DEVASTATING NATURE OF LANDSLIDE IN HIMALAYAN REGION OF INDIA

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Abstract: Landslide refers to sudden rapid movement of rocks, soils, and vegetation over the hilly slopes. It is a very common in the mountain regions. India, the miniature of earth having high altitudinal mountain ranges known as Himalayan young fold mountain system. This mountain regions are basically famous for tourism. The infrastructural development is running on over the unstable geology. Thus, leads to severe vulnerable condition by landslide during few decades. The vulnerability and intensity have firstly increased this region.

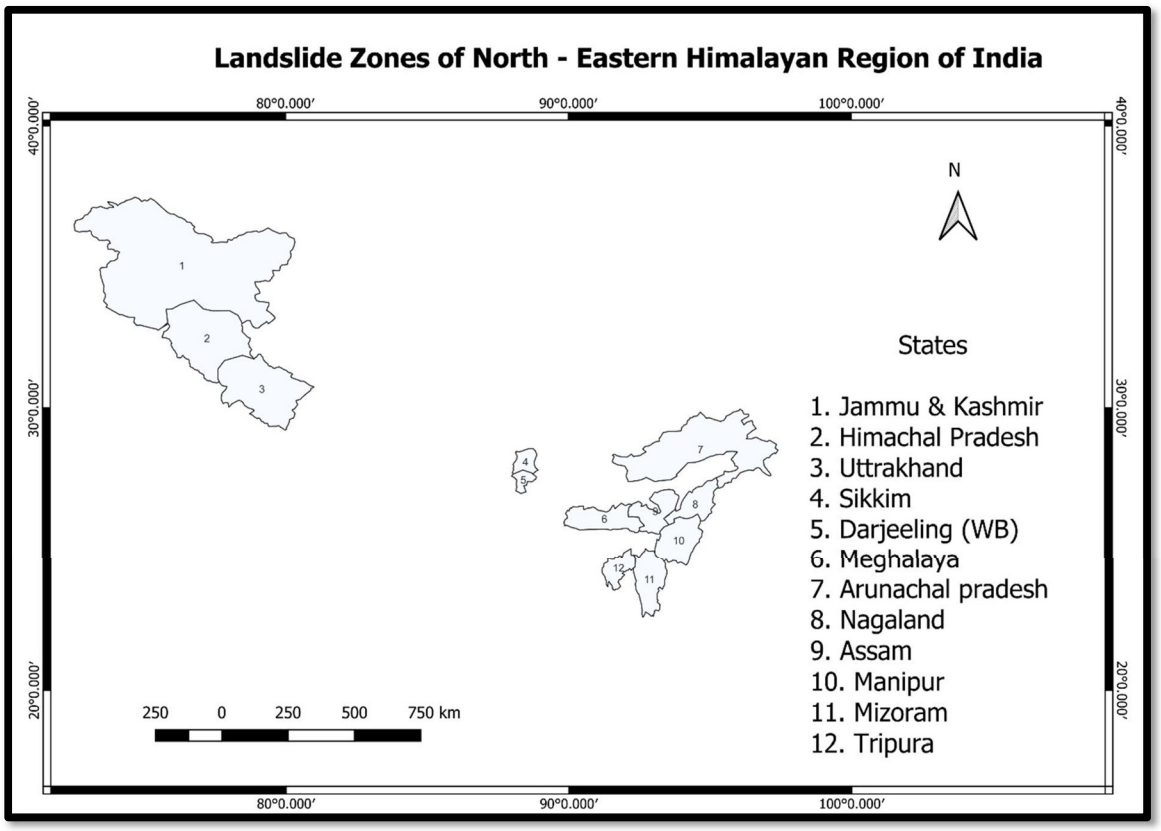
Here, in this project I want show the different causes of landslides both natural and man induced by using different types of maps, diagram, and statistical methods. The correlation has drawn between the reason of landside and monsoon. The project is totally based on secondary data. At the starting of the project, I have discussed about the physiographic and climatic characteristics of the study area then different types of causes are interpreting. After the causes impact and suggestive measures are said.

Key words: Landslide, cause, impact, and management

Introduction: All types of mass movement including rock wastes, debris, soil and ice are together said landslide. It is the mostly common disaster in the Himalayan subcontinent of India which is a largest mountain chain in the world, especially in monsoon. It is a natural as well as quasi natural hazards in the mountain regions and it becomes a disaster when it occurs rapidly in the populated areas. Generally, hills, mountains, and cliffed sea coast are highly venerable to landslides. Different types of physical as well as anthropogenic activities are responsible for landslide, thus include, essive rainfall, unmature soil structure, deforestation, unplanned urbanization, population increased etc. Some recent major landslides in the Himalayan region include, in 2013 landslide for severe flush flood in Kedarnath, Uttarakhand, 2021 in Rishikesh in Uttarakhand, 2023 Joshimath of Uttarakhand, 2023 Kannur in Himachal Pradesh etc.

Study Area: The Himalayan region is world famous region of Indian subcontinent which is situated Northeastern part of Asia and Northern part of India. The Himalaya stretches uninterruptedly for about 1,550 miles (**2,500 km**) in Asia, in between the Plateau of Tibet to the north and the alluvial plains of the Indian subcontinent to the south. The study area extending from 20°00'00''N to 35°00'00''N along the latitude and 80°00'00''E to 95°00'00''E along the longitude. The States of Himalayan region, which are highly vulnerable to landslide are as follows; Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, northern part of West Bengal, Meghalaya, Arunachal Pradesh, Nagaland, part of Assam, Manipur, Mizoram, and Tripura. The average height of this region is 3700 – 8848 metres. The average population density of this region is 181 per/sq. km.

Fig: Map of Study area [1.1]



Source: Prepared by Author

GEOMORPHOLOGY OF STUDY AREA : Himalayan Mountain system is a young fold mountain where the formation is till continuing. Due to the prevalence of tectonic activity the geomorphic processes are very active in this region.

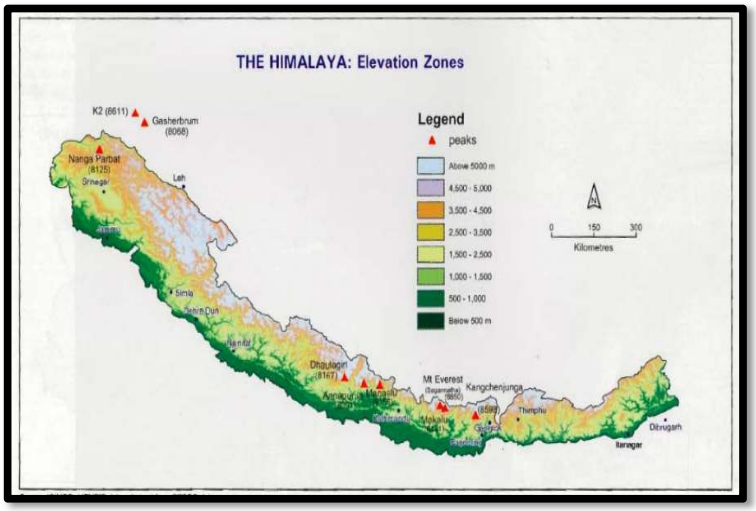
- **Elevation:** This region is still in the stages of development. The elevation is not equal everywhere. The slope is generally decreasing north to south. Based on altitude of slopes, this region has classified into major three parts, these are as follows;

i) The great Himalayas or Himadri which having elevation on an average 6,100m from the sea-level. The major peaks of this region are : Mt. Everest (8848m), K2 (8611m), Kanchenjunga (8586m) etc.

ii) The middle Himalayas or Himachal having average elevation 3500 to 4500m. The major ranges are included Pir Panjal, Dhaola Dhar, Mussoorie etc.

iii) The lesser Himalayas or Shiwalik which having the height 600 to 1500m. The major hills are Mishmi, Churia Ghat, Dundwa range etc.

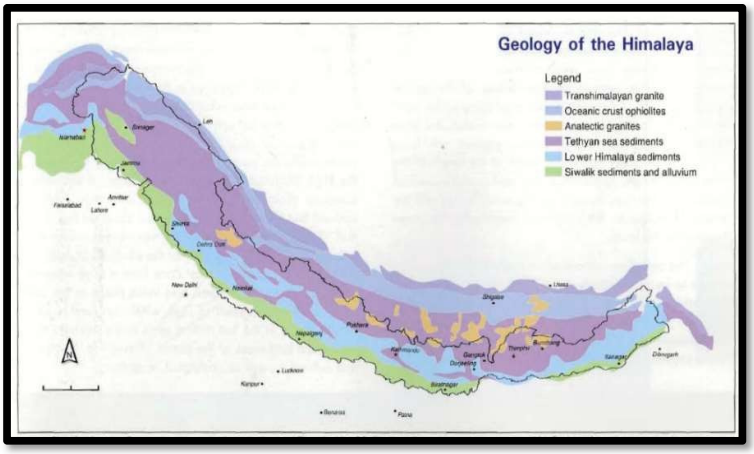
Fig: Elevation Map [1.2]



Source: Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya

- **Geological Structure:** Geologically Himalayan region of India has represented different types of assemblage of rocks with different characteristics. The geological set up of Himalaya is totally new and unmature according to the time scale. It is basically compacted by the uplifted sedimentary and igneous rocks. The major deposits are granite, sediments, alluviums etc.

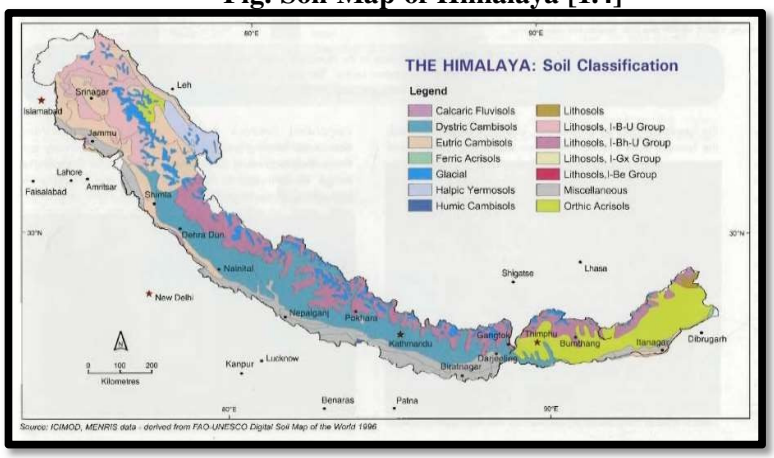
Fig. Geological Map of Himalaya [1.3]



Source: Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya

- **Soil:** Himalayan region having different types soils which are highly fertile in nature. The major soil of this region is forest and mountain soil which is mainly formed by the deposition of organic matter. By the rivers of this region has owned highly productive alluvial soil. Due to the prevalence of fertile soil, many types of farming and plantation are being practiced in this region.

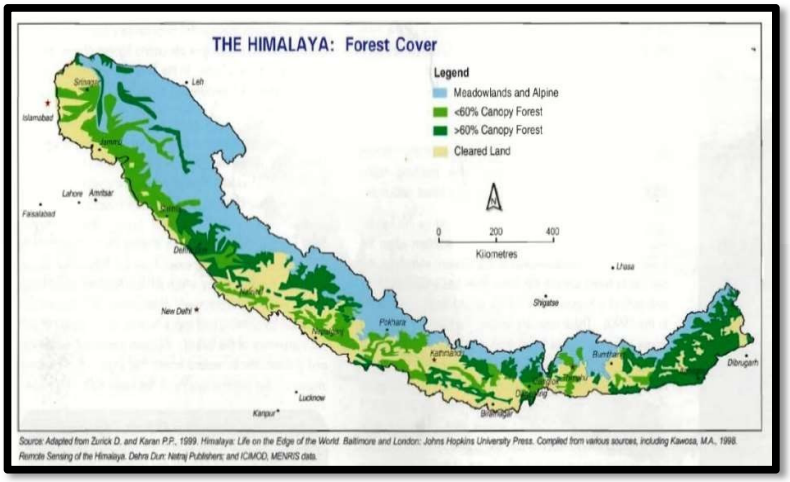
Fig. Soil Map of Himalaya [1.4]



Source: Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya

- **VEGETATION COVER OF STUDY AREA:** Himalayan region is dominated by several types of plant species. These are the part of tropical evergreen forest. Maximum trees are tallest and creating canopies. The important species of these forests are mesua, toon, semul, kanju etc. Meadowlands and alpine are major dominated forest cover of this region.

Fig. Vegetation Map of Himalaya [1.5]



Source: Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya

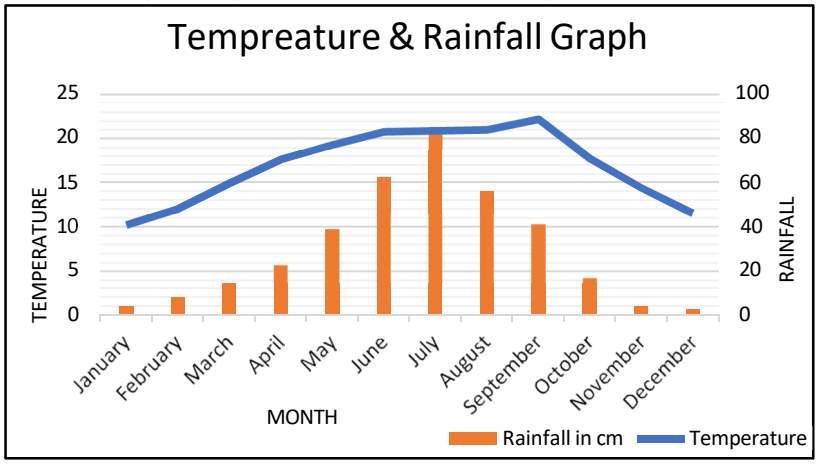
- **Climate:** India is the part of Tropical Monsoonal climate. On other hand Himalayan Mountain range is an important controller of the climate of this region. The climatic characteristics of this region are as follows:

Months	Average				
	Temperature	Rainfall in cm	Cloud Coverage in %	Sunshine hour	Humidity
January	10.2	3.9	15	7.3	77
February	12.0	7.9	16	7.0	76
March	14.9	14.4	18	8.0	69
April	17.6	22.7	24	8.0	75
May	19.3	38.9	30	7.0	84
June	20.8	62.2	43	5.2	91
July	20.9	85.4	56	4.4	93
August	21.0	56.0	51	5.5	92
September	22.2	41.0	42	5.9	90
October	17.7	17.2	24	7.4	84
November	14.4	3.9	17	7.4	77
December	11.5	2.3	16	7.4	77

Table No: 1.1 Source: IMD

- **Temperature & Rainfall**: The average temperature of this region is about 15°c. Maximum temperature recorded in between the month of June to August where abundance of rainfall is also higher. Other side minimum temperature recorded in between the month of November to February where rainfall is also lesser in compare to others.

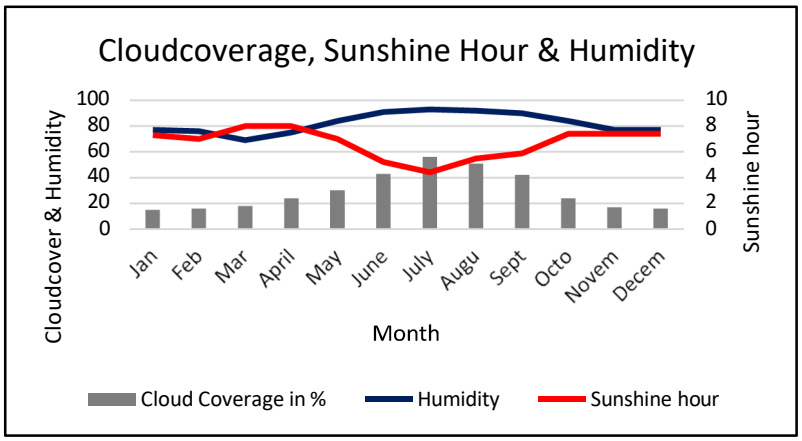
Fig. Temperature & Rainfall Graph [1.6]



Source: Prepared by Author

- **Other atmospheric phenomena**: Cloud coverage is relatively higher in the month of May to September where humidity is also higher. In this time sunshine hour is less due high amount of cloud cover. In this region it has shown that relative humidity is higher throughout the year.

Fig. Cloud coverage, Sunshine Hour & Humidity [1.7]



Source: Prepared by Author

- **Objective:** The major objective of this study are as follows:

1) Identifying the landslide suspectable zones of Himalayan region,
2) to identify the causes of landslide in this region,
3) to understand the vulnerable impact of landslide.
4) to know the strategies that taken for the management of landslide.

- **Methodology:** This paper has formed, based on secondary data. Several types of journals and reports are taken as a data resource of this project.

i) Pre-field: Landslide related journals were downloaded for literature review and gathering the data from this journal.
ii) During-field: Tabulation of data, construction of diagrams and their interpretation has done.
iii) Post-field: Based on the discussion, conclusion has been drawn and project has submitted.

- ***Literature Review***

The eastern Himalayan region joining the parts of Nepal, Assam, West Bengal, Arunachal Pradesh, Manipur, Nagaland, and the hinterland of Tibet is the zone of active plate margin and prone to earthquake and landslide. The reasons behind landslide are earthquake, tectonic activities, steep slopes, lofty hills, complex geological setting, and others physical and anthropogenic activities. Major landslides are formulated by earthquake or tectonic activities.[***Bansal, Verma, Gupta, Prasath,].*** Himalaya the young fold mountain is the home of landslides which is belong to moderate to very high global hotspot landslide zonation with high mortality rate. It is the dominant event in this region for its rugged topography, high intensity of rainfall, rain-shadow zone along with northward moving plate, resulted high magnitude of earthquake. Presently India Govt. emphasise on the monitoring process in the vulnerable zones which is done through the proper understanding of landslide in terms of geology, geomorphology, geohydrology, and others civil engineering aspects. [***Singh, Joshi, Sahu, Prasad].*** Suddenly occurring phenomena landslide is inherently prone in the part Himalayas. Day by day, nature and intensity of landslide has increased. Monsoon is the most important suitable time of landslide rather than winter, pre monsoon and post monsoon. Now a days, it is a frequent and wide spread activity there is not only upward rise in annual and decade frequency but the number of years with exceptionally high occurrence during each decade has also increased. The vulnerability has increased due to manmade activities like deforestation, changing pattern of agriculture, road, dam construction etc. [***Simrit Kahlon, Panjab University]***

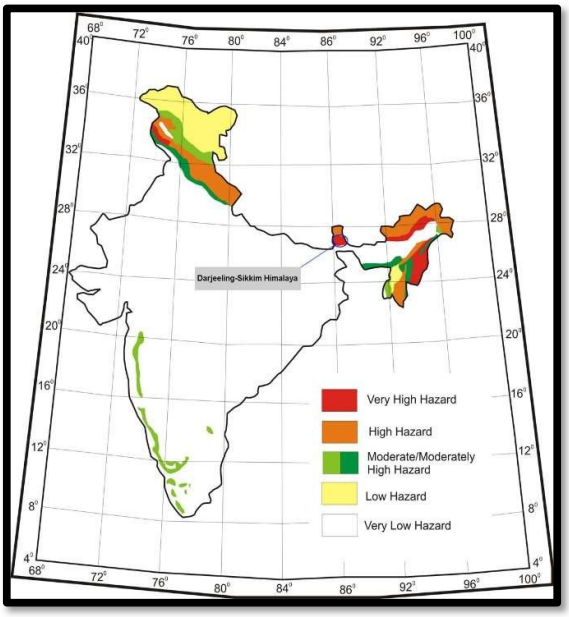
Result & Discussion

Major Landslide Zones of Himalayan Region of India: Himalayan region is highly prone to landslide, major landslide zones of this region are Uttarakhand, West Bengal, Himachal Pradesh, Sikkim, Jammu & Kashmir, Mizoram, Manipur, Assam and Arunachal Pradesh. Disaster Management Authority of India said that landslide is very common and vulnerable at the time of monsoon on this region which has heavy vulnerable impact over this region. Some notable landslides of this region are as follows,

Si No.	Decades	Seasonal Distribution				Decades total	Landslide Character
		Winter	Pre-Monsoon	Monsoon	Post-Monsoon		
1	1970 - 1979	14	19	129	02	164	High landslide activity
2	1980 - 1989	04	01	153	04	162	Declined activities
3	1990 - 1999	20	05	169	25	219	Increase in landslide activities
4	2000 - 2009	30	82	352	10	474	Intensification over time & space
5	2010 – 2019	35	97	420	18	570	Intensification over time & space
Total		103	204	1103	59	1589	

Table No: 3.1 Source: INTERNATIONAL JOURNAL OF RESEARCH CULTURE SOCIETY

Fig: Landslide Hazard zones of India. [3.1]



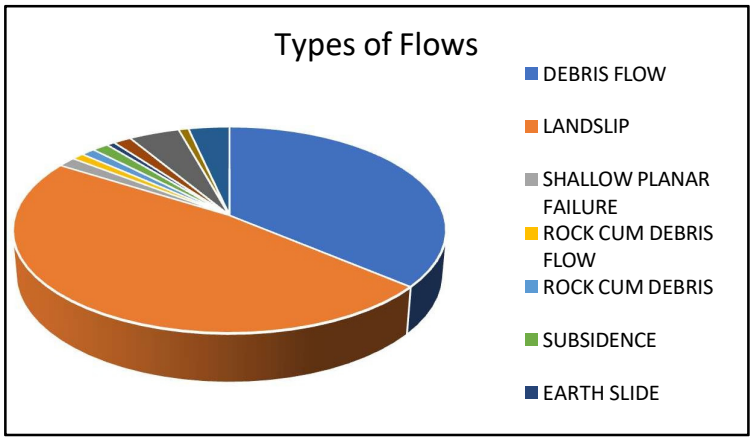
Source: http://savethehills.blogspot.com/2016/01/why-sth-must-prevail-gsis-new-map-of.html

- **Types of Landslides**: Different types of flows are seen in Himalayan region; these are as follows:

TYPES OF SLIDING	NUMBER
DEBRIS FLOW	516

LANDSLIP	683
SHALLOW PLANAR FAILURE	22
ROCK CUM DEBRIS FLOW	15
ROCK CUM DEBRIS	17
SUBSIDENCE	20
EARTH SLIDE	10
DEBRIS SUBSIDENCE	22
SOIL SLIDE	62
ROCK CUM DEBRIS SLIDE	12
OTHERS	50

Table No: 3.2 Source: IEEE Humanitarian Activities Committee. F**ig: Types of Flows in Himalayan region [3.2]**



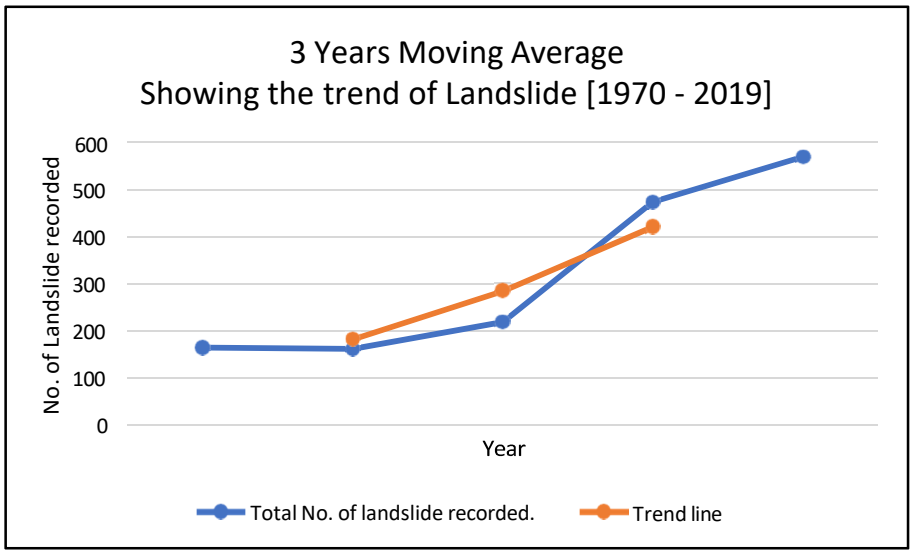
Source: Prepared by Author

- **Decadal Pattern of landslide**:

Year	Total No. of landslide recorded.	3 Years Total	Trend line
1970 - 1979	164		
1980 - 1989	162	545	182
1990 - 1999	219	855	285
2000 - 2009	474	1263	421
2010 – 2019	570		

Table No: 3.3 Data Source: **I.J.R.C.S.**

Fig: Landslide trend over few decades. [3.3]



Source: Prepared by Author

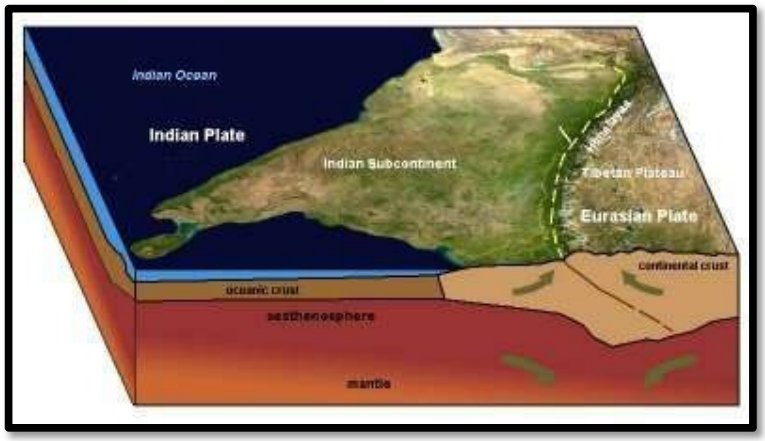
From the given data series, it is clear to understand that the intensity of landslide has been increasing day by day in Himalayan region which badly affected the people of this region. In near future velocity will be increasing if the measures not taken positively. The reasons behind this calamity are being discussed below.

- ***Causes of Landslide***: The causes of landslide has been classified into two parts
  a) Physical or Natural activities, b) Anthropogenic activities.

A) ***Physical or Natural Activities***: Himalayan Mountain system is a young fold mountain system and its formation till in progress. In this region geomorphic processes are very active that also plays an important role for landslide in this region. These are as follows;

i) **Plate Tectonic Movement**: Himalaya lies in a tectonically active convergent plate boundary where; Indian Plate is moving towards the Eurasian Plate and subducted within it. This creates isostatic imbalance that causes frequent landslides in this region.

Fig: Plate movement. [3.4]



Source: https://www.quora.com

ii) **Unstable Rock Structure**: The Himalayan region is compacted by different types of sedimentary rocks which are more susceptible to landslide. By excessive rainfall and other anthropogenic activities, sedimentary rocks degraded as result landslide occurs.

iii) **Earthquakes**: Earthquakes are the most common and an important factor for the landslides in this Himalayan folded mountain regions. Due to the unstable geological structure and prevalence of seismic activities landslide is being occurred. In present decades the magnitude of earthquake has been increasing thus result severe landslides in this region.

iv) **Rainfall and Snowfall**: Himalayan region are the zone of extreme rainfall and snowfall. Due to heavy rainfall, during monsoon maximum landslides are recorded.

Si No.	Decades	Average no. of. Rainy days in Monsoon	Number of landslides
1	1971 - 1979	69	129
2	1980 - 1989	76	153
3	1990 - 1999	80	169
4	2000 - 2009	95	352
5	2010 – 2019	109	420

Table No: 3.4 Source: IMD & IJRCS

Si.No.	Decades	X (Rainy Days)	Y (No. of Landslides)	X^2	Y^2	XY
1	1970 - 1979	69	129	4761	16641	8901
2	1980 - 1989	76	153	5776	23409	11628
3	1990 - 1999	80	169	6400	28561	13520
4	2000 - 2009	95	352	9025	123904	33440
5	2010 – 2019	109	420	11881	176400	45780
N = 5	total	429	1223	37843	368915	113269

$$R = \frac{sxy - \frac{sx.sy}{n}}{\sqrt{sx^2 - \frac{(sx)^2}{n}\, sy^2 - \frac{(sy)^2}{n}}}$$

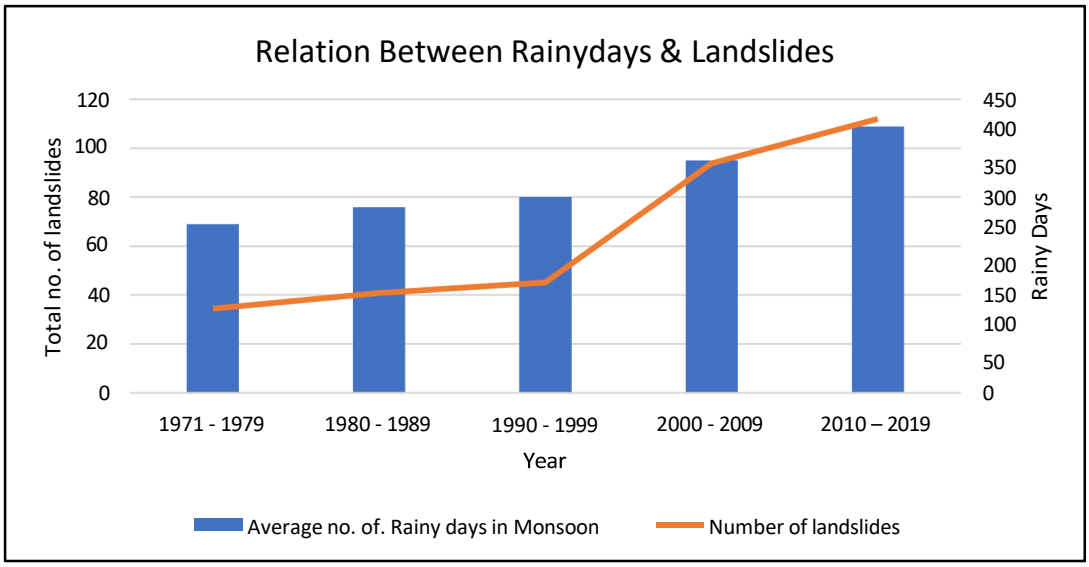
$$= \frac{113269 - \frac{429X1223}{5}}{\sqrt{37843 - \frac{[429]^2}{5} X 368915 - \frac{[1223]^2}{5}}}$$

$$= \frac{8335.6}{\sqrt{1034.8 \text{ X } 69769.2}}$$

$$= \frac{8335.6}{8496.9}$$

$= 0.98\ (approx)$ [Perfectly Positive Relationship]

Fig: Relation between Rainy days & Landslide [3.6]

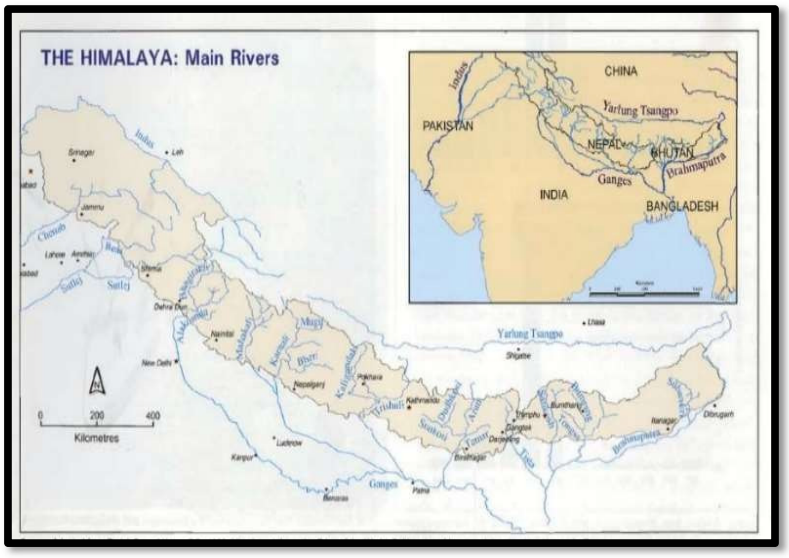


Source: Prepared by Author

By using the diagram & Pearson's correlation coefficient, it is proved as well as seen that there is a perfect positive relationship among these two variables. That means that, the number of landslides are increasing with increasing rainfall.

v) **Hostile Nature River Channels**: Himalaya is the mother of many young and rapid flowing rivers like Ganges, Yamuna, Brahmaputra, etc. These rapid flowing rivers are playing an active role in denudation and erosion of this mountain region. With degraded materials by river and steep slopes leads to landslide in this region.

Fig: Main rivers of Himalayas. [3.7]



Source: Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya

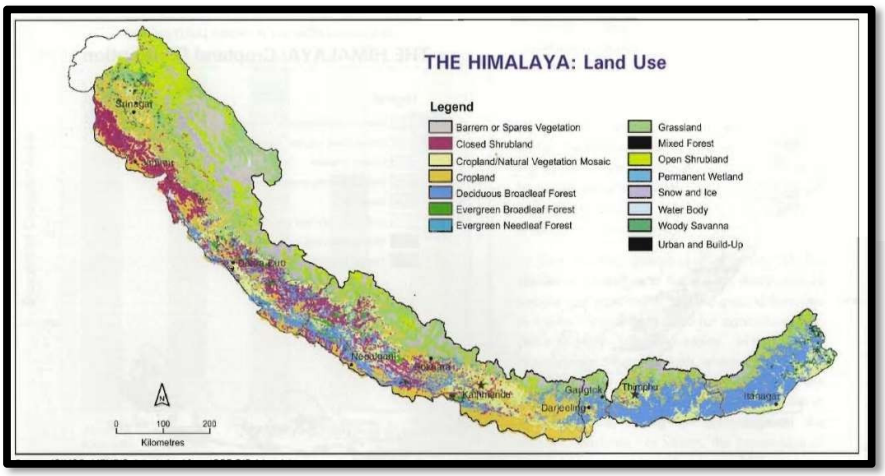
B) ***Anthropogenic Activates***: This include man induced activities which have a large impact in generating landslides in Himalayan region. These are as follows:

Forest Cover Changing Over Himalayan Region [1987-2013]

400
350
300
250
200
150
100
50
0

i) Human interference : Himalayan region is world famous site for tourism. Day by day huge number of people visiting this tourist sport, as result infrastructural development are continuing in this region. These include unplanned urbanization, construction of road and railways, and other developmental activities including population pressure. Simply said unplanned land use pattern over unstable unmature geology denudation and erosion have occurred thus ultimately resulted as landslide.

Fig: Unplanned land use in Himalayan Region [3.8]



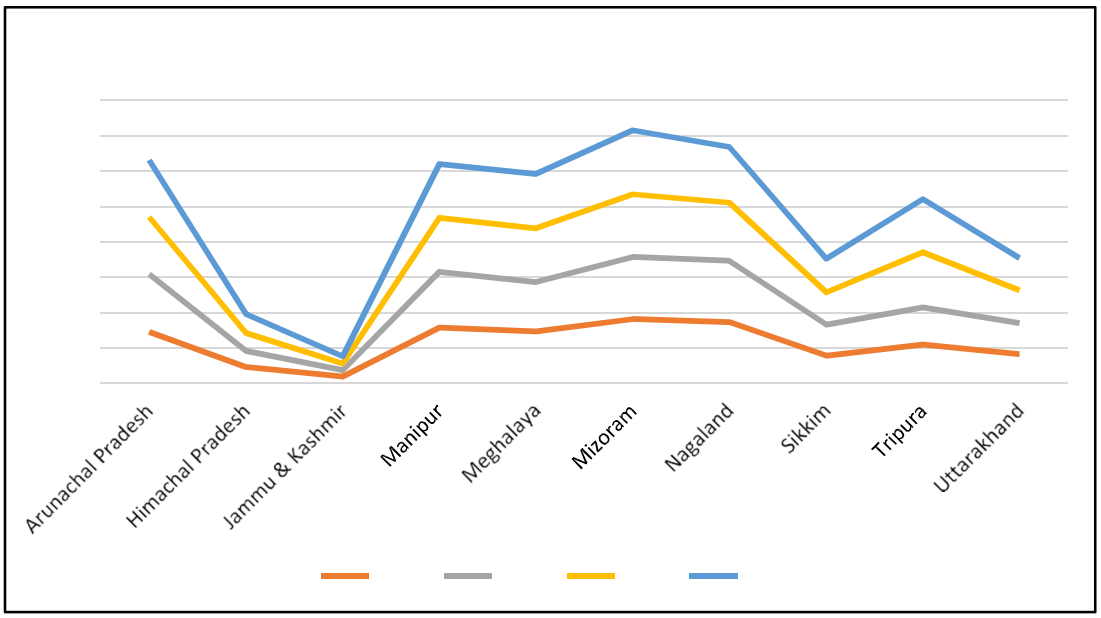
Source: Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya

ii) **Deforestation**: It is one of the major factors of human-induced landslides in Himalayas. Deforestation are continuing in these areas for construction of settlements, road construction, agricultural fields. Day by due to heavy population pressure and improvement of tourism, the rate of deforestation in increasing which ultimately denoting soil erosion which resulted landslides in these zones.

Proportion of state forest cover to state's geographic area and change (in %)					
States	**1987**	**1995**	**2005**	**2013**	**Change (%)**
					1987-2013
Arunachal Pradesh	72.39	81.94	80.93	80.39	11
Himachal Pradesh	23.14	22.45	25.81	26.37	14
Jammu & Kashmir	9.4	9.19	9.57	10.14	7.8
Manipur	79.07	78.64	76.53	76.1	-3.8
Meghalaya	73.41	70.06	75.74	77.08	5
Mizoram	90.53	88.12	88.63	90.38	-0.2
Nagaland	86.82	86.2	82.75	78.68	-9.4
Sikkim	38.89	44.07	45.97	47.32	21.7
Tripura	54.8	52.81	77.77	75.01	36.9
Uttarakhand	41.14	44.32	45.7	45.82	11.4
Total					94.4

Table No: 3.5 Source: *State of Forest Report (1987, 1995, 2005 and 2013)*

Fig: Forest Cover change over Himalayan Region [3.9]



Source: Prepared by Author

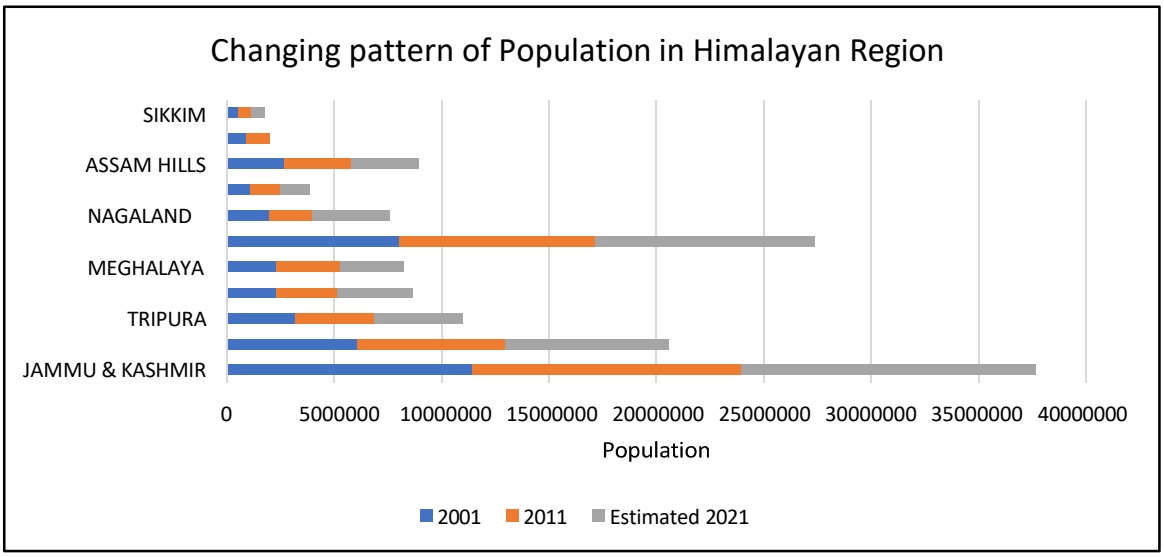
This diagram portray that deforestation is firstly increasing over some decades, which has a large impact not only in landslide but also other environmental activities. Deforestation is the key indicator of severe disaster in near future.

iii) **Increasing Population Pressure**: Though Himalayan regions are high altitudinal zones but the population pressure is increasing day by day. For increasing the growth of population, industrialization, urbanization, and other economic sectors are developing in this region. Peoples are practicing unscientific agriculture in these regions. As result degradation processes are being activated and leads to landslide.

States	Decades		
	2001	2011	Estimated 2021
Jammu & Kashmir	11437000	1,25,41,302	1,36,91,409
Himachal Pradesh	60,77,900	6864602	76,20,000
Tripura	31,99,203	3674000	4110000
Manipur	22,93,896	28,55,794	35,00,000
Meghalaya	23,18,822	29,64,007	29,66,889
West Bengal Hills	8020000	9130000	1,02,19,000
Nagaland	1979000	1990000	36,00,000
Arunachal Pradesh	10,97,968	13,82,611	13,83,727
Assam Hills	26,65,552	31,20,557	31,20,557
Mizoram	8,88,573	10,91,014	1,330,000 13
Sikkim	5,40,851	610000	632000

Table No: 3.6 Source: Regional Demographic profile

Fig: Growth of Population [3.10]

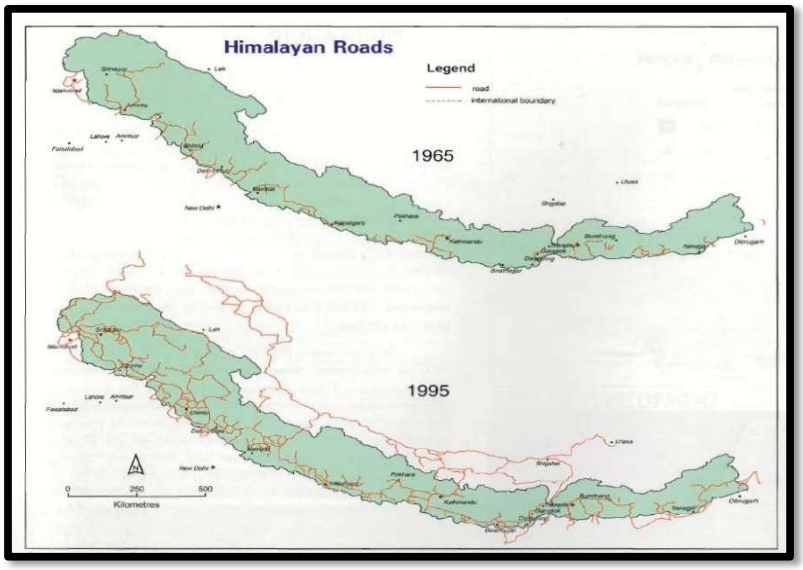


Source: Prepared by Author

From this diagram it is understand that every decade's population pressure is increasing which might be creating a big disaster if it not controlled by using scientific measures.

iii) **Constructions of Roads**: Though the artificial development is continuing in this region, construction of communicational lines like roads, railways, airports are also going on in this region to improve transportation & communication system. Roads and railways are formed by cutting of slopes over the hills. Dynamite blasting is the common and short way to do it. For this reason, the geological setup of this region is badly affected thus result landslide.

Fig: Increasing Number of Road ways. [3.11]



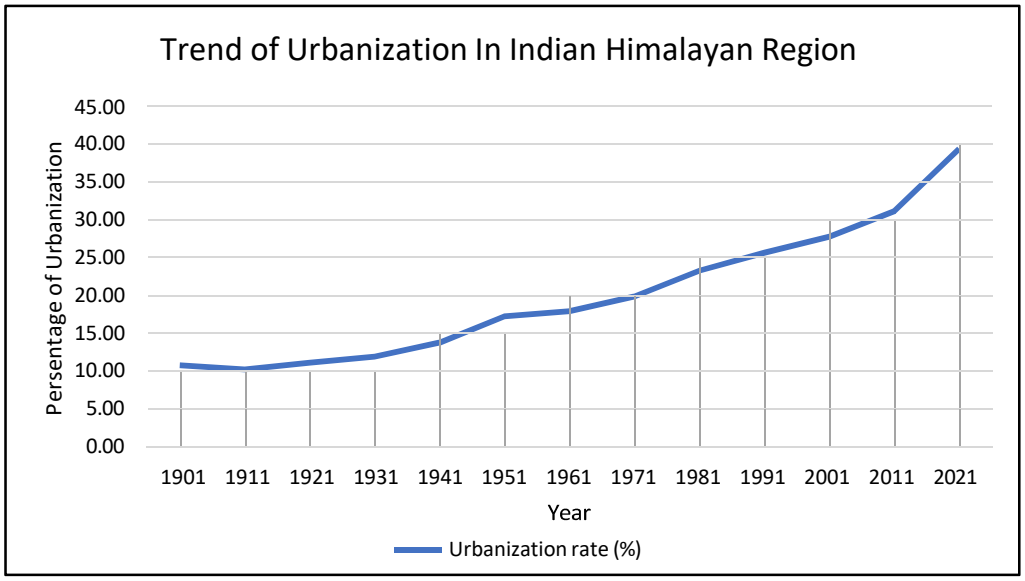
Source: Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya

iv) **Unplanned Construction of Houses:** In the hilly regions, the unplanned growth of towns and cities are noticeable to control the population pressure as well as maintaining tourist visitors. Unplanned houses, hotels over the hilly slopes are dangerous for this region. Urbanization rate is firstly increasing these areas which are the one of an important factor for the calamity landslide. For example, Nainital of Uttarakhand is now facing landslide problems due to the heavy load of hotels, and other residential infrastructure for housing as well as tourism purpose.

Year	Urbanization rate (%)	Year	Urbanization rate (%)
1901	10.84	1971	19.91
1911	10.29	1981	23.34
1921	11.18	1991	25.70
1931	11.99	2001	27.82
1941	13.86	2011	31.16
1951	17.29	Estimated 2021	39.41
1961	17.97		

Table No: 3.7 Source: Census Authority of India

Fig: Trend of Urbanization in Himalayan region of India 1901 – 2021 [3.12]



Source: Prepared by Author

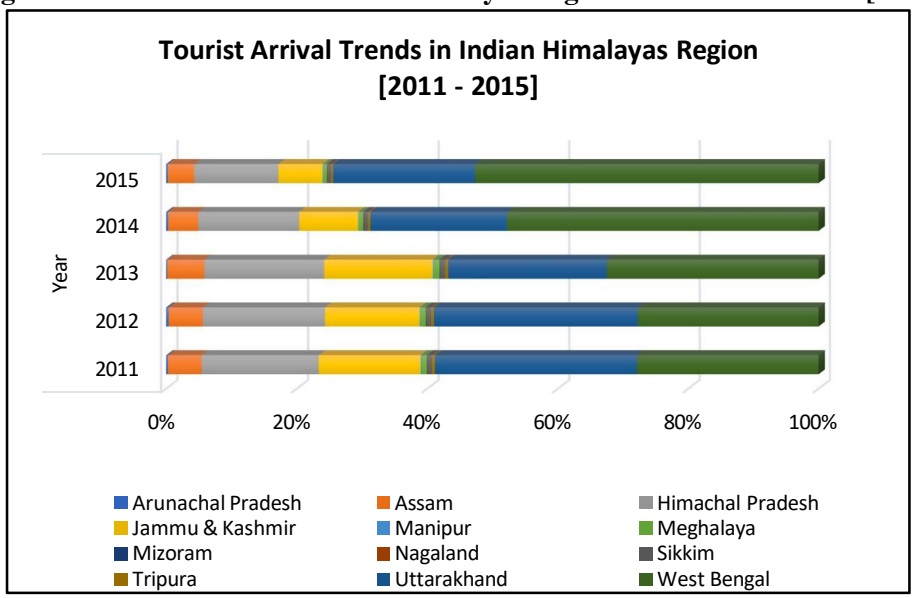
v) **Tourism**: It another most important thing behind landslide in this zone. Number of visitors are increasing day by day in these zones. To provide them luxuries and facilities many artificial projects are developing in this region. By the tourism, GDP of the states are improving which is a key indicator of stable economy of the states. It is estimated that 25million peoples will be visited Himalayan region in 2025. For that reasons, communication system, transport routes, hotels, hospitals and other economic sector and institution are firstly set up on this region which badly impacted the natural environment of this region which promotes vulnerable landslides in these zones.

Tourist arrival trends in the IHR states (2011-2015)

Indian Himalayan States	Year					Total
	2011	2012	2013	2014	2015	
Arunachal Pradesh	2,37,980	322378	1,36,307	3,41,178	3,57,772	13,95,615
Assam	43,55,885	45,28,950	47,02,165	48,48,239	55,16,565	2,39,51,804
Himachal Pradesh	1,50,89,406	1,61,46,332	1,51,29,835	1,63,14,400	1,75,31,153	8,02,11,126
Jammu & Kashmir	1,31,43,124	1,25,05,924	1,37,03,247	95,25,021	92,03,584	5,80,80,900
Manipur	1,35,083	1,35,290	1,42,581	1,18,268	1,49,429	6,80,651
Meghalaya	6,72,307	6,85,567	6,98,042	7,25,133	7,59,192	35,40,241
Mizoram	62,832	64,993	64,177	69,124	67,403	3,28,529
Nagaland	27,471	38,404	38,942	61,092	67,385	2,33,294
Sikkim	5,76,055	5,85,027	6,08,447	6,11,593	7,43,502	31,24,624
Tripura	3,65,561	3,69,626	3,71,439	3,87,935	3,98,058	18,92,619
Uttarakhand	2,60,70,907	2,69,51,884	2,00,38,811	2,20,93,281	2,96,02,820	12,47,57,703
West Bengal	2,34,70,238	2,39,49,815	2,67,92,530	5,04,05,330	7,16,82,950	19,63,00,863
Total	8,42,06,849	8,62,84,190	8,24,26,523	10,55,00,594	13,60,79,813	49,44,97,969

Table No: 3.8 Source: Ministry of Tourism, Government of India

Fig: Pattern of tourist arrival in Himalayan region since 2011 to 2015 [3.13]



Source: Prepared by Author

Theses are the major causes that resulted landslides which are creating vulnerable condition in this region specially in monsoon.

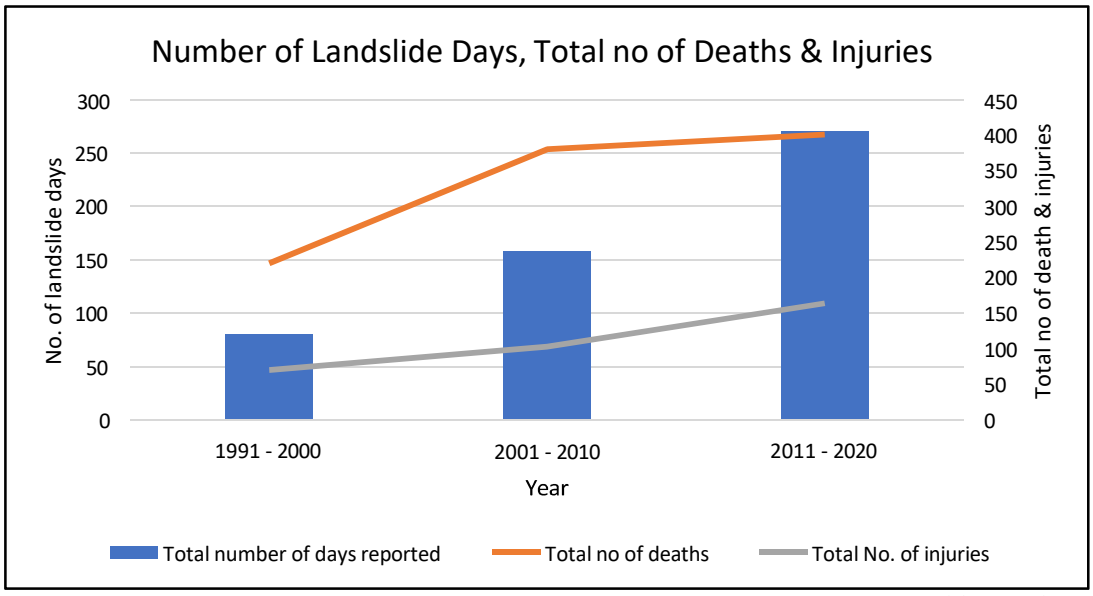
➢ *Impact of Landslides*: Landslides are always vulnerable for the common people which have a large impact over this region for a certain time. The impacts are as follows:

- Many peoples are died and injured by this vulnerable calamity. The numbers are relatively increasing every year which is denoting severe landslides in this region. In 2013 severe landslide in Kedarnath of Uttarakhand is highest recorded death and injuries over the decades. For this vulnerability not only affected in Uttarakhand but also the entire north and northeast Indian states are heavily affected.

• Landslide and their impacts from 1991-2020			
Year	**Total number of days reported**	**Total no of deaths**	**Total No. of injuries**
1991 - 2000	80	220	70
2001 - 2010	158	380	103
2011 - 2020	270	401	164

Table No: 3.9 Source: Landslide Hazard Scenario of Kashmir Himalaya from the Historical Events.

Fig: Number of Landslide Days, Total no of Deaths & Injuries [3.14]



Source: Prepared by Author

- Damaged of natural as well as human resources are one of the important extensive impacts over the people of this region. Not only natural resources but also human properties are severely damaged due to this calamity. According to recent studies more than 1 billon dollar property losses due to landslide. 2013 in Uttarakhand recorded 4 billion property loss.
- It not only impacted on human but also natural processes are being disturbed by its vulnerability. Deforestation, soil erosion, resulted environmental degradation.
- Roads, railways simply said transportation routes are totally damaged for the long time.
- Trees, telephone , electric towers are being uprooted as resulted communication system among the peoples are being disturbed.
- Many houses and being damaged as result peoples are suffering for shelter, food, clothes, drinking water etc.

- Many travellers are suffered for landslide as they do not return as well as do not communicate with their native place.
- Animals and birds are suffering for food and shelter. They entered in locality as result man-animal conflict are increasing.
- Agricultural lands, plantation plots either damaged or do not distribute as transportation routes were disturbed. Thus, resulted break down of the economy.
- Biodiversity lose, disturbance of Ecosystem, and environmental degradation is highly affected. Etc.

➢ ***Management*:** To avoid the vulnerable impact of landslide some measures should be follows pre, during and post disaster situation. These are as follows;

- By using landslide hazard zonation mapping vulnerable zones must be identified and classified it based on intensity of landslide.
- Afforestation should be promoted in the vulnerable zones.
- Land use should be scientific on the vulnerable areas.
- Retaining walls should be made beside the roads to protect debris flow.
- The surface drainage control work should be promoted.
- Road, dam construction should be restricted.
- Industrialization, urbanization should be done scientifically.
- Sustainable tourism should be promoted.
- Spreading the concept of Sustainable development among the people of that region.
- Agriculture, Plantation should follow scientific methodology.
- During disaster, rescue must be started and primary treatment must be given to the suffered people.
- Hazard monitoring cell and controlling team should be implemented.
- During disaster food, clothes, shelter, drinking water and other essential needs should be provided.
- Post disaster situation sustainable development must be promoted.

Conclusion: Landslide are the vulnerable calamity that had intensified by both natural and man induced activities. The velocity has been increasing day by day. Monsoon is the time of landslide. Landslides are always happened either in little or large magnitude. It has highly impacted the peoples, animals, and plants of this region. Environmental degradation, biodiversity lose also has done through this calamity. After 2000 the destruction magnitude and intensity has firstly increased thus resulted severe flush flood and landslide over Himalayan region. Some notable landslides with higher magnitude are 2003 in Uttarkashi, 2004 in Badrinath, 2013 in Kedarnath including other states of north and north-eastern Himalayan state., 2017 in Mandi of Himachal, 2021 in Rishikesh, 2023 in Joshi Math of Uttarakhand, etc. The vulnerability should be maintained if the measures are being followed on maintain. If artificial development not controlled over the unstable geology it might be resulted in severe calamity of Landslide in near future.

References:

- A study on Landslides in Himalayan Mountains: Dr. Neeru Yadav
- AN ASSESSMENT OF FOREST COVER CHANGES IN THE INDIAN HIMALAYAN REGION: V. P. Sati
- ANALYSIS OF LANDSLIDE REACTIVATION USING SATELLITE DATA: A CASE
- Atlas of Himalayas : David Zurick, Julsun Pacheo, Basant Sherstha, Birandra Bicharaya
- Compendium of Task Force Sub group reports on National Landslide Risk Management Strategy : National Disaster Management Authority of India & Home Affairs Government of India.
- Developing Landslide Hazard Scenario of Kashmir Himalaya from the Historical Events: Bilquis shah, M. Sultan Bhat, Akhtar Alam, Hilal Sheikh, Noureen Ali
- Geological Survey of India: Vision - 2030 Landslide Hazard Management
- Himalayan Landslides-Causes and Evolution: Sandip Singh, A. Joshi, A. Sahu, R.A Parsath
- Himalayan Nature-Based Tourism. Potential, Regional Diversity, Nature Conservation And Touristic Load: Michal Apollo, Viacheslav Andreychouk, Joanna Mostowska, Ziming Jin
- Impact of Environmental Hazards in Munsyari Block: Kumaun Himalaya by Nisha* and Jyoti Joshi**
- Indian Himalaya: A Demographic Database: *S.N. Nandy, Rekha Pant, K.S. Rao*
- Indian landslide scenario: with special reference to landslide
- Kasauli – Parwanoo road corridor using weight of evidence, information
- Landslide Affected Areas and Challenges Imposed in North Eastern Region of India: An Appraisal: Kuntala Bhusan1*, Tushar Pande1, and Jnana Ranjan Kayal2
- Landslide causes: Human impacts on a Himalayan : Martin Haigh and Jiwan Singh Rawat
- LANDSLIDE MANAGEMENT IN INDIA: A STRATEGY PAPER BY GSI
- Landslide scenarios in North East Himalaya (Active and Passive slopes): Dr. Pankaj Jaiswal

Landslide susceptibility assessment in the Himalayan range based along

- Landslide Susceptibility Mapping in East Sikkim Region of Sikkim Himalaya Using High Resolution Remote Sensing Data and GIS techniques Prakash Biswakarma1, Binoy Kumar Barman2, Varun Joshi1,*, K. Srinivasa Rao2
- Landslides in Himalayan Mountains: A Study of Himachal Pradesh, India : Simrit Kahlon
- Linking Hazards of Landslide and Urban Flood in the North-East Himalayan
- National Seminar on Earthquake risk mitigation: P. Dhara Chakraborti and Chandan Ghosh
- On mitigation of earthquake and landslide hazards in the eastern Himalayan region: Brijesh K. Bansal1,2 · Mithila Verma1 · Arun K. Gupta1 · R. Arun Prasath1
- PROCEEDINGS OF THE SYMPOSIUM ON: Dr. Premlet B Chair, Educational activities.
- Rainfall Induced Landslide Studies in Indian Himalayan Region: A Critical Review: Abhirup Dikshit 1 , Raju Sarkar 2, Biswajeet Pradhan 1,3,* , Samuele Segoni 4 and Abdullah M. Alamri 5
- Report of Working Group II Sustainable Tourism in the Indian Himalayan Region: Dr. Vikram Singh Gaur, and Dr. Rajan Kotru, research method: *Hemalatha T. and Ramesh, Maneesha V.*
- STUDY OF KOTRUPI LANDSLIDE, MANDI, HIMACHAL PRADESH, INDIA: N. Singh1, S. K. Gupta1,*, D. P. Shukla1
- Trends of Urbanization and its implications on Environment and Economy in the Uttarakhand Himalaya: A Case Study of Dehradun Municipal Corporation: Vishwambhar Prasad Sati

- Urbanisation and water insecurity in the Hindu Kush Himalaya: Insights from Bangladesh, India, Nepal and Pakistan: Sreoshi Singha, S. M. Tanvir Hassanb,*, Masooma Hassanc and Neha Bhartid
- Value, and frequency ratio: Abdullah H. Alsabhan a, Kanwarpreet Singh b,⇑, Abhishek Sharma b, Shamshad Alam b, Desh Deepak Pandey c, Shamshad Alam S. Rahman a, Anwar Khursheed a, Faris M. Munshi a