. The grade of metamorphism increases towards the Vaikrita Thrust. The Munsiari Thrust at the bottom is a broad zone showing ductile deformation characters, occupied by quartz-sericite schist containing graphite, highly pulverized gneisses and bands of amphibolites. Few meters away from the thrust zone, towards North, garnet appears in the mica schist. The mica schist is inter banded with quartzites and fairly thick tabular bodies of augen gneisses.

The Munsiari Formation is made up of preponderant porphyritic granite and its mylonitized variants, together with sericite-chlorite schist (with or without garnet) and amphibolite and marble intercalated with graphitic or black carbonaceous phyllite/schist. Plutonic rocks vary in composition from granite to granodiorite. They are commonly porphyritic, rich in biotite and quartz, and invariably converted to augen gneiss, ultramylonite and porphyry schist. The entire succession exhibits pronounced retrograde metamorphism.

Schists range from metapelitic, metasemipelitic to metapsammatic in composition. Apart from these schists, calcareous meta sediments are also observed (Barman, 1988). Meta semipelites are represented by quartz-mica schist and metapsammites are represented by micaceous and massive quartzites.

6.2. Vaikrita Group

It was Griesbach (1891) who introduced the Sanskrit word to describe the highly deformed crystalline complex of rocks of Central Himalaya. In Sanskrit, Vaikrita means the deformed, and the metamorphosed. The huge pile of rocks between the Vaikrita Thrust and the Trans-Himadri Fault is designated as the Vaikrita Group (Valdiya, 1973, 1979, 1980b, 1981, 1988; Valdiya & Goel, 1983). Subsequent workers have called this unit variously as the Central Crystalline or Basement Complex. Vaikrita Group consists of medium-to high-grade metamorphics and intrusive porphyritic gneissic granite. There are plutons of Miocene anatectic leucogranites in the upper part of the Vaikrita succession. It is divisible into three distinctive lithological formations namely Joshimath, Pandukeshwar and Pindari. These formations extend unbroken from end to end except the middle unit (Pandukeshwar) whose thickness and extent seems to have been affected considerably by the over thrusting of the overlying Pindari unit (Bhakuni, 1995) as well as by lateral facies variations.

Joshimath Formation comprises of kyanite-garnet-two mica psammitic gneiss and schist, Pandukeshwar Formation of biotite - garnet ± kyanite quartzite and subordinate schist, and the Pindari Formation calc-silicate rocks with sillimanite/kyanite - garnet - biotite gneiss and schist with anatectic granite (and intimately associated migmatite). The upper part of the Pindari is a transition to calc-schist and biotite porphyroblastic schist and biotite-marble, described as Budhi Schist by Heim and Gansser (1939) and Gansser (1964).

6.3. Joshimath Formation

In the lower half of the formation, garnetiferous mica schists and garnet mica quartos schists predominate, and mica quartzites are subordinate constituent. They are fine to medium grained and well cleaved, and alternate in various scales from several to some tens of cms. Vaikrita thrust runs at Bhangiyul with about N 50^0 W trend and about 30^0 NE dip. Apparent thickness of the lower half of the formation is about 3500 m.

The rock types of Joshimath Formation consists dominantly of medium to high grade gneisses, represented by garnet, kyanite, sillimanite bearing gneisses and quartzo-feldspathic gneisses. Amphibolites also occur as bands inter-bedded with the various rock types of this unit.

Quartz-mica-gneisses are similar to the garnet mica-gneiss but the garnets are not visible megascopically in these gneisses. These are medium grained, hard, grayish in colour with gneissic banding and occur as bands few meters thick interlayered with other gneisses. Foliation (s1) is well marked by quartz rich and mica rich bands. Quartz, muscovite, biotite are seen megascopically. The gneissic rocks are more developed in Joshimath area

Table1. *Lithotectonic subdivision of the "Central Crystalline Zone" in the study area (After Valdiya, 1973; Valdiya and Goel, 1983)*

Tethyan Facies		Martoli Formation of greywacke-slate alternation or Garbyang Formation of argillacalcareous sediments.
----------------------- ***Trans-Himadri Fault*** ------------------------		
	(3)	Pindari Formation: Predominantly babded calc-silicate gneiss and calc-schist interbedded with subordinate biotite-psammitic gneiss and schist with characteristic sillimanite and/ or kyanite. Extensively penetrated by stocks and laccoliths and network of dykes and veins of aplite, pegmatite and adamellite. Pervasive invasion and penetration of granite plutons (Badrinath Granite) has brought about widespread migmatization and development of porphyroblastic augen gneisses, characterized by sillimanite, cordierite and garnet. The upper part, known as Budhi Schist consists of biotite porphyroblastic calc-schist interbedded with micaceous schist and phyllites. Locally there are carbonaceous, pyretic or staurolite-bearing phyllites.
		------------------- ***Pindari Thrust*** ----------------------
Vaikrita Group	(2)	Pandukeshwar Formation: Biotite- and / or muscovite-rich quartzite intercalated with kyanite-garnet-bearing mica schists and subordinate psammitic gneiss. Locally, lenses and subordinate layers of calc-silicate gneisses and garnet-bearing amphibolite. Where garnet is developed in abundance the quartzite resembles leptynitic granulite.

	(1)	Joshimath formation: Streaky and babded psammitic gneiss and garnet-kyanite rich muscovite-biotite schist and the phyllonites at the base. Very subordinate and local lenses of cal-silicate gneiss.
----------------*Vaikrita Thrust (the actual MCT)* ------------------		
Main Central Thrust Zone		Munsiari Formation: Profoundly mylonitised bodies of granodioritic, granitic and aplitic composition grading locally into augen mylonite or porphyry schist. Interbedded with chlorite-sericite schist, graphitic schist and crystalline blue-grey limestone.
--------------------------------------- ***Munsiari Thrust*** ------------------------------		
Garhwal Group		Crystalline magnesite with talc pockets and basic intrusives, quartzites, chlorite, schists, massive limestone and dolomites alternating with carbonaceous slates

6.4. Pandukeshwar Formation

The pelitic gneisses of the Joshimath Formation pass gradually into the arenaceous sequence of Pandukeshwar Formation and the contact plane passes through near Lata at the southern boundary of this Formation. The Pandukeshwar Formation is exposed as an arc shaped outcrop having more width in the Alaknanda valley and less width in the Dhauliganga and Rishiganga valley where it turns to the right. Towards the northern boundary quartzite of Pandukeshwar Formation are in contact with the pelitic gneisses of Pindari Formation

Pandukeshwar Formation lies in the core of a huge isoclinal anticline (Suraithota anticline), the axis of which can be traced through Suraithota in the Dhauliganga valley. The whole structure of the area is controlled by the Suraithota anticline (f2) (Virdi, 1986). This thick sequence of quartzites is SE extension of what Heim and Gansser (1939) have described Pandukeshwar Quartzites in Alaknanda Valley and measured 9000 m in thickness. Observed thickness of the series of quartzites is reduced to about 3500 m in the Rishiganga catchment. The quartzites overlies garnet mica schists and is overlain by a highly metamorphosed sedimentary series of gneisses, augen gneisses and clac-silicate rocks

The lithology of this formation consists about 90% of quartzites which are massive, banded and schistose in character. Quartzites are highly jointed and occur as vertical peaks thus exhibiting steep slopes. Quartzite is medium to coarse grained, grey, dirty white or brown in colour. Banded quartzite and schistose quartzite occur as bands varying from 2-10 meters in thickness at various places in between the massive quartzite of this formation. The bands of quartz mica schist and garnet mica schist vary in thickness from 2-5 m and are medium to coarse grained. Quartz, muscovite, biotite and garnet are seen megascopically in these schists. These schist bands exhibit the grade of metamorphism of the quartzites in which they are present. The quartzites encountered in the Pandukeshwar Formation in general exhibit a fairly constant dip and strike, the strike in general trends NW-SE while dip is directed towards NE with an amount varying from 25^0-40^0.

A very characteristic feature of this formation which is not observed in other formations is the occurrence of lenticular layers and thin veins of quartz in between quartzites with profound development and concentration of garnets in them ranging from 0.2 – 1 cm in diameter. Garnet grains are also well developed in the pelitic schist bands which are present at various places throughout this formation. Bands of metabasic rocks occurring as amphibolites are encountered in between the quartzites of this Formation. These amphibolite bands vary from 5 - 10m in thickness.

6.5. Pindari Formation

The Pindari Formation consisting of quartz-plagioclase-orthoclase-biotite-sillimanite (fibrolite) bearing gneisses and schists is intercalated with calc silicates and amphibolites, towards the top the volume of leucocratic granitic increases. This zone contains pegmatite and aplite veins and small lenses and dykes of leucogranite mostly related to the SW directed shearing event. The granitic material contains garnet, biotite and tourmaline, is highly intermingled with the country rock, the melanocratic sillimanite schist. These melanocratic schists occur as enclaves in the anatectic zone where the quartz lenses and granite lenses are wrapped by fibrous sillimanite and occur as nodules. To the north these rocks are represented mainly by migmatites, containing laths of fibrolite (lillimantite) with subordinate schist bands. These rocks trend in NNW-SSE to NW-SE direction with moderate dips in NNE to NE.

Across the Malari-Dibrugetha fault (Yuji Maruo, 1979) highly metamorphosed rocks of the Pindari Formation are distributed on both sides of the Rishi Ganga. Aluminosilicate (Kyanite and sillimanite) bearing garnet mica gneisses and garnet mica quartzose gneisses prevail in lower part and some thin layers of calc-silicate banded gneisses are intercalated.

7. STRUCTURES OF THE STUDY AREA

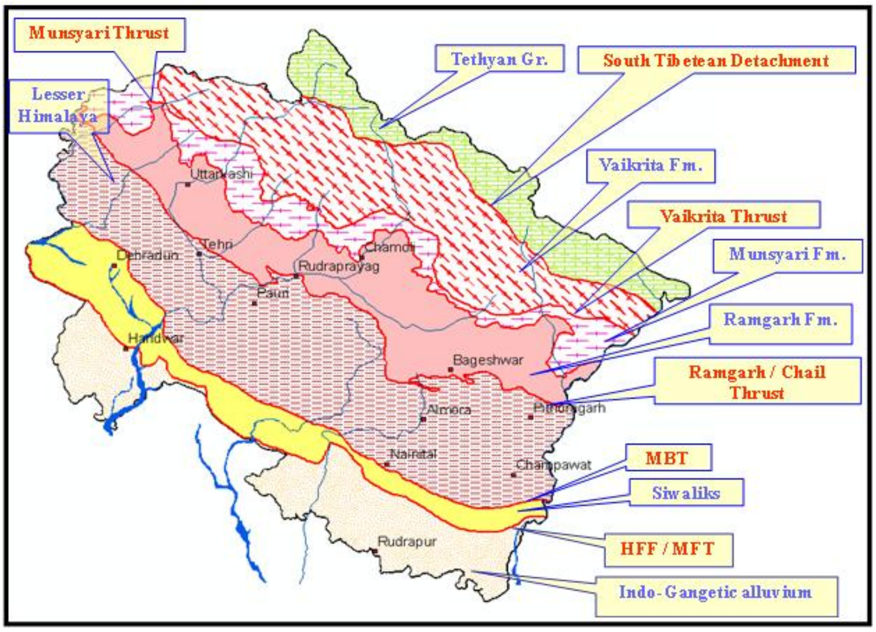
7.1. Maine Central Thrust (MCT) Zone

Munsiari formation is defined by < 2 to 12 km thick shear zone now known as the Main Central Thrust zone instead of a single thrust plane at the base of the shear zone shown by Heim and Gansser (1939) and Gansser (1964). It comprises severely tectonized and drastically condensed and truncated succession mainly of granitic rocks that represent the root of the crystalline nappes and klippen now covering large parts of the Lesser Himalayan Proterozoic sedimentary zone.

7.2. Munsiari Thrust

This base of the MCT shear zone was designated as Munsiari Thrust by Valdiya (1976, 1979, 1980a, 1981) in order to distinguish and differentiate it from the thrust plane at the top of the shear zone named Vaikrita Thrust (by Valdiya). However, Jangpangi and Phukan (1975), Gairola (1975), Misra and Bhattacharya (1976), Bhatacharya, (1987, 1999), Rao and Pati (1980), Pati and Rao (1983), Pati et al. (1986), Saklani and Doval (1981), Thakur and Choudhury(1983), Jain and Anad (1988), Chamyal and Kaur (1994), among others, describe the Munsiari thrust as the actual MCT. Recognizing the MCT zone as a zone of multiple thrusting (Bist & Sinha, 1990) or as made up of "a family of thrusts related to a major duplex structure: Bahuguna & Saklani, 1988, Saklani et al., 1991) the basal Munsiari Thrust has also been described as a: "floor thrust" as the MCT-1.

The Munsiari Thrust (MT) separates the Proterozoic sedimentary rocks of the Lesser Himalaya from the crystalline rocks of the Great Himalaya. The thrust zone is characterized by schuppen structure (Valdiya, 1980a) and sheeted packs of phyllonite, augen mylonite, ultramylonite and porphyry-schists derived form porphyritic granite. The associated amphibolite is also mylonitize or transformed into chlorite-schists. The MT is described as a discrete thrust plane that developed under brittle-ductile condition (Roy & Valdiya, 1988; Metcalfe, 1993). The 10 to 12 km wide shear zone of the MT-described as the Main Central Thrust-demonstrates, according to Bhattacharya (1987, 1999) extremely strong ductile flattening strain > 90%. It is the MT which caused the squeezing out tens of kilometers southward and translation of mylonitised packages of granitic and associated metamorphic rocks, now occurring as nappes overriding the Proterozoic sedimentary succession (Heim & Gansser, 1939; Valdiya, 1976, 1979, 1980b). Later compression of the whole of the Himalayan province resulted in folding of the nappes as well as their root at the foot of the Himadri. This is seen in the Kali-Gori valleys in the east and Mandakini-Bhilangana-Bhagirathi valleys in the west.



7.3. Vaikrita Thrust

The upper boundary of the MCT shear zone was first recognized by Valdiya (1976, 1979, 1980a, 1980b, 1981, 1988a) who named it the Vaikrita Thrust (VT); it is a plane that marks a distinct change in style and orientation of structures and registers a jump in the grade of metamorphism form greenschist facies to upper amphibolite facies. The VT is high temperature shear zone which registers a 4 kb jump of pressure and 200^0 C rise of temperature (Metcalfe, 1993).

7.4. Fragile Ecosystem Developmental Activities

There are two aspects to the Joshimath problem. First is rampant infrastructure development which is happening in a very fragile ecosystem. Secondly, the way climate change is manifesting in some of the hill states of India is unprecedented. For example, 2021 and 2022 have been years of disaster for Uttarakhand. There have been some climate risk events like high rainfall events triggering landslides. Geologically these areas are very fragile and little changes or disturbances in the ecosystem will lead to severe disasters, which is evident in Joshimath.

7.5. Loss of Infrastructure

So far, as per the Chamoli district administration report on dated January 6, 2023 total 868 houses and several roads have developed cracks as the land beneath the town continues to gradually sink, and these numbers are increasing by the day. Total 181 unsafe houses in nine wards of the town, Singhdhar has the maximum 98, followed by 28 each in Gandhi nagar and Sunil and 27 in Manohar bagh. All residents of these houses have been moved out. Among the 868 houses with crocks in the' sinking town', Ravigram ward has the maximum 168 followed by 156 such houses each in Singhdhar and Gandhinagar,131 in Manoharbagh,78 in Sunil,55 in Parsari,53 in Marwari,40 in Upper bazaar and 38 in Lower bazaar. Yet, it is not as if the catastrophe that struck the holy town was unexpected.

7.6. Power Projects

In Uttarakhand, it is common to see bulldozers and other heavy machinery lying casually alongside roads and to hear the continuous noise of construction work. Over the years, the government has undertaken a slew of big projects in the area, including 500 km of highway. Blasting and dynamiting the mountains are common occurrences in the State. Some projects currently undertaken or proposed near Joshimath are Jhelum Tamak, Malari Jhelum, Lata Tapovan, Tapovan Vishnugad, and Vishnugad Pipalkoti hydroelectric projects; the Vishnuprayag dam project; the Rishi Ganga Power Project; and the Char Dham road between Helang and Marwari.

7.7. Required Planning and Measures

As we know that these areas are very fragile and small changes or disturbances in the ecosystem will lead to grave disasters, which is what we are witnessing in Joshimath. In fact, this is a particular point in history which should be remembered as what should be done in the Himalayan region.

According to the book 'Central Himalaya' by Heim, Arnold and August Gansser, Joshimath town of Chamoli district is situated on the debris of a landslide. A few houses had already reported cracks back in 1971, post which a report had suggested few measures that included conservation of the existing trees and plantation of more trees, boulders on which the town is located should be touched and reinforced cement concrete (RCC) should not be done.

These measures were never followed. It is also mentioned that traditional housing construction technologies are able to withstand earthquakes and landslides much more strongly than the newly constructed infrastructures.

In fact, the entire planning should be done at the bio-regional scale that should include what is allowed and what is not and has to be very stringent. However, it has to be done in a planned manner. We must leave out some things and look out for other ways for energy generation. The return investment cost in hydropower projects is very less when compared to the cost associated with environmental and ecological damage. In this perspective following measures are essential.

(1) It is very important to establish a monitoring, early warning, and alert system for the potential disaster risks in the area so that the people in the affected areas can be informed timely through scientifically validated and credible forecasting models by the concerned nodal agencies and the disaster management authorities. There was no functional early warning and alert system for the specific event which took place on 7th February 2021.

(2) It also recommended that no houses, religious places or other buildings and infrastructural projects be allowed near the High Flood Level (HFL).

(3) Creation of a State Institute of Disaster Management (SIDM) in Uttarakhand. The Uttarakhand Himalayas are geo-tectonically fragile young mountain systems and prone to different types of hazards such as landslides, earthquakes, flash floods, cloud bursts, Glacial Lake Outburst Flood (GLOF), Landslide Lake Outburst Flood (LLOF), etc. This institute will identify and study the probable risks and hazards that exist in the state in a technically and scientific manner in coordination with existing disaster management authority (Uttarakhand State Disaster Management Authority) and other scientific and training institutions.

(4) Development should be done in the area but not at the cost of environmental degradation. This entire Himalayan area is very fragile and susceptible to disasters. It incontestably needs development but not at the cost of environmental degradation. That is most important, we have to follow a strategy so that the environment is not harmed and development reaches everywhere.

(5) It is critical that the geological and geographical context of a development project be taken into consideration. It should be the starting point for any project. Designing inappropriate infrastructure has destroyed the Himalaya and other ecologically sensitive zones. Engineers are not taught enough about ecology, neither from the perspective and knowledge of pure science nor from the perspective of social science.

(6) For these disaster prone areas or in every region a permanent godown must be prepared near the airport, where every basic amenities should be kept ready like medicines, dry fruits, clothes, blankets etc. During crisis these all can be provided within hour in any disaster affected area to save the life of the people.

(7) A provision of "Land bank" is required to be introduced. State government must establish a separate department for this purpose where certain patches of land should be kept for the rehabilitation purpose of disaster affected people.

(8) Need of a proper rehabilitation and compensation policy is indispensible for the safety of the land subsidence or disaster affected people, so that they can survive with their dependent family members in this difficult time.

(9) Need of a proper rehabilitation and compensation policy is indispensible for the safety of the land subsidence or disaster affected people, so that they can survive with their dependent family members in this difficult time.

Mountains, due to their geology, climate, vegetation, glaciers, high-flowing rivers, fountains and lack of growth, are one of the most disaster-prone regions. One of the main problem in the management is improper implementation of policies, for this purpose adoption of an holistic approach is essential. The majority of environmental issues in the mountains are the product of human-induced actions that have exposed the mountain's natural beauty. Settlements are built near dangerous areas. As a result, we must formulate a disaster management system that minimizes disaster effects while also ensuring swift and efficient evacuation, relief, and rehabilitation of disaster victims. Disaster management norms must be implemented with true spirit in all over the region for the sake of human beings.

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