

VIDYASAGAR UNIVERSITY

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



**B.SC HONOURS (GEOGRAPHY)
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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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CONTENTS:-

- A. Acknowledgment
- B. List of Map
- C. List of Tables
- D. List of figures
- E. List of photographs

1.0. INTRODUCTION

- 1.1. Introduction
- 1.2. concept of landslide
- 1.3. Study Area
- 1.4. Objectives
- 1.5. Research question
- 1.6. Data base and Methodology
- 1.7. Tools and Techniques
- 1.8. Limitation of study

2.0. GENERAL OVERVIEW

- 2.1. Physical Environment
 - 2.1.1. Physiography
 - 2.1.2. Drainage
 - 2.1.3. Soil
 - 2.1.4. Climate
 - 2.1.5. Flora & Fauna
- 2.2. Socio-economic Environment
 - 2.2.1. Demography
 - 2.2.2. Literacy
 - 2.2.3. Culture
 - 2.2.4. Health

2.2.5. Economy

2.2.5.1. Agriculture

2.2.5.2. Industries

2.2.5.3. Eco - tourism

2.2.6. Transport

3.0. LANDSLIDE IN STUDY AREA

3.1. causes of landslide

3.2. consequence

3.3. Some instances of lands-
lide the study area

3.4. Management

3.5. Suggestive measures

4.0. CONCLUSION

LIST OF TABLE

- 1) Temperature and rainfall data of Sikkim (17)
- 2) Population composition in Sikkim (17)
- 3) Literacy rate of Sikkim (17)

LIST OF FIGURES

- 1) Temperature and rainfall of Sikkim
- 2) Population composition in Sikkim (2011)
- 3) Literacy rate of Sikkim (2011) (18)

LIST OF PHOTOGRAPHY

- 1) Physical Environment
- 2) Socio-economic environment
- 3) Some instances of landslide the study area
- 4) Management

Introduction :-

Disasters and natural 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-climatic conditions. Disasters such as floods, earthquakes, drought, cyclones and landslides have been major events within the country (Chopra, R., 2018). A hazard may be defined as the perilous conditions or events that are threatening or have the potential for causing injury to life, 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 geological such as cyclone, tsunami, earthquake, landslide, floods, drought and volcanic eruption. 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 explosion, leakage of toxic wastes, pollution, dam failure, wars or civil strife (Dey & Singh, 2006).

Landslide is also called as semi-natural hazard as it originates due to natural phenomena and also by human activities. Landslide is the 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 landslide in Sikkim. In the present project paper it is discussed about the causes, effects and management of landslide 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 by activities along with natural phenomena.

Concept of landslide :-

A landslide is the movement of a mass of rock, debris of earth down a slope. landslide is a type of mass wasting which denotes any down-slope movement of soil and rock under the direct influence of gravity (S. Singh 2018). The term "landslide" encompasses five modes of slope movement, falls, topples, slides, spreads and flows. These are further subdivided by the type of geologic material (bedrock, debris or earth). A landslide is further subdivided by the type of geologic material (earth or soil). Landslide occurs when gravitational and other type of shear stresses can be built up with up with in a slope by a 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 Himalays high rainfall regions with steep slope, 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 and the 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 define and extremely deep watershed. The state is situated between $27^{\circ}09' N$ 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 chuombi 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, west, north and south

The state lies between very high and high landslide vulnerable zone on the basis of intensity of the controlling factors of landslide, though north and East Sikkim are in very very risk zone of landslide.

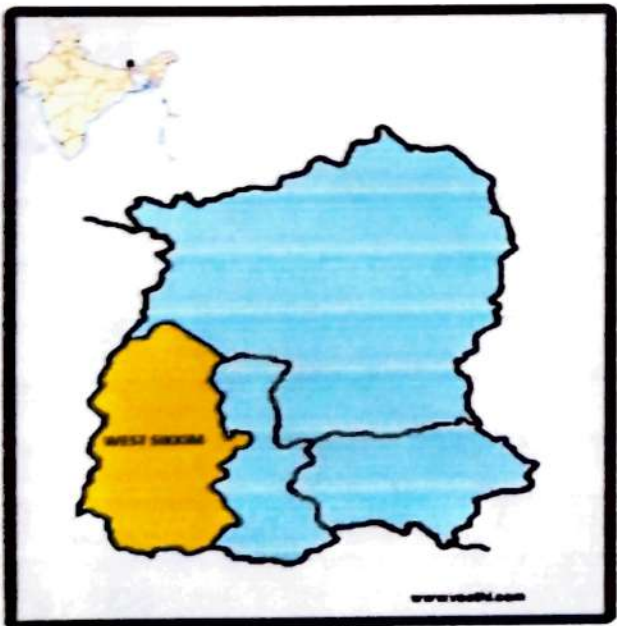
LOCATION MAP



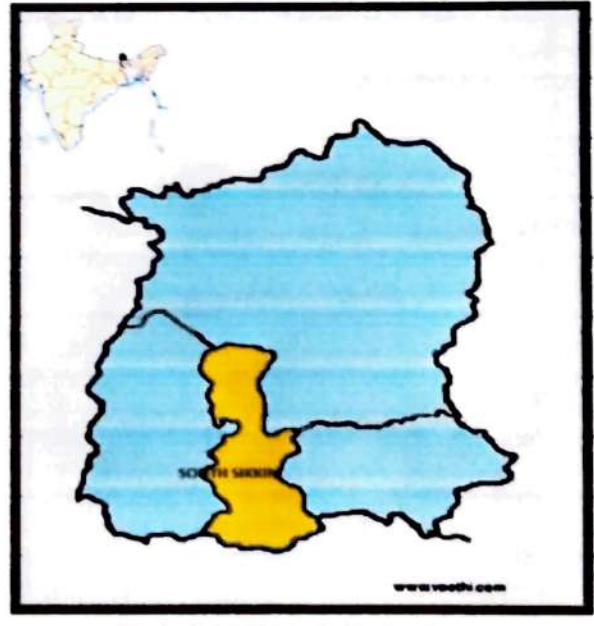
1. INDIA



2. SIKKIM



4. WEST SIKKIM



3. SOUTH SIKKIM

frone areas. west and south District of sikkim lies at an altitude of more or less 400 meters to 2500 meters with unique countryside escape of endless waves of agricultural fields and the terraced slope, intercepted by spring patched forests. Tourism development road construction increasing rate settlement triggering the rate of landslide every year. Hence, in the present study area 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, consequences 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 of landslide and its consequences 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.

Research question :-

- (i) what is the nature of landslide in west and south Sikkim.
- (ii) what are the main causes of landslide?
- (iii) what are the effects of landslide on the lives of the local people?
- (iv) what measures have been taken to prevent landslide from government?

Data base and methodology :-

→ The data has been collected from two sources — primary and secondary. The primary data has been collected from hotel manager, car driver, local people and seller of souvenir shop. The secondary data were collected from — various books, article, different link from website journal etc.

→ We collected data from hotel manager, car driver, 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 prone area.

→ Different cartographic techniques have been chosen to represent the data properly. we used bar and

Line graph to show rainfall and temperature, to represent demography and literacy we have use pie or bar diagram.

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 condition, different language between survey field and surveyor, bad weather condition etc. which prevailed in that area was not dealt properly.

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, relief structure, nature of slope, type of rock and its resistance power to erosion, soil, climatic nature (specially rainfall), vegetation cover, etc all are the controlling factors of landslide. Apart from these, human activities such as, economic activities, developmental works also affect on landslide. on the other hand, physical and socio 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 thought to know the cause and consequence of landslide in the study area.

Physical Environment

Physiography :-

Situated in the Himalayan mountains, the state of Sikkim is characterised by mountainous terrain. Almost the entire state is hilly, with an elevation ranging from 580 meters (1904ft) in south of the border with West Bengal to 8586 meters (28169ft) in northern peaks near Nepal and Tibet. The Summit of Kangchenjunga, 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 unfit for agriculture because of the rocky precipitous slopes. However, some hill slopes have been converted into terrace farms.

Drainage ::

Sikkim is drained by large number of perennial rivers, which merge into two prominent rivers, The Teesta and the Rangit, Rest of other streams.

eventually joins one or the other. Rongit also joins the teesta just near the boundary between Sikkim and West Bengal.

The Rongit river and its tributaries originate in the Talung glaciers in West Sikkim and after flowing for about 60 km, joins Teesta below Mallick near the border of Sikkim with West Bengal. River Rongit is a major tributary of River Teesta from the western Sikkim. Major tributaries of Rongit are Rimbi Khola, Rathongchhu, Kaley Khola, Ramam Khola and the little Rongit.

Soil :-

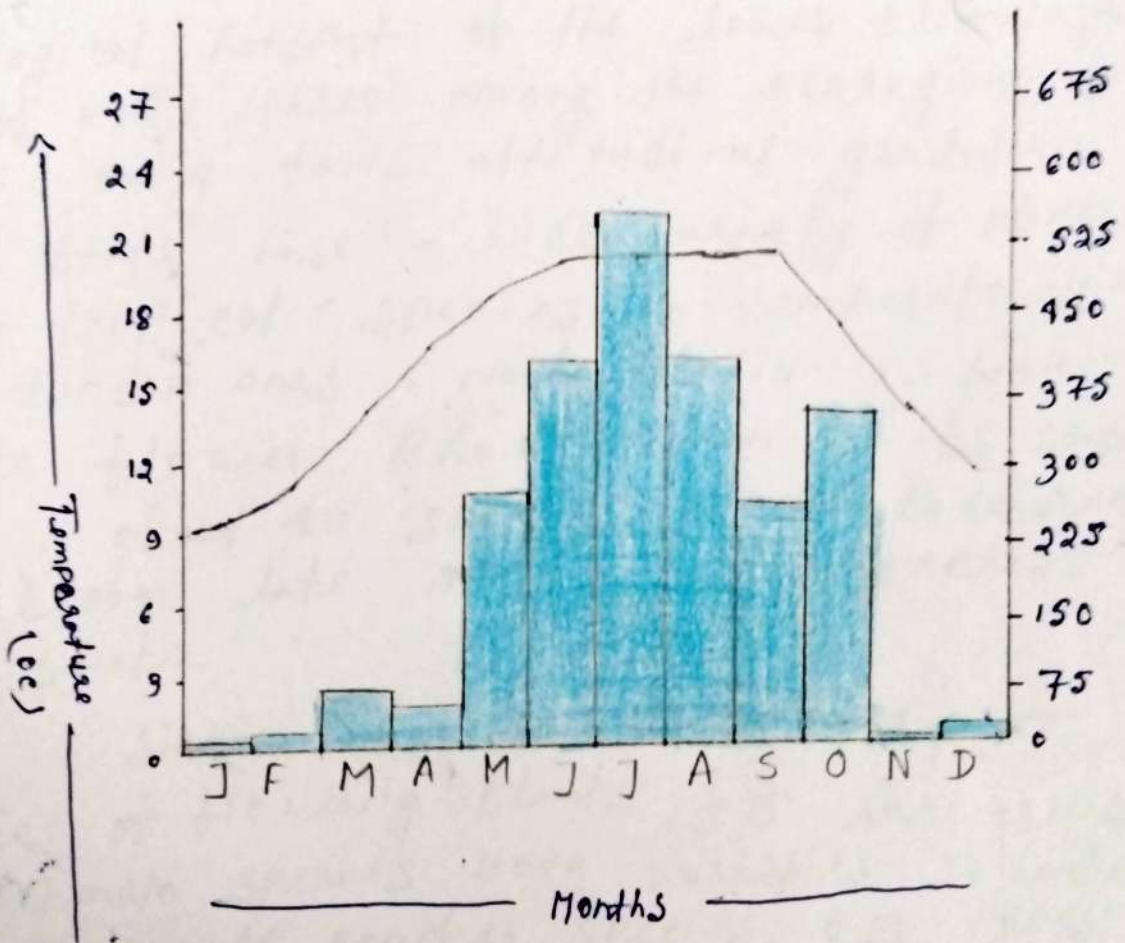
The hills of Sikkim mainly consist of gneiss and schist, which weather to produce generally shallow brown clay soils. The rock consists of phyllites and schists.

Climate :-

The State has five seasons: winter, summer, spring, autumn; and monsoon seasons. Most of the inhabited regions of Sikkim experience a temperate climate with temperatures seldom exceeding 28°C in summer. The average annual temperature for most of Sikkim is around 18°C . During the monsoon heavy rains increase the risk of landslides. The record for the longest period of continuous rain in Sikkim is

Month	temperature (°C)	scale	tempura Fahrenheit	Rainfall mm	scale	Rainfall (cm)
January	9.7	1 cm = 3°	3.13	6.1	1 cm = 7.5 mm	0.09
February	10.9		3.63	21.9		0.29
March	13.7		4.56	57.0		0.76
April	16.6		5.53	45.5		0.60
May	18.7		6.23	266.4		3.55
June	20.3		6.76	397.0		5.28
July	20.3		6.76	594.1		7.38
August	20.4		6.8	401.3		5.35
September	19.6		6.53			3.41
October	17.3		5.76	339.9		4.46
November	13.9		4.63	3.9		0.052
December	11.1		3.7	22.7		0.30

CLIMATE GRAPH FOR SIKKIM



11 days. Fog affects many parts of the state during winter and the monsoons, making transportation perilous. Temperatures in the mountain can drop to as low as -40°C in winter.

Flora and fauna :-

Sikkim is situated in an ecological hotspot of the lower Himalayas, 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, noble orchid is Sikkim state flower. Rhododendron is its state tree, about 40 species of Rhododendron bloom late April - mid May across the state.

Sikkim is home to around 5,000 species of flowering plants, 515 rare orchids, 60 primula species 1100 varieties 23 bamboo varieties, 16 conifer species, 362 types of ferns and ferns allies, 8 tree ferns, and over 900 medicinal plants. A relative of the poinsettia locally known as "Christmas flower", can be found in abundance in the mountainous state.

The found Sikkim include the snowed pard, musk deer, Himalayan

Yak, Red Panda, Himalayan monal pheasant, Himalayan serow, Himalayan goral muntjac, common langur, Asian black bear, clouded leopard, marbled cat, leopard cat, shal, 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.



Hydrobiography



Water flow system (runoff)



Red Clay Soil



Phododendron Plant



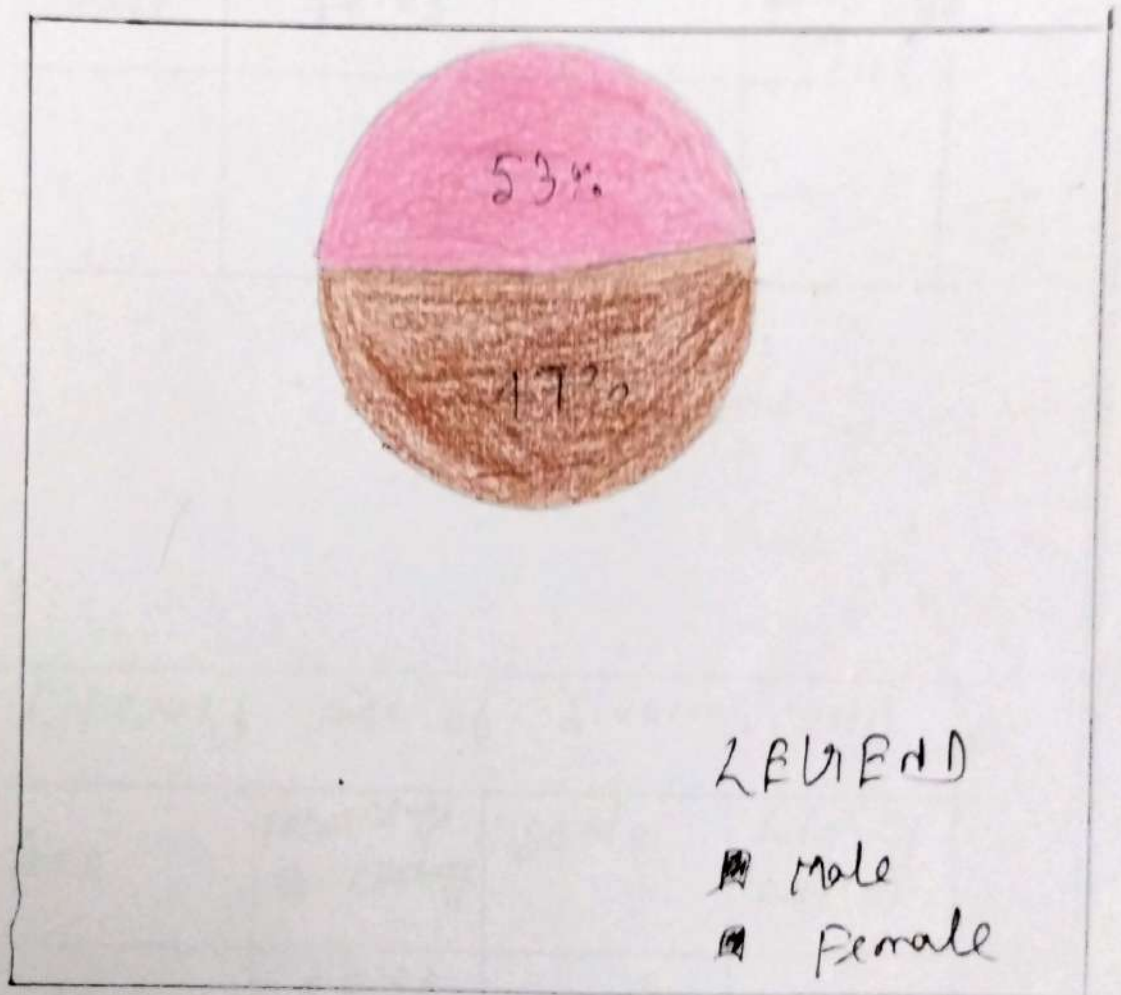
National Animal Red Panda

: Socio economic environment

Demography:

AS PER CENSUS OF INDIA, 2011 TOTAL population of Sikkim was 6.11 Lakhs, Sikkim is the Least populated State of India male 52.87% and female 47.03%.

population composition in Sikkim (2011)



Population composition of Sikkim, 2011

Sex	Percentage of Population	Total Population	Population
Male	53.87		$\frac{53.87}{100} \times 360$
Female	47.05		$\frac{47.05}{100} \times 360$
		✓	

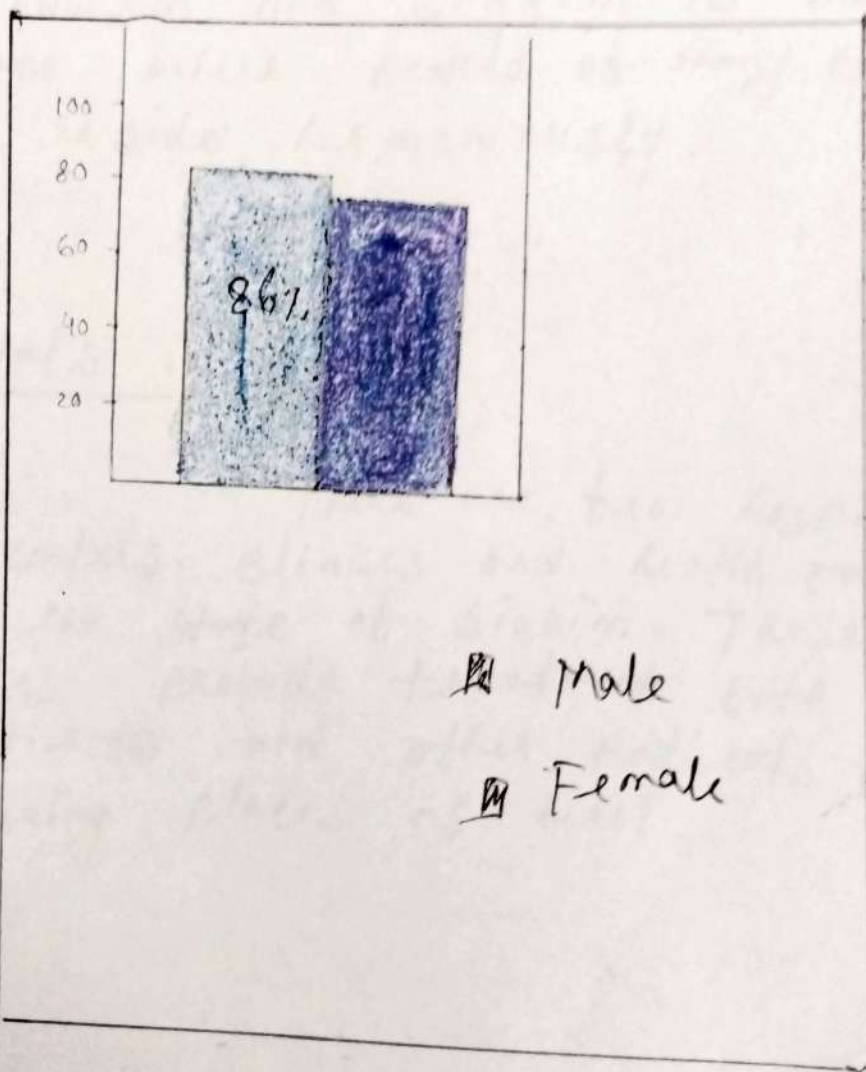
Literacy Rate of Sikkim, (2011)

Sex	Percentage of Literacy	Scale	Literacy Rate (%)
Male	86.55	100 - 20	4.32
Female	76.09		3.80

Literacy :-

Literacy rate in Sikkim stood at 81.42%. where male literacy rate was at 86.55% and female literacy rate 76.09%. census of india, 2011

Literacy Rate of Sikkim



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 Sikkimese are highly devout people and religions play major role in Sikkim. There are major two religions Buddhism and Hinduism. And Sikkim is multi-lingual state where people of many communities reside harmoniously.

Health

Hospitals in Sikkim:-

There are few 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/ STN MHOSPITAL	1	.	.	.	1
2.	DISTRICT HOSPITAL	1	1	1	1	4
3.	COMMUNITY HEALTH CENTER	1	.	.	1	2
4.	PRIMARY HEALTH CENTRE	6	7	5	6	24
5.	PRIMARY HEALTH SUB-CENTRE	48	41	18	39	146
6.	DISTRICT TUBERCULOSIS CENTRE, NAMCHI	.	.	.	1	1
7.	CENTRE REFERRAL HOSPITAL MANIPAL TADONG (PVT)	1	.	.	.	1
8.	TOTAL	58	49	24	48	179

Economy :-

The economy of Sikkim is mainly based on Agricultural and animal husbandry, and tourism. Sikkim's nominal state gross domestic product (GDP) was estimated US\$ 4.6 billion in 2019, with GDP per capita being \$ 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 maize, millet, wheat, barley, oranges, tea and cardamom. Sikkim produces cardamom than any other India state and is home to the largest cultivated area of cardamom (88%). It is estimated that over 80 percent of the rural population depend on agriculture and allied sectors for economic, food and nutritional.

Industry :-

Sikkim has long been an agrarian society. The govt. has formulated certain policies such as Sikkim Industrial Promotion and Incentive (SIPI) Act 2000 and its subsequent amendments in 2003 and 2007, some of the industries of Sikkim that deserve special mention in this context are :- Pharmaceuticals

cosmetics, food processing, Breweries, Matt-
ress, corrugated Boxes, Tea processing etc.

Eco-Tourism:

In January 2016, Sikkim became India's first "100 percent organic" state. The Directorate of eco-tourism under the Forest, Environment and Wildlife Management Department has identified and demarcated 11 areas in Sikkim as eco-tourism. Eco-tourism 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 the restricted and protected areas.

Protected parks and sanctuaries for eco-tourism activities :- Kanhedzong National Park, Singba Rhododendron Sanctuary

Pambong Lho Wildlife Sanctuary, Kyongnosla Alpine Sanctuary, Macnam Wildlife Sanctuary, Varsey Rhododendron's Sanctuary

Transport system of Sikkim

□ Road ways:

National Highway 10 (NH 10; 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. A branch of the highway from Melli connects western Sikkim. Towns in eastern, southern, and western Sikkim are connected to the hill stations of Kalimpong and Darjeeling in northern West Bengal. The state is further more connected to Tibet by the mountain pass of Nathu La.

List of National Highways of Sikkim

Number	Length (km)	Length (mi)	Southern or western Terminus	Northern to Eastern Terminus
NH 10	52	32	Wangtok	Singtam - Rangpo - west Bengal Border.
NH 310	87	54	Ranipool (NH-31A)	Burtok - Menta - Nathula
NH 310A	55	34	Tashi view point	Phodong - Mangon
NH 510	70	43A	Singtam	Damthang - Legsrip - Uyalshing
NH 710	45	28	Melli	Manpur - Namechi - Damthang - Tarku
NH 717A	112	70	West Bengal Border	Rhenock Rorathang Paayong a junction with new NH no 10 at Ranipool near Wangtok.
NH 717B	42	26	Junction with NH 717A at Rhenock - Rongli, Rolep	- junction with NH no. 310 near Menta at Sheathang.

□ Airways :-

There is just one airport is Pasyong, which is around 111.9 km from Sikkim but Bagdogra is well connected to Sikkim about 128 km from Sikkim township.

Here, helicopter service started mainly from tourism purpose.

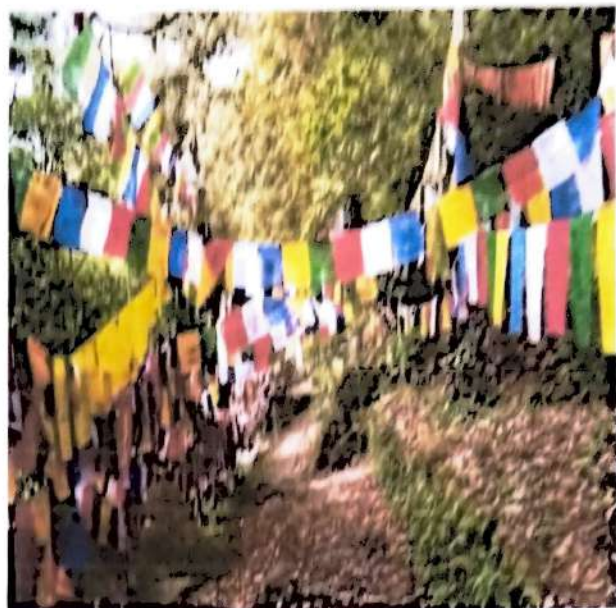
□

Railways :-

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



culture of Sikkim



culture of Sikkim



primary health centre
Dentham



opium cultivation



NH 10

Landslide in study area :-

The frequent occurrence of landslide is a very common phenomena in Sikkim Himalaya, and one that cause the most damage to property and consequence in the landlocked state and also loss of the lives and property. Apart from this recent unplanned development activities, particularly road construction and ill planned settlement, have further aggravated the incidence of the landslide and subsidence.

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 seismically active region and experiences various geological process that can contribute to landslides.

I. Slope Stability:

Step slopes and unstable geological formations can contribute to landslides. The Sikkim region is characterised by rugged terrain with steep slopes, especially in the Himalayan mountain range. The presence of weak rock formation and loose soil can make these slopes prone to landslides.

II. Geological formation:

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

B. Environmental causes:

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

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 month of June to September. The excess water can infiltrate the ground, leading to landslides. 6th August, 2020 saw a large 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 landslide in the region, resulting in loss of life and infrastructure damage.

iii. Erosion :-

Natural erosion process such as river erosion can undercut slopes and weaken their stability, continuous erosion removes support from the base of slopes, making them prone to landslides.

c.

Human related causes :-

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

i. Deforestation

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

ii. 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 without appropriate engineering measures can increase the risk of landslides.

iii. Defective drainage systems.

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.

in Surface modification.

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

↳

Irrigation and water leakage:

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

Consequence :-

The effects of landslide in Sikkim can be significant and have various consequences on the region, the 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 soil pipelines, offices, furniture, commodities, transport system etc. are severely damaged and put out of gear by massive landslide.

B. Social objects

1. Human casualties

If landslides occur in the inhabited areas, the first and foremost adverse impacts are on human population. If 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.

"> Damage to settlement, roads and railroads.

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

* 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 in practice. In the event of massive landslides the terraced 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 floors 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 overtops the debris dams, they are suddenly breached and impounded water gushes downstream 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 in habitations and their belongings resulting in heavy loss of human lives and their properties in the downstream section of the rivers.

E. Effect on Ecosystem

1) Impact of water quality.

When landslide - occurs, 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. This invariably has severe repercussions on water quality and marine life.

ii. Wipe out forest land.

what's more, these hazards can wipe out large tracts of forest, wildlife habitats and remove productive soils from slopes.

iii. Dam up or 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 to. 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.

A. Loss of lives and social disruption

Landslide are, responsible for a number of deaths, injury to people, damage to housing, infrastructure and agricultural lands. In sikkim on sunday, 18 september 2011 at 6.11pm (local time). a Ma 6.9 earthquake with and epicenter located near the sikkim region ($27.723^{\circ}N$, $88.067^{\circ}E$). Killed 77 people, including 16 at the Teesta Stage III Hydroelectric Power Project site,

injured 719, thousands homeless, and temporarily displaced many and also caused substantial loss to livestock.

b. 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, life lines such as roads and highways, railroads, and communication system, Educational institutions, etc. It is significant to note that Socio-Economic problems caused by mass movement of rock waste and landslide due to slope failure are many fold and are assuming large proportion due to expansion of built environment in environment fragile and vulnerable mountainous areas.

Some instances of landslide in the study area.

2007, 19th July

Heavy rain triggered a landslide in Rabangla South Sikkim. The Singtam, Rabangla road has seen as many as 11 landslides while the Namchi - Rabangla 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 19 people perished on the Pelling - Dertam 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 northern Indian state of Sikkim, between Nepal and Bhutan.

2020, 21st June:

A landslide occurred in Totopani at 6pm on Friday. The road constructed across a steep terrain near Totopani remains vulnerable to landslide especially during rainy season and recent baka cutting initiated for the road expansion has added to risk of landslips during on going monsoon season. Legship - Nayabazar road was blocked near Totopani due to the landslide. The commuters travelling from Jorethang to Jyting, Yuasam and Tashiding were compelled to take Reshi - Rinchenpong route via Legship to reach their destination.

2020, 27th June :-

A landslide occurred at national hydro power project of expropriation (NHPE) Teesta stage - V dam on the left bank of the river in Dikhu. According to the local people of Jang and Anpdara, the landslide was occurred due to the negligence of NHPE, and it could have been avoided with proper preventive work on time. The landslide has severely damaged the 55 metre high dam of the 510 MW Teesta hydro power project of NHPE.

2020, 6th August

A massive landslide occurred in Jorathang in south Sikkim. A road in Jorathang was also washed off due to heavy rainfall in the region. The open laboratory in the Mahitar, Jorathang 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 Pothing village in Namchi district due to heavy rainfall. 60 houses were damaged in this landslide.

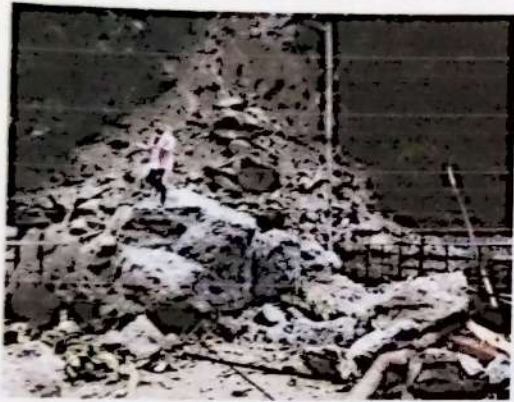
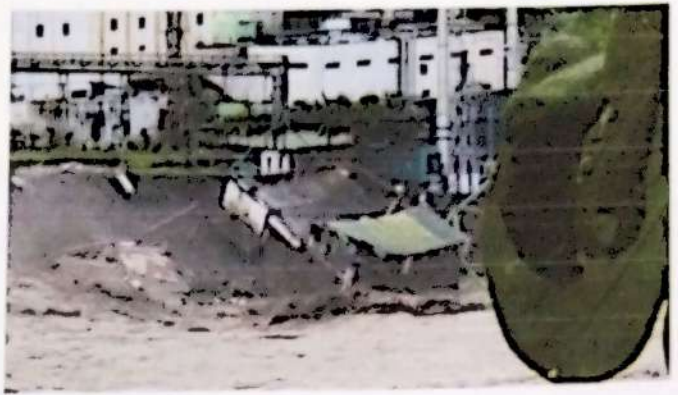
2023, 18th June

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.

Some Instances of Landslide in the study area



A landslide



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 hazard it may be mentioned that landslides cannot be stopped but number, frequency, recurrence and severity can be minimized. Some preventive measures have been taken to manage landslides in the study area -

Contourbundling :-

Earthen embankment was constructed at intervals across the slope and along the contour line of the many landslides in Sikkim. A series of such bunds 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 during across

the slope of many landslide in south sikkim

Rock slope netting :-

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

Contours trenching :-

Series of deep pit or trenches across the slope at convenient distance was built with in 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.

SOME OTHERS PHOTOGRAPHS RELATED TO LANDSLIDE



A landslide occurred at Pothner village in Namche district

The IPCC Jan



Suggestive measure:

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

i) During permitting of any disruptive projects in the high risk zone like Sikkim, should be proceed with prudence.

ii) Environment 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 funding 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 techniques such as contouring agriculture to valleys and place with moderate slopes, fostering large available trained people scale afforestation initiatives and building water bunds should be encouraged.

vii) Encourage the use of effective landslide rehabilitation and mitigation techniques.

Conclusion:

Physiography, climate and other natural phenomena of Sikkim Himalayas make it hazardous with frequent landslides. Human activities play the role as positive catalyst for this calamity. There are spatio-temporal variation in frequency of landslides throughout the districts of Sikkim in the study area. Landslides occur basically due to heavy rainfall along with some associated factors. Many times in erodes massive and unwarranted loss of life and property. Therefore, there should be efficient management of the landslide hazard. There are necessities of the development of institutional capacity and training of institutional engineers and planners. It may be mentioned that landslides can not be stopped by their number, frequency, recurrence and severity can be minimized with some preventive and corrective measures to lessen the impacts of landslides which will help to prevent water entering the hill slopes through joints and cracks, decrease water pressure in the rocks through shallow and sub-surface drainage, place drainage trenches in order to reduce water pressure in the vicinity of hill slopes. The inhabitants of this area should be sensitized through awareness programs, mock drills, posters, and so on and the landslide prone areas of Sikkim require special attention and vigilance to cope up with this calamity.

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