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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Certificate

To whom it may concern

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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.

Date: 08/08/2023

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Place : Rankinipur

Date : 06-08-2023

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Signature

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INTRODUCTION

1.1 Introduction:

Disasters and natural hazards are common and occur not only in India but all over the world. India has been pron to natural disasters, on accunt of geo-climatic conditions; disasters such as floods, earthquakes, droughts, cyclones and landslides have been major within the countny. (Kapur. R. 2018). A hazard may defined as the perilous conditions or events that are thenatening or have the potential for causing injury to life, property on the environment (Dey and 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 methonological, biological and geological such as cyclones, Tsunamis, earthquakes, landslides, floods, drought and volcanic eruptions. On the other hand, manmade hazard are the ones that occur due to human negligence; these are associated with landslide or energy generation power plants and include explosions, leakage of toxic wastes, pollution, dam failura, wars or civil strife or occurrence of fires (Day and Singh, 2006).

Landslide is also called as semi or quasi natural hazard as it originate 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 activities along with natural phenomena.

1.2 Concept of Landslide :

A Landslide is the movement of a mass of Rock, debris or 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 the movement down slope of a Mass of Rock, debris, earth or Soil. Landslide occurs when gravitational and other type of shear Stresses with in a slope exceed the shear strength of the materials that form the slope. Shear stresses can be built up with in a slope by a number of processes.

India has been divided into a number of zone on the basis of vulnerability. Very High and High vulnerability zone having highly unstable, relatively young mountainous areas in the Himalayas, high rainfall regions with steep slopes, the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes etc. and area of intense human activities, particularly these related to construction of roads, dams etc. are included in this zone. All the Hymalayan 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.

1.3 Study Area:

Sikkim is a small, extremely mountainous state in the Himalayas with sharply and extremely deep watershed. The state is situated between 27°04'N to 28.07'N and 88°01'E to 21°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 7096SQ. Km. Sikkim is devided into four districts – East, West, North and South.

The state lies between very high and high Land-Slide vulnerable zone on the basis of intensity of the controlling factors of landslide. Though north and East Sikkim are in very risk zone of landslide. South and West districts of Sikkim are also in high risk zone of landslide prone areas. West and South District of Sikkim lies at an altitude of more or less 400 meters to 2500 meters with unique contryside 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 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.

LOCATION MAP

1. INDIA

2. SIKKIM

3. SOUTH SIKKIM

4. WEST SIKKIM

1.4 Objectives:

The present project paper on landslide has been initated 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 inentify the major causes 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.

1.5 Research Questions:

(i) What is the nature of landslide in West and South Sikkim?

(ii) What are the main causes of Landslide?

(iii) What are the effect of Landslide on the lives of the local people?

(iv) What measures have been taken to prevent landslides from government?

1.6 Data base and methodology:

1.6.1 Source of Data:

The data has been collected from two Sources - Primary and Secondary.

→The primary data has been collected form hotel manager, car driver, local people and Souvenir shop.

→The Secondary data were collected from various book, article, different link from website, Journal etc.

1.6.2 Methods of data collection:

We collected data from hotel manager, car driver, local people and seller of Souvenir shop through interview method. and we gain an understanding of landslides through the observation method while traveling near landslide prone area.

1.6.3 Choice of Techniques:

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.

1.7 Limitation of the Study:

Due to the limited time period surveyor were not able to collect data properly. Besides this some other problem such as poor financial condition, communication gap between respondent and surveyor due to different language etc, which was prevailed in that area. Hence, the study 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 landslide, 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 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 an elevation ranging from 280 metress (920 ft) in the south at the border with west Bengal to 8,586 metress (28,169 ft) 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 becauses of the rocky, precipitous slopes. However, some hill 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 Teesta just near the boundary between Sikkim and West Bengal.

The Rangit river and its tributaries originate in the Talung glacier in West Sikkim and after flowing for about 60km. Joins Teesta bellow Melli near the border of Sikkim withe west Bengal. River Rangit is a major tributary of River Teesta from the western Sikkim. Major tributaries of Rangit are Rimbi Khola, Rathang chhu 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 brown clay soils. The rock consists of phyllites and schists.

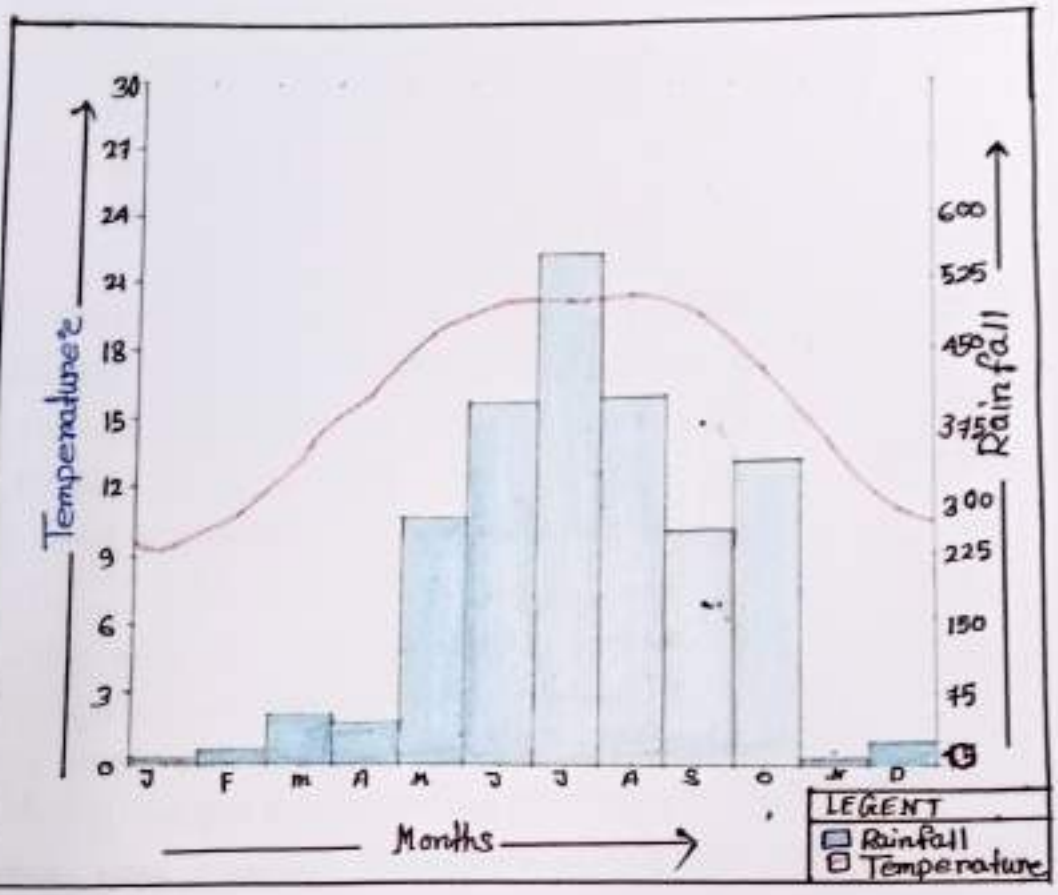
2.1.4 Climate:

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°c in summer. The average annual temperatures 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 11 days. Fog affects many parts of the state during winter and monsoons, making transportation perilous. Temperatures in the mountain can drop to as low as 40°c in Winter.

Month	Temperature (°c)	Scale	Temperature (cm)	Rainfall (mm)	Scale	Rainfall (cm)
January	9.4	1cm = 3°c	3.13	6.1	1cm = 75 mm	0.08
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	394.0		5.25
July	20.3		6.76	554.1		7.38
August	20.4		6.8	401.3		5.35
September	19.6		6.53			3.41
october	17.3		5.76	334.9		4.46
November	13.9		4.63	3.9		0.052
December	11.1		3.7	22.7		0.30

Source: Hydrome Division, India meteorological Department, New Delhi

Temperature and Rainfall data of Sikkim, 2011



2.1.5 Flora and Fauna:

Sikkim is situated in an ecological hotspot of the lower Himalayas, one of only three among the ecoregions of India. 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's state flower. Rhododendron is its state tree; about 40 species of Rhododendron bloom late April – mid may accross the state.

Sikkim is home to around 5,000 species of flowering plants, 515 Rare orchids, 60 primula species 11 oak varieties, 23 bambo 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 Fauna of Sikkim include the snow leopard, musk deer, Himalayan tahr, red panda, Himalayan marmot, Himalayan serow, Himalayan goral, muntjac, Common langur, Asian black beard, clouded leopard, 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 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.

Physiography

Drainage System (Rangeet)

Brown clay Soil

Rhododendron plant

National animal Red panda

Socio-economic Environment

Demography

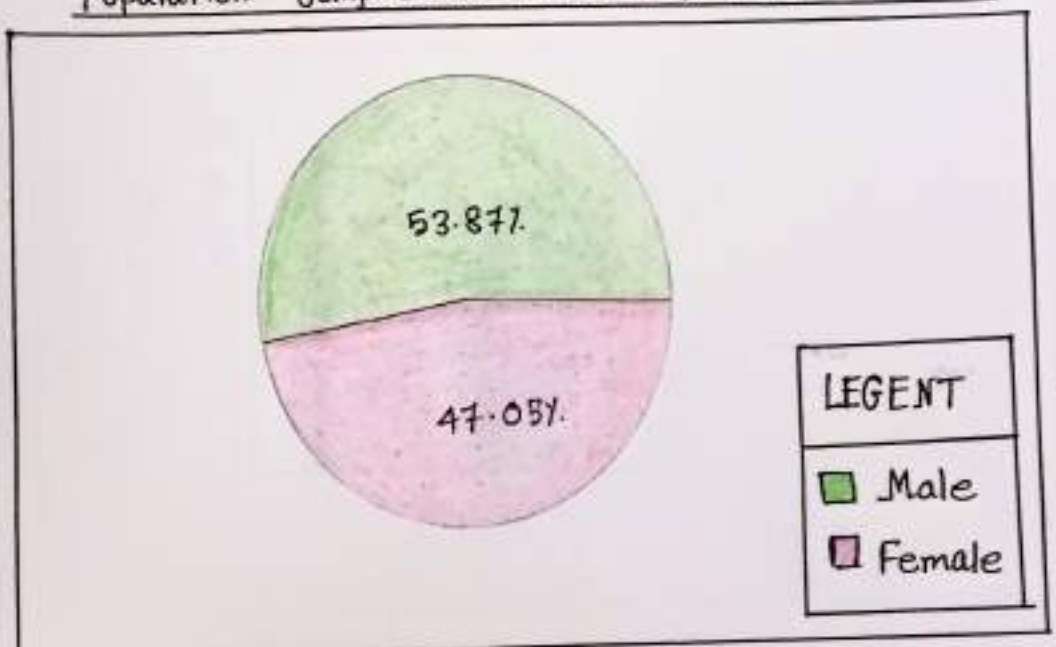
As per census of India, 2011 total population of Sikkim was 6.11 Lakhs. Sikkim is the least populated state of India male 52.87% and Female 47.05%.

Population Composition of Sikkim, 2011

Sex	Percentage of population	Total population	Population
Male	53.87	100	$\frac{53.87}{100} \times 360^\circ = 190^\circ$
Female	47.05		$\frac{47.05}{100} \times 360^\circ = 169^\circ$

Source: Census of India, 2011

Population Composition in Sikkim, 2011



Literacy:

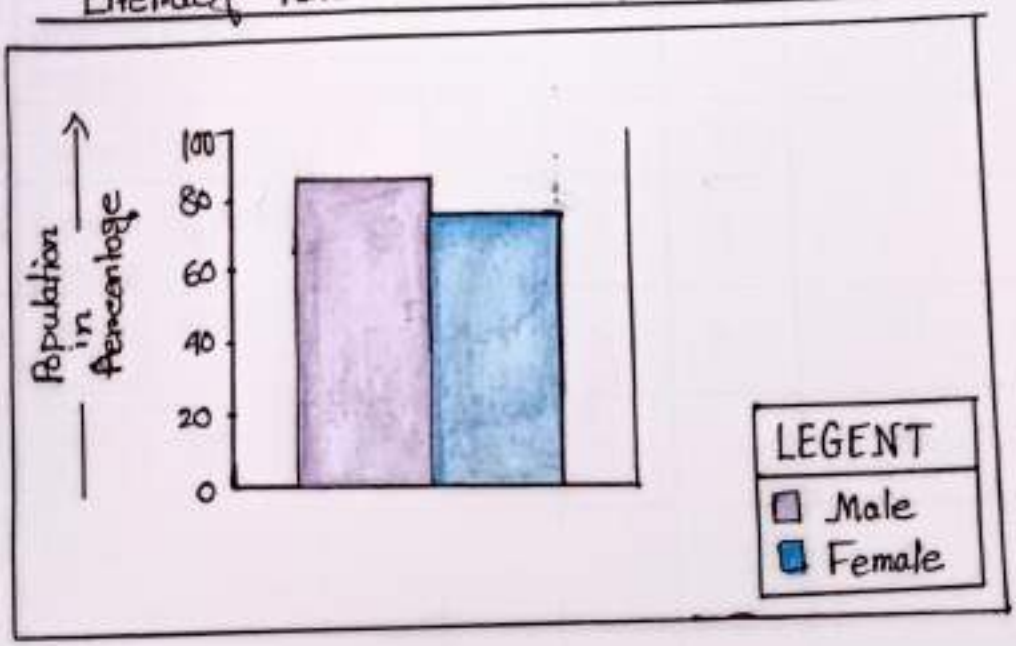
Literacy rate in Sikkim stood was at 81.42%. Where, Male literacy rate was at 86.55% and Female literacy rate 76.04% census of India, 2011.

Literacy Rate of Sikkim, 2011

Sex	Percentage of literacy	Scale	Literacy Rate (Cm)
Male	86.55	1cm = 20	4.32
Female	76.04		3.80

Source: Census of India, 2011

Literacy Rate of Sikkim, 2011



2.2.3 Culture:

In Sikkim the leading communities are the Lepchas, Bhutias and Nepalese. The offical languages of the state are English, Nepali, Sikkimese and Lepcha. The Sikkimeses are highly devout people and Religions play major role in Sikkim. There are mejor 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 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 weel.

Sl No.	Health Institution	East	West	North	South	State
1.	State Referral Hospital/ STNM Hospital	1	-	-	-	1
2.	District Hospital	1	1	1	1	4
3.	Community Health centre	1	-	-	1	2
4.	Primary Health Centre	6	7	5	6	24
5.	Primary Health Sub-Centre	48	41	18	39	146
6.	District Tubbercul-sis Centre, NAMCHI	-	-	-	1	1
7.	Centre Referral Hospital Manipal Tabong (PVT.)	1	-	-	-	1
8.	Total	58	49	24	48	179

2.2.5 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 more cardamom than any other Indian 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 national security.

2.2.6 Industry:

Sikkim has long seen agro-based 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 deserves a special mention in this context are – pharmaceuticals, Cosmetics, Food processing, Breweries, Maltness, Corrugated Bokes, Tea processing etc.

2.2.7 Eco-Tourism:

In January 2016, Sikkim become India's first "100 percent organic" state. The Directorate of Ecotourism under the Forest, Environment and wildlife management Department has identified and demarcated 11 areas in Sikkim as ecotourism. Ecotourism in Sikkim started in the year 1995-96 with training, awareness, changes in regulations to adapt to the mountainous terrain and entry of foreign tourists is many of restricted and protected areas.

protected parks and sanctuaries for eco-tourism activies - kanchendzonga National park, Singba Rhododendron Sanctuary, Fambong lho wildlife Sanctuary, Kyongnosla Alpine Sanctuary, Maenam wildlife Sanctuary, Varsey Rhododendron Sanctuary.

2.2.8 Transport System:

2.2.8.1 Roadways:

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. Towns in 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 Nathula.

- **List of National Highways of Sikkim**

Number	Length (Km)	Length (mi)	Southern or Western Terminus	Northern to Eastern Terminus
NH10	52	32	Gangtok — Singtam — Rangpo — West Bengal Border.	
NH310	87	54	Ranipool (NH-31A) — Burtuk — Menla — Nathula.	
NH310A	55	34	Tashi view point — Phodong — Mangan	
NH510	70	43	Singtam — Damthang — Legship — Gyalshing.	
NH710	45	28	Melli — Manpur — Namchi — Damthang — Tarku.	
NH711A	112	70	West Bengal Border — Rhenoc, Rorathang pakyong a Junction with new NH 10 at Ranipool near Gangtok.	
NH711B	42	26	Junction with NH NO. 117A at Rhenock — Rongli, Rolep — Junction with NH NO. 310 near menla at Sherathang.	

2.2.8.2 **Airways**:

There is just one airport is pakyong, which is around 111.9 km from Sikkim but Bagdogra is well connected to Sikkim (about 125 km from Sikkim township).

Here, helicopter service started mainly for tourism purpose.

2.2.8.3 **Railways**:

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

Culture of Sikkim

Culture of Sikkim

Primary Helth center in Dentham valley

cardamon Cultivation

NH 10

Landslide in Study Area :

The frequent occurrence of landslide is a very common phenomenon in Sikkim Himalaya and one that causes the most damage to property and connectivity in the landslide locked state and also loss of the lives and property. Apart from this, resent unplanned development activites, particularly road construction and ill planned settlements, 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 —

Geological Causes :

Sikkim, a state in north-eastern India, is located in a Seismically active region and experiences various geologically process that can contribute to landslides.

Slope Stability :

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

Geological formation :

The Geological formation of Sikkim consistes of complex and varied rock types, including schits, gneisses, phyllites. and quintzites. Some of these rocks have inherent weaknesses and discontinuities, such as bedding plans, soints and faults which can act as potential sliding surfaces.

Environmental Causes :

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

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 September. The excess water can infiltrate the ground, leading to landslides. 6th August, 2023 Zarathang, Land Slide in west Sikkim.

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.

Erosion:

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

Human-related Causes:

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

Deforestation:

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

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 landslide.

Defective Drainage Systems

Inadequate on poorly designed drainage Systems can lead to the accumulation of water in the soil, increasing poore pressure and reducing the shear strength of slopes. This can result in slope failures and landslide.

Surface Modification

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

Irrigation and Water Leakage

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

Consequences of landslide in Sikkim

Physical Effects:

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

Social Effects:

Human casualties:

If landslide occur in the inhabited areas, the first and foremost advers impacts are on human population. If there is no timely forewarning of probable occurrence of landslide 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 settlements, roads and railroads:

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

Economical Effects:

Loss of agricultural farms and crops:

At the very outset it may be pointed out that mejority 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 terrace farms are completely destroyed by falling debris of rocks. Bouldens, 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 coven.

Environmental Effect

Damming of rivers and Flash floods:

Huge volume of debris produced by landslide of various size coming into the rivers Rapid 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 lives are also ruined When the impounded water overtops the debris dams, they are suddenly breached and impounded water pushes downstream with high velocity resulting into flash floods. Such landslide dam generated flash floods wash out every thing 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.

Effect on Ecosystem:

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. This instability has severe repercussions on water quality and marine life.

Wipe out Forest land:

What's more, these hazards can wipe out huge tracts of forest, wildlife habitats and numerous productive soils from slopes.

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 too. Outburst floods can introduce a tremendous amount of new sediment into streams, or they can submerge and kill vegetation in the flooded region. I Great Floods, flood killed 22 people, triggered a series of landslides and

Washed away nearly 30 Km of highway in north Sikkim amid torrential rain.

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 6:11 PM (local time), a Mw 6.9 earthquake with an epicenter located near the Sikkim region (27.723°N, 88.064°E), killed 77 people, including 16 at the Teesta stage III Hydroelectric power project site, injured 719, left thousands homeless and temporarily displaced many and also caused substantial loss to livestock.

Socio-Economic effect 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 system, educational institution etc. It is significant to note that socio-economic problems caused by mass movement of rock waste and landslide due to slope failures are many fold and are assuming larger 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-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 landslide in pelling. Where 14 people perished on the Pelling-Dentam 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 occured in Tatopani at 6PM on Friday. The road constructed across a steep terrain near Tatopani remains vulnerable to landslide especially during rainy season and recent back cutting initiated for the road expension 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 Jorethang to Geyzing, Yuksam and Tashiding were compelled to take Reshi-Rinchenpong route via Legship to reach their destination.

2020, 27th June:

A landslide occured at National Hydro-power Project of Corporation (NHPC) Teesta stage-v dam on the left bank of the river in Dikchu. According to the local people of Jang and Aapdara, the landslide was occured 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 510 MW Teesta Hydropower project of NHPC.

2020, 6th August:

A massive landslide occured in Jorethang in South Sikkim. A road in Jorethang was also washed off due to heavy rainfall in the region. The IPCA Laboratory in the Mazhitar, 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 occured at Pathing village in Namchi district due to heavy rainfall. 60 houses were damaged in this landslide.

2023, 18th June:

Mutiple 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

Pathing village in namchi district due to heavy rainfall

The IPCP laboratory was badly effected due to landslide

Teesta Stage - V dam was broken due to landslide

Landslide all over Sikkim due to earthquake

14 people died in pelling due to landslide

Legship - Nayabazar road was damaged due to Landslide

Namchi - Rabongla road was closed due to landslide

Management of Landslide in Sikkim:

Guidelines by the National Disaster Management Authority (NDMA) on management of landslide 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 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 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 steeps land was transformed into a series of level or nearly level strips or steeps running across the slope of many landslides 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.

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 where 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

Landslide prone area unplained Settlement

Heavy Rainfall Lad devastated over a hundred houses in west Sikkim

Uprooted tree due Landslide

Land Subsidence

Rock Slope Netting

Benth terracing

Suggestive Measures

Along with the management system of land-Slide in Sikkim Himalaya some other measure should be taken.

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

(ii) Environmental Impact Assesment Standards Should be followed befor 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 awarness efforts, locally available trained people should be enlisted.

(vi) Mitigation techniques 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 techniques.

Conclusion

Physiography, climate and other natural Phenomena of Sikkim Himalayas, make it hazardous, with frequent landslide. Human activities play the role as positive catalyst for this calamity. There are spatio-temporal variation in frequency of landslide throughout the districts of Sikkim. In the study area landslides occur basically due to heavy rainfall along with some associated factors. Many times it creates 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 for geo-scientist, engineers and planners. It may be mentioned that landslide can not be stopped but their number, frequency, recurrence and severity can be minimized with some preventive and corrective measures to lesser 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-shallow 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 the landslide prone areas of Sikkim require special attention and vigilance to cope up with this calamity.

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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 :- 1520145 OF 2020 - 2021

ROLL NO :- 1126152 - 200019

SESSION :- 2022 - 2023

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Certificate

To whom it may concern

This is to certify that Susmita Gini
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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.

Date: 08/08/2023

09.08.23

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CONTENT

SECTION-III :- LANDSLIDE IN STUDY AREA

SECTION-IV :- CONCLUSION

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Place: Amdabad

Date: 6.08.2023

Susmita Giri

Signature

LIST OF MAP

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1.0 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, droughts, cyclons and landslides have been major with in the country. (Kapur, R, 2018). A hazard may defined as the perilous conditions or events that are threatening or have the potential for causing, injured 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 cyclones, tsunamis, earthquakes, landslide, 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 wastes, 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 originate 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 on constructional works in different of 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 also triggered by human activities along with natural phenomena.

1.2 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°04′ N to 28°07′ N and 88°01′ E to 27°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, 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. Through north and East Sikkim are in very risk zone of landslide, South and West districts of Sikkim

LOCATION MAP

1. INDIA

2. SIKKIM

3. SOUTH SIKKIM

4. WEST SIKKIM

are also in high risk zone of landslide prone 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 slopes, intercepted by spring patched forests. Tourism development, road construction, increasing rate settlement triggering the rate of 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, consequences and manggement

1.3 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 consequences in the study area specially in West and South Sikkim.
- To asses the effective landslide management techniques and to give some suggestive measures to prevent landslide in the study area.

1.3 ⊘ **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 landslides 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 managen, car driver, 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 managen, car driver, local people and seller of souvenir shop through interview method, and we gain an understanding of landslides through the observation method while travelling near landslide prone area.

→ Different cartographic techniques have been chosen to represent the data properly. We used to bar and Line graph to show rainfall and temperature. To represent demography and literacy we have use pie and/ bar diagram.

1.7 Limitation of the study :-

Due to the limited time period surveyor were not able to collect data properly. Besides this some other problem such as poor financial condition, communication gap between respondent and surveyor due to different language etc. which was prevailed in that area. Hence the study was not dealt properly.

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, 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 devasted 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 an elevation region from 580 metres (920 ft) in-the south at-the border with West Bengal 8.586 metres (28,169 ft) in northern peaks near nepal and Tibet. The summit of Kangchenjunga the world's "third-highest peak. is-the state" highest point, situated on-the border between Sikkim and Nepal. For-the most part-the land is unfit agriculture because of-the rocky, precipitous slopes. However, some hill 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 Rongit river and its tributaries originate in the Talung glacier in West Sikkim and after flowing for about 60 km. Joins Teesta below Malli near the border of Sikkim with West Bengal. River Rangit is a major tributary of River Teesta from the Wester Sikkim. Major tributaries of Rangit are Rimbi khola, Rathangchhu Kalej Khola. Ramam khola and the little Rangit.

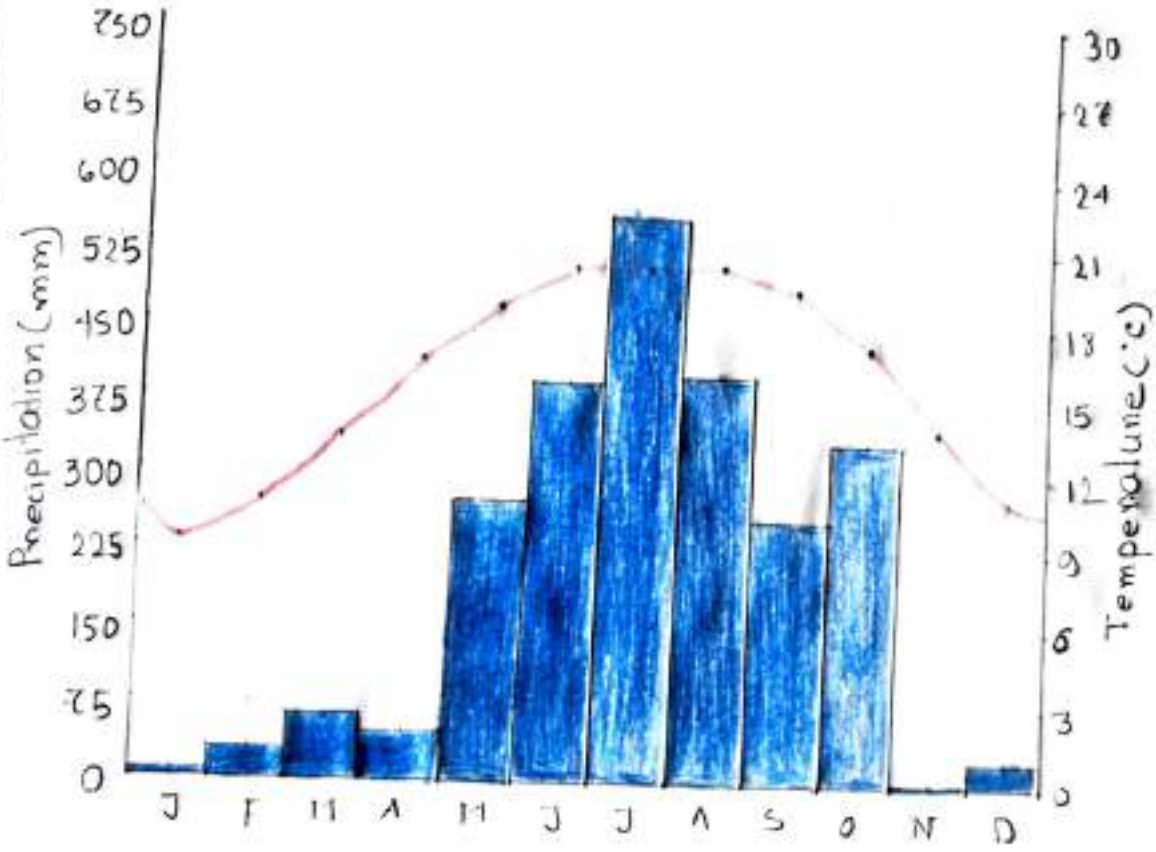
2.1.3 Soil :—

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

2.1.1 **Climate** :-

The state has five season: Winter, Summer, Spring, Autumn, and Monsoon season. 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 continous rain in Sikkim is 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° in Winter.

CLIMATE GRAPH FOR SIKKIM



SCALE	
Precipitation	1 cm 75 mm.
Temperature	1 cm to 3°C

LEGEND	
Precipitation	
Temperature	

2.1.5 **Flora and Fauna** :-

Sikkim is situated in an ecological hotspot of the lower Himalayas, one of only three among the ecoregions 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 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 ferns allies, 8 tree ferns and over 900 medicinal plants. A relative of the poinsettia, locally know as "Christmas Flower", can be found in abundance in the mountainous state.

The Fauna of Sikkim include the snow leopard, muskdeer, Himalyan tahr, red panda goral, muntjac, common langun, Asian black bear clouded leopard, Marbled cat, leopared cat, dhole, Tibetan wolf, hog badger, binturong and Himalyan jungle cat. Among the animals more commonly found in the alpine zone are yaks, mainly reared for their milk, meat and as 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.

1. Physiography.

2. Rangeet River.

3. Brown-clay soil

4. Rhododendron tree.

5. Red pand, state animale of Sikkim

2.2 Socio-Economic Environment :-

2.2.1 Demography :-

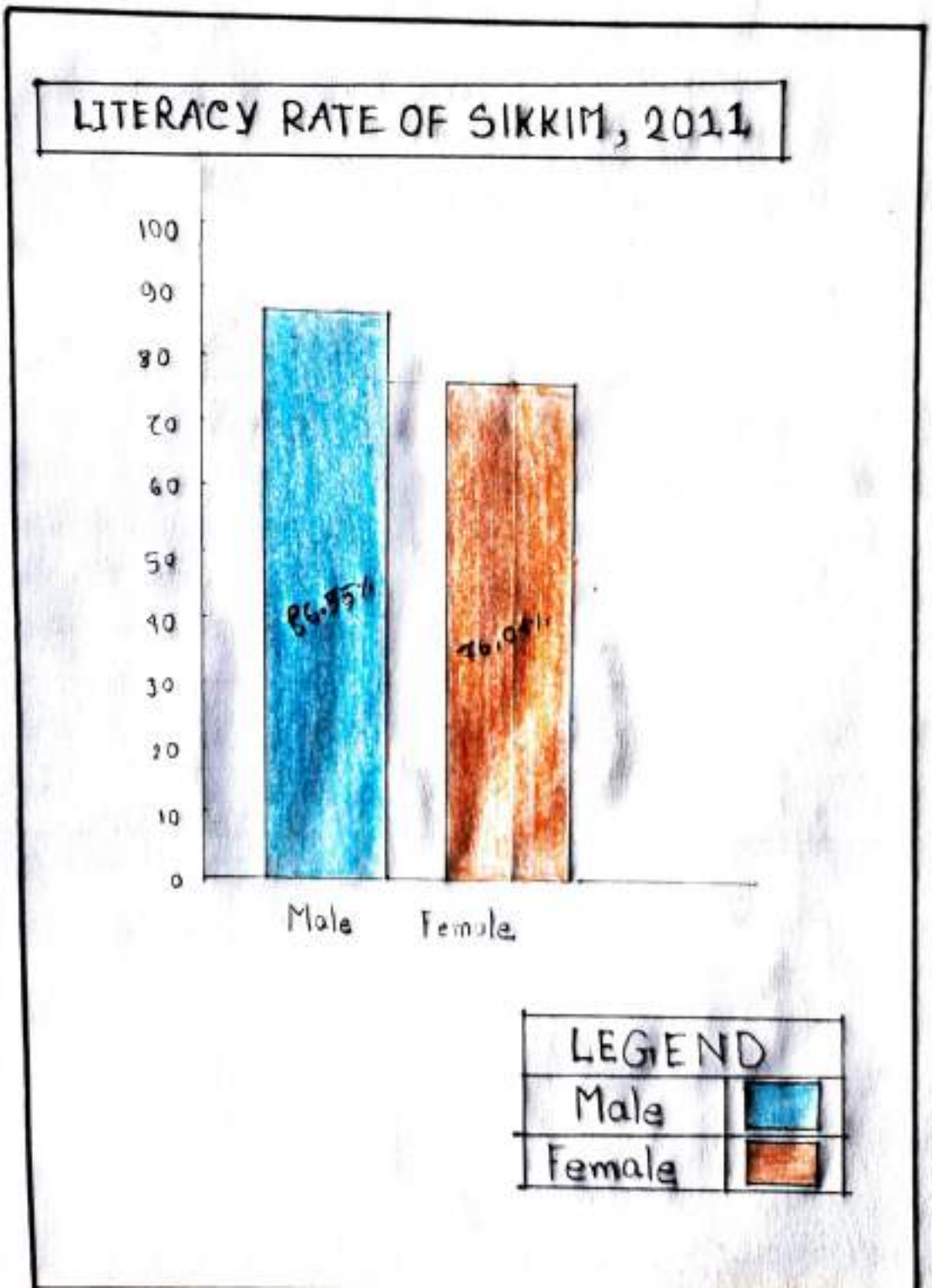
As per census of India, 2011 total population of Sikkim was 6.11 lakhs. Sikkim is the least populated state of India. male 52.87% and female - 47.05%.

POPULATION COMPOSITION

LEGEND	
Male	
Female	

2.2.2 **Literacy :-**

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



2.2.3 Culture :-

In Sikkim the leading communities are the Lepchas, Bhutias and Nepalese. The official language 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 Bhuddhism and Hinduism. And Sikkim is multi-lingual state where people of many communities beside harmonously.

2.2.4 Health :-

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 phaces as weel.

Sl. No.	HEALTH INSTITUTION	EAST	WEST	NORTH	SOUTH	STATE
1	STATE REFERRAL HOSPITAL/ STAM HOSPITAL	1	.	.	.	1
2	DISTRICT HOSPITAL	1	1	1	1	4
3	* COMMUNITY HEALTH CENTRE	1	.	.	1	2
4	PRIMARY HEALTH CENTRE	6	7	5	6	24
5	PRIMARY HEALTH SUB-CENTRE	18	41	18	39	116
6	DISTRICT TUBERCULOSIS CENTRE, NAMCHI	.	.	.	1	1
7	CENTRE REFERRAL HOSPITAL MANIPAL TADONG (PVT)	1	.	.	.	1
8.	TOTAL	58	49	24	48	179

2.2.5 ECONOMY :—

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

2.2.5.1. Agriculture :—

Economy of Sikkim is largely agrarian based on the ternaced farming of rice and the cultivation of crops such as maize, millet, wheat, barley, oranges, tea and cardamom. Sikkim produces more cardamom than any other Indian state and it's home to the longest 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 national security.

2.2.5.2. Industry :—

Sikkim has long been agrobased 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 deserves a spetial mention in this context are :— Pharmaceuticals, Cosmetic, Food processing, Mattress, Tea processing etc.

2.2.5.3. **Eco-Tourism** :-

In January 2016, Sikkim became India's first "100 percent Organic" state. The Directorate of Ecotourism under the forest, Environment and Wildlife Management Department has identified and demarcated 11 areas in Sikkim as ecotourism. 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 tourist in many of restricted and protected areas.

Protected parks and santuanies for ecotourism activities :- Kanchedzong National Park, Singba Rhododendron sanctuary, Fambong Lho Wildlife Santuary, Kyongnosla Alpine Santuary, Maenam wildlife santuary, Versey Rhododendron santuary.

2.2.6 **Transport** :-

National Highway 10 (NH 10; Formerly NH 31A) links Siliguri to Gangtok. Sikkim nationalised transport runs bus and truck services. Primately run bus, tourist taxis and jeep services operate throughout Sikkim and also connect it to Siliguri. A branch of the highway from Melli connects western Sikkim. Towns is 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	Gangtok - Singtam - Rangpo - West Bengal Border.	
NH 310	87	54	Ranipool (NH-31A) - Burtuk - Menla - Nathula.	
NH310A	55	34	Tashi view point - Phodong - Mangan	
NH 510	70	43	Singtam - Damthang - Legship - Gyalshing.	
NH 710	45	28	Melli - Manpur - Namchi - Damthang - Tarku.	
NH 717A	112	70	West Bengal Border - Rhenock, Ronathang pakyong a junction with new NH 10 at Ranipool near Gangtok.	
NH 717B	42	26	Junction with NH NO 717A at Rhenock - Rongli, Rolep - Junction with NH NO. 310 near Menla at Shenathang.	

West Bengal. The state is Further more connected to Tibet by the mountain pass of Nathu La.

● List of National Highways of Sikkim :—

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- **Airways** :-

There is just one airport is pakyong which is around 111.9 km from sikkim but Bagdogra is well connected to sikkim (about 125 km from Sikkim township.)

Here helicopter service started mainy for tourism purpose.

- **Railways** :-

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

1. Cultune in Sikkim.

2. Cultune in Sikkim.

3. Primary Health centre in DENTUM

4. Cardamom cultivation.

5. NH - 10

3.0 Landslide in study area :-

The frequent occurance of landslide is a very common phenomena in Sikkim, Himalaya and one that causes the most damage to property and connectivity 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 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 north-eastern India, is located in a seismically active region and experiences various geological processes that can contribute to landslide.

1. Slope stability :-

Steep slopes and unstable geological formation can contribute to landslides. For example, the Sikkim region is chanactenised by rugged terrain with bteep slopes, especially in the Himalayan mountain range. The presence of weak rock formations and loose social can make these slopes prone to landslide.

2. Geological Formation :-

The geological formation of Sikkim consists of complex and varied rock type, including schits, gneisses, phyllites, and quartzites Some of these rocks have inherent

weaknesses and discontinuities, such as bedding plans, joints and faults which can act as potential sliding surfaces.

B. **Environmental causes** :—

Sikkim state is prone to landslide due to its rugged terrian and high rainfall. Several environmmental causes contribute to Landslide.

(1) **Heavy Rainfall** :—

Intense or proloenged rainfall can saturate the soil, increasing its weight and 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 jorethang Landslide in West Sikkim.

2. **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 balanced of slopes and trigger land.

3. **Erosion** :—

Natural erosion processes such as riven erosion can undercut slopes and weaken their stability. Continous 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-

1. **Deforestration** :-

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

2. **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 appropriate engineering measures can increase the risk of landslide.

3. **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.

3.2 Consequences of Landslide :-

1. Physical Effects :-

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

B. Social Effect :-

1. Human casualities :-

If landslide occure in the inhabited areas, the first and foremost adverse impacts area on human population. If there is no timely forewarning of problem occurrence of landslide and if there is no proper timely evacuation, a large number of people are buried under enormous mass of debris of varying sizes and theire is heavy toll of human lives.

C. Economical Effect :-

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 in practice.

D. **Environmental Effect** :—

- **Damming of rivers and flash floods** :—

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

E. **Effect on Ecosystem** :—

1. **Impact on water quality** :—

When landslide occur, they can seriously damage or destroy ecosystem. Sometimes the effects can last for thousands of years.

2. **Wipe out forest land** :—

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

3. **Dam up or flood streams** :—

Also they can dam up rivers and streams. In so doing water flow is restricted. Marine and terrestrial organism that depend on the water flow may eventually die.

4. **Loss of lives and social disruption** :—

Landslide are responsible for a number of deaths, injury to people, damage to housing, infrastructure and agricultural land.

3.3 Some instances of landslide in the study area:-

1. **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.

2. **2011, 23rd June :-**

A torrential spell of rain from 6.30 pm to a little past midnight on the 23 June 2011 triggered numerous small landslide in Pelling. Where 14 people perished on the Pelling-Dentam road in West Sikkim.

3. **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.

4. **2020, 21st June :-**

A landslide occured in Tatopani at 6PM on Friday. The road constructed across a steep terrain near Totopani remains vulnerable to landslide especially during rainy season and recent back cutting initiated for the road expension has added to risk of landslide during on going monsoon season.

Legship- Nayabazar road was bloked near Tatopani due to the landslide. The commuters travelling from Jorethang to Gayzing, Yuksam and Tashiding were compelled to take Reshi-Rinchenpong route via Legship to reach their destination.

5. **2020, 27th June** :-

A landslide occured at National Hydropower Project of Corporation (NHPC) Teesta Stage-V dam on the left bank of the river in Dikchu. According to the local people of Jang and Napdang the landslide was occured due to the negligence of NHPC, and it could have been avoided with proper preventive work on time. The landslide has severly damaged the 55 metre high dam of the 510 MW Teesta Hydropower Project of NHPC.

6. **2020 6th August** :-

A massive landslide occured in Jorethang in South Sikkim. A road in Jorethang was also washed off due to heavy rainfall in the region. The IPCA laboratory in Mazhitar, 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.

7. 2022, 5th February :—

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

8. 2023, 18th June :—

Multiple landslide 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

1. A landslide occurred at Pathing village in Namchi district due to heavy rainfall

2. The IPCA laboratory was badly effected due to landslide

3. Teesta stage-V dam was broken due to landslide.

4. Landslide all over Sikkim due to earthquake.

5. 14 people died in pelling due to landslide.

6. Legship-Nayabazar road was damaged due to landslide.

7. Namchi-Rabongla road was closed due to landslide.

3.1 Management of landslide :-

These 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. It may be mentioned that landslides cannot be stopped but their number, frequency, recurrence and severity can be minimized. Some preventive measures have been taken to manage landslide in the study area —

(i) 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.

(ii) Bench Terracing :-

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

(iii) **Rock Slope Netting** :-

Rock Netting is used to coven an entine anea of unstable nock. The slope netting can be either draped or bolted in each cornen of each panel. Rock netting is used whene the unstable nock is big and blocky. It is a new technique of landslide contnol which is used for landslide contnol in Sikkim.

(iv) **Contour Trenching** :-

Senies of deep pit on trenches acnoss 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 whene fonest trees wene planted.

(v) **Sausage well** :-

Pneference was given to sausage well among the mechanical method in evenu landslides was nearly checked by applying sausage wall.

SOME OTHERS PHOTOGRAPHS RELATED TO LANDSLIDE

1. Landslide prone area. unplaned settlement.

2. Landslide occured by heavy rainfall had devastated over a hundred houses in Sikkim

3. Uprooted tree due to landslide

4. Subsidence of slope.

5. Rock slope Netting

6. Bench terranceing.

3.5. Suggestive Measure :—

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

(i) During pursuing of any disruption projects in the high risk zone like Sikkim, should be proced with prudence.

(ii) Environmental impact Assesment standards should be followed before mining or dam building.

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

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

(v) To strengthen hazard reduction and public awarness, 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 initiatives and building water bunds should be encouraged.

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

4.0 Conclusion

Physiography, climate and other natural phenomena of Sikkim Himalayas make it hazardous with frequent landslide. Human activities play the role as positive catalyst for this calamity. There are spatio-temporal variation in frequency of landslide throughout the disaster of Sikkim. In the study area landslides occur basically due to heavy rainfall along with some associated factors. Many time it creates massive and unwanranted 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 for geo-scientist, engineer and planners. It may be mentioned that landslide can not be stopped but their number, frequency, requrrence and severity can be minimized with some preventive and corrective measure to lesser 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-shallow 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 awarness programme, and so on and the landslide prone area of Sikkim require special attention and vigilance to cope up with this calamity

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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 :- 1520136 OF 2020 - 2021

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SESSION :- 2022 - 2023

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Certificate

To whom it may concern

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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.

Date: 08/08/2023

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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

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3.1. causes of landslide
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3.3. some instances of landslide the study area
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1.0 INTRODUCTION

1.1 Introduction :-

Disastens and natural hazards are common and occur not only in India but all over the world. India has been prone to natural disastens on account of geo-climatic conditions; disastens such as floods, earthquakes, droughts, cyclones and landslides have been major within the country. (Kapur, R.., 2018). A hazard may defined as the perilous conditions or events that are threatening or have the potential for causing injury to life, property or the environment (Dey and 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 cyclones, Tsunamis, earthquakes, landslide, 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 wastes, pollution, dam failure, wars or civil strife or occurrence of fires (Dey and singh, 2006).

Landslide is also called as semi or quasi natural hazard as it originate due to

natural phenomena and also by human activities. Landslide is the common disaster in different parts of Sikkim. The high steep slopes, 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 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 activities along with natural phenomena.

Concept of Landslide

A landslide is the movement of a mass of Rock, debris on 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 the movement down slope of a Mass of Rock, debris, earth or soil. Landslide occurs when gravitational and other type of shear stress with in a slope exceed the shear strength

of the materials that form the slope. Shean stresses can be built 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 Zones having highly unstable, relatively young mountainous areas in the Himalayas, high rainfall regions with steep slopes the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes, etc. 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.

1.2 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°04'N to 28°07'N and 88°01' E to 27°06 E. It is bounded by Nepal in the west by the vast stretches of Tibetan plateau in the

LOCATION MAP

1. INDIA

2.SIKKIM

3.SOUTH SIKKIM

4.WEST SIKKIM

North and by Bhutan and chumbi valley of Tibet in the East. Danjeeling district of West Bengal stretches along its southern boundary. The state has a total area of 7096sq. 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. Thought north and East sikkim are in very risk zone of landslide, South and West districts of sikkim are also in high risk zone of landslide prone 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 slopes, intercepted by spring patched forest. Tourism development, road construction, increasing rate settlement thriggering the rate of 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, consequences and management.

1.3 Objectives

The present project papen on landslide has been initiated to fulfill some basic objectives which ane as follows :

- To study the genenal overview physical and economic, socio-cultunal environment of the study anea as both ane veny much nelated to landslide.
- To identify the majon causes of landslide and its consequences in the study anea specially in West and South Sikkim.
- To assess the effective landslide management techniques and to give some suggestive measunes to prevent landslide in the study anea.

1.4 Research Questions

i) What is the natune of landslide in west and South Sikkim ?
ii) What ane the main causes of landslides?
iii) What ane the effects of landslids on the lives of the local people ?
iv) What measunes have been taken to prevent landslide from govennment ?

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 managen, can driven, local people and sellen of souvenn shop. The secondary data were collected from — various book, article, different link from website, journal etc.

→ We collected data from hotel managers can driven, local people and sellen 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.

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

1. Physiography

2. Rangeet River

3. Brown-clay soil

4. Rhododendron tree.

5. Red panda, state animale 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, relief structure, nature of slope, type of rock and its resistance power to erosion, soil, climatic nature (specially rainfall), vegetation cover etc. all one 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 devasted 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 raining from 580 metress (920 ft) in the south at the border with West Bengal

2.0 A general overview on physical and socio-economic environment of sikkim

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to 8.586 metres (28.169 ft) in northern peaks near Nepal and Tibet. The summit of Kangchenjunga, the world's third highest peak is the state "highest point, situated on the borden 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 forms.

2.1.2 Drainage

Sikkim is drained by large number of perennial rivers. Which menge into two prominent rivers, the teests and the Rangit, Rest of other stream eventually Joins one or the Other. Rangit also joins the Teests just near the boundary between sikkim and west Bengal.

The Rangit riven and its tributanies originate in the Talung glacier in west sikkim and after flowing for about 60 km. Joins Teesta bellow Molli near the borden of Sikkim with west Bengal. River Rangit is a major tributary of River Teesta from the Westen Sikkim.

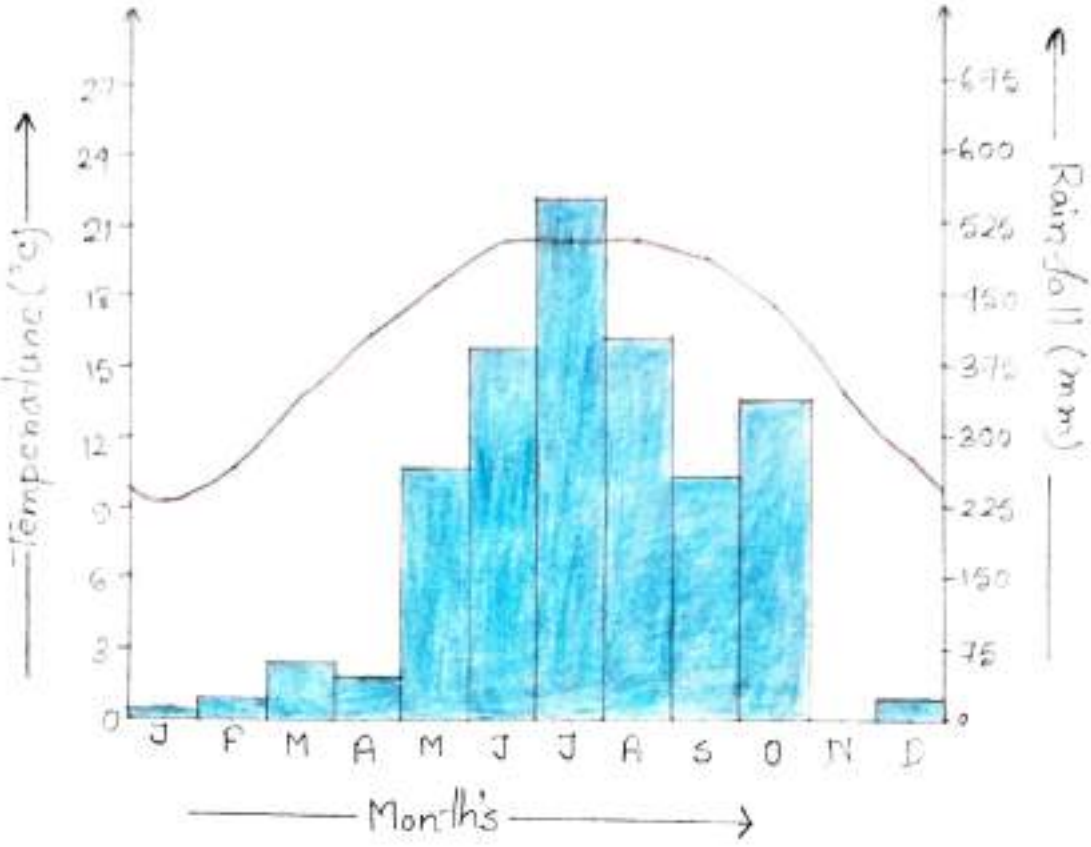
Major tributanies of Rangit are Rimbi Khola, Rathangchhu, Kaley Khola. Ramam Khola and the little Rangit.

2.1.3 Soil

The hills of sikkim mainly consist of gneiss and schist which weather to produce generally shallow brown 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 excleding 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 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.


Temperature (°C)
Rainfall (mm)
Months
J
F
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A
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J
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D
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3
6
9
12
15
18
21
24
27
0
75
150
225
300
375
450
525
600
675

2.1.5 Flona and Fauna

→ Sikkim is situated in an ecological hot-spot of the lowen Himalayas, one of only three among the econegions of India. Owing to its altitudinal gradation, the state has a wind variety of plants from tropical species to temperate, alpine and tundna ones. Noble orchid is Sikkim's state flowen Rhododendnon is its state tnee: about 40 species of Rhododendnon bloom late April - mid may achoss the state.

→ Sikkim is home to anound 5000 speaies of flowening plants, 515 nane orchids 60 primula species 11 oak vanities, 23 bambo vanieties, 16 conifenspeaies, 362 types of fenns and fenns allies, 8 tnee fenns, and ovens 900 medicinal plants. A nelative of the poinsettia, locally known as "christ mas flowen, can be found in abundance in the moun tainous state.

→ The fauna of sikkim include the snow leopand musk deep, Himalyan tahn, ned panda, Himalayan manmot, Himalayan senow, Himalayan gonal, mundjac, common langun, Asian black bead louded leopand, Manbled cat, leopand cat dhole, Tibetan wolf, hog badgen, bintunong and Himalayan Jungle cat. Among the animals mone commonly found in the alpaine zone ane yaks, mainly neaned fon thein milk, meat, and asabeast of bunden. Sikkim has mone than 550 species of binds. Some of which have been declaned endangened. The ned panda is the state animal of sikkim.

2.2 Socio economic environment

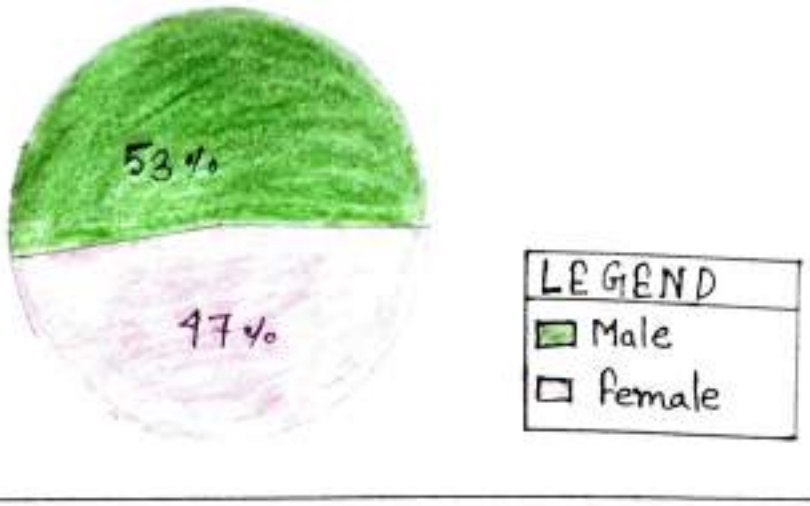
2.2.1 Demography

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 47.05%.

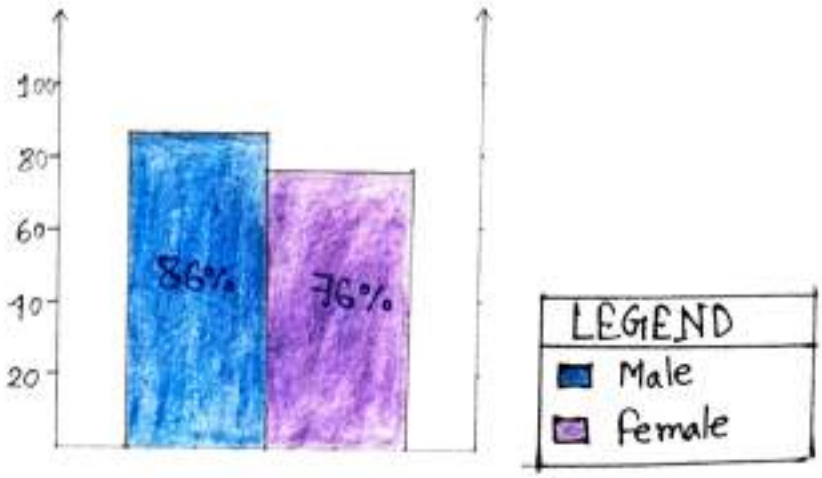
2.2.2 Literacy

Literacy rate in sikkim stood was at 81.42%. Where male literacy rate was at 86.55% and female literacy rate 76.04% census of India, 2011.

Population composition in Sikkim (2011)



Literacy Rate of sikkim (2011)



2.2.3 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 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.

2.2.4 Health treatment

Hospitals in sikkim :-

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 / STNM HOSPITAL	1	.	.	.	1
2	DISTRICT HOSPITAL	1	1	1	1	4
3	COMMUNITY HEALTH CENTRE	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

2.2.5 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 at US$ 1.6 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 more cardamom than any other Indian 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 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 amendments in 2003 and 2007. Some of the Industries of Sikkim

that deserves a special mention in this context are :- pharmaceuticals, cosmetics, Food processing, Breweries, Methanes, corrugated Boxes, Tea processing etc.

Eco-tourism :-

In January 2016, Sikkim became India's first "100 percent Organic" state. The directorate of Ecotourism under the Forest, Environment and wildlife management department has identified and demarcated 11 areas in Sikkim as ecotourism. 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 restricted and protected areas.

Protected parks and santuaries for ecotourism activies :- Kanchedzong National park, singba, Rhododendron sanctuary.

Fambong Lho wildlife santuary, kyongnosla Alpine santuary, Maenam wildlife santuary, Varsey Rhododendron santuary.

2.2.6 Transport system of sikkim

Roadways

National Highway 10 (NH 10) formerly NH 31 A) likks siliguni to Gangtok. Sikkim nationalised transport runs bus and truck services. Privately run bus, tourist tani and jeep services operate throughd sikkim and also connect it to siliguni. A branch of the highway from Melli connect's western sikkim. Towns in eastern, southern and western sikkim. Towns in connected to the hill stations of kalimpong and Danjeeling in northern west Bengal. The state is further more connected to Tibet by the mountain. pass of Nathula.

List of National Highways of Sikkim

Number	Length (km)	Length (mi)	Southern on western Terminus	Northern to Eastern Terminus
NH 10	52	32	Gangtok – Singtam – Rangpo – West Bengal Borden.	
NH 310	87	54	Ranipool (NH-314) – Buntak – Menla – Nathula.	
NH 310A	55	34	Tashi view point – phodong – Mangan.	
NH 510	70	43	Singtam – Damthang – Legship – Gyalshing	
NH 710	45	28	Melli – Manpur – Namchi – Damthong – Tanku.	
NH 717A	112	70	West Bengal Borden – Rhenock, Ronathang pakyeng a junction with new NH 10 at Ranipool near Gangtok.	
NH 717B	42	26	Junction with NH No. 717 A at Rhenock – Rongli. Rolep – Junction with NH No. 310 near menla at shenathang.	

- **Airways**

There is just one airport is pakyong, which is around 111.9 km. from Sikkim but Bagdogra is well connected to sikkim (about 125 km. from sikkim township).

- Here, helicopter service started mainy for tourism purpose.

- **Railways**

The nearest railway station to sikkim are New Jalpaiguni and siliguni station located in West Bengal.

1. Culture in Sikkim

2. Culture in Sikkim.

3. Primary Health centre in DEMTUM

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 landlocked state and also loss of the lives and property. Apart from this, recent unplanned development activities, particularly road construction and ill planned settlaments, have further aggravated the incidence of the landslide and subsidence.

3.1 Causes of landslide

The frequent occurrence of landslides 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 beismically active region and experiences various geological processes that can contribute to landslides.

① slope stability :-

Steep slopes and unstable geological formation

tions can contribute to landslides. the sikkim region is characterized by rugged terrain with steep slopes. especially in the Himalayan mountain range. The presence of weak rock formations and loose soil can make these slopes prone to landslide.

(ii) Geological formation :-

The geological formation of sikkim consists of complex and varied rock types, including schits, gneisses, phyllites and quartzites. some of these rocks have inherent weaknesses and discontinuities, such as bedding plans, Joints and faults which can act as potential sliding surfaces.

B. Environmental causes :-

sikkim state is prone to landslide due to its rugged terrian and high rainfall. Serenal environmental causes contribute to landslide.

(i) 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 septemben. The excess waten can infilthate the ground leading to landslides, 6th August, 2020 Jonethang 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 triggen landslides. 2011 sikkim earthquake with a magnitude of 6.9 caused significant landslides in the region, resulting in loss of life and infrastructure damage.

(iii) **Erosion :-**

Natural erosion processes such as river erosion can undercut slopes and weaken their stability. Continous 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. Trees 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. with out appropriate engineering measures can increase the risk of landslide.

(iii) **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.

(iv) **Surface modification :-**

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

(v) **Irrigation and water leakage :-**

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

3.2 Consequence

The effects of landslides 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 Landslides

A. Physical Effects

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

B. Social Effect

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 forewarning 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.

② Damage to settlements, roads and railroads

settlements comprising both rural and urban located at vulnerable sides such as on hill slopes, at the foothills, alluvial fans and cone, 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 in practice. In the event of massive landslide the terrace 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, 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 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 forests, 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. Con-

versely. dams May flood the opposite side too. Outburst floods can introduce a tremendous amount of new sediment into streams. On they can submerge and kill vegetation in the flooded region. In Sikkim Flash flood killed 22 people, triggened a series of landslides and washed away deanly 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 agricultural 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°N), (88.061°E), killed 77 people, including 16 at the Teesta stage III Hydroelectric power project site, injured 719, left thousands homeless, and temporarily displaced many and also caused substantial loss to livestock.

G. Socio-Economic effects of landslide :

Socio-economic effects include advense 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 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 are many fold and 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 landslide in Pelling. Where 14 people perished on the Pelling-Dentam road in West Sikkim.

2011, 18th september :-

On september 18, 2011 a 6.9 magnetude earthquake struck the India-Nepal borden 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 occured in Tatopani at 6 PM on Friday. The road Constructed across a steep terrain near Tatopani remains vulnerable to landslide especially remains vulnerable to landslide near Tatopani especially during rainy season and recent back cutting initiated for the road expension has added to risk of landslips during on going monsoon season. Legship-Nayabazar road was bloked near Tatopani due to the landslide. The commuters travelling from Jorethang to Geyzing, Yuksom and Tashiding were compelled to take Reshi-Rinchenpong route via Legship to reach thein destination.

2020, 27th June :

A landslide occured at National Hydropower project of corporation (NHPC) teesta stage-v dam on the left bank of the river in Dikchu. According to the local people of Jang and Aapdara, the landslide was occured 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 510 MW Teesta Hydropower Project of NHPC.

2020, 6th August :-

A massive landslide occured in Jonethang in south sikkim. A road in Jonethang was also washed off due to heavy rainfall in the region. The IPCA laboratory in Mazhitar, Jonethang 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 occured at pathing village in Namchi district due to heavy rainfall. 60 houses were damaged in this landslide.

2023, 18th June :-

Mutiple 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

1. A landslide occurred at Pathing village in Namchi district due to heavy rainfall

2. The IPCA laboratory was badly affected due to landslide

3. Teesta stage - v dam was broken due to landslide

4. Landslide all over sikkim due to earthquake

5. 19 people died in pelling due to landslide

6. Legship Nayabazar road was damaged due to landslide

7. Namchi - Pakyong road was closed due to landslide

3.9 Management :-

Guidelines by the National Disasten Management Authority (NDMA) on management of landslides reduce the ennomous destructive potential of landslides and minimize the consequential losses by institutionalizing the landslide hazard mitigation efforts. Preventive and connective measures to lessen the impacts of landslide it may be mentioned that landslides can not be stopped. But number, frequency, recurrence and severity can be minimized. Some preventive mesures have been taken to manage landslide in the study area—

Contounbunding :-

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 bannier to the flow of waten.

Bench terracing :-

Relatively steeps land was transformed into a series of level on nearly level strips on steeps running across the slope of many landslides 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.

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.

SOME OTHERS PHOTOGRAPHS RELATED TO LANDSLIDE

1. Landslide prone area unplanned Settlement

2. Landslide occurred by heavy rainfall had devastated over hundred houses

3. Uprooted trees due to landslide

4. Subsidence slope

5. Rock slope Netting

6. Bench terracing

Suggestive Measures :-

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

(i) During pursuing of any disruptive project in the high risk zone like sikkim, should be proced with prudence.

(ii) Environmental Impact Assesment standards should be followed befor mining or dam building.

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

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

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

(vi) Mitigation techniques 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 techniques.

Conclusion :

Physiography, climate and other natural phenomena of sikkim Himalayas make it hazardous with frequent landslide. Human activities play the role as positive catalyst for this calamity. There are spatio-temporal variation in frequency of landslide throughout the districts of Sikkim. In the study area landslides occur basically due to heavy rainfall along with some associated factors. Many times it creates massive and unwannanted 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 for geo-scientist, engineers and planners. It may be mentioned that landslide can not be stopped but 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-shallow 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 awarness 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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VIDYASAGAR UNIVERSITY

Report On

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

B.SC HONOURS (GEOGRAPHY)

SEMESTER - VI

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This is to certify that Gayatri Sheet
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student of B. Sc., Sem-VI, Geography Honours of Swarnamoyee Jogendranath Mahavidyalaya for the session 2022-23; submitted his/her project report entitled as landslide and its causes ; Consequence and managment ; 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.

Date: / /2023

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place :- Kamalpur

Date :- 6.08.2023

Gayatri Sheet

Signature

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Introduction :-

Disasters and natural hazards are common and occur not only is India but all over the world. India has been prone to natural disasters on account of geo-climatic conditions; disasters such as floods, earthquakes, droughts, cyclones and landslides have been major within the country. (Kapur, R., 2018). A hazard may 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 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 wastes, pollution, dam failure, wars or civil strife or occurrence of fires (Dey & singh, 2006).

Landslides is also called as semi or quasi natural hazard as it originate due to natural phenomena and also by human activities, Landslide is the common disaster in different parts of sikkim. The high step 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 activities along with natural phenomena.

Concept of Landslide :-

A Landslide is the movement of a mass of Rock, debris or 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 the movement down slope of a mass of rocks, debris, earth or soil. Landslide occurs when gravitational and other type of shear stresses can be built 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 zones having highly unstable, relatively young mountainous areas in the Himalayas, High rainfall regions with steep slope, the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquaks, 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 :-

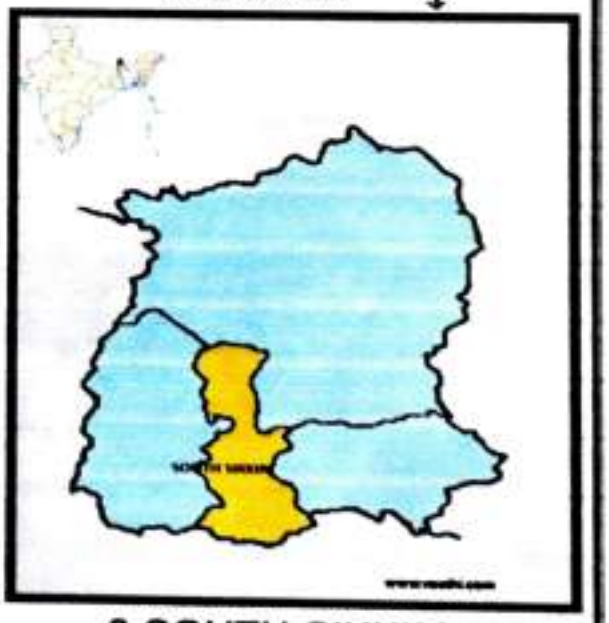
SiKKm is a small, extremly mountainous state in the Himalayas with sharply defind and extremly deep watershed. The state is situated between 27°04'N to 28°07'N and 88°01'E to 27°06'E. It is bounded by Nepal in the west by the vast stretches of Tibetan plateau in the North and by Bhutan and chumbi valley 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 district s- 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 risk zone of landslide, south and west districts of sikkim are also in high risk zone of landslide prone areas. West and south district of sikkim lies an at altitude of more or less 400 meters to 2500 meters with unique Countryside escape of endless waves of agricultural fields and the terraced slopes, intercepted by spring patched forests. Tourism development, road construction, increasing

LOCATION MAP

1. INDIA

2. SIKKIM



3. SOUTH SIKKIM

4. WEST SIKKIM

rate settlement triggering the rate of 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, consequences and mangment.

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 mason causes of landslide and its consequences in the study area specily in west and south sikkim.
- To assess the effective landslide manggment technique and to give some suggestive measures to prevent landslide in the study area.

Research Question :-

1) What is the nature of landslide in west and south sikkim?
11) What are the effects of landslide on the lives of the local people?

iii) What are the main cause of landslide?

iv) What measures have been taken to prevent landslides 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, can diver, 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 manager, can diver, local people and seller of souvenir shop through interview method, and we gain an understanding of landslides 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 survey on were not able to collect data properly. Besides this some other problem such as poor financial condition, communication gap between respondent and surveyor due to different language, etc, which was prevailed in that area. Hence the study 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 causes and consequences of landslide in the study area.

Physical Environment

Physiography :-

Situated in the himalayan mountains, the State of sikkim is characterised by mountains terrain. Almost the entire state is hilly. with an elevation ranging from 580 metress (920ft) in the south at the border with west Bengal to 8.586 metres (28.169ft) in northern peaks near Nepal and Tibet. The summit of Kangchenjunga, the world's third-highest peak. is the state' 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 drainage by large number of perennial rivers. which merge into two prominent rivers, The teesta and the Rangit; Rest of other stream

eventually joins one on the other. Rongit also joins the Teesta just near the boundary between sikkim and West Bengal

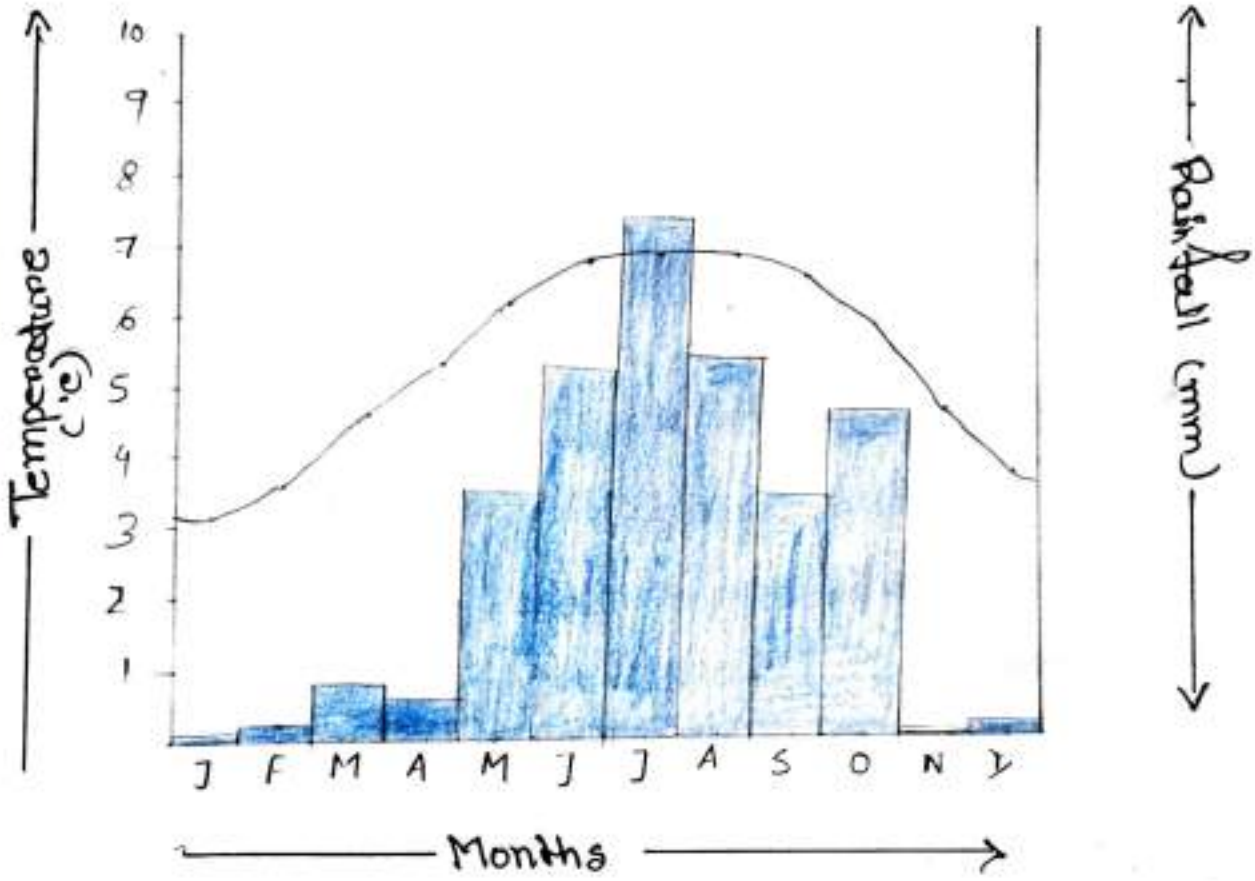
The rongit river and its tributaries originate in the Talung glacier in west sikkim and after flowing for about 60 km. Joins Teesta below malli near the border of sikkim with west Bengal. River Rangit is a major tributary of River Teesta from the western sikkim. Major tributaries Rongit are Rimbi Khola, Rathangchhu, Kaley Khola. Ramam Khola and the little Rongit.

Soil:- The hills of sikkim mainly consist of genesis and schist. which weather to people produce generally shallow brown clay soils. The rock consists of phyllites and schists.

climate:- The state has been 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 avarage annual temperature for most of sikkim is around 18°c. During the monsoon heavy rains increase the risk of landslide. The record for the longest period of continuous rain in sikkim is

Months	Temperature (°C)	Scale	Temperature (cm)	Rainfall (mm)	Scale	Rainfall (cm
January	9.4	1cm = 3°C	3.13	6.1	1cm = 75mm	0.08
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	394.0		5.25
July	20.3		6.76	554.1		7.38
August	20.4		6.8	401.3		5.35
septem ber	19.6		6.53			3.41
oetober	17.3		5.76	334.9		4.46
Novemb er	13.9		4.63	3.9		0.052
Decem ber	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 hase 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.

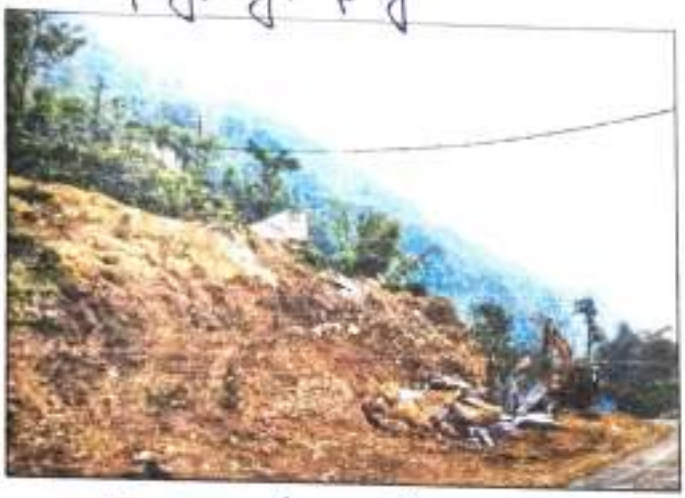
sikkim is home to around 5,000 species of flowering plants, 515 rare orchids, 60 primula species, 11 oak varieties, 23 bambo varieties, 16 conifer species, 362 types of ferns and ferns allies, 8 tree ferns, and over 900 medicinal plants. A relative of the poinsettia, locally known as "christmas flower," can be found in abundance in the mountainous state.

The fauna of sikkim include the snowleo pard, musk deer, Himalayan tahr, red panda Himalay an marmot, Himalayan serow, Himalayan goral,

muntjac, common langur, Asian black bear, clouded leopard, 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.

Physiography

Drainage system (Ranged)



Brown lay soil

Rhododendron (Flora)
(State tree

Red panda (Fauna)
(State Animal of sikkim)

Socio economic environment

Demography :- As per census of India, 2011 total population of sikkim was 6.11lakhs. sikkim is the least population state of India male 52.87%, and female 47.05%.

population Composition in sikkim (2011)

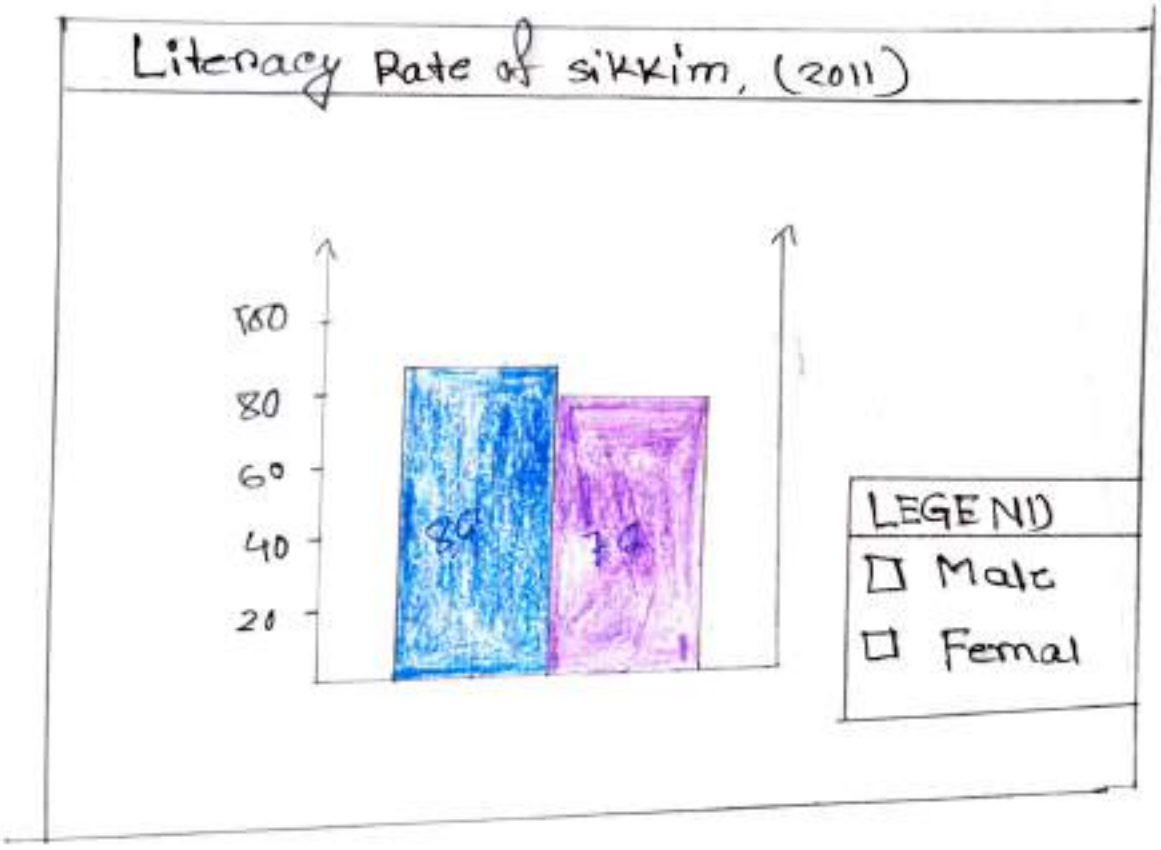
LEGEND

- Male
- Female

population Composition of sikkim, 2011			
sex	persentage of population	Total population	Population
Male	53.87		$\frac{53.87}{100} \times 360' = 190'$
Female	47.05		$\frac{47.05}{100} \times 360' = 160'$

Literacy Rate of sikkim, 2011			
Sex	Perceentage of Literacy	scale	Literacy Rate (°)
Male	86.55		4.32
Femal	76.04		3.80

Literacy :- Literacy rate in sikkim stood was at 81.42%. Where male literacy rate was at 86.55%. and female literacy rate 76.04%. census of India, 2011.



Culture:- In sikkim the leading communities are the Lepchas, Bhutias and Nepalese. The offical 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 religiones 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 weel.

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SL NO	HEALTH INSTITUTION	EAST	WEST	NORTH	SOUTH	STATE
1.	STATE REFERRAL HOSPITAL/ STNMH OSPITAL.	1	.	.	.	1
2.	DISTRICT HOSPITAL	1	1	1	1	4
3.	COMMUNITY HEALTH CENTRE	1	.	.	1	2
4.	PRIMARY HEALTH CENTRE	6	7	5	6	24
5.	PRIMARY HEALTH SUB-CENTRE	48	41	12	39	148
6.	DISTRICT TUBER CULOSIS 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 at 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 more cardamom than any other Indian stat 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 seedors for economic, food and national security.

Industry :-

sikkim has long been agrobased 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 deserves a special mention in this context are:- pharmaceutieals, cosmetics, food processing; Breweries, Mettress, 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 managment 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 destricted and protected areas.

protected parks and sancturies for eco-tourism activites:- Kanchedzong National park, Singba Rhododendron sanctuary.

Fambong Lho wildlife santuary, Kyongnosla Alpine santuary, Maenam wildlife santuary, Varsey Rhododendon's Santuary.

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 Highway of sikkim

Number	Length (km)	Length (mi)	Southern or western Terminus	Northern to Eastern Terminus
NH10	52	32	Gangtok - singtam - Rangpo - West Bengal Border	
NH 31A	87	54	Rainpool (NH-31A) Burtak - Menla - Nathula	
NH 310 A	55	34	Tashi view point - phodong - Mangan	
NH 510	70	43	Singtam - Damthang - Legship - Gyalshing	
NH 710	45	28	Melli - Manpur - Namchi - Damthang - Tarku	
NH 717A	112	70	West Bengal Border - Rhenaek, Rorathang pakyong a Junction with new NH10 at Rainpool near Gangtok.	
NH 717B	42	26	Junction with NH No 717A at Rhenaek - Ranggli, Rolep - Junction with NH No. 310 near Menla at Sherathang.	

Airways :-

There is just one airport is pakyong, which is around 111.9 km from sikkim but Bagdogra is well connected to sikkim (about 125 km, from sikkim township).

Here helicopter service started mainly for tourism purpose.

Railways :-

The nearest railway station to sikkim are new Jalpaiguri and siliguri station located in west Bengal.

Culture of sikkim

Culture of sikkim

primary health centre in Dentam valley

Cardamom cultivation

NH 010

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 connectivity in the landlocked state and also loss of the lives and property. Apart from this, resent 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, Hire are some common causes that contribute to landslide —

A. Geological causes :-

sikkim, a state in northeastern India, is located in sesmically active region and experiences various geological processes that can contribute to landslides.

1. Slope stability :-

Step slopes and unstable geological formations can contribute to landslide the sikkim region is characterised by rugged terrain

with steep slopes, especially is the Himalayan mountain range. The presence of weak rock formation and loose soil can make these slopes prone to landslide.

11. **Geological formation** :-

The geological formation of sikkim consists of complex and varied rock types, including schits, genisses, phyllites and quartzites. Some of these rocks have inherent weaknesses and discontinaties; such as bedding plans, joints and faults which can act as potential sliding surfaces.

B. **Environmental causes** :-

sikkim state is prone to landslide due to its rugged terrian 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 month of june to septemben. The excess water can infiltrate the ground, leading to landslides. 6th August, 2020 Jorethang landslide in west sikkim.

II) **Earthquakes** :-

Sikkim falls in a sismically active region due to its proximity to the Himalayan tectonic plate boundary. Earthquakes can generate ground shaking, which can disturb the balance of slops and trigger landslide. 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 processes such as river erosion can undercut slops and weaken their stability. Continous 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, mand made causes of landslides —

1) **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 landslide.

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 structure on steep slope with out appropriate engineering measures can increase the risk of landslide.

III) **Defective drainage systems** :-

poorly designed drainage system 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.

IV) **surface modification** :-

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

V) **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 for pipes or sewers can infiltrate the soil leading to instability.

Consequence :-

The effects of landslides in sikkim can be significant and have various consequence on the region, the environment, and the local communities. Here are some of the protential 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, furniture, commodities, transport system etc. are severely damaged and put out of gear by massive landslide.

B. **Social effects** :-

» **Human casualties** :-

If landslides occur in the inhabited areas, The first and foremost adverse impacts are on human population. If there is no timely forewarning 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 settlement, roads and railroads** :-

Settlement comprising both rural and urban located at vulnerable sides such as on hill slops, at the foothills, alluvial fans and cons, 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.

e. **Economical effects**

i) **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 terrace 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, 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**

a) **Impact of 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. This invariably has severe reperecussions on water quality and marine life.

iii) **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 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 deeply 30km of highway in north sikkim amid torrential rain.

F. **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 6.11 pm

(Local time). a Mw 6.9 earthquake with an epicenter located near the sikkim region (27.723°N, 88.064°E), killed 77 people, including 16 at the Teesta stage III 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, life lines 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 landslide due to slope failures 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 Rabongla South sikkim. The singtam, Rabangla 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 landslide in pelling. Where 14 people perished on the pelling - Dentam road in West sikkim.

2011, 18th september :-

On september 18. 2011, a 6.9 magnetude earthquake struck the India - Nepal border region. According to news reports, impacts of the earthquake included landslide in the northern Indian state of sikkim, between Nepal and Bhutan.

2020, 21st June :-

A landslide occured in Tatopani at 6pm on friday. The road constructed across a steep terrain near Tatopani remains vulnerable to landslide especially during rainy season and recent back cutting initiated for the road expension has added to risk of landslips during on going monsoon season. Legship - Nayabazar road was bloked near Tatopani due to the landslide. The commuters travelling from Jorethang to Geyzing, Yuksam and Tashiding were compilled to take Reshi - Rinchenpong route via legship to reach their destination.

2020, 27th June :-

A landslide occured at National hydropower project of corporation (NHPC) teesta stage-v dam on the left bank of the river in Dikchu. According to the local people of Jang and Aopdara, the landslide was occured 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 510 MW Teesta Hydropower project of NHPC.

5)

2020, 6th August :-

A massive landslide occurred in Jorethang is South sikkim. A road in Jorethang was also washed off due to heavy rainfall in the region. The IPCA laboratory in the Mazhitar, 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 occured at pathing village in Namchi district due to heavy rainfall. 60 houses were damaged in this landslide.

2023, 18th June :-

Mutiple landslide induced by heavy rainfall have damaged over a hundred houses in West sikkim district. The incessant rain has caused extensive damaged to infrastructure and property in the state.

Some Instances of Landslide in the study area

pelling village in Namchi distroied due to

The IPCA laboratory was badly effected due to landslide

Teesta stage-III dam was broken due to landslide

landslide all over sikkim due to earthquake

14 people died in pelling due to landslide

Legship - Naya bazar road was damaged due to landslide

Namchi - Bavangla road was closed due to 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 landslide cannot be stopped. But number, frequency recurrence and serverity can be minimized :- some preventive measures have been taken to manage landslide in the study area —

Contourbunding

Earthen embankment was constructed at intervals across the slope and along the contour line of the may 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 waters.

Bench terracing

Relatively steeps land was transforms into a series of level or nearly level strips or steeps running across the slope of many landslides 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.

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.

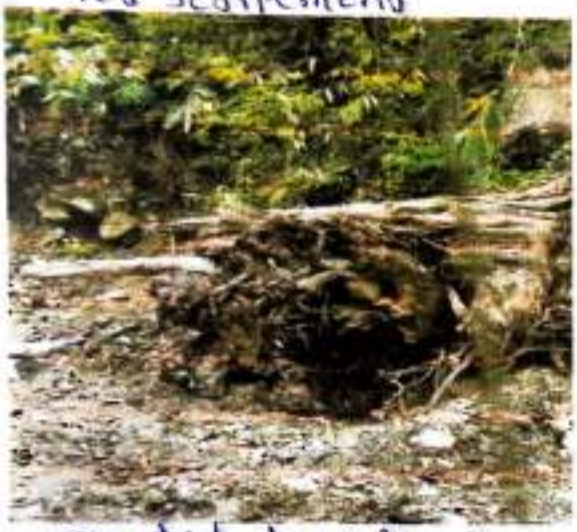
Sausage wall

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.

SOME OTHERS PHOTOGRAPHS RELATED TO LANDSLIDE

landslide prone unplanned settlement

Heavy Rainfall had devastated over a hundred houses in west Sikkim



uprooted tree due to landslide

land subsidence

Rock slope Netting

Bench terraeing

Suggestive Measures :-

Along with the management system of landslide in sikkim Himalaya some othe measures should be taken—

I) During pesing of any disruptive projects 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 extremlly vulnerable areas.

IV) To strengthen disaster management potential more funding should be given to landslide planning and mitigation ageneies.

V) To strengthen hazard riduction and public awarnes efforts, locally available trained people should be enlisted.

VI) Mitigation techniques such as confining agriculture to vallyes and places with moderate slopes, fostering large-scale afforestation initiatinen and building water bunds should be encouraged.

VII) Encourgged the use of effective landslide rehabilitation and mitigation techniques.

Conclusion

physiography, climate and other natural phenomena of sikkim Himalayas make it hazardous with frequent landslide. Human activities play the role as positive catalyst for this calamity. There are spatio-temporal variation in frequency of landslide throughout the districts of sikkim. In the study are landslide occur basically due to heavy rain fall along with some associated factors. Many times it creates 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 for geo-scientist engineers and planners. It may be mentioned that landslide can not be stopped preventive and corrective measure to lessen the impacts of landslide which will help to prevent water entering the hill slopes through joints and cracks, decrease water pressure in the rocks through shallow and sub-shallow drainage, place drainge trenches in order to reduce water pressure in the vicinity of hill slopes. The inhabitants of this area should be sensitized through awareness programes, mock drills, posters, and so and the landslide prone areas of sikkim require special attention and vigilance to cope up with this clamity.

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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 :- 1520131 OF 2020 - 2021

ROLL NO :- 1126152 - 200005

SESSION :- 2022 - 2023

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Certificate

To whom it may concern

This is to certify that Moumita Giri,
Roll 1126152 No. 200005 Registration No. 1520131 of 2020-2021
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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.

Date: 08/08/2023

		Supervisor
09.08.23	8/8/23.	8/8/23
Dr. Ratan Kumar Samanta	**Mr. Aparesh Mandal**	**Miss Arpita Majumder**
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CONTENT

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Place: Ronkinipur, Amsabod

Date: 010.08.2023

Moumita Giri
Signature

LIST OF MAP

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REPORT ON LANDSLIDE and its Causes, Consequence & Management: A Study in Some Parts of Sikkim Himalayas

[1.0] INTRODUCTION:

[1.1] Introduction:—

Disaster 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, droughts, cyclones and landslides have been major within the country. (Kapur, R., 2018). A hazard may 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 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 wastes, pollution, dam failure, wars or civil strife or occurrence of fires (Dey & Singh, 2006).

Landslide is also called as semi or quasi natural hazard as it originate due to natural phena-

mena and also by human activities. Landslide is the common disaster in different parts of Sikkim. The high steep slope, making of the houses or construction 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 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 activities along with natural phenomena.

[1.2] 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°04' N to 28°07' N to 28°07' N and 88°01'E to 27°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, 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 risk zone of landslide, South

LOCATION MAP

1. INDIA

2. SIKKIM

3. SOUTH SIKKIM

4. WEST SIKKIM

and West districts of Sikkim are also in high risk zone of landslide. South and West districts of Sikkim are also in high risk zones of landslide prone areas. West and South district of Sikkim lies at an altitude of more or less 400 meters to 2500 meters with unique countryside escapes of endless waves of agricultural fields and the terraced slopes interspersed by spring patched forests. Tourism development, road construction, increasing rate of settlement triggering the rate of 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, consequences and management.

[1.3] 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 landside.

➤ To identify the major causes 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.

[1.4] 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 landslides 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 manager, car driver, local people and seller of souvenir shop. The secondary data were collected from - various article, book, 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 landslides through the observation method while traveling near landside prone area.

→ Different cartographic techniques have been choosen to represent the data properly. We used to bar and line graph to show rainfall and temperature. To represent demography and literacy we have use pie and bar diagram.

[1.6] Limitation of the Study:—

Due to the limited time period surveyor were not able to collect data properly. Besides this some other problem such as poor financial condition, communication gap between respondent and surveyor due to different language etc. which was prevailed in that area. Hence the study was not dealt properly.

[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, 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 causes and consequences of landslide in the study area.

[2.1] Physical Environment

Physiography :

Situated in the Himalayan mountains, the ~~table~~ state of Sikkim is characterised by mountainous terrain. Almost the entire state is hilly. With an elevation ranging from >80 meters (920 ft.) in the south at the border with West Bengal to 8586 meters (28,169 ft.) in the ~~south at the border with west~~ northern peaks near Nepal and Tibet. The summit of Kanchenjunga, 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.

[2.1] Physical Environment

Physiography:

[2.1.1] Drainage:—

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

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

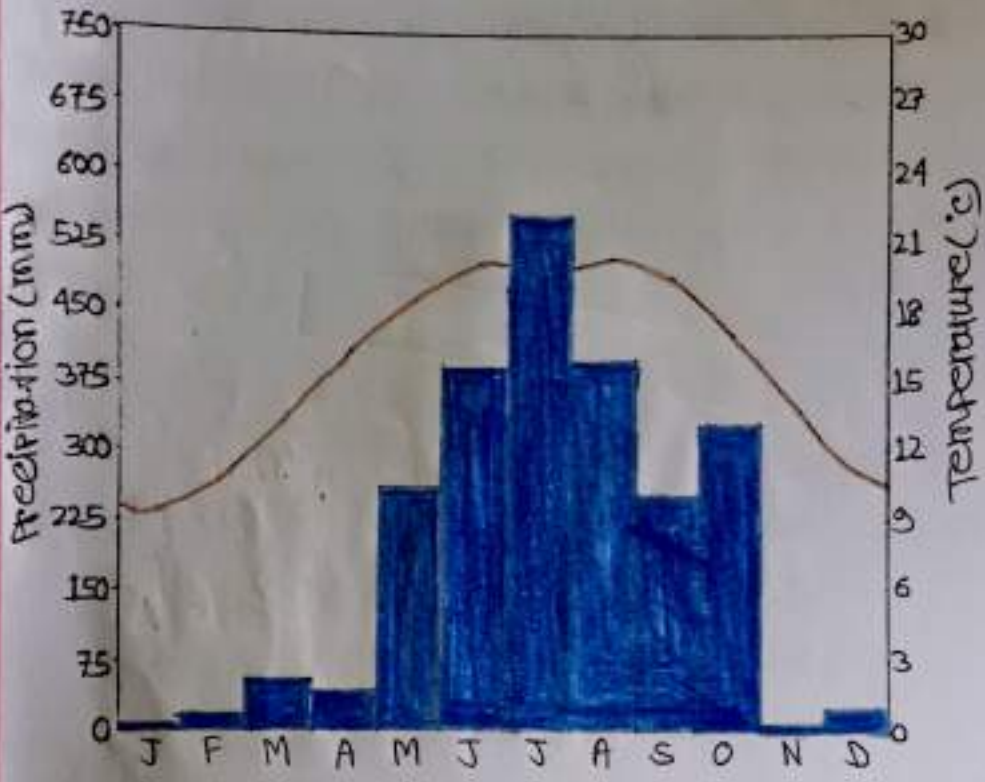
[2.1.2] Soil:—

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.

[2.1.3] Climate:—

The state has five seasons - Winter, summer, spring, Autumn and Monsoon season. Most of the inhabited regions of Sikkim experience a tem-pe-

CLIMATE GRAPH FOR SIKKIM



SCALE	
Precipitation	1 cm to 75 mm
Temperature	1 cm to 3°C

LEGEND	
Precipitation	
Temperature	

rate climate, with temperatures seldom exceeding 25°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 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.

[2.1.4] **Flora and Fauna**:—

Sikkim is situated in an ecological hotspot of the lower Himalayas, one of only three among the ecoregions of India. 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's 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 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 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 Fauna of Sikkim include the snow leopard, musk deer, Himalayan tahr, red panda, Himalayan marmot, Himalayan serow, Himalayan goral, muntjac, common langur, Asian black bear, Clouded leopard, 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 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.

Physiography

Teesta River

Brown clay soil

Rhododendron Tree

Red Panda, State animal of Sikkim

[2.2] Socio-Economic Environment

[2.2.1] Demography :—

As per census of India 2011, total population of Sikkim was 6.11 lakhs. Sikkim is the least populated state of India where percentage of male was 52.21% and female percentage was 47.05%.

[2.2.2] Literacy :—

Literacy rate in Sikkim 2001 was at 81.42%, where male literacy rate was at 86.55% and female literacy rate was 76.04% according to census of India, 2011.

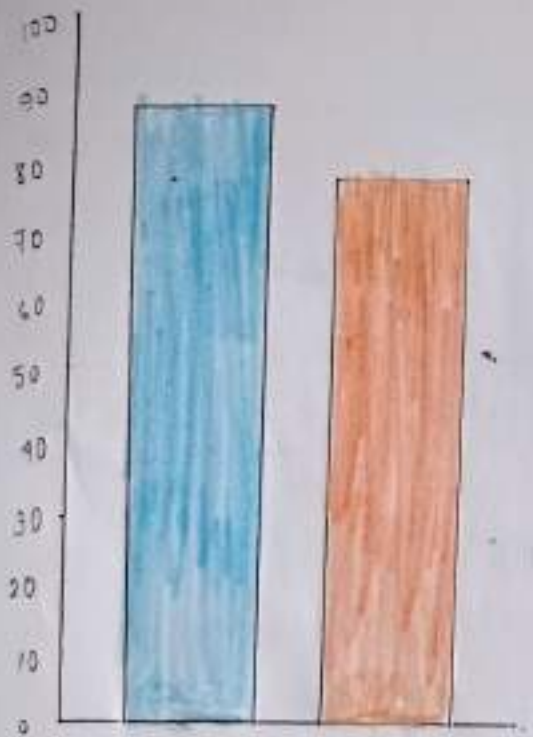
[2.2.3] Culture :—

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

POPULATION COMPOSITION

LEGEND	
Male	
Female	

LITERACY RATE OF SIKKIM, 2011



LEGEND	
Male	
Female	

[2.2.4] Health :—

There are few hospitals, health centres, 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

SL.NO.	HEALTH INSTITUTION	EAST	WEST	NORTH	SOUTH	STATE
1.	State Referral Hospital/ St m Hospital	1	.	.	.	1
2.	District Hospital	1	1	1	1	4
3.	Community Health Centre	1	.	.	1	2
4.	Primary Heath 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 Ta	1	.	.	.	1
	TOTAL –	58	49	24	48	179

Culture of Sikkim

Culture of Sikkim

Primary Health Centre in Dentam

Cardamom cultivation

NH-10

[2.2.5] 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 at 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.

[2.2.5.1] 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, orange, tea and cardamom. Sikkim produces more cardamom than any other Indian state and is home to the largest cultivated area of cardamom (88%). It is estimated that over 80% of the rural population depend on agriculture and allied sectors for economic, food and national security.

[2.2.5.2] Industry : Sikkim has long been agro-based society. The Government has formulated certain policies such as Sikkim Industrial promotion and Incentive (SIPI) act 2000 and its subsequent amendments in 2003

[2.2.6] Transport :—

■ **Roadway** : National Highway (NH 10; formerly NH 31 A) 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
NH10	52	32	Gangtok — Singtam — Rangpo — West Bengal Border	
NH 310	87	54	Ranipool (NH 31 A) — Burtuk — Menla — Nathu La	
NH 310A	55	34	Tashi View Point — Phadong — Mangan	
NH 510	70	43	Singtam — Damthang — Legship — Gyalshing	

Number	Length (km.)	Length (mi.)	Southern to Western Terminus	Northern to Eastern Terminus
NH 710	45	28	Melli — Manpur — Namchi — Damthang — Tarku	
NH 717 A	112	70	West Bengal border — Rhenock, Rorathang Pakyong a junction with new NH 10 at Ranipool near Gangtok	
NH 717 B	42	26	Junction with NH 717 A at Rhenock — Ronali, Rolep — Junction with NH 310 near Menla at Sherathang.	

■ **Airway** : There is just one Airport is Pakyong, which is around 111.9 km from Sikkim but Bagdogra is well connected to Sikkim (about 125 km. from Sikkim township).

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.

[3.0] Landslide in the Study Area :

The frequent occurrence of landslide is a very common phenomenar in Sikkim Himalaya and one that causes the most damage to property and connectivity in the land locked state and also loss of the lives and property. Apart from this, recent unplanned developement 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 landslides 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 ——

i) Geological Causes :-

Sikkim is a state in north-eastern India, is located in a seismically active region and experiences various geological processes that can contribute to landslides.

ⓐ Slope Stability: Steep slopes and unstable geological formations can contribute to landslides. For example, the Sikkim region is characterized by rugged terrain with steep slopes, especially in the Himalayan mountain range. The presence of weak rock formations and loose soil can make these slopes prone to landslide.

ⓑ 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 plans, joints and faults which can act as potential sliding surfaces.

ii) Environmental causes:-

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

ⓐ 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 September. The excess water can infiltrate the ground,

leading to landslides.

① 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.

② Erosion: Natural erosion processes such as river can undercut slopes and weaken their stability. Continuous erosion removes support from the base of slopes making them prone to landslides.

iii) Human-Related Causes:-

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

① 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.

(b) 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 landslide.

(c) 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.

(d) Surface Modification: Altering the natural drainage patterns by modifying rivers, streams or water channels can cause increased water flow and erosion, which can weaken slopes and trigger landslide.

(e) 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 for pipes or sewers can infiltrate the soil, leading to instability.

[3.2] Consequences of Landslide: The effects of landslides 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:-

A. Physical Effects:-

- Damage to Infrastructure:

The infrastructure facilities such as telephone and communication system, electricity supplies, water and oil pipelines, offices, furniture, 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 foremost adverse impacts are on human population. If there is no timely forewarning 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 railroads: settlements comprising both rural and urban located at vulnerable sides such as on hill slopes, at the foothills, alluvial fans and cone, 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 Effect :—

■ 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 terrace 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 :—

■ 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 rushes downstream with high velocity resul-

ting 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 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 forests, 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 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.

(IV) Loss of lives and social disruption: Landslides 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 6:11 PM (local time), a Mw 6.9 earthquake with an epicenter located near the Sikkim region (27.723° N, 88.064° E), killed 77 people, including 16 at the Teesta Stage III Hydroelectric power project site, injured 719, left thousands homeless, and temporarily displaced many and also caused substantial loss to livestock.

(V) 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 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 are many fold and are assuming larger proportion due to expansion of built environment in environment fragile and vulnerable mountainous areas.

[illegible] instances of landslide in the [illegible]

- **[illegible] July** :-

Heavy rain triggered a landslide in [illegible], South Sikkim. The [illegible] road has seen as many as 11 land slides while the Namchi-[illegible] route via Damthang has been closed because of an uprooted tree.

Namchi-[illegible] road was closed due to landslide

- **23rd June, 2011** :-

A torrential spell of rain from [illegible] to a little past midnight on the 23 June 2011 [illegible] numerous small landslide in pelling, where 14 people perished on the pelling-Dentam road in West Sikkim.

14 people died in pelling due to landslide

- **18th September, 2011**:—

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.

Landslides all over Sikkim due to earthquake

- **21st June, 2020**:—

A landslide occured in Totopani at 6 PM on Friday. The road constructed across a steep terrain near Totapani remains vulnerable to landslide especially during rainy season and recent back cutting initiated for the road expension has added to risk of landslips during on going monsoon season. Leashi-Naya-bazar road was blocked near Totopani due to the landslide. The commuters travelling

from Jorethang to Geyzing, Yuksom and Tashiding were compelled to take Reshi-Rinchenpong route via Leaship to reach their destination.

Leaship-Nayabazar road way damaged due to landslides

- **27th June, 2020**:—

A landslide occured at National Hydropower project of corporation (NHPC) Teesta Stage-V dam on the left bank of the river in Dikchu. According to the local people of Jong and Aapdara, the landslide was occured 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

510 MW Teesta Hydropower project of NHPC.

Teesta Stage-V dam was broken due to Landslide

- 6th August, 2020 :—

A massive landslide occured in Jorethang in South Sikkim. A road in Jorethang was also washed off due to heavy rainfall in the region. The IPCA laboratory in Mazhitar, 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.

The IPCA labratory was badly effected due to landslide

- **5th February, 2022:—**

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

A landslide occures at Pathing village in Namchi district due to heavy rainfall

- **18th June, 2023:—**

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

Landslide occured by heavy rainfall had devasted over a hundread houses in west sikkim

[3.4] Management of Landslide:

These 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. It may be mentioned that landslides cannot be stopped but their number, frequency, recurrence and severity can be minimized. some preventive measures have been taken to manage landslide in the study area.—

i) **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.

ii) **Bench Terracing**:—

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

iii) **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.

iv) **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 way deposited on the lower edge of trenches where forest trees were planted.

v) **Sausage Wall**:—

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

SOME OTHERS PHOTOGRAPHS RELATED TO LANDSLIDE

Landslide prone area, un-planned settlement

Landslide occured by heavy rainfall had devastated over 100 houses in Sikkim

Uprooted tree due to landslide

Subsidence of slope

Rock slope Netting

Bench Terracing

[3.5] Suggestive Measures:

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

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

b) Environmental Impact Assesment standards shall be followed before mining or dam building.

c) Landslide micro-zoning method should be implemented in the extremely vulnerable areas.

d) To strengthen disaster management potential more funding should be given to landslide planning and mitigation agencies.

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

f) Mitigation techniques such as confining agriculture to valleys and places with moderate slopes, fostering large-scale afforestation initiatives and building water bunds should be encouraged.

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

[9.1] CONCLUSION :—

Physiography, climate and other natural phenomena of Sikkim Himalayas make it hazardous with frequent landslide. Human activities play the role as positive catalyst for this calamity. There are spatio-temporal variation in frequency of landslide throughout the districts of Sikkim. In the study area landslides occur basically due to heavy rainfall along with some associated factors. Many times it creats massive and unwarranted loss of life and property. Therefore, there ~~should~~ should be efficient management of the landslide hazard. There are necessities of the development of institutional capacity and training for geo-scientist, engineers and planners. It may be mentioned that landslide can not be stopped but their number, frequency, recurrence and severity can be minimized with some preventive and corrective measures to lesser the impacts of landslides which will help to prevent water ~~entir~~ entering the hill slopes through joints and cracks, decrease water pressure water pressure in the rocks through shallow and sub-shallow 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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