

**A PROJECT WORK  
ON  
DISASTER MANAGEMENT**



**DEPARTMENT OF GEOGRAPHY**

**A STUDY ON THE IMPACT OF LANDSLIDE OF SIKKIM, INDIA**

A Project Submitted for the partial fulfillment of the requirement for the degree of Bachelor of Arts in Geography of Dibrugarh University.



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Registration No. SJ921611..., a 6<sup>th</sup> Semester (Core) student of the Department of Geography,  
Nanda Nath Saikia College has worked under my guidance and supervision for preparing the project  
entitled "*A Study on the Impacts of Landslide of Sikkim, India*" for partial fulfillment of the  
requirement for the degree of Bachelor of Arts/ Science in Geography of Dibrugarh University. The  
project is the results of his/her own investigation and neither the project as a whole, nor any part of it  
has ever been submitted for any degree or diploma.

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Place: Nanda Nath Saikia College, Titabar-30

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Supervisor

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*Janamoni Kusumi*

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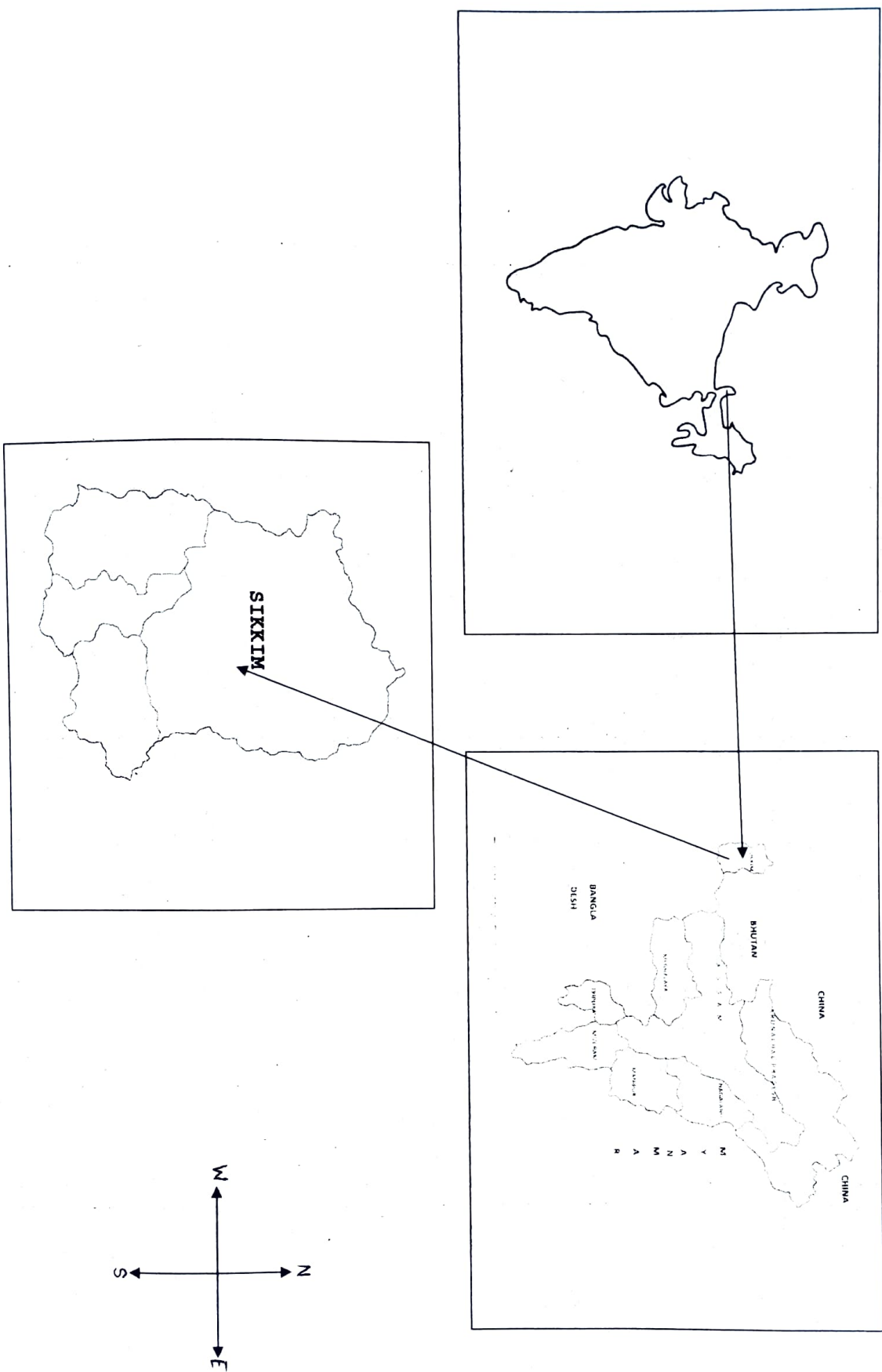
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LOCATION OF THE STUDY AREA OF SIKKIM





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## 1. INTRODUCTION

Since archaic times, the enthusiastic and anxious nature of humans have been inspiring them to apply numerous methods for the invention of new facts. Field study, in regard can be considered as a result of eager of humans towards study. Field study has immense value in any branch or in any subject of our education system. It increase the accuracy of the particular subject, as it represent the facts practically with an accurate and orderly manner. For these reasons, geography is also associated with field study. It provides us the opportunity to recognize the real facts personally by observing in the particular area and to develop our geographical thinking to a large scale.

Disaster is an event of natural or manmade. Causes that leads to sudden disruption of normalcy within society, causing damage to life and property to such an extent that normal social and economic mechanisms available are inadequate to restore normalcy. Disaster education aims to provide knowledge among individual and groups to take action to reduce their vulnerability to disaster.

Sikkim is a Himalayan state in North East India situated between 27°00'46" to 28°48"N latitude and 88°00" to 88°25"E longitude covering a geographical area of 7096 sq.KM. Sikkim state being a part of inner mountain range of Himalaya is entirely hilly, having virtually no plain Area with altitude varying from 213 meter to above 8500 meter .The state experiences different types of natural disasters at its various location

Disaster of varying nature and magnitudes experienced by Sikkim state. Land slide, flood, flash, earthquake are a common natural disasters in a tectonically fragile and sensitive mountainous terrain like the Himalayas.

There are different types of disaster occurred in the state and to convenient for us, we have selected landslides among them for our study purpose. According, we visited the state on the 1 May, 2022 and remain there a week long. The report has entitled as study on the impact of landslides of Sikkim, India.



## 2. OBJECTIVE

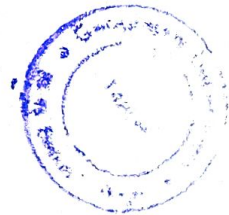
1. The main objective of our project report is all about the study of disaster prone areas of Sikkim.
2. To identify the causes of disaster in the Sikkim.
3. To assess the critical areas and impact of disaster.
4. To suggest necessary measures to mitigate disasters.

### 3. METHODOLOGY/DATABASE

Data is one of the most important features in field study. To obtain a perfect result of a field study, an observer should follow precise primary and secondary data source.

For gaining the primary result, we follow the path of personal observation. By arriving there, we collect some data from local peoples of Sikkim, driver, shopkeepers, and workers in hotels. During our days of travel in Sikkim, in some parts we also experience some minor landslides. Thus, this type of primarily collected data helps us to a large extend regarding our field study.

Different kinds of secondary data sources also became useful in our field study. They can be the theses; different website related to Sikkim, data obtain from different newspapers, news channels etc.





## 4. THE STUDY AREA

### 4.1 Physical Background

#### 4.1.1 : Location

Sikkim is a small mountainous state in the Eastern Himalayan region in India. It covers an area of 7,096 Sq.km, extending approximately 114 km from north to south and 64 km from East to West. The state is situated between 88°00'58" and 88°55'25" East longitudes and 27°04' and 28°07'44" North latitudes. It is surrounded by vast stretches of Tibetan plateau in North; Chumbi Valley & Kingdom of Bhutan in the East; Darjeeling district of West Bengal in South and Kingdom of Nepal in West.

#### 4.1.2: physiography

Sikkim has a very rugged topography due to which there are very less flat lands. The rivers, mountains are the main physical features that defined the boundaries of the state of Sikkim with its neighbours.

Sikkim is a basin surrounded on three sides by precipitous mountain walls. There is little lowland, and the variation in relief is extreme. Within a stretch of roughly 50 miles ( 80 km ), the land rises from an elevation of about 750 feet ( 225 meters ) in the Tista River Valley to nearly 28,200 feet ( 8,600 meters ) at Kanchenjunga , India's highest peak and the world's third highest mountain. The Singalila Range separates Sikkim from Nepal in the West, while the Dongkya Range forms the borders with the Tibet Autonomous region of China to the east. Some two-thirds of Sikkim consist of perpetually snow covered mountains, dominated by the Kanchenjunga massif. Other major peaks-all above 23,000 feet-include Tent, Kabru and Pauhunri.

#### 4.1.3: Drainage

The Sikkim basin is drained by the Teesta River and its tributaries, such as the Rangit, Lhonak, Talung and Lachung which have cut deep valleys into the mountains. Major rivers in the East district are Teesta or Tista and Rangit. Teesta can be called as Ganga of the State of Sikkim as most of the Sikkim settlement are found along the banks of the river. But Teesta comes out as a snout from the Zemu-Glacier above Lachen, Compha.

The entire city drains into the two rivers, Rainkhala and Korochu though numerous small streams and Jharas. Rainkhola and Korachu rivers confluence with Teesta river, the major source of drinking water to the population downstream.

The drainage of the district is controlled by the perennial Teesta and Rangit rivers passes through the area which originates from the central crystalline zone defined by high mountain ranges which is covered by glaciers. The Teesta and its tributaries drain different parts of the area the rivers are perennial in nature which are fed by both snowmelt water and rain water, Rangit, another river originate from west Sikkim. During its southerly course it receives MilliChhu, Nomlongkhola, Rathongchhu, Koligchhu, Royangkhola etc. The southerly following Teesta is joined by Rangpachchhu at the extreme north of the south Sikkim. The type of drainage is trellis and dendritic. Most of the kholas have originated from the higher altitudes and flow down by cutting deep gorges in lower altitudes where they ultimately join with main river Teesta.

#### 4.1.4: Soils

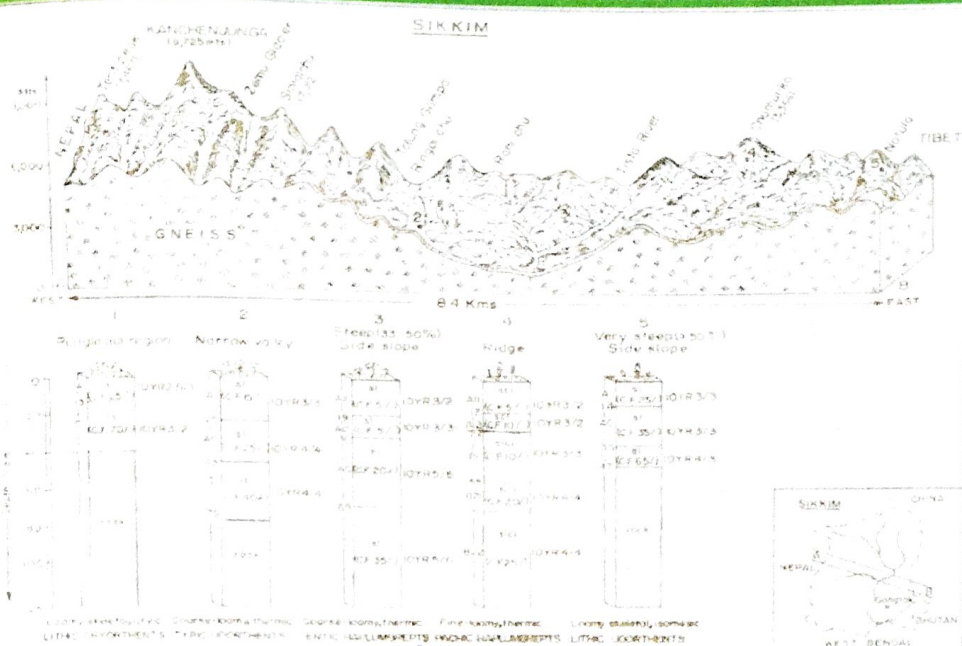
Sikkim enjoys a wide range of climates, mapped physiography, geology and vegetation that influence formation of different kind of soil these soils have been mapped, described, analyzed, characterized and classified under 5 broad physiographic units.

TABLE 1 : Major physiographic units and dominant soils found in Sikkim

SL. No	Physiographic Units	Area (ha.)	% of TGA	Dominant Soils(Subgroup)
1	Summit and ridge (<30%)	31459.45	4.43	Typic Haplumbrepts Typic Hapludolls Pachic Haplumbrepts Typic Udorthents
2	Side slope of hills	213100.01	30.03	Typic Hapludoll
2.1	Very steeply sloping (>50%)			Entic Hapludolls Dystric Eutrochrepts Lithic Cryorthents
2.2	Escarpments (>50%)	30480.73	4.30	Typic Udorthents Entic Hapludolls Umbric Dystrichrepts
2.3	Steeply sloping (30 - 50%)	214641.28	30.24	Umbric Dystrichrepts Typic Hapludolls Typic Argiudolls Cumulic Haplumbrepts Entic Cryumbrepts
2.4	Moderately steep sloping (15-30%)	16024.82	2.26	Fluventic Eutrochrepts Mollic Udarents Typic Argiudolls Cumulic apludolls
3.	Valleys (15-30%)	9683.36	1.37	Typic Haplumbrepts Aquic Udorthents Cumulic Hapludolls
4	Rocky cliffs and Precipitous slope	85700.29	12.08	Lithic Udorthents Lithic Haplumbrepts
5.	Glacier/Perpetual snow	108510.06	15.29	

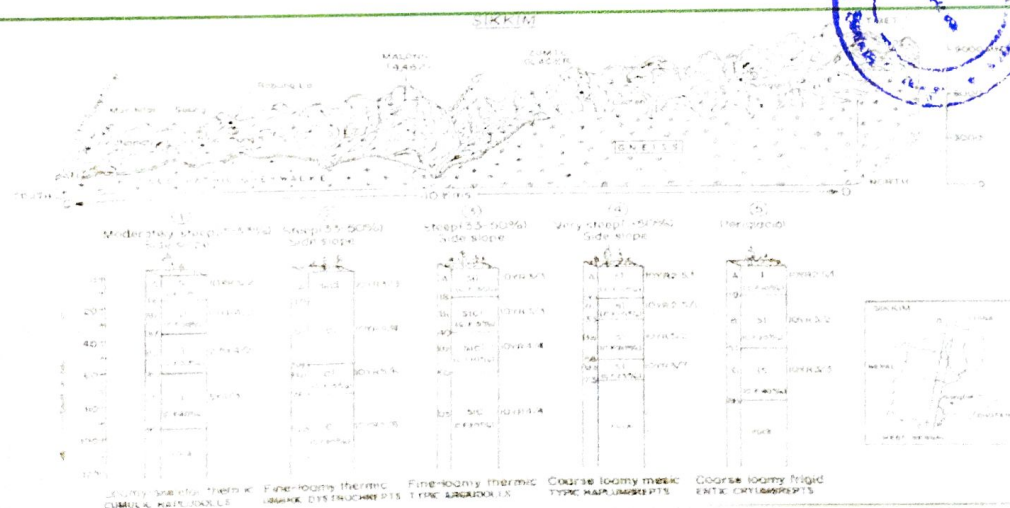


TABLE 2 : Soil depth of Sikkim (West-East)



Source : Agriculture Department, Govt. of Sikkim

TABLE 3 : Soil Depth of Sikkim(South-North)



Source : Agriculture Department, Govt. of Sikkim

### Identified soils:

Soils acquiring in different landforms are studied in respect of their morphology, physical and climate characteristics, in accordance with the physiographic sequence of the terrain features, 78 soil families were identified in Sikkim state and mapped into 69 mapping units.

### Soil of summits and ridges:

Soil vegetation on summit and ridges is markedly influenced by degree of slope and climate. The climate is characterized with summer and cold winter. Soil moisture and temperature region is udic and thermic respectively.

### Soil of side slopes of hills:

Formation of soil on side slopes is influenced by the steepness of the slope as it controls surface run off and erosion. Soil temperature is identified as isorigid.

### Soil of valley:

Valley of Teesta river is very narrow with moderately steep slope. They experience a wide variation of climate. Southern area receives annual rainfall of 2500mm. Its soil temperature and soil moisture regimes are thermic and udic respectively. The northern portion experiences mild summer and cold winter. Soil temperature and moisture region are medic and periodic respectively.

### Soil of glacial drifts/moraines/stones:

This soil comprises of moraines and boulders. They are shallow excessively drained, loamey, skeletal with much surface stoniness and severe erosion. They cover 25468 ha. Representing 3.59% of total area. Soils are lithic haplumbrepts and typichaplumbrepts. Land use is forest vegetation. Soil depth, soil erosion and steepness of slope are constraints.

## **4.1.5 CLIMATE:**

Sikkim's geographical location with its altitudinal variation allows it to have tropical, temperate and alpine climatic conditions within its small area of 7096 kms. Most of the inhabited regions of Sikkim experience a temperate climate with temperatures seldom exceeding 28°C (82°F) in summer. The average annual temperature for most of Sikkim is around 18°C (64°F). Sikkim has three seasons -----



**WINTER**---The winter season in Sikkim begins from January and lasts till March. The average temperature can vary from 5° to 7°C during the winter. Most areas of the state receive snowfall in this season.

**SUMMER**---The summer season in Sikkim is in the months of March and April. The average day time temperature can vary from 5° to 25°C. During this season, the weather remains pleasant. Summer is warm and moderate.

**MONSOON**---The monsoon in Sikkim usually starts from April and lasts till December. The average temperature can vary from 4 to 17°C during the season. The monsoon in Sikkim takes the form of incessant rain during the months from May till September while July be the wettest of all.

**RAINFALL**---The rainy season is classified into two types in Sikkim i.e summer rains and winter rains. Southern part of Sikkim sees more of summer rains. Whereas Northern part foresees winter rains during August and September. Rainfall is heavy and well distributed during the month from May to early October. July is the wettest month in most of the places. The highest annual rainfall for the individual station may exceed 5000mm. and average number of rainy days ranges from 100 at Thangu in North Sikkim to 184 at Gangtok in East Sikkim.

**SNOWFALL**--- Sikkim, which lies in the top of the Himalayas, is one of the coldest places in the country. The North Eastern part of India is home to one of the tallest peaks in the world, Kanchenjunga, where the temperature falls as low as -32°C. Sikkim is one of the few states in India to receive regular snowfall. The snow line ranges from 6,100 meters (20,000ft) in the South of the state to 4900 meters (16100ft) in the North. The Tundra type region in the North is snowbound for four months every year and the temperature drops below 0°C (32° F) almost every high temperature in the mountains can drop to as low as -40°C (-40° F) in winter.

#### 4.1.6. VEGETATION:

Sikkim in addition with its mountains and lakes, has acquired its maximum splendor owing to its loaded flora. Located in a natural spot of the lower Himalayan, Sikkim is one amongst the three eco region of India. Sikkim has acquired a small portion in the domain of India, yet the state boasts of a rich variety of plants. Perhaps, the main reason could be the weather that remains favorable for the vegetation. Due to the altitudinal shift Sikkim possesses an extensive range of plants and foliage, providing a great place to explore for a naturalist.

**FLORA:** Sikkim has approximately 5,000 blossoming plants, 515 extraordinary orchids, 60 primula species, 36 rhododendron species, 11 oak varieties, 23 bamboo varieties, 16 conifer species, 362 type of ferns and fern's, allies, 8 trees ferns and more than 424 medicinal plants. The rhododendron to acclaim to be the stapes tree. Sikkim boasts of a wide range of the species that grows in sub-tropics to alpine regions. In the lower altitudes, orchids, figs, laurel, bananas, saltrees and bamboo are traceable enjoying the sub tropical climate. Above 1,500 meters (in temperate regions) caks, chestnuts, maples, birches, alders and magnolians are found in large numbers under alpine affected regions, juniper, pine, firs, cypresses and rhododendron are quite common that happen to come across between the altitudes of 3,500 to 5,000 m. The official flower of Sikkim is orchid Dendrobium Nobile.

## 4.2 SOCIO ECONOMIC BACKGROUND

### 4.2.1- POPULATION GROWTH AND DENSITY COMPOSITION

To know how disaster affect a region, it is very important to have knowledge of the population of that particular area. Since we had selected Sikkim as study area. Some information about population of Sikkim is given below-

TABLE 4 : Population data of Sikkim (census 2011)

STATE	SIKKIM
CAPITAL	GANGTOK
POPULATION	610,577
PERCENTAGE OF TOTAL POPULATION	0.05
MALES	323,070
FEMALES	287,507
SEX RATIO	889
LITERACY RATE(%)	81.42
RURAL POPULATION	455,962
URBAN POPULATION	151,726
AREA(km)2	7,096
DENSITY(per sq km)	86

Source: 2011 census of India Wikipedia

The total area of Sikkim is 7,096 km<sup>2</sup>. According to 2011 census, the total population of Sikkim is 610,577 with a rate of 0.05%. The percentage of male among the total population is 52.91 and female is 47.08%. The sex ratio of this



state is 890. 74.71% of the total population lives in rural areas and 25.29% lives in urban areas. The literacy rate of this state is 81.42% and the population density is 86 per sq km.

Sikkim is divided into 4 districts-

South Sikkim, East Sikkim, North Sikkim, West Sikkim. Sikkim district wise population as per census 2011 and census 2020 projection is given below-

TABLE 5 : District wise Sikkim Population (Census 2011)

SOURCE:2011 census ,population data on district/sub district level

DISTRICT	AREA PER SQ KM	POPULATION(2020 projection)	POPULATION(2011 census)	PERCENTAGE
NORTH SIKKIM	4,226	49,828	43,709	7.16
WEST SIKKIM	1,116	155,536	136,435	22.35
SOUTH SIKKIM	750	167,409	146,850	24.05
EAST SIKKIM	954	323,285	283,583	46.45

In the table:2 we notice that, North Sikkim is the largest with 4,226 sq km in area, but population figures; it the smallest with 49.828. West Sikkim is the second largest 1166 sq km in area but in term of population it is the third highest with 155,536. South Sikkim is the last 750 sq km in area with the population 167,409. East Sikkim is the third highest with 954 sq km in area, that is 323,285.

#### POPULATION GROWTH RATE:

The growth of population in Sikkim has been qutesignificant. In the last 10 years it has shown on increase of 12.4% starting from 200%. From a more figure of 138.000 in 1951, the population of Sikkim has gone upto 679,366 in the year 2021. In the last 60 years, there has been steady growth of population in Sikkim.

TABLE 6 : POPULATION GROWTH RATE OF SIKKIM (Decadely)

YEAR	POPULATION	GROWTH RATE
1951	138,000	
1961	162,000	17.4%
1971	210,000	29.6%
1981	316,000	50.5%
1991	406,000	28.5%
2001	541,000	33.5%
2011	607,688	12.9%
2021	679,365	11.79%

SOURCE: India online page

### POPULATION DENSITY:

The area of Sikkim is 7,096 sq km. Density of Sikkim is 86 per sqkm, which is lower than national average 382 per sq km. It is highest in the east Sikkim with 295 per sq km and lowest in the North 10 per sq km.

TABLE 7 : SIKKIM POPULATION DENSITY

District	Population	Area(in km)	Density
East Sikkim	283,583	954	295
North Sikkim	43,709	4,226	10
South Sikkim	146,850	750	196
West Sikkim	136,435	1166	117

Source: census of India 2011 SEX RATIO:

Sex ratio in Sikkim is 889 i.e. for each 1000 male, which is below national average of 940 as per census 2011. In 2001 the sex ratio of female was 875 per male in Sikkim.



**TABLE 8 : SEX RATIO OF SIKKIM-1962-2021**

Sex Ratio(No of females per 1000 males)

DISTRICT	1961	1971	1981	1991	2001	2011
NORTH SIKKIM	888	853	789	828	752	769
WEST SIKKIM	NA	937	936	915	929	941
SOUTH SIKKIM	917	909	854	892	927	914
EAST SIKKIM	884	719	797	859	844	872
SIKKIM	904	863	835	878	875	889

Source:Census of India 2011, provisional population total, population 18,2011, Sikkim series 12 SIKKIM LITERACY RATE:

Literacy rate in Sikkim has been upward trend and is 82.20% as per 2011. Population census of total male literacy stands at 87.29% while female literacy is at 76.43% in 2001, literacy rate in Sikkim stood at 68.81 % which male and female were 77.38% and 59.63% literacy respectively.

**TABLE 9 : Literacy rate of Sikkim**

DISTRICT	POPULATION	LITERATES	LITERACY
EAST SIKKIM	283,583	214,329	83.85%
SOUTH SIKKIM	146,850	106,741	81.42%
NORTH SIKKIM	43,709	30,450	78.01%
WEST SIKKIM	136,439	93,432	77.39%

SOURCE: Sikkim literacy rate-current population of india 2022 POPULATION COMPOSITION:

Roughly  $\frac{3}{4}$  of Sikkim resident are Nepalese in origin, most speak Nepali and are Hindu in religion and culture. About  $\frac{1}{5}$  of population consists of scheduled tribes. The most prominent of this tribal groups are the q Bhutia ,The Lepcha and The Limbu, they all speak Tibeto-Burman languages and practice. Mahaya

Buddhism as well as the indigenous born religion. There is a not able Christian minority in Sikkim, as well as a tiny community of Muslims. A small fraction of Sikkim people to the scheduled castes.

TABLE 10 : Religion wise population of Sikkim.

RELIGION	PERCENTAGE
HINDU	57.76%
MUSLIM	1.62%
CHRISTIAN	9.91%
SIKH	0.31%
BUDDHIST	27.39%
JAIN	0.05%
OTHER RELIGIONS	2.67%
NOT STATED	0.30%

SOURCE: Sikkim religion data-census 2011

### 4.2.3 SEX RATIO:

Sex ratio in Sikkim is 889 i.e. for each 1000 males, which is below national average of 940 as per census 2011. In 2001 the sex ration of females was 875 per male in Sikkim.

TABLE 11 : SEX RATIO OF SIKKIM 1961 – 2011

District	Sex Ratio (Number of Females per 1000 males )					
	1961	1971	1981	1991	2001	2011
North Sikkim	888	853	789	828	752	769
West Sikkim	NA	937	906	915	929	941
South Sikkim	917	909	854	892	927	914
East Sikkim	884	791	797	859	844	872
Sikkim	904	863	835	878	875	889

Source : Census of India 2011, provisional population total, proper 1 of 2011, Sikkim series 12



#### 4.2.4 : ECONOMIC ACTIVITIES

The people of Sikkim mainly economically associated with the primary sector. The Economy of Sikkim is mainly based on agricultural and animal husbandry. Approximately 11 % of the total geographical area is under agriculture. Agriculture is of the mixed type and still at the subsistence level rather than commercial level. The work force participation rate as per 1991 census was 40.44 %, through here, the productivity is low and hence all the able-bodied people are employed in agriculture and other activities. Cultivators account for the grater majority of the people in the state, their percentage is 57.84 %. Agricultural laboures as a whole constitute only 7.81% of the workers in the state, house holders and other industries are negligible, but other workers at the state level represent a good percentage of population. The decreasing ratio of worker at the state level indicates the low level of economic diversification. The importance of Agriculture can be judged by the high percentage of pollution approximately 65% engaged in it. Animal husbandry is an integral part of the house hold economy of the region. There are certain house hold industries also which substantially adds to house hold incomes. The past one and half decade has witnessed a tremendous upward swing in various development programs giving a new thrust to the Sikkim's economy. Though most of the inhabitants are basically agricultural, they have diver sifted in to tertiary jobs such as government services.

#### 4.2.5 MINERAL RESOURCES-

Several minerals are found in the state, among them, coal, copper, limestone and graphite are the most important. Dolomite, garnet, talc and magnetic are less important.

➤ **COOPER** – The area of copper or widespread in Sikkim and are in the paling beds. Some are situated in the transition rocks between to doling and the gneiss, but none in the given itself, Copper depositors are found in east and west Sikkim. To deposits one at rangpo and the other near dikchu (Moth of Gangtok) are being explored. Both are Small multimental deposits. Sikkim mining corporation is working on the copper deposits which ennisages mining and milling only.



- **COAL**- A Coal filed bounded on the south by the ranman and rangit rivers near Naya bazaar Occur in south western Sikkim. The Coal is reportedly non cooking variety, low in moisture and violation matter and high in fixed carbon.
- **LIMESTONE** – Crystalline limestone has been reported from chhangu in Eastern Sikkim and chungtang in North sikkim. Sedimentary deposits of limestone are reports in West Sikkim in Naya bazaar. Reshi Namchi area and the North Sikkim.
- **GRAPHITE** – Graphite occurrence in North Sikkim and West Sikkim of amorphous to lumpy varieties have been reported.
- **Iron** – This occurs chiefly as pyrites in associations with chalcopyrite. It is most plentiful at Bhotang, where magnetite also occurs. The iron areas have no where been put to any economic use.
- **GARNET** – It is abundant in the gneiss and micas chests at places. But is does not appear to be fit for the market.

#### 4.2.6 TRANSPORT AND COMMUNICATION

The State of Sikkim is accessible through both airways and roadways. There is however, no direct transportation service to Sikkim by railways. Being a very hilly region, the communication services of Sikkim are still at a budding stage but undergoing developments with the best efforts from the government. The state of Sikkim is convicted by national high way 31A which links Siliguri in West Bengal to Gangtok in Sikkim . There are bus and truck services run by the Sikkim National Transport. There are also privately run bus jeeps and to tourist Taxi services through Sikkim. Regular buses, taxis and cabs are available to make journey to Sikkim and within Sikkim. The nearest railway station is located in Siliguri and New Jalpaiguri. New Jalpaiguri ( NJP) railway station is located 125 Kms away from Gangtok. Through Sikkim does not have any airports because of it is tough terrain, there is a helipad in Gangtok which is the only. Civilian helipad in the state. The closest air port to Sikkim is in Bagdogra near the town of Siliguri in West Bengal. The helicopters services not only are for the transport and communication but also for sightseeing purposes.

## 5. GLIMPSE OF VISITED PLACES OF SIKKIM

**5.1: TIGER HILL:-** At sunrise, the peaks of Kanchenjunga are illuminated before the sun is seen at lower elevations. From Tiger Hill, Mount Everest (8848m) is just visible. Kanchenjunga (8598m) looks higher than Mt. Everest owing to the curvature of the Earth as it is several miles closer than Everest. The distance in a straight line from Tiger Hill to Everest is 107 miles.



fig:- 1 (Tiger Hill)

**5.2: BATASIA ECO GARDEN:-** The Batasia loop is a spiral railway created to lower the gradient of ascent of the Darjeeling Himalayan railway in Darjeeling district of West Bengal, India. At this point, the track spirals around over itself through a tunnel and over a hilltop. It was commissioned in 1919.

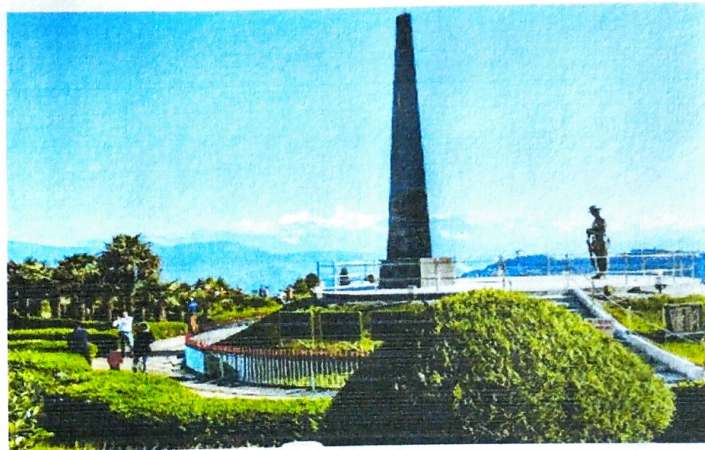


fig:-2 (Batasia Eco Garden)



**5.3:PEACE PAGODA:-** Peace Pagoda, Darjeeling is one of the Peace Pagodas design to provide a focus for people of all races and creeds to help unite them in their search for World peace. It is located in the town of Darjeeling in the Indian State of West Bengal. It was built under the guidance Nichidatsu Fujii (1885-1985), a Buddhist monk from Japan and founder of the Nipponzan-Myohoji Buddhist order. It was design by M. Ohka, and it took 36 months for construction, (hight28.5 metres, dia meter= 23 meters).



fig:-3 (Peace Pagoda)

**1. ROCK GARDEN:-** Rock garden is an exquisite picnic spot terraced with natural fall known as Chunu summer fall, located 10 k.m away from Darjeeling. It is also known as Barbotey Rock garden. It is one of the magnificent places to visit in Darjeeling.



fig:-4 (Rock garden)



**5.5:PADMAJA NAIDU HIMALAYAN ZOOLOGICAL PARK:-** In India, Darjeeling zoo is the largest high altitude zoo. It spans across 67.5 acres of area at an average altitude of 7000 ft.(2133m). Indira Gandhi dedicated this zoo in memory of Padmaja Naidu(ex Governer of West Bangle). Since then the zoo is officially known as the Padmaja Naidu Himalayan Zoological park. This zoo which is located at the Birch Hill area (now known as Jawahar Parvot) was established in 1958. In Darjeeling zoo, there are vulnerable and endangered high altitude Himalayan animals like the Tibetan walf, Red panda, snow leopard, cloud leopards etc all in semi natural habitates. And them there are Siberian Tigers, Yaks and more. The zoo has over 200 spaces of trees and plants, Shruds, climber, medical plants etc.



fig:-5 (Padmaja Naidu Himalayan Zoological park)

and to tourist Taxi services through Sikkim. Regular buses, taxis and cabs are available to make journey to Sikkim and within Sikkim. The nearest railway station is located in Siliguri and New Jalpaiguri. New Jalpaiguri (NJP) railway station is located 125 Kms away from Gangtok. Through Sikkim does not have any airports because of it is tough terrain; there is a helipad in Gangtok which is the only. Civilian helipad in the state. The closest air port to Sikkim is in Bagdogra near the town of Siliguri in West Bengal. The helicopters services not only are for the transport and communication but also for sightseeing purposes.

**5.6: TEA GARDEN :-** Over the years several tea gardens in Darjeeling have closed down or have been taken over by the other tea estates .Currently there are 87 operational tea garden in Darjeeling district covering an aggregate area of about 19,000 hectares(i.e 46,950 acres) under tea plantation .



The tea gardens in Darjeeling presently employ about 52,000 permanent workers . most of the garden workers are women and almost all employees are Nepalis .



Fig6: (Tea Garden)

**5.7: M.G MARG (GANGTOK):**-M.G. Marg is the main market area of Gangtok. "MARG" in hindi means road. So M.G Marg means M. G road. The road is lined up with glittering shops, restaurants, cafes and bars on both sides. The annual Gangtok food and cultural festival is held here at M.G Marg in December. The entire area is free of litter, smoke and vehicle.



Fig7: (M.G Marg)



**5.8. NATHU LA PASS** :- The historic pass on the Chino-Indian border on the Tibetan Plateau lies at an altitude of 14,200 ft. and is one of the highest motorable roads in the country. The serene site full of alpine flora fauna is open only for Indian Nationals on Wednesday, Thursday, Saturday and Sunday. A permit from the Tourism Department is required to visit the picturesque pass. In June 2015 the first group of Indian to Mansarovar lake (Tibet) went and returned back through Nathu La Pass.



Fig8: Nathu La Pass

**5.9 TSOMGO LAKE**:- The oval -shaped glacial Lake perched at an altitude of 12,210 ft. about 20 km from the Nathu La Pass is noted for its mystical environs and wild flowers. Tsamgo Lake meaning 'source of the lake' in Bhutia language is 1km long and 50 ft. deep and is considered to be very sacred. The lake remains frozen during winter and the best time to visit is between may and august, when its surroundings are covered by a rich variety of flora, including the rhododendrons, various species of primulas, blue and yellow poppies, iris etc. It is home to the Brahmini ducks and is also a stop over for many migratory birds. Red panda can be seen around the lake.





Fig 9:- Tsomgo Lake

**5.10 BABA HARBHAJAN SINGH TEMPLE :-** Baba Harbhajan was born on 30 August 1946 at village "SADRANA" of district Yujranwala on 9<sup>th</sup> February 1966. He got enrolled into the Punjab regiment of Indian army as a sepoy. It is widely believed that sepoy Harbhajan Singh appeared in the dreams of a colleague and requested for his "SAMADHI" its be constructed. The unit is keeping with belief constructed a "SAMADHI". Approximately, 9 kms from the present site for the convenience of the visitors. The New Baba Mandir was constructed at the present location on 19 November 1982.



Fig10 :-Baba Harbhajan Singh Mandir

## 6. DISCUSSION:

The common disasters in Sikkim range from landslides, earth-quakes, flash floods, hail storms, drought, forest fire and avalanches etc. Table 1 enimerates these disasters and their usual periods of occurrence respectively.

TABLE 12: VARIOUS TYPES OF DISASTER IN SIKKIM

Disasters	Periods of occurrence
Landslide	June to September
Flash Flood	June to September
Hail, Storm	March to June
Drought	October to April
Avalanche	January to March

**LAND SLIDE:** Landslide is a rapid movement of rock, soil, and vegetation dawn the slope under the influence of gravity. They are generally sudden and sporadic.

Sikkim, the North Eastern India State – a place with the Eastern Himalayan Range is often affected by the landslide, a huge type of natural disaster.

TABLE 13: FREQUENCY OF LANDSLIDE IN SIKKIM

DISTRICTS	VERY SEVERE	SEVERE	MODERATE	TOTAL
North	32	N/A	N/A	32
South	90	148	130	368
East	5	9	3	17
West	0	0	0	0

Source: Threat of landslides seismicity in Sikkim Himalayas (sikkimmines.gov.in, Government of Sikkim)

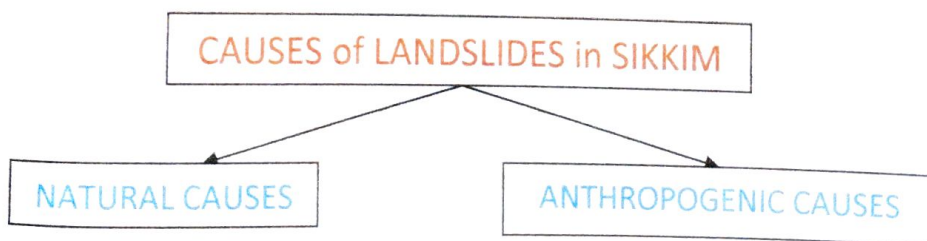


FIG 11: CLASIFICATION OF LANDSLIDE CAUSES





Figure 12: House Collapsed Due to Landslide from heavy rainfall



Figure 13: Roads Blocked due to Rainfall Trigger Landslide

1. Rainfall and other water sources: Landslides in Sikkim by and large happen after continuous with exposure to rainstorm, and sometimes amid or not long after torrents or when precipitation intensity surpasses 135-145 mm in 24 hours. As per SSDMA (2015), a cloudburst is in the speed of thunder, from a few minutes to as long as three hours, and leaving a trail of obliteration which is more terrible than that delivered by the consolidated impact of precipitation of the season. The



precipitation record of the Teesta Valley for the period 1891- 1965 demonstrates that precipitation force which surpassed 250 mm in 24 hour was rehashed in excess by 40 times. By considering 5000 mm as the mean yearly precipitation for the Teesta Valley, the Event Coefficient was ascertained, which ran in the vicinity of 0.06 and 0.36 and are generally connected with avalanches. Precipitation is therefore one of the primary starting variables other than feeble topography, overburdened soak slants, visit seismic tremors and so on., for activating landslides. Precipitation builds pore water pressure inside the soil and stops from normal movement of the load. At the point when the slope is loaded with water, the liquid weight gives the buoyancy, diminishing the protection from slide occurrence. Also, at times liquid weight can act downwards because of groundwater stream giving a water powered push to the slide that further declines the dependability of the slope. In some circumstance, the nearness of abnormal state of liquid may destabilize the slope through different techniques given below:

- Certain past events cause fluidization of debris leading to its flow.
- In silty materials, shallow failures occur due to loss of suction forces which is an important mechanism in residual soils of tropical areas after deforestation.
- River erosion causes toe undercutting of the slope other water triggering factors are snowmelt and changes in groundwater level.
- Snowmelt, which is a general phenomenon in cold mountainous areas, is the key mechanism which initiates landslides when rapid increase in temperature leads to quick melting and water infiltrates many a times into impermeable layers as the soil and rock below is frozen leading to excessive pore water pressure and landslides undoubtedly.
- Quick changes in groundwater level along an incline likewise triggers slides and this is frequently the situation when the slope is close to a water body or waterway and when nearby water level falls quickly the groundwater can't disseminate sufficiently quick, bringing about an impermanent high water table which subjects the slant to higher than ordinary shear pressure, prompting insecurity.

2. **SEISMIC TRIGGERS:** Seismicity triggers landslides as a result of two separate, but interconnected processes namely seismic shaking and pore water pressure. The passage of earthquake waves through rock and soil generates a complex set of accelerations which changes the gravitational load on the slope due to which seismic landslides are more widespread and sudden. Rock falls and slides are the most common type of earthquake-induced landslides and liquefaction failure is induced solely by earthquakes causing fissures leading to subsidence.



3. **ANTHROPOGENIC TRIGGERS:** Increasing landslides in Sikkim since 1995 is attributed to human activities and in fact their activities not only trigger, but also cause landslides, for example destabilizing a slope through deforestation. The following are the principal human triggers:

- Excavation of a slope at its toe.
- Drawdown.
- Road cut.
- Construction of hydroelectricity projects.

**TABLE 14: MAJOR LANDSLIDES IN SIKKIM**

YEAR	PEOPLE KILLED IN THE LANDSLIDE
1968	33000*
1995	30(causing damage to houses)
1997	48(and more than 100 people injured)
2008	2
2009	4
2010	3
2011	No deaths

Source: Researchgate ([shorturl.at/czEN6](http://shorturl.at/czEN6))

\*These slides were caused by a heavy downpour ranging from 500 to 1000 mm. in 3 days. Such incidents have a return period of 1000 years claimed the meteorologists. The impact of the range was such that the Darjeeling. Sikkim's road was breached at 92 places and the road transport was totally disrupted.

#### **DISTRIBUTION OF LANDSLIDES:**

Each year a large number of people in Sikkim are affected by natural disasters as the state is prone to landslides, floods, and riverbank erosion leading to loss of life and property thereby reducing rate of development. Among all disasters, landslides occur the most due to mountainous terrain and the State Government of Sikkim has requested Department of Science & Technology (DST), Government of India to undertake a systematic study of landslides. In this section an attempt has been made to study the distribution of landslides in North, South and East Districts of Sikkim.

- Although North Sikkim is most affected by landslides but, a few old, perennial and dangerous landslides recur annually. It constitutes 59.55 percent area (4226 sq.km) of Sikkim, of which a large part (average elevation of over 2500 m) is devoid of vegetation with poor prospect for cultivation. These include ice and glaciers 19.4 percent (819.84 sq.km), barren land, exposed rocks and talus fields 24.45 percent (1033.16 sq.km) and 28.4 percent (1200 sq.km) is glaciated valley and alpine meadows with moraines. Road transport is the only means of



transportation due to inaccessibility in the rugged terrain and in fact an uninterrupted smooth journey even up to Mangan (the district Headquarter) from Gangtok (67 km) is considered a luxury during dry season and from Mangan to Chungthang, a distance of mere 30 km, is a nightmare and only a few survive the quirky slides of Relli and Toong and rushing Meyong Chu. From Chungthang to Lachen (26 kms) and Lachung (21 kms) by road is smooth but, from Lachen to Thangu (30 kms) is prone to frequent landslides, especially between Zema and Yathang villages (SSDMA, 2015). Thus, almost whole of North Sikkim is affected by landslide.

- Major administrative centres and densely populated towns are situated in East Sikkim district and thus being, most vulnerable to landslides. The area constitutes a part of the lesser Himalayas in Sikkim, with height ranging from 350 m to 1,800 m and the terrain is characterised by highly dissected broad valleys with steep gorges, sharp peaks and ridges. Although the whole of East Sikkim is not taken as the study area, but the area taken, which is adjacent to the capital city, is infested with Seven Sisters slides and innumerable landslides on NH 32 A (the only connectivity between Gangtok and other districts of the state).

- South Sikkim is prone to major landslides, but human interference due to increasing population and tourism has brought tremendous changes worsening the situation affecting the main connecting road disabling people both economically and socially. LANDSLIDES HAZARD MAPS: Landslide hazard map has been prepared with the help of ten layers through Analytical Hierarchy Process (AHP) method of analysing the hazard zones of landslide. The landslide hazard zone after completion is divided into five zones. The reason behind construction of the hazard map is to analyse landslide prone area or the prediction of the future areas of landslide occurrences and hence notify the concerned people. The different layers for construction of the hazard map in order of significance are slope, aspect, curvature, geology, vegetation, land use/land cover, geomorphology, lineaments, soil, and drainage distance from the stream. In East Sikkim the geological sequence of Juluk-Nathang-Kupup-Chhangu indicates that lithologically the area comprises of high grade gneisses with inter bands of meta sedimentary and these rocks are younger of Permo-carboniferous age (comprising of sandstone, shale pebble beds carbonaceous shale, slate, gneiss, limestone, quartzite etc.) and exhibit structures belonging to three phases of deformation, with each phase being distinguished from others by a typical fold morphology, inter-relations, orientations and minerals paragenesis. Due to complex folding/faulting and mechanical weathering the rocks are highly disturbed and found in disjointed form. In the study area Chungthang formation is the most susceptible and permafrost



region and Reyong formation the least to landslides. Using AHP method, the susceptibility map was made in raster calculator which gave automated rankings. It was found that the landslide locations fitted well in the high and very high susceptible regions. The study area was divided into five vulnerable levels - very high, high, moderate, low and very low. The western and south western regions of the study area are the most susceptible to landslide, followed by northern, southern and parts of central region and almost the entire eastern part is comparatively less hazardous. It was found that 28.44 percent area fell under very high risk, moderate 31.61 percent and 26.25 percent low. The western portion, though more susceptible to landslide, has smaller landslides because of dense vegetation and lesser development than that of the east, which faces less, but bigger landslides due to barren slopes and encroachment by the capital city. Although the whole area is tectonically active, yet the role of vegetation and developmental activities is very important. Landslides of North Sikkim are big enough to destroy a village and the hazard level is more because of its climate, barren slopes, geology and scanty vegetation. The government has initiated various programs to deter the landslides from creating further havoc, but as of now only a few could be controlled. Landslide exposure map is the second step towards the making of the landslide risk map. Assessing the number and location of hazard threatened people and property is a crucial step in landslide risk management and emergency planning has been confirmed by Proper and Glade (2016) in their paper on multilayer exposure map of Austria. In this study population exposed to landslide risk was assessed using 2011 census data. The exposure map has been created using the thematic layers of population density, number of household, housing structure (permanent, semipermanent, temporary), road network, agriculture, poverty and infrastructure.



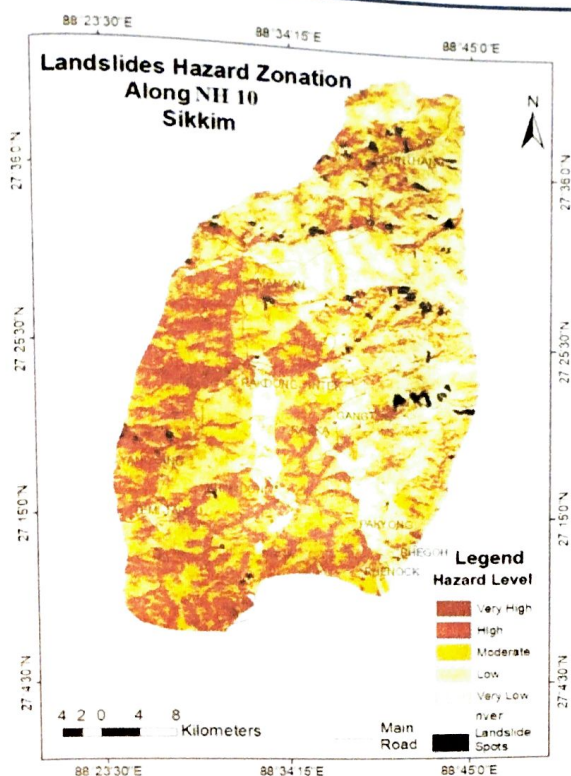


Figure 14 : Landslide Susceptibility Map

**FLASH FLOOD:** Flash floods are short time events, occurring within 6 hours of the causative event (heavy rain fall, dam break, levee failure and rapid snow melt) and often within two hours of the start of high intensity rainfall. A flash flood is characterized by rapid stream rise with depends of water that can reach well above the banks of the river, carrying with it large amount of debris and causing high damage due to its suddenness. Flash flood damage and most facilities tend to occur in areas immediately adjacent to the river where they weaken the soil and cause mudslides, damaging home, roads and property.

Heavy rainfall and landslides in upstream can cause flash floods downstream. Since Sikkim receives a high amount of annual rainfall, especially during the monsoons and landslides occur frequently and flash flood are the common phenomenon and pase constant threat to life and property. Also the presence of large dams in Sikkim, passes a great danger of flash flood in case of dam breakage.

Sikkim: Flesh flood leave a trail of destruction in Upper Dzongu: 19 damaged by Flesh Flood, 35 families evacuated to PHE in North Sikkim.

Gangtok: Incessant rainfall over the past couple of days has lead to a huge flash flood in Passingdang, Upper Dzongu in North Sikkim on Saturday Night. At least 19 houses and public properties including the hostel of Passingdang Secondary School had been damaged. No causalities have been reported so far as civilians were evacuated on time. As per the information from SDM Dzongu Norbu Tshering

Bhutia, 19 houses have been damaged by the flash flood and 35 families were evacuated to the Passingdang PHE house on Passingdang-lingthem Road. The effected families were provided with ration by the district administration.

## DISASTER MITIGATION MEASURES

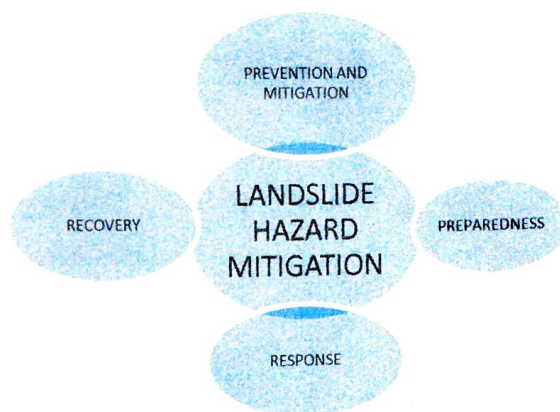


Fig 15: Risk Management Cycle of Sikkim

- Disaster Management: The disaster management of Sikkim requires a continuous and multi sectoral, multi disciplinary process of planning and implementation of measures, aimed at-
  - Preventing or reducing the risk of disaster.
  - Mitigating the severity or consequences of disasters.
  - Emergency preparedness.
  - A rapid and effective response to disasters.
  - Post disaster recovery and re-habilitation.

Disaster mitigation is a collective term used to encompass all activities undertaken in anticipation of the occurrence of a potentially disastrous event, including assessment, preparedness and long term risk reduction measures. Mitigation involves reducing the actual or probable effects of extreme disaster on man and his environment. These are generally achieved through identification of vulnerable areas, monitoring and setting up of control rooms, warnings, alerting administration, police and army authorities, and community preparedness etc.

\*Pre disaster reduction phase in Sikkim:

- Prevention: - This phase encompasses measures which are adopted in advance and which seek to prevent it occurring or to reduce its severity.
- Mitigation: - Actions taken to reduce the effects of disaster in a community.



➤ Preparedness: - Comprise activities designed to minimize loss of life and damage by temporary removal of people from a threatened location etc.

\*Post disaster recovery phase in Sikkim:

➤ Response:- The initial response is normally provided by statutory emergency services of a local authority. The basic objectives of the response will be to save life, prevent escalation of the event, relieve suffering by meeting the basic needs such as shelter, food, water and medical care and the protection of property.

Steps adopted by different agencies and localities of Sikkim-

- Hazard Mapping: Since it locates areas prone to slope failure, through this process different agencies of Sikkim identifying areas prone to landslide that people avoid this areas for building settlements.
- Land Use: Localities of Sikkim take an important step to prevent disaster that is land use. Land use pertains to preservation of vegetal cover. Denuded path slopes provoke landslides. They also reforested with suitable tree species for prevent landslide. Local people of Sikkim also avoid blockage of natural drainage while constructing roads, buildings and canals.
- Retaining Wall: These are build along the roadsides to stop debris from slipping.
- Surface drainage control works: The surface drainage control works are implemented to control the movement of landslide accompanied by infiltration of rain water and spring flows.
- Increasing vegetal cover: The people of Sikkim take this step to arrest landslides. This helps in binding the top layer of soil with layers below, while preventing excessive run off and soil erosion.

\*Sikkim State Disaster Management Authority (SSDMA)

The land revenue department is primarily concerned with Revenue Administration in the state which encompasses survey and settlement operation, maintenance and upgradation of land records and enforcement of land laws of Sikkim. It approves disaster management plan in accordance to the guidelines laid down by National Authority and co ordinates its implementation. SSDMA recommends provision of funds for mitigation and preparedness measures.

## 7. MAJOR FINDINGS

- Our study has informed about physiography, climate, population, and disaster in Sikkim as well as its mitigation.
- We found that 33000 people died in the big landslide in 1968 and also came to know about the many damages caused to the landslide in East Sikkim in 2011.
- The low population density of Sikkim (86person per km) results low amount of damage /destructions by the disasters that occur in the regions at different times.
- Apart from these, we came to know that the East and North Sikkim in the disaster prone area.



## 8.CONCLUSION

Sikkim, as on hilly state, its natural environment is quite charming. It is also a highly clean and under populated state in India. Apart from its charming beauty, disasters are also seen here in large numbers as the state is hilly. We decided to purpose on this place to enjoy the beauty of this state as well as to get proper knowledge about the disaster that have taken place here and to that and we have reached /arrived here .We were impressed with many places in Sikkim like temples, lakes, waterfalls, rivers etc. The economics growth of the state is mainly dependent on tourism.

There have been many disasters in this state since the past. Earthquake and landslides are more common in the state than other disasters as they are hilly. However, the extent of its damage is low. From this projects report, we have greatly benefited from acquiring knowledge about the climate, natural conditions, economics, social culture etc of Sikkim. We have been helped a lot of by primary and secondary data in this record (report).

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