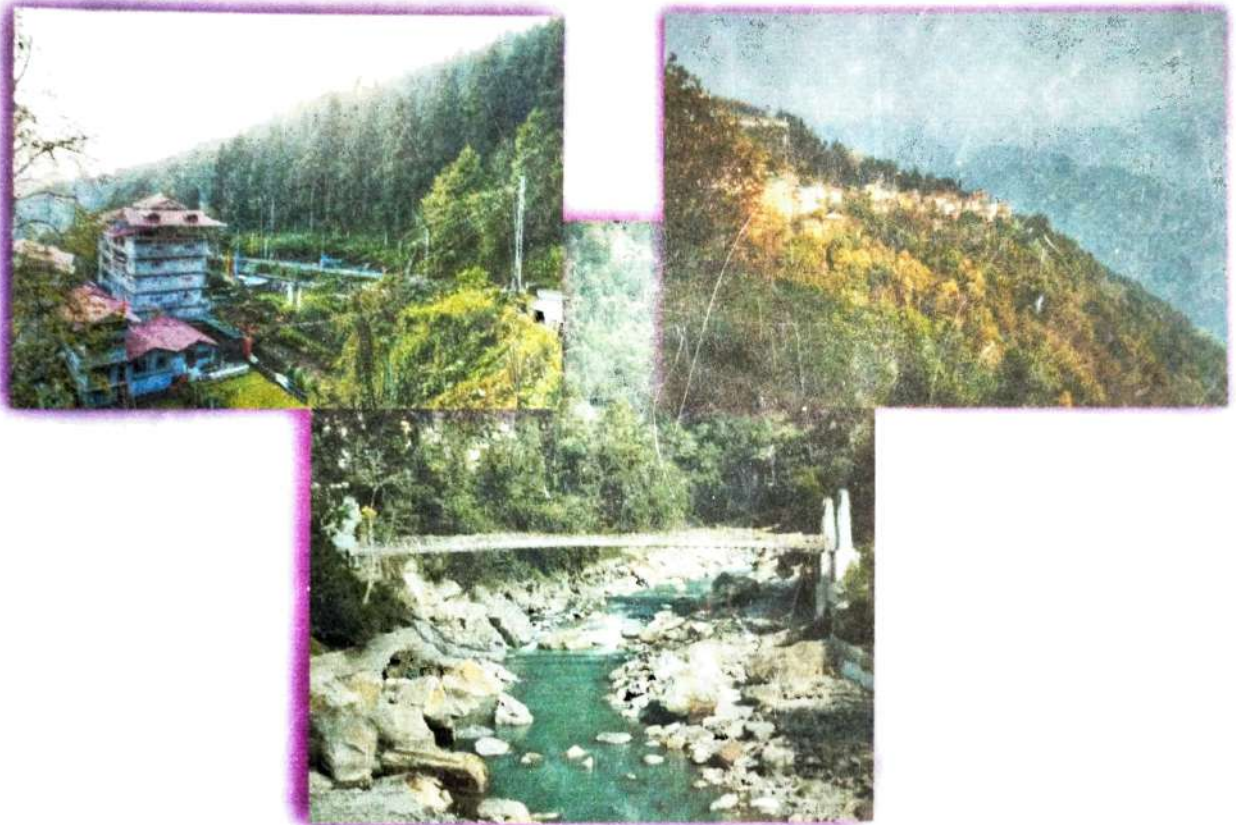


# VIDYASAGAR UNIVERSITY

Report On  
Landslide and Its Causes, Consequennces & Management :  
A Study in Some Parts of Sikkim Himalayas



**B.SC HONOURS (GEOGRAPHY)**  
**SEMESTER - VI**

**REG. NO :- 1520147 OF 2020 - 2021**

**ROLL NO :- 1126152 - 200021**

**SESSION :- 2022 - 2023**



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entitled as Landslide and its causes, consequence

and management: A study in some parts of

Sikkim Himalayas.

for partial fulfilment of the syllabus prescribed by Vidyasagar University. The

report has been prepared under the supervision of Miss Arpita Majumder and

may be placed before examiner for evaluation.

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## ACKNOWLEDGEMENT

I would like to convey my deep appreciation to my teachers Miss Anpita Majumder, Assistant Professor; Mr. Nabayan Chandra Bera, Guest Teacher; Mr. Apakesh Mondal, Assistant Professor and HOD; of the Department of Geography of Surenchandra Jyotindra Nath Mahavidyalaya. For their valuable suggestions and encouragement in completion of my project work.

I would also like to express my sincere gratitude to our principle Dr. Ratan Kumar Samanta for providing all the required facilities to accomplish the report.

Finally, I would like to thank my Parents, Friends, Staff of College and the local residents of Pelling in West Sikkim, with out their support and help, this assignment would not have been completed.

Place: Amdabad

Date: 06.08.2023

Sweety Mondal

Signature

## LIST OF MAP

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3. WEST SIKKIM
4. SOUTH SIKKIM

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## Introduction:

Disasters and hazards are common and occur not only in India but all over the world. India has been prone to natural disasters on account of geo-climate conditions; disasters such as floods, earthquake, droughts, cyclones and landslide have been major within the country. A hazard may be defined as the perilous conditions or events that are threatening or have the potential for causing injury or loss of property or the environment (Dey & Singh, 2006). Hazards are of two kinds: natural and manmade; natural hazards are the ones that take place as a result of natural phenomena, these can be meteorological, biological and geographical such as cyclones, Tsunamis, earthquakes, landslides, floods, drought and volcanic eruptions. On the other hand, manmade hazards are the ones that occur due to human negligence; these are associated with industries or energy generation power plants and include explosions, leakage of toxic waste, pollution, dam failure, wars or civil strife or occurrence of fire (Dey & Singh, 2006).

landslide is also called as semi or quasi natural hazard as it originates due to natural phenomena and also by human activities. Landslide is common disaster in different parts of Sikkim, the high steep slope, making of the houses or constructional works in the hilly slope etc. causes are

responsible for landslides in Sikkim. In the present project paper it is discussed about the causes, effects and management of landslides disaster in west and south Sikkim along with an overview of physical and socio-economic status of Sikkim as landslide is also triggered by human activities along with natural phenomena.

### Concept of landslide:

A landslide is the movement of a mass wasting which denotes any down-slope movement of soil and rock under the direct influence of gravity. The term "Landslide" ~~occurs~~ encompasses five modes of slope movement. Falls, topples, slides, spreads and flows. These are further subdivided by the type of geologic material (bedrock, spread soil or earth). A ~~occurs~~ landslide is the movement down slope of a mass rock, debris, earth or soil, landslide occurs when gravitational and other type of shear stresses within a slope exceed the shear strength of the materials that form the slope. Shear stresses can be built up within a slope by number of processes.

India has been divided into a number of zones on the basis of vulnerability. Very high and high vulnerability zone having highly unstable, relatively young mountainous areas in the Himalayas, high rain fall regions with steep slopes, the north eastern regions, along with areas that experience frequent ground-shaking due to earthquakes, etc. and areas of intense human activities.

Particularly those related to construction of roads, dams, etc. are included in this zone. All the Himalayan states from the north-eastern regions except the plains of Assam are included in the high vulnerability zones. Sikkim is one of the vulnerable state in India due to landslide.

### Study area: -

Sikkim is a small, extremely mountainous state in the Himalayas with sharply defined and extremely deep watershed. The state is situated between  $27^{\circ}04'N$  to  $28^{\circ}07'N$  and  $88^{\circ}01'E$  to  $27^{\circ}06'E$ . It is bounded by Nepal in the west by the vast stretches of Tibetan Plateau in the north and by Bhutan and Chumbi valley of Tibet in the East. Darjeeling district of West Bengal stretches along its southern boundary. The state has a total area of 7096 sq. km. Sikkim is divided into four districts - East, North and South.

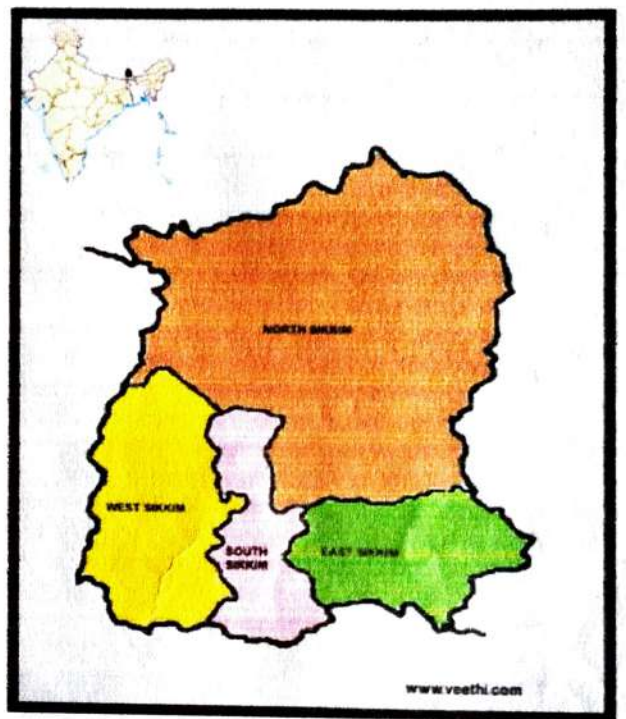
The state lies between very high landslide vulnerable zone on the basis of intensity of the controlling factors of landslide. Though North and West Sikkim are in very risk zone of landslide. South and West districts of Sikkim lies at an altitude of more or less 400 meters to 2500 meters with unique countryside escape of endless waves of agriculture fields and the terraced slopes. Intercepted by spring patched forests. Tourism development road construction, increasing by spring patched hote settlement triggering the hote



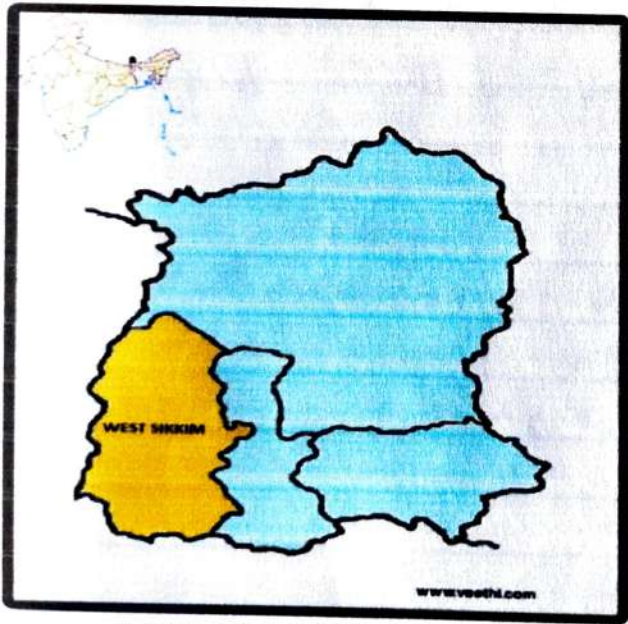
# LOCATION MAP



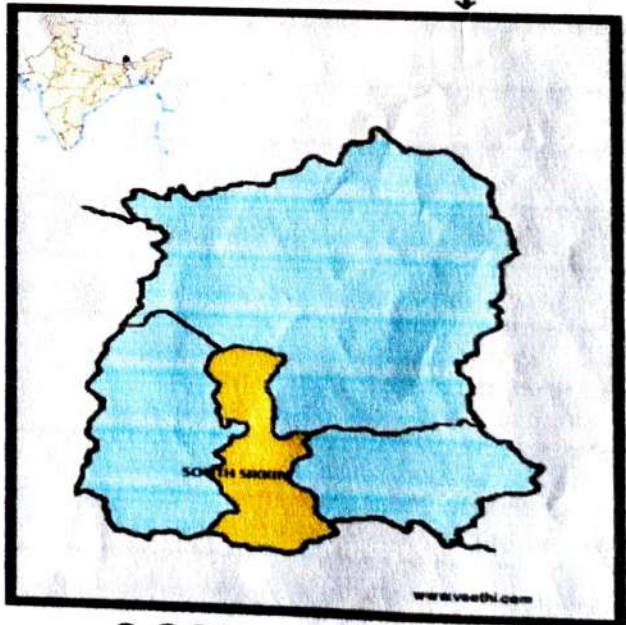
1. INDIA



2. SIKKIM



4. WEST SIKKIM



3. SOUTH SIKKIM

landslide every year Hence, in the present study south sikkim and west sikkim has been taken as special consideration in the study area to show the general scenario of the landslide with its causes, consequence and management.

### Objectives: -

The present Project Paper on landslide has been initiated to fulfill some basic objectives which are as follows:

- To study the general overview physical and economic, socio cultural environment of the study area, as both are very much related to landslide.
- To identify the major causes of landslide and its consequence in the study area specially in west and south sikkim.
- To assess the effective landslide management techniques and to give some suggestive measures to prevent landslide in the study area.

## 1.4 Research questions:

- ① what is the nature of landslide in west and south sikkim?
- ② what are the main causes of landslide?
- ③ what are the effects of landslide on the lives of the local people?
- ④ what measures have been taken to prevent landslide from government?

## 1.5 Data base and methodology:

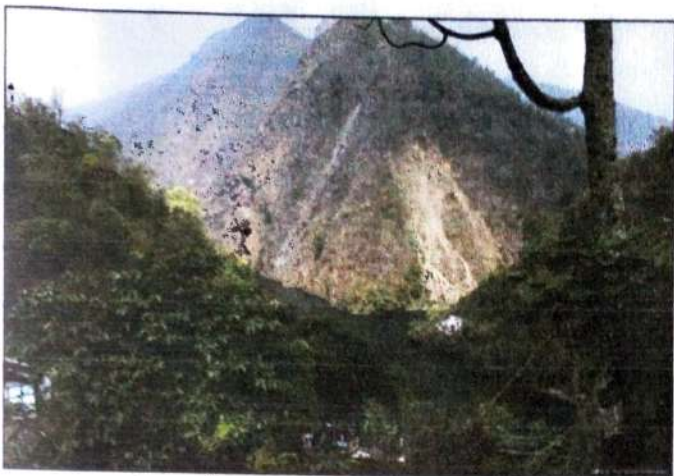
→ The data has been collected from two sources - Primary and secondary. The primary data has been collected from hotel managers, car drivers, local people and seller of souvenir shop. The secondary data were collected from - Various book, article, different link from website, journal etc.

→ we collected data from hotel managers, car drivers, local people and seller of souvenir shop through interview method, and we gain an understanding of landslide through the observation method while traveling near landslide.

→ Different cartographic techniques have been chosen to represent the data properly we used bar and line graph to show rain fall and literacy we have use pie or bar diagram.

## 1.6 Limitation of the study:

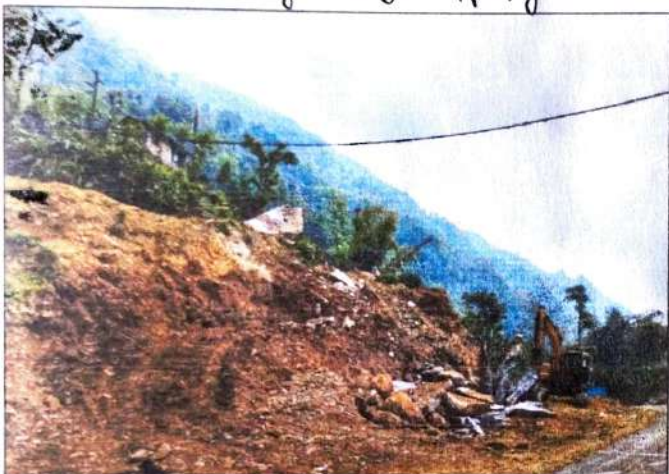
Due to the limited time period surveyor were not able to collect properly. Besides this some other problem such as poor financial field and surveyor, bad weather condition etc. which prevailed in that area was not dealt properly.



1. Physiography



2. Ranget River



3. Brown-clay



4. Rhododendrohee



5. Red Panda, state animal of Sikkim

## 2.0 A general overview on Physical and Socio-economic environment of Sikkim

As landslide is called as semi or quasi natural hazard. It is originated by natural phenomena and triggered by human activities. Sikkim is one of the vulnerable state in India due to landslide. Geology, bed & structure, nature of slope, type of rock and its resistance power to erosion, soil, climate nature (specially rain fall), vegetation cover etc. all are the controlling factors of landslide. Apart from these, human activities such as, economic environment of the region can be devastated due to landslide.

Hence, a brief introduction on Physical and Socio-economic environment of Sikkim should in through to know the causes and consequences of landslide in the study area.

### 2.1 Physical Environment :-

#### 2.1.1 Physiography:-

Situated in the Himalayan mountains, the state of Sikkim is characterised by mountainous terrain. Almost the entire state is hilly with one elevation ranging from 580 metres (1920 ft) in the south at the border with West Bengal to 8586 metres (28169 ft) in northern peaks Nepal and Tibet. The summit of Kongchenjunga

the world's third-highest peak is the state's highest point, situated on the border between Sikkim and Nepal. For the most part, the land is unsuitable for agriculture because of the rocky, ~~partly~~ precipitous slopes. However, some well slopes have been converted into terrace farms.

2.1.2

### ☐ Drainage:

Sikkim is drained by large number of perennial rivers which merge into two prominent rivers, the Teesta and the Rangit. Rest of other stream eventually joins one or the other. Rangit also joins the Teesta just near the boundary between Sikkim and West Bengal.

The Rangit river its tributaries originate in the Talung glacier in West Sikkim and after ~~to~~ flowing for about 60 km. joins Teesta below Melli near the border of Sikkim with West Bengal. River Rangit is a major tributary of River Teesta from the western Sikkim.

Major tributaries of Rangit are Rimbi Khola, Rathangchu, Kaley Khola, Ramam Khola and the little Rangit

2.1.3

☐ Soil :-

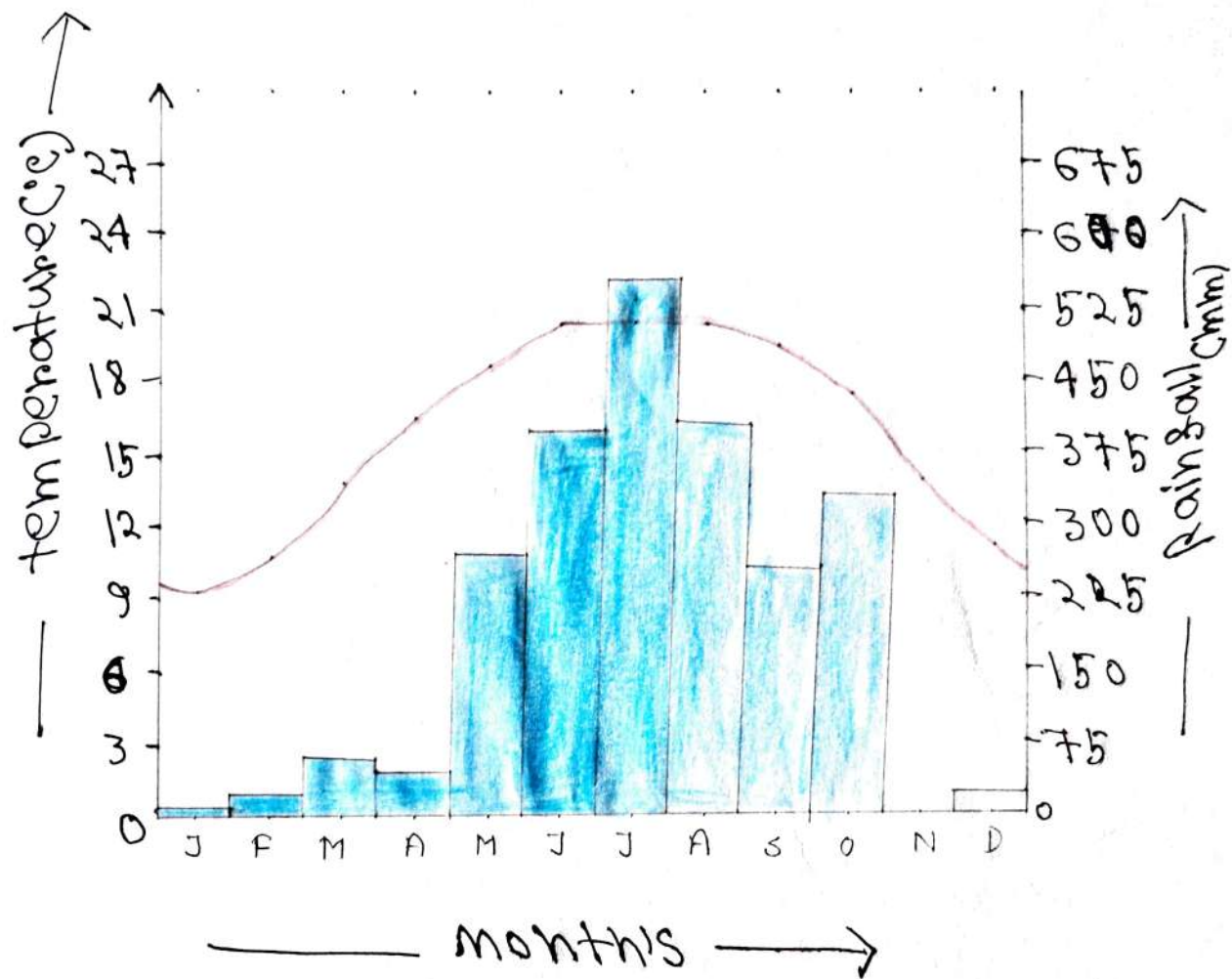
The hills of Sikkim mainly consist of gneiss and schist which weather to produce generally shallow clay soils. The rock consist of phyllites and schists.

2.1.4

☐ Climate :-

The state has five seasons: winter, summer, spring, autumn and monsoon season. Most of the inhabited regions of Sikkim experience a temperate climate with temperatures seldom exceeding  $28^{\circ}\text{C}$  in summer. The average annual temperature for most of Sikkim is around  $18^{\circ}\text{C}$ . During the monsoon, heavy rains increase the risk of landslides. The record for the longest period of continuous rain in Sikkim is 11 days. Fog affects many parts of the state during winter and the monsoons, making transportation perilous, temperatures in the mountains can drop to as low as  $-40^{\circ}\text{C}$  in winter.





## 2.1.5 Flora and Fauna:-

→ Sikkim is situated in the ecological hotspot of the lower Himalays, one of only three among the ecoregions of India. Owing to its altitudinal gradation, the state has a wide variety of plants from tropical species to temperate, alpine and tundra ones, none of which is Sikkim; about 40 species of Rhododendron bloom late April - mid May across the state.

→ Sikkim is home to around 5000 species of flowering plants, 515 rare orchids, 60 Primula species, 11 oak varieties, 23 bamboo varieties, 16 conifer species, 362 types of ferns and fern allies, 8 tree ferns and over 900 medicinal plants. A relative of the poinsettia, locally known as "chirstmas flower", can be found in abundance in the mountainous state.

→ The Fauna of Sikkim include the snow leopard, musk deer, Himalayan red panda, Himalayan marmot, Himalayan serow, Himalayan goral, muntjac, common langur, marbled cat, leopard cat, dhole, Tibetan wolf, hog badger, binturong and Himalayan jungle cat. Among the animals more commonly found in the alpine zone are yaks, mainly reared for their milk, meat, and as a beast of burden. Sikkim has more than 550 species of birds, some of which have been declared endangered. The red panda is the state animal of Sikkim.

2.2. Total amount of expenditure

2.2.1. Development

At the end of 2002 the total expenditure was 16 million USD. 6.5 million were used for the purchase of equipment and 9.5 million for the purchase of land. The total amount of expenditure was 16 million USD.

# Population composition in sikkim (2011)

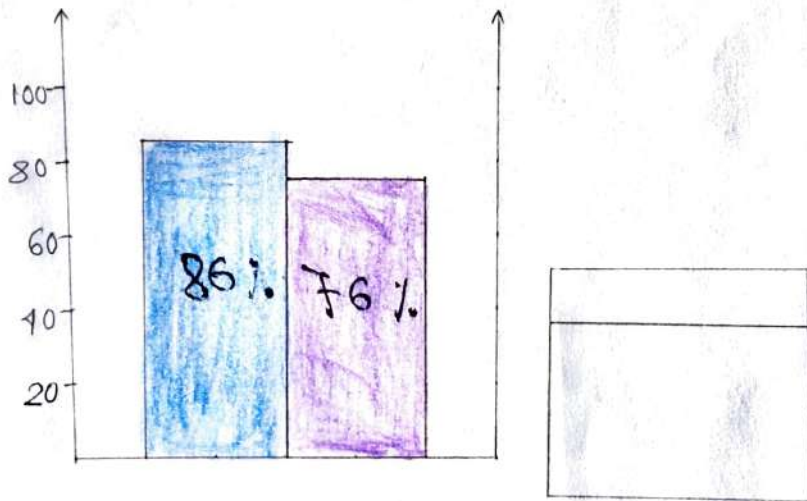


2.2.2

Literacy:—

Literacy rate in Sikkim stood  
was at 81.42%. Where male literacy  
rate ~~76~~ was at 86.55% and female  
literacy rate 76.04% Census of India,  
2011.

# Literacy Rate of sikkim (2011)



### 2.1.3 culture:—

In Sikkim the leading communities are the Lepchas, Bhutias and Nepalese, the official languages of the state are English, Nepali, Sikkimese and Lepcha. The Sikksims are highly devout people and religions play major role in Sikkim, there are majorly two religions Buddhism and Hinduism. And Sikkim is multi-lingual state where people of many communities reside harmoniously.

### 2.2.4 Health:—

There are few many hospitals, health centers, clinics and health facilities across the state of Sikkim, these medical facilities provide treatment both to the local patients and other patients from neighbouring places as well.

Sl No	HEALTH INSTITUTION	EAST	WEST	NORTH	SOUTH	STATE
1.	STATE REFERRAL HOSPITAL STVM HOSPITAL	1	.	.	.	1
2.	DISTRICT HOSPITAL	1	1	1	1	4
3.	COMMUNITY HEALTH CENTER	1	.	.	1	2

SL NO	HEALTH INSTITUTION	EAST	WEST	NORTH	SOUTH	STATE
4.	PRIMARY HEALTH CENTER	6	7	5	6	24
5.	PRIMARY HEALTH SUB-CENTER	48	41	18	39	146
6.	DISTRICT TUBERCULOSIS CENTER NAME #1	.	.	.	1	1
7.	CENTER RURAL HOSPITAL MANIPAL	1	.	.	.	1
8	TOTAL	58	49	24	48	179



### 2.2.5 Economy: -

The economy of Sikkim mainly based on agricultural and animal husbandry and tourism. Sikkim's nominal state gross domestic product (GDP) was estimate of US \$4.6 billion in 2019. with GDP per capita being ~~US~~ \$7,530 (₹ 5,50,000) thus constituting the third-smallest GDP among India's 28 states.

### Agriculture: -

Economy of Sikkim is largely agrarian based on the terraced farming of rice and the cultivation of crops such as millet, wheat, barley, oranges, tea and cardamom, Sikkim produces more cardamom than any other Indian state and is home to the longest cultivated area of the rural population depend on agriculture and allied sectors for economic, food and national security.

### Industry: -

Sikkim has long been agro-based society. The Govt. has formulated certain policies such as Sikkim Industrial Promotion and Incentive (SIPI) Act 2000 and its subsequent in 2003 and 2007. Some of the industries of Sikkim that deserves special

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mention in this context are pharmaceuticals, cosmetics, Food Processing, Breweries, Metallurgy, corrugated boxes, Tea Processing etc.

### Eco-Tourism: -

In January 2016, Sikkim became India's first "net zero present organic" state. The Directorate of Ecotourism under the Forest, Environment and Wildlife Management Department has identified and demarcated 11 areas in Sikkim as ecotourism in Sikkim started in the year 1995-96 with trainings, awareness, changes in regulations to adapt to the mountainous terrain and entry of foreign tourists in many of District and Protected areas.

Protected Parks and Sanctuaries for ecotourism activities: - Kanchenjunga National Park, Singha Rhododendron Sanctuary, Fambong Wildlife Sanctuary, Kyongchola Alpine Sanctuary, Maenam Wildlife Sanctuary, Varsey Rhododendron Sanctuary.

## Transport system of Sikkim: -

### Road ways: -

National Highway 10 (NH10; Formerly NH 31A) links Siliguri to Gangtok. Sikkim nationalised transport runs bus and truck services. Privately run bus, tourist taxi and jeep services operate throughout Sikkim and also connect it to Siliguri. The highway Shomnelli connects western Sikkim. Towns in eastern, southern and western Sikkim are connected to the hill stations of Kalimpong and Darjeeling in northern of Bengal. The state is further more connected to Tibet by the mountain pass of Nathu La.

## 2. Hist of National Highways of Sikkim:-

Number	Length (km)	Length (mi)	Southern or western Terminus	Northern to Eastern Terminus
NH 10	52	32	Gangtok - Singtam - Rangpo - West Bengal Border	
NH 310	87	54	Rahipool (NH-31A) Burtuk	Mehta - Nathua
NH 310A	55	34	Tashi View Point - Phodong	Megha
NH 510	70	43	Singtam - Damthang - Legsrip	- Gyalsing
NH 710	45	28	Melli - Manpuh - Namchi - Damthang - Takku	
NH 717A	112	70	West Bengal Border - Rhehoek	Rohathang Pokyonga Junction with new NH 10 at Rahipool near Gangtok
NH 717B	42	26	Junction with NH No 717A at Rhehoek - Rangit, Rolap - Junction with NH No. 310 near Mehta at Shekathang	

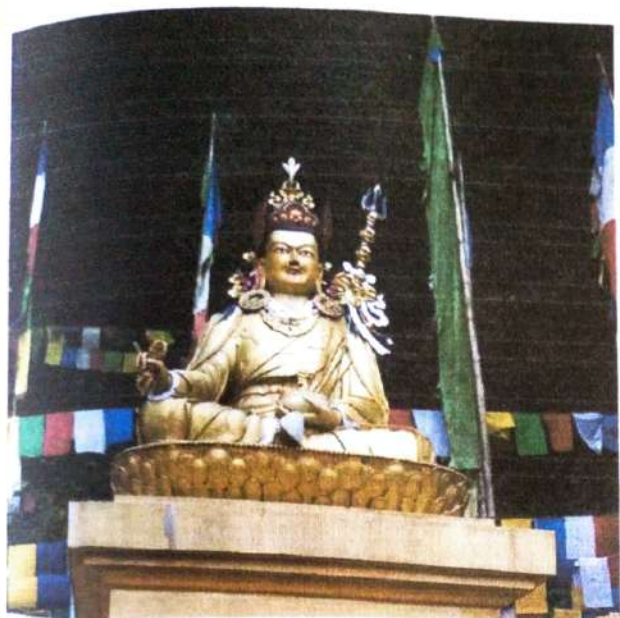
### \* Airways :-

there is just one airport Pakyong which is about 11.9 km. from Sikkim but Bagdogra is well connected to Sikkim (about 125 km. from Sikkim touch-ship)

\* Here, helicopter service started mainly for tourism purpose.

### \* Railway :-

the nearest railway station to Sikkim are New Jalpaiguri and Siliguri station located in West Bengal.



1. Cutube in Sikkim



2. Cutube in Sikkim



3. Primary health center in DENTUTT



4. Cardamom cultivation



5. NH - 10

### 3.0 landslide in study area:

the frequent occurrence of landslide is a very common phenomena in Sikkim. Himalaya and one that causes the most damage to property and connectivity in the lives and property. apart from this recent unplanned development activities, particularly road construction and ill planned settlements, have further aggravated the incidence of the landslide and subsidence.

### 3.1 causes of landslide

the frequent occurrence of landslide is a very common phenomena in Sikkim Himalaya. In the Sikkim region can be caused by a variety of factors including geological, environmental and human-related. Here are some common causes that contribute to landslide.

#### A. geological causes:

Sikkim, a state in northeastern India is located in a seismically active region and experience various geological processes that can contribute to landslide

#### ① slope stability:

step slopes and unstable geological formation can contribute to landslids. the Sikkim region is characterized by rugged terrain with steep slopes. especially in the Himalayan



mountain range the presence of ~~weak~~ weak rock formations and loose soil can make these slopes prone to landslide.

### ① Geological formation:-

The geographical formation of Sikkim consists of complex and varied rock types, including schists, gneisses, phyllites and quartzites. Some of these rocks have inherent weakness and discontinuities, such as bedding planes, joints and faults which can act as potential sliding surfaces.

### B. Environmental causes:-

Sikkim state is prone to landslide due to its rugged terrain and high rainfall. Several environmental causes contribute to landslide.

#### ① Heavy rainfall:

Intense or prolonged rainfall can saturate the soil, increasing its weight and reducing its stability. Sikkim experiences heavy monsoon rains, particularly during the months of June to ~~at~~ September. The excess water can infiltrate the ground leading to landslide, 6th August, 2020 Jorethang landslide in West Sikkim.

## (ii) Earthquakes: -

Sikkim falls in a seismically active region due to its proximity to the Himalayan tectonic plate boundary. Earthquakes can generate ground shaking, which can disturb the balance of slopes and trigger landslides. 2011 Sikkim earthquake with a magnitude of 6.9 caused significant landslides in the region, resulting in significant loss of life and infrastructure damage.

## (iii) Erosion: -

Natural erosion processes such as river erosion can undercut slopes and weaken their stability. Continuous erosion removes support from the base of slopes making them prone to landslide.

## c. Human related causes: -

Human activities can also contribute to the occurrence or exacerbation of landslides. Here are some man-made causes of landslide -

### (i) Deforestation:

Clearing large areas of forests for agriculture, logging or urbanization reduces the stability of slopes. These roots help bind soil and prevent erosion, so their removal can make slopes more prone to landslide.

(i) Construction and excavation:—

Poor Construction Practices improper grading of slopes and excessive excavation can alter the natural stability of the land. Building roads, highways or structures on steep slopes with out appropriate engineering measures can increase the risk of landslide.

(ii) Defective drainage systems:—

Inadequate or poorly designed drainage systems can lead to the accumulation of water in the soil increasing pore pressure and reducing the shear strength of slopes this can result in slope failures and landslides

(iii) Surface modification:—

Altering the natural drainage patterns by modifying rivers, streams or water flow and erosion, which can weaken slopes and trigger landslide.

(iv) Irrigation and water leakage:—

Improper irrigation practices, such as excessive water application or inadequate drainage systems can saturate slopes and increase their susceptibility to landslide. water leakage from pipes or sewers can infiltrate the soil, leading to instability.

## 5.2 Consequence:

Sikkim can be the effects of landslides in various consequence and have environment and the local communities. Here are some of the potential effects:-

### Effects of landslide:

#### A. Physical Effects:

Damage to Infrastructure:  
The infrastructure facilities such as telephone and communication system, electricity supplies, water and oil pipelines, offices, substation, commodities, transport system etc. are severely damaged and put out of gear by massive landslide.

#### B. Social Effect:

##### (i) Human casualties:-

If landslides occur in the inhabited areas, the first and some most adverse impacts are on human population. There is no timely forecasting of probable occurrence of landslides and if there is no proper timely evacuation a large number of people are buried under enormous mass of debris of varying sizes and there is heavy toll of human lives.

##### (ii) Damage to settlements, roads and rail roads:-

settlements comprising both rural and urban located at vulnerable sides such as on hill sides, at the foothills, alluvial fans in the valleys facing steep hill slopes etc.

are damaged and sometimes villages are completely destroyed by the thick debris of rocks, muds and other materials dislodged from the hills caused by landslides of various sorts triggered by earthquakes or heavy rainfall or human activities.

### C. Economical Effects:-

① Loss of agricultural farms and

crops: At the very outset it may be pointed out that majority of settlements are built on the hill slopes and foothills in mountainous areas, and thus agriculture is also practiced on hill slopes and in the valleys. Generally, terraced cultivation is the practice farms are completely destroyed by falling debris of rocks, boulders, mud, fine loose materials etc. the debris is dumped in the valleys and hence farms and crops on the valley slopes are also buried under thick debris cover.

### D. Environmental Effect:-

① Damming of rivers and flash floods:-

Huge volume of debris produced by landslides of various sorts coming into the rivers forms temporary dams across the rivers and thus blocks the river flow. In such situation substantial volume of water is impounded behind the temporary dams and some lakes are also formed when the impounded

water gushes downstreams with high velocity resulting into flash floods. Such landslide dam generated flash floods wash out everything coming in their way including human settlements, domestic animals, inhabitants and their belongings resulting in heavy loss of human lives and their properties in the downstream section of the rivers.

### E. Effect on Ecosystem:—

(i) Impact on water quality:— when landslide occur, they can seriously damage or destroy ecosystem. sometimes the effects can last for thousands of years. they can pollute streams and water bodies with sediment and debris. the invariably has severe repercussions on water quality and marine life.

(ii) wipe out forest land: what's more, these hazard can wipe out large of forests, wildlife habitat and remove productive soils from slopes.

(iii) Dam up on flood streams: also they can dam up rivers and streams. In so doing, water flow is restricted. marine and terrestrial organisms that depend on the water flow may eventually die. conversely dams may flood the opposite side too. outburst floods can introduce a tremendous

amount of new sediment into streams. or they can submerge and kill vegetation in the flooded region. In Sikkim flash flood killed 22 people, triggered a series of landslides and washed away nearly 30 km of highway in north Sikkim amid torrential rain.

#### F. Loss of lives and social disruption:

landslides are responsible for a number of deaths, injury to people damage to housing, infrastructure and agriculture lands. In Sikkim on Sunday, 18 September 2011 at 6:11 PM (local time) a Mw 6.9 earthquake with an epicenter located near the Sikkim region ( $27.723^{\circ}N$ ) ( $88.064^{\circ}E$ ). Killed 77 people, Sikkim including 16 at the Testa Stage II Hydroelectric power project site, injured 79. Left thousands homeless, and temporarily displaced many and also caused substantial loss to livestock.

#### G. Socio-economic effects of landslide:-

Socio-economic effects include adverse impacts, as enumerated above, on people, their homes and properties, industries and factories, agricultural lands and crops timber, lifelines such as roads and highways, railroads, and communication systems, educational institutions etc. It is significant to note that socio-economic problems caused by mass movement of rock waste and landslides

due to slope failures and many fold are assuming larger proportion due to expansion of built environment in environment fragile and vulnerable mountainous areas.

### 3-3 some instances of landslide in the study area:-

2007, 19th July:

Heavy rain triggered a landslide in Rabongla south Sikkim. The Singtam - Rabongla road has seen as many as 11 landslips while the Namchi Rabongla route via Damthang has been closed because of an uprooted tree.

2011, 23rd June:

A torrential spell of rain from 7:30 pm to a little past midnight on the 23 June 2011 triggered numerous small landslides in Pelling. where 14 people perished on the Pelling - Dantam road in west Sikkim.

2011, 18th September:

on September 18, 2011 a 6.9 magnitude earthquake struck the India-Nepal border region. According to news reports, impacts of the earthquake included landslides in the ~~east~~ northern Indian state of Sikkim, between Nepal and Bhutan.



2020, 21st June:

A landslide occurred in Tatopani at 6 PM on Friday. The road constructed across a steep terrain near Tatopani remains vulnerable to landslides & especially ~~remains~~ during rainy season and recent back cutting initiated for the road expansion has added to risk of landslips during on going monsoon season. Legship - Nayabazar road was blocked near Tatopani due to the landslide. The commuters travelling from Jorhang to Creying, Yoksam and Tashding were compelled to take Reshi-Rinchenpong route via Legship to reach their destination.

2020, 27th June:

A landslide occurred National Hydropower Project of Corporation (NHPC) Teesta Stage-V dam on the left bank of the river in Dikhu. According to the local people of Jang and Adpaba, the landslide was occurred due to the negligence of NHPC, and it could have been avoided with proper preventive work on time. The landslide has severely damaged the 55 metre high dam of the 610 MW Teesta Hydropower Project of NHPC.

2020 8th August:

A massive landslide occurred in Jorethang in south Sikkim. A road in Jorethang was also washed off due to heavy rainfall in the region. The IPCA laboratory in Mazhitang, Jorethang was badly damaged in the landslide. The house was also completely washed away due to the landslide triggered by heavy rainfall in the area.

2022, 5th February:

A landslide occurred at Pathing village in Namchi district due to heavy rainfall. 60 houses were damaged in this landslide.

2023, 18th June:

Multiple landslides induced by heavy rainfall have damaged over a hundred houses in West Sikkim district. The incessant rain has caused extensive damage to infrastructure and property in the state.

## Management: -

Guidelines by the National Disaster Management Authority (NDMA) on management of landslides reduce the enormous destructive potential of landslides and minimize the consequential losses by institutionalizing the landslide hazard mitigation efforts. Preventive and corrective measures to lessen the impacts of landslides can not be stopped. But Number, frequency, recurrence and severity can be minimized. Some preventive measures have been taken to manage landslide in the study area -

**Contour bunding:** Earthen embankment was constructed at intervals across the slope and along the contour line of the many landslides in Sikkim. A series of such bund is very useful in dividing the area into strips and act as barrier to the flow of water.

### Bench terracing:

Relatively steep land was transformed into a series of level or nearly level strips or benches running across the slope of many landslides in south Sikkim.

### Rock slope netting:

Rock netting used to cover on entire area of unstable rock. The slope netting can be either draped or bolted in each corner of each panel. Rock

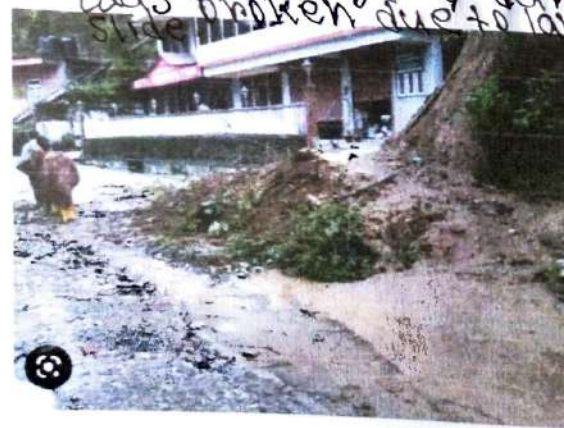
# Some Instances of Landslide in the study area



A landslide occurred at Pathing village in Namerhidue. The IDEA laboratory was badly affected due to landslide.



3. Teesta stage-y dam was broken due to landslide 4: landslide



### 34 Management:-

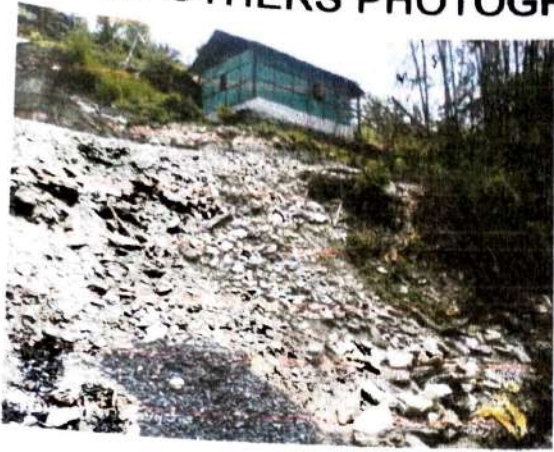
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Contour bunding: Earthen embankment was constructed at intervals across the slope and along the contour line of the many landslides in Sikkim. A series of such bund is very useful in dividing the area into strips and act as barrier to the flow of water.

Bench terracing: Relatively steep land was transformed into a series of level or nearly level strips or steps running across the slope of many landslides in south Sikkim.

Rock slope netting: Rock netting used to cover on entire area of unstable rock. The slope netting can be either draped or bolted in each corner of each panel. Rock

SOME OTHERS PHOTOGRAPHS RELATED TO LANDSLIDE



Netting is used where the unstable rock is big and blocky. It is a new technique of landslide control which is used for landslide control in Sikkim.

### Contour trenching:-

Series of deep pit or trenches across the slope at convenient distance was built within the landslide of South Sikkim. The soil excavated from the trenches was deposited on the lower edge of trenches where forest trees were planted.

### Sausage wall:

Preference was given to sausage wall among the mechanical method in every landslide of Sikkim and every landslide was nearly checked by applying sausage wall.

## Suggestive measures:—

Along with the management system of landslide in Sikkim Himalaya a some other measure should be taken.—

(i) During Planning of any disruptive project in the high risk zone like Sikkim, should be proceed with Prudence.

(ii) Environmental Impact Assessment standards should be followed before mining or dam building.

(iii) Landslide micro zoning method should be implemented in the extremely vulnerable areas.

(iv) To strengthen disaster management potential more soundings should be given to landslide planning and mitigation agencies.

(v) To strengthen hazard reduction and public awareness efforts, locally available trained people should be enlisted.

(vi) mitigation technique such as confining agriculture to valleys and places with moderate slopes fostering large-scale afforestation initiative and building water bunds should be encouraged.

(vii) Encouraged the use of effective landslide rehabilitation and mitigation technique



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