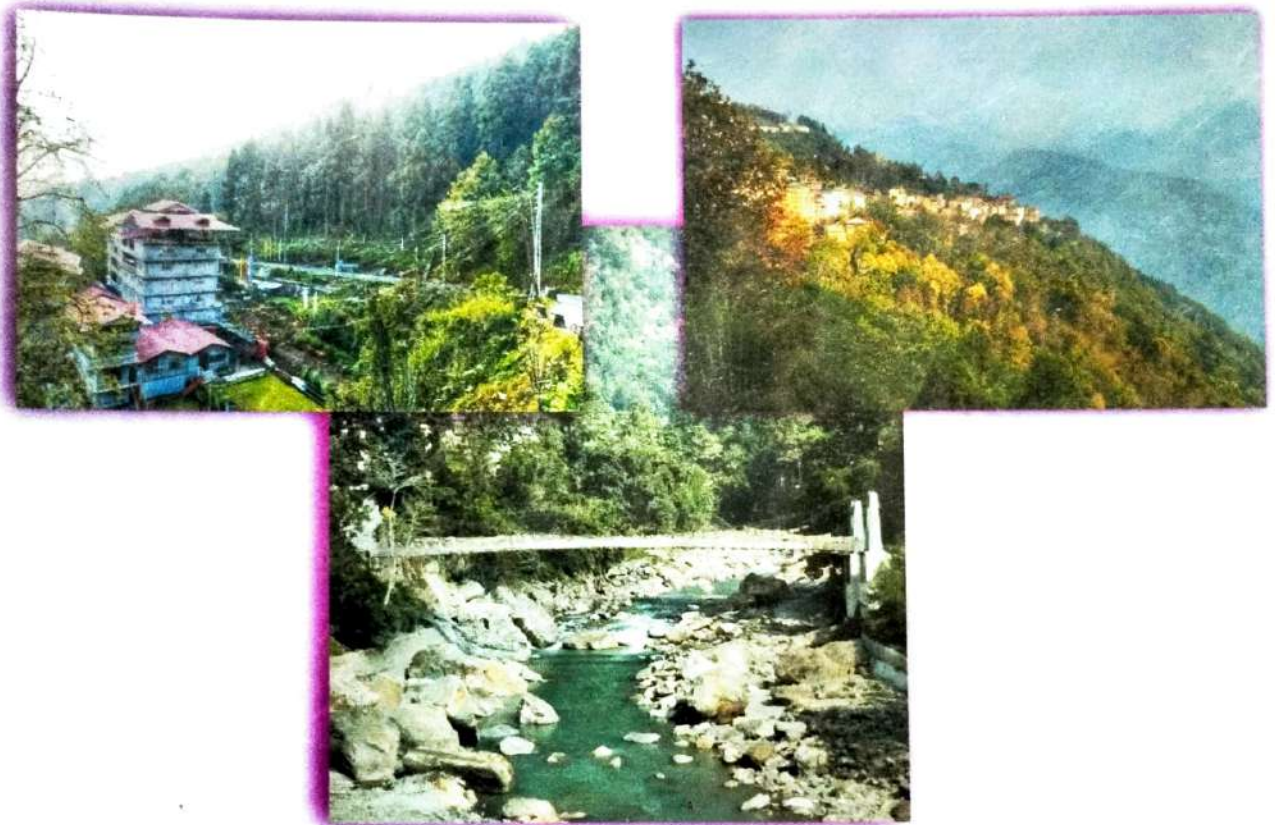


# VIDYASAGAR UNIVERSITY

Report On

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



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

**REG. NO :- 1520130 OF 2020 - 2021**

**ROLL NO :- 1126152 - 200004**

**SESSION :- 2022 - 2023**



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management :A study in some parts of Sikkim  
Himalayas.

for partial fulfilment of the syllabus prescribed by Vidyasagar University. The report has been prepared under the supervision of Miss Arpita Majumder and may be placed before examiner for evaluation.

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place : Amdabad

Date : 06.08.2023

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Signature

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## 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, earthquake, droughts cyclone 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, 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 or 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 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.

## Study Area:

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

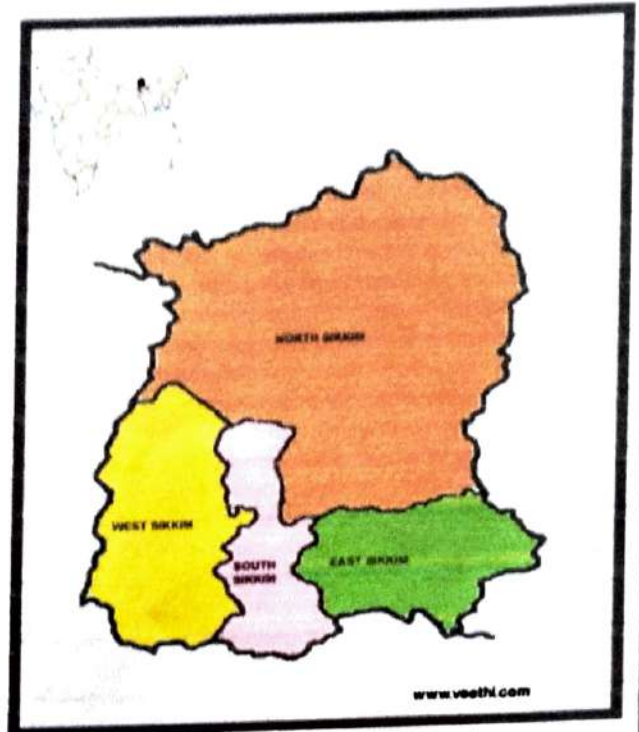
The state lies between very high and high landslide vulnerable zone on the basis of intensity of the controlling factors of landslide. Through north and East Sikkim are in very risk zone of landslide, South and West districts of Sikkim are also in high risk zone of landslide prone areas. West and South 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 management.



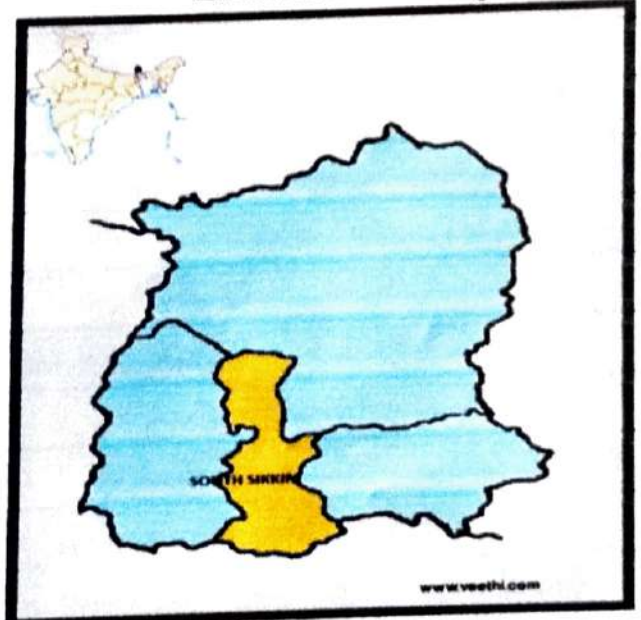
# LOCATION MAP



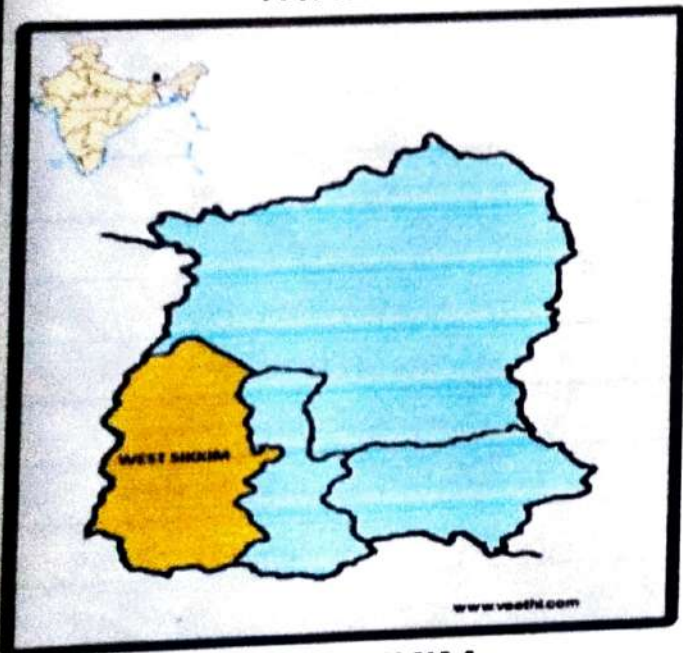
1. INDIA



2. SIKKIM



3. SOUTH SIKKIM



4. WEST SIKKIM

## Objectives :

The present project paper on landslide has been initiated to fulfill some basic objectives which are 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 ~~ind~~ 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.

## 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?

## 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 book, article, different link from website, journal etc.

We collected data from hotel manager, car driver, local people and seller of souvenir shop through interview method, and we again 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 the data properly to show rainfall and temperature. To represent demography and literacy we have pie and / bar diagram.

## 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 erosion, soil, climatic, nature (speciature, nature of slope, type of rock and its resistance, 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 be through 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 mountainous terrain. Almost the entire state is hilly with an elevation ranging from 580 metres (920 ft) in the south at the border with West Bengal to 8586 metres (28169 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 unsuit for agriculture because of the rocky, precipitous slopes. However, some hill slopes have been converted into terrace farms.

① 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 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 60 km, joins Teesta below Maili near the border of Sikkim with West Bengal. River Rangit is major tributary of River Teesta from the western Sikkim. Major tributaries of Rangit are Rimbi khola, Rathangchhu, Kaloy khola, Ramam khola and the little Rangit.

② Climate : The state has five seasons: Winter, summer, spring, autumn; and monsoon season. Most of the inhabited regions of Sikkim experience a temperate climate, with temperatures seldom exceeding  $28^{\circ}\text{C}$  in summer. The average annual temperature for most of Sikkim is around  $18^{\circ}\text{C}$ . During the monsoon, heavy rains increase the risk of landslides. The record for the longest period of continuous rain in Sikkim is 11 days. Fog affects many parts of the state during winter and the monsoons, making transportation perilous. Temperatures in the mountain can drop to as low as  $4^{\circ}\text{C}$  in winter.

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.

④ Flora and fauna : Sikkim is situated in an ecological hotspot of the lower Himalayas, one of only three among the ecoregions of India. owing to its altitudinal gradation, the state has a wide variety of plants and animals. The state flower is Rhododendron and the state tree is the Noble orchid. About 40 species of Rhododendron bloom from late April - mid May across the state.

Sikkim is home to around 5,000 species of flowering plants, 515 rare orchids, 60 primula species, 1100k varieties, 23 bamboo varieties.

16 conifer species, 362 types of ferns and fern allies, 8 tree ferns and over 900 medicinal plants. A relative of the poinsettia, locally known as "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, cheetah, Tibetan wolf, hog badger, binturong, and Himalayan jungle cat. Among the animals more commonly found in the alpine zone are yaks, many reared for their milk, meat and as beasts 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 (Rangit)



Ground clay soil



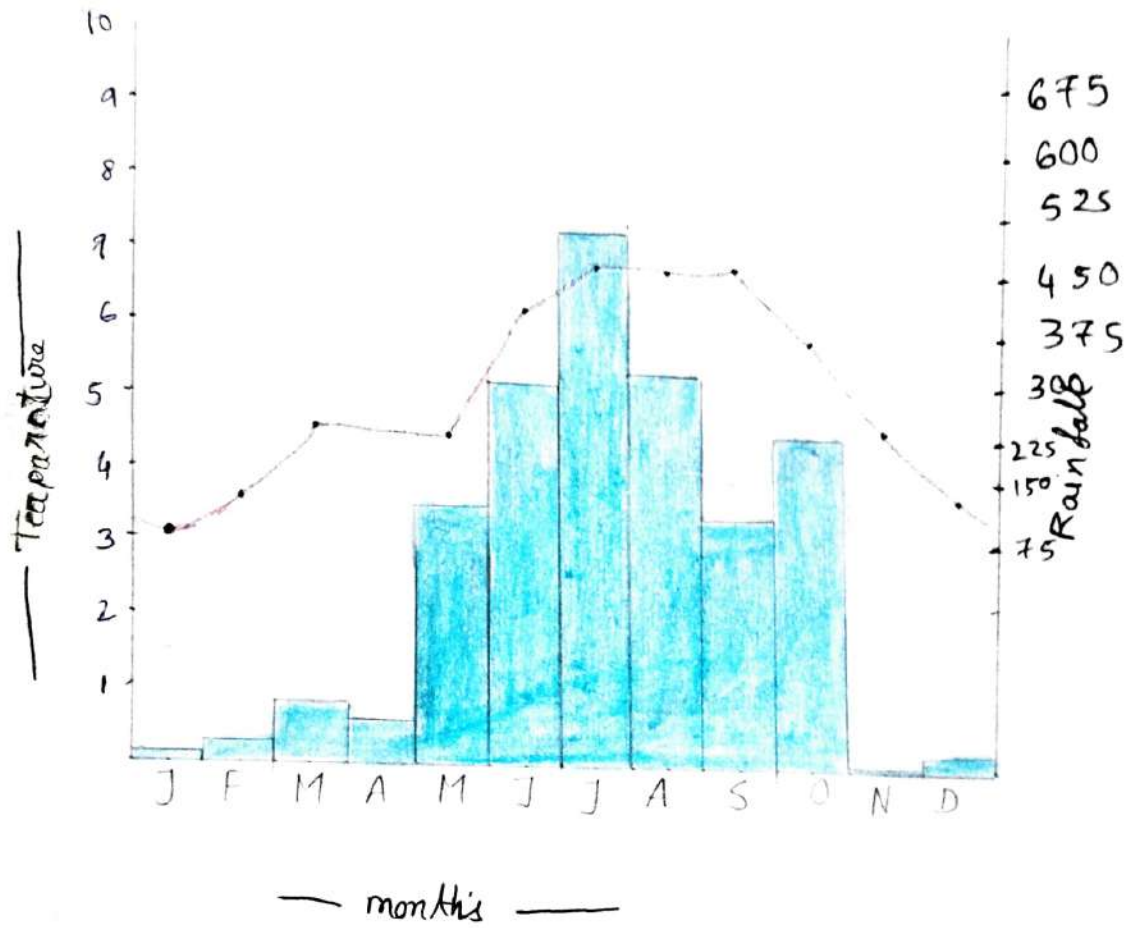
Rhododendron plant



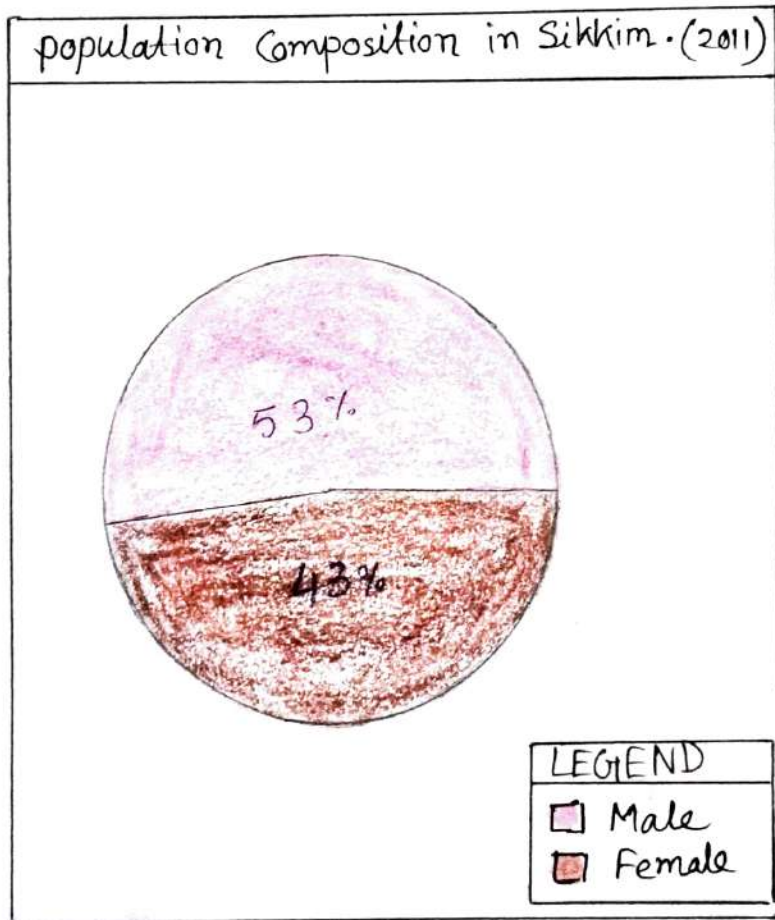
National Animal Red panda



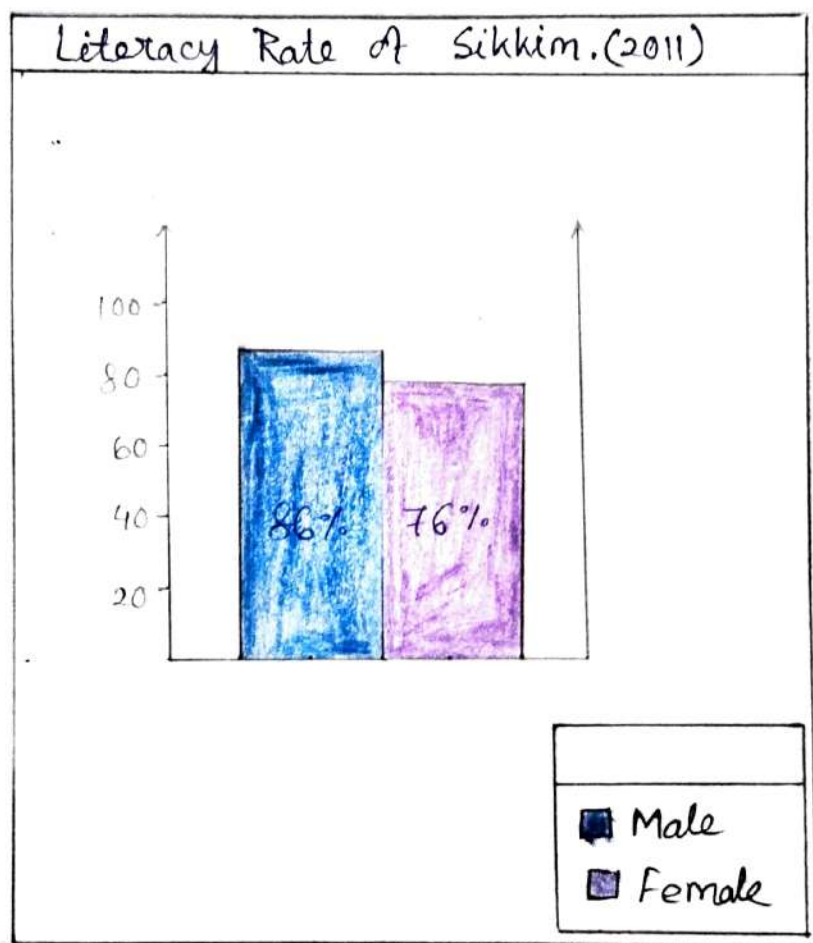
Months	Temperature (°C)	Scale	Temperature (cm)	Rainfall (mm)	Scale	Rainfall (cm)
January	9.4	1cm = 75 mm	3.13	6.1	1cm = 75 cm	0.08
February	10.9		3.63	21.9		0.29
March	13.7		4.56	57.0		0.76
April	16.6		5.53	45.5		0.66
May	18.7		6.23	266.4		3.55
June	20.3		6.76	394.0		5.25
July	20.3		6.76	554.6		7.38
August	20.4		6.8	401.3		5.35
September	19.6		6.53	225.8		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



**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%.



**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 of Sikkim, 2011

Sex	percentage of population	Total population	population (
Male	52.87	100	190°.5
Female	47.05	100	169°.5

Literacy Rate of Sikkim, 2011

Sex	percentage of Literacy	Scale	Literacy Rate (%)
Male	86.55	5cm = 20	4.32
Female	76.04	1cm = 20	3.80

**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.

**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 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 (prt)	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 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.

**Industry** : Sikkim has long been an 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 deserve a special mention in this context are:- pharmaceuticals, cosmetics, food processing, breweries, Matress, corrugated boxes, tea processing etc.



**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 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 sanctuaries for ecotourism activities :- Kunchedzong National Park, Singba Rhododendron Sanctuary, Fambong Tho Wildlife Sanctuary, Kyongrosta Alpine Sanctuary, Macram Wildlife Sanctuary, Varsey Rhododendron Sanctuary.

## Transport system of Sikkim :

**Road ways** : National Highway 10 (NH 10; formerly NH 31A) links Siliguri to Gangtok. Sikkim nationalised transport runs bus and truck services. Privately run bus, tourist taxi and jeep services operate throughout Sikkim and also connect it to Siliguri. A branch of the highway from Melli connects western Sikkim. Towns in eastern, southern and western Sikkim are connected to the hill stations of Kalimpong and Darjeeling in northern 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	
NH 310A	55	34	Tashi view point - phodong - Mangan	
NH 510	70	43	Singtam - Damthang - legship - Gyalshing	
NH 710	45	28	Melli - Manpur - Namchi - Damthang - Tarlu	
NH 717A	112	70	West Bengal Border - Rhenock, Rorathang pokhyong 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 sheralhang.	

## 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 A Sikkim



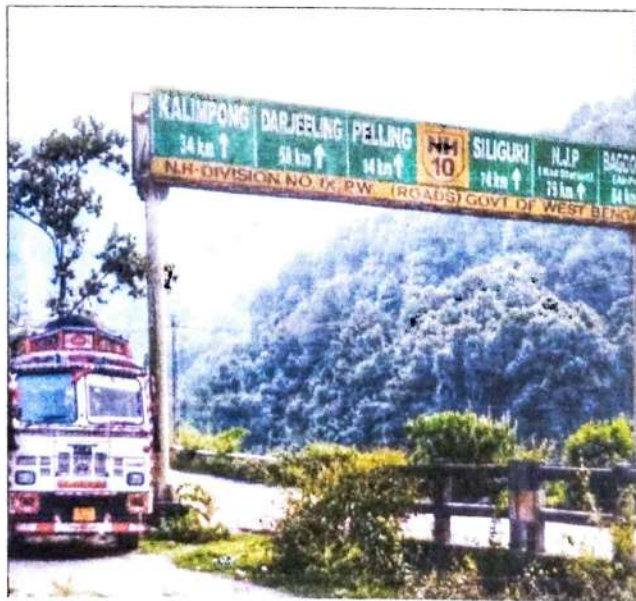
culture of Sikkim



primary Health centre in  
Dentam



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

## Causes of landslide :

The frequent occurrence of landslide is a very common phenomenon 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 formations can contribute to landslide. The Sikkim region is characterised by rugged terrain with steep slopes, especially in the Himalayan mountain range. The presence of weak rock formation and loose soil can make these slopes prone to landslide.

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

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

1. **Heavy rainfall**: Intense or prolonged rainfall can saturate the soil, increasing its weight and reducing its stability. Sikkim experiences heavy monsoon rains, particularly during the 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 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.

3. **Erosion**: Natural erosion processes

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

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



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

3. **Defective drainage systems**: poorly designed drainage system can lead to the accumulation of water in the soil, decrease strength of slopes. This can result in slope failures and landslides.

4. **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.

5. **Irrigation and water leakage**: Improper irrigation practices, such 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 consequences on the region, the environment, and the local communities. Here are some of the potential effects -

**Effects of landslide**: Damage to Infrastructure, The infrastructure facilities such as telephone and communication system, furniture, commodities, transport system etc. are severely damaged and put out of gear by massive landslide.

B. **Social effects**:

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 size and there is heavy toll of human lives.

## 2. Damage to settlement, roads and railroads :

Settlement comprising both rural and urban located at vulnerable sides such as on hill slopes, at the foothills, alluvial fans and cones, in the valleys, facing steep hill slopes etc. are damaged and sometimes village are completely destroyed by the thick debris of rocks, muds and other materials dislodged from the hills caused by landslides of various sorts triggered by earthquakes, or heavy rainfall or human activities.

## C. Economical effects :

### 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 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 :

1. 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 repercussions on water quality and marine life.

2. Wipe out forest land: What's more, these hazards can wipe out large tracts of forest, 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 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 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~~ 2011 at 06:11 pm (local time), a Mw6.9 earthquake with an epicenter located near the Sikkim region ( $27.723^{\circ}\text{N}$ ,  $88.064^{\circ}\text{E}$ ), 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.

iv. [Socio-economic effects of landslide] Socio-economic effects include

Adverse impacts, as enumerated above, on people, their homes and properties, industries and institutions, agricultural lands and crops, timber, tele lines such as roads and highways, railroads, and communication system, educational institutions etc. It is significant to note that socio-economic problems caused by mass movement of soil, waste and landslides due to slope failures are many and are increasing large proportion due to expansion of built environment in environment ~~to~~ and subsequent maintenance work.

[Some instances of landslide in the study area]:

[2007, 19th July]: Heavy rain triggered a landslide in Kabungla south Sikkim. The Singtam, Kabungla road has seen as many as 11 landslides while the Namchi-Kabungla route via Namthing has been closed because of an uprooted tree.

[2011, 23rd June]: A torrential spell of rain from 1:30 pm to a little past midnight on the 23 June 2011 triggered numerous small landslides in polling. Whose 14 people perished on the polling Dantam road in West Sikkim.

[2011, 18th September]: On September 18, 2011, a 6.9 magnitude earthquake struck the India-Nepal border region. According to news reports, impacts of the earthquake included landslide in the northern Indian state of Sikkim, between Nepal and Bhutan.

[2020, 21st June]: A landslide occurred in Totopani at 6 pm 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 expansion has added to risk of landslips during on going monsoon season. Legship-Nayabazar road was blocked near Totopani due to the landslide. The commuters travelling from Jorethang to Gyering, Yulsam and Tashiding were compelled to take Reshi-Rinchenpong route via Legship to reach their destination.

[2020, 27th June]: A landslide occurred at National hydropower project of corporation (NHPC) Teesta stage-V dam on the left bank of the river in Dehehu. According to the local people of Jang and Dapdara, the landslide was occurred due to the negligence of NHPC, and it could have been avoided with proper preventive work on time. The landslide has severely damaged the 55 metre High dam of the 510 MW Teesta Hydropower project of NHPC.

**2020, 6th August** : A massive landslide occurred in Jorethang in south Sikkim. A road in Jorethang was also washed off due to heavy rainfall in the region. The IPCA laboratory in the Marhitari, Jorethang was badly damaged in the landslide. The house was also completely washed away due to the landslide triggered by heavy rainfall in the area.

**2022, 5th February** : A landslide occurred at pathing village in Namchi district due to heavy rainfall. 60 houses were damaged in this landslide.

**2023, 18th June** : Multiple landslides induced by heavy rainfall have damaged over a hundred houses in West Sikkim, district. The incessant rain has caused extensive damage to infrastructure and property in the state.

**Management** : Guidelines by the National Disaster Management Authority (NDMA) on management of landslides reduce the enormous destructive potential of landslides and minimize the consequential losses by institutionalizing the landslide hazard mitigation efforts. Preventive and corrective measures to lessen the impacts of landslides 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 area -



# SOME OTHERS PHOTOGRAPHS RELATED TO LANDSLIDE



Landslide prone area unplanned Settlement



Heavy Rainfall



uprooted plant



land subsidence



Rock slope Mitting



Bench terracing

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

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

**Rock slope Netting**: Rock Netting 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 slopes at convenient distance was built with in the landslide of south Sikkim. The soil excavated from the trenches was deposited on the lower edge of trenches where forest trees were planted.

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

# Some Instances of Landslide in the study area



Pathing village in Namchi destroyed due to heavy rainfall



The IPCA laboratory was badly affected due to landslide



Teesta stage-V dam was broken due to landslide



Landslides all over Sikkim due to earthquakes



14 people died in pelling due to landslide



Leogshup - Mayajaborar road was damaged due to landslides



Namchi - Ravangla road ways closed due to landslide

**Suggestive Measures**: Along with the management system of landslide in Sikkim Himalaya some other measures 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 Assessment should be followed before mining or dam building.

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

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

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

vi) Mitigation techniques such as 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 and the landslide-prone area of Sikkim require special attention and vigilance to cope up with this calamity.

## Bibliography

Agriculture. (2022) Retrieved from [http://sikenvis.nic.in/Database/Agriculture\\_777.aspx](http://sikenvis.nic.in/Database/Agriculture_777.aspx)

Ahuja, R. (2018). Research Methods. Rawat Publications, Satyam Apts, Sector-3, Jawhar Nagar, Jaipur-302004(India).

Biodiversity(n.d.). Retrieved from <https://sikkim.gov.in/departments/forest-environment-and-wildlife>  
[department/biodiversity#:~:text=Species%20wise%2C%20the%20State%20harbors.Fishes%20and%20over%20600%20Butterflies](https://sikkim.gov.in/departments/forest-environment-and-wildlife/department/biodiversity#:~:text=Species%20wise%2C%20the%20State%20harbors.Fishes%20and%20over%20600%20Butterflies)

Bhattacharya, A. Bhowal, S. (2022). Report On Aquifer Mapping Studies & Management Plan In Parts Of West Sikkim District, Sikkim. *Central Groundwater Board Eastern Region, Kolkata Ministry of Jal Shakti Department of Water Resources, River Development & Ganga Rejuvenation Government of India.*

Chakraborty , N. (2022). Duryog O Biparjay Byabosthapana. Nabodaya Publication, 61-Surya Sen Street, Kolkata- 700009

Culture and Tradition of Sikkim(n.d.) Retrieved from  
<https://www.tourmyindia.com/states/sikkim/people-and-culture.html>

DNA Web Team( 2020). Massive landslide hits Sikkim's Jorethang ,IPCA laboratory damaged [Blog post] Retrieved from <https://www.dnaindia.com/india/photo-gallery-massive-landslide-hits-sikkim-s-jorethang-see-pics-2836274>

Gaunia, G.(2022). Landslide and Management: A Study on Gangtok, Sikkim, India. *International Journal Of Multidisciplinary Educational Research. Vol.11, Issue7(6), pp. 20-29,ISSN: 2277-788 DOI: http://ijmer.in.doi./2022/11.07.95*

<https://en.m.wikipedia.org/wiki/Sikkim>

<https://www.mapsofindia.com/maps/sikkim/districts/southdistrict.htm>

<https://gyalshing.nic.in/economy/>

[https://india.fandom.com/wiki/Economy\\_of\\_Sikkim/About#:~:text=Sikkim's%20economy%20is%20largely%20agrarian,%2C%20apples%2C%20tea%20and%20orchids](https://india.fandom.com/wiki/Economy_of_Sikkim/About#:~:text=Sikkim's%20economy%20is%20largely%20agrarian,%2C%20apples%2C%20tea%20and%20orchids)

[https://ssdma.nic.in/Home/ContentFor?MenuID=3&ContentFor=Content\\_SubMenu](https://ssdma.nic.in/Home/ContentFor?MenuID=3&ContentFor=Content_SubMenu)

<https://www.slideshare.net/pramodgpramod/disaster-management-landslide>

Kothari, C,R, Garg, G. (2019). *Research Methodology- Methods and Techniques* . New Age International (P) Limited, Publishers, New Delhi- 110002. ISBN- 978-93-86649-22-5

**Landslides**, (2022). Retrieved from <https://odpm.gov.tl/node/17>

**Landslide on NHPC's Teesta V hydropower project in Sikkim damages the 55-metre high dam(2020)** . Retrieved from <https://en.gaonconnection.com/landslide-on-nhpcs-teesta-v-project-in-sikkim-damages-the-dam/>

**Lachungpa, C.(2009)**. Report On Treatment Of Land Slide And Erosion Control Project Under Tdet - South Sikkim 2004-05 To 2007-08. *Envis Centre Sikkim On Status Of Environment & Its Related Issues. Forests, Env. & Wildlife Management Department Government of Sikkim.*

Management of landslides and snow avalanches - National disaster management guidelines by National Disaster Management Authority. (2011) National Disaster Management Authority.Retrieved from <https://www.indiawaterportal.org/articles/management-landslides-and-snow-avalanches-national-disaster-management-guidelines-national>

**Nag, C. (2022)**. *Research Methodology & Field Survey in Geography*. Nadia Publishers, Kolkata-13

Ongmu, D. (2019). Landslides hit West Sikkim, CM PS Golay visits affected areas. Retrieved from <https://www.eastmojo.com/sikkim/2019/09/20/landslides-hit-west-sikkim-cm-ps-golay-visits-affected-areas/>

Rai D, Singhal, V, Mondal, G, Parool, N, Pradhan, T, Mitra, K. (2012). The M 6.9 Sikkim (India-Nepal Border) earthquake of 18 September 2011. *Current Science Association*. Vol. 102, No. 10, pp. 1437-1446. Retrieved from <https://www.jstor.org/stable/24107802>

Roy, T, Mondal, B, Maity, M, Bandyopadhyay, C, Bishal, P. (2021) *Geographical Research Methods and Field Survey*. Kalyani Publishers, Diamond Agencies Pvt. Ltd., B-125, Sec. 63, Noida. ISBN: 978-93-90522-21-7

Sarkar, A. (2008) *Practical Geography- A Systematic Approach* Orient Black Swan Private Limited, Kolkata- 700072. ISBN: 81-250-3529-X

Shil, A. (2021). *Research Methodology with Geographical Field Survey*. The Himalayan Books, 39 B Sri Gopal Mallik Lane, Kolkata-700012. ISBN: 978-81-926509-8-2

Sikkim's ecotourism evolution(2018). Retrieved from <https://www.greeneconomycoalition.org/news-and-resources/sikkims-eco-tourism-evolution>

South Sikkim District - Population 2011-2023 Retrieved from <https://www.census2011.co.in/census/district/463-south-sikkim.html#:~:text=Out%20of%20the%20total%20South,as%20per%202011%20census%20data>

Sikkim Culture (n.d). Retrieved from <https://www.bharatonline.com/sikkim/culture/index.html>

Sikkim Economy ,(2018). Retrieved from <https://www.globalsecurity.org/military/world/india/sikkim-economy.htm>

Taneja, S.( 2017). Sikkim is 100% organic ! Take a second look. Retrieved from <https://www.downtoearth.org.in/news/agriculture/organic-trial-57517>