CAPACITY BUILDING STRATEGIES FOR MANAGING COMPLEX DISASTERS IN THE FACE OF CLIMATE CHANGE

ANNUAL REPORT 2018-2019

Indian Institute of Public Administration, New Delhi

Project Sponsor by

सत्यमेव जयते

NMHS, MoEF&CC

Project Lead

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SEEDS INDIA

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Climate School: A Pilot Project

Photograph: © SEEDS/ Siddharth Behl

1. Climate School – A Pilot Project

Education helps in promoting awareness and imparting knowledge and skill-development. It is an important aspect when it comes to combating climate change at global level. It can be used as a driving force by educating the young and ensuring a sustainable future. UN Framework Convention on Climate Change (UNFCCC) also encourages Parties to promote, develop and implement educational, training and public awareness programmes on climate change and its effects stated in the Article 6 (UNFCCC: Learn, 2013).

To safeguard the future, it is important to impart the knowledge of sustainable practices, create skill sets and add value which will ensure that the coming generations have the ability to deal with any unanticipated climatic conditions. Sensitizing the future generations about the effects of unexpected heat waves, flooding, droughts, intense tropical cyclones, rising sea levels, and damages biodiversity, all being a part of climate change, in our economic and social life is essential for this.

Hill towns and regions of the Himalaya ranges are more susceptible to effects of climate change. Frequent landslides, high rainfall and flash floods are experienced more often in these regions than in flats lands. Vulnerable groups like children living in these areas are the hit hardest by climate change. The changing climate is making it harder for children to access education in a safe environment as disasters caused by climate change can damage or destroy schools. And the economic impacts of disasters reduce school enrolment, as children are kept out of school to help their families earn a living.

Despite being threatened by the changing climate, education offers a valuable opportunity to combat climate change. It gives children and young people the knowledge and skills to make informed decisions about how to adapt individual lives and ecological, social or economic systems in a changing environment. Education plays a vital role in bringing about behavioural change.

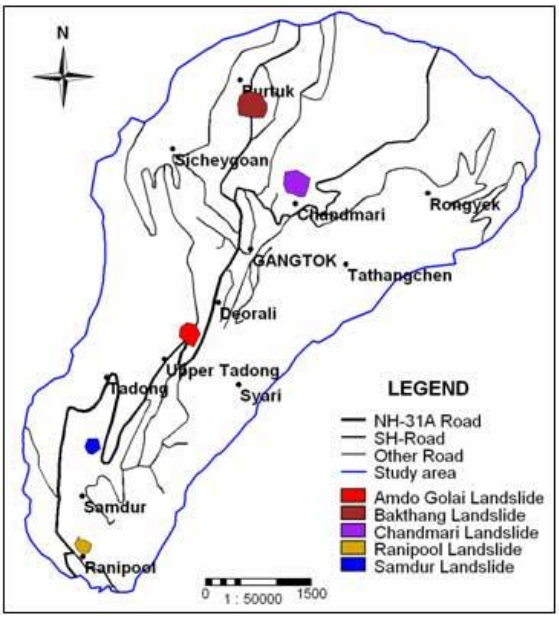
Objective

The Climate school as a concept works towards sensitizing the school children towards Climate change under practical conditions. The Climate Change Education programme undertaken by UNESCO informs the student about the phenomenon of climate change and effects of it. As another means to generating awareness, the climate school demonstrates the actual variation in the weather conditions by measuring the local weather parameters of the area where the school is situated. In this way the students get a quantitative idea of how the weather varies during seasons.

The objective of the exercise is to sensitize the school students about the effects of climatic parameters and to instill a curiosity in the young minds to know about the various facets of climate science. The study does not use the data recorded by the students for any research purpose as the objective of the exercise is to make children better understand the parameters that affect the weather of their city in the backdrop of complex disasters.

Site Selection

The school selected for this pilot project is the Govt. Junior High School, Upper Syari, Deorali, Gangtok. The school is located in the main city and the proximity to the amenities is more.



(Map by Geospatial World)

Figure 1.1 Location of the Climate School

Materials and Methodology

As Climate has a huge influence on complex disasters, measuring of climatic parameters and establishing their linkages with disasters can be done in order to sharpen the knowledge of complex disasters. The climate school aims to record daily weather data through the students for six parameters. These parameters include maximum and minimum temperature, humidity, wind direction, wind speed, rainfall and atmospheric pressure.

A training session of the seventh grade students was conducted for awareness of school students about climate change and weather instruments. The various parameters for monitoring weather were discussed with the students and the operation of the instruments was shown and explained to them. A group of six students was selected to record weather data from the instruments for a period of one month. After that another group of six students would be selected from the class to record the data. This was planned such that each student gets accustomed to use the instruments.

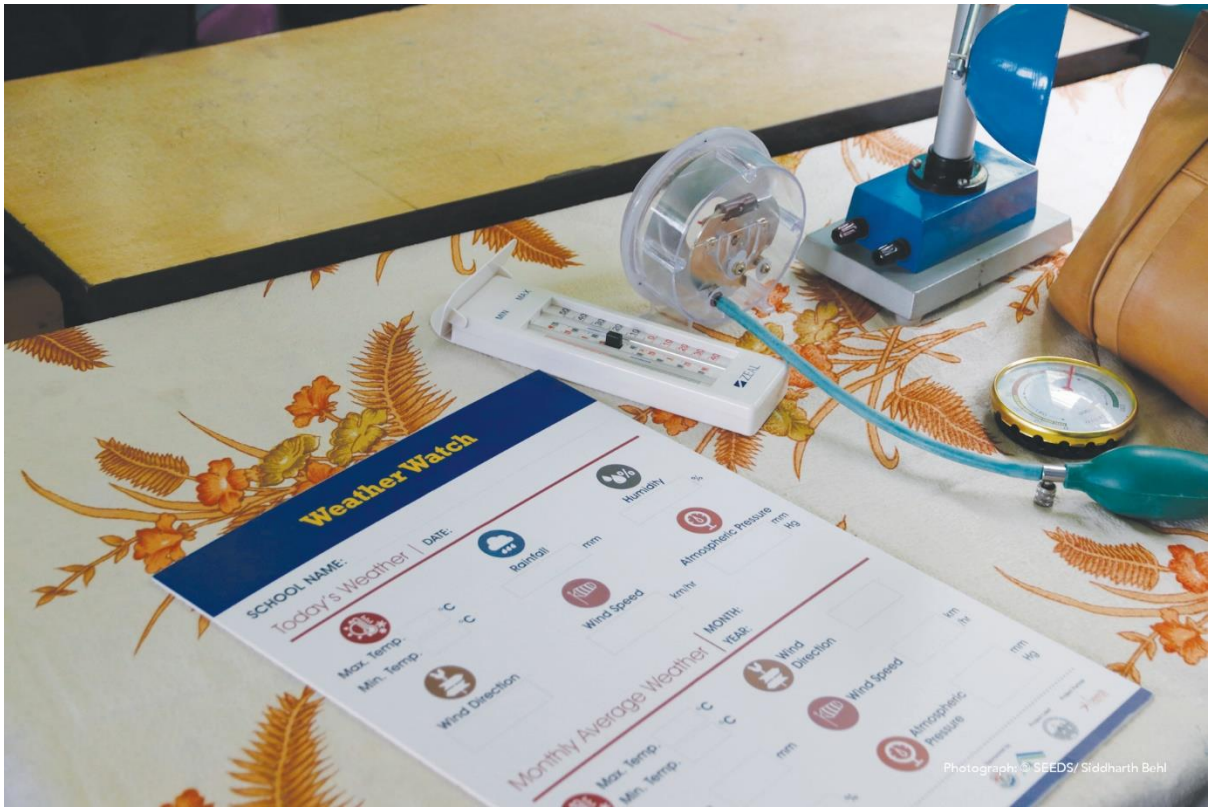
After that the selected group of six students was taught on how to operate the instruments and take the readings. The student practiced and took reading from the instruments and recorded in the register. A weather information board by the name of 'Weather Watch' was also put up at the school which displays daily weather data and monthly average weather data for the last month for the recorded parameters.

A nodal teacher was nominated by the school to supervise this activity and act as In-charge of the data recording session. The teacher also acts as a link between the project and the investigators. They are also responsible for the maintaining of the register of daily recordings.

Instruments Provided

The following instruments were handed over to the school for recording weather data and running climate school:

Maximum and minimum thermometer: This registers temperature which can record the maximum and minimum temperatures reached over a period of time, for example 24 hours. It is used to record the extremes of temperature at a location. The thermometer indicates the current temperature and the highest and lowest temperatures since last reset.



Picture 1.1 Maximum and minimum thermometer with display board

Hygrometer: It is an instrument used for measuring the amount of humidity and water vapour in the atmosphere, in soil, or in confined spaces. Humidity measurement instruments usually rely on measurements of some other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed.

Wind vane: A weather vane, wind vane, or weathercock is an instrument for showing the direction of the wind. It is typically used as an architectural ornament to the highest point of a building.

Anemometer (cup-type with counter): An anemometer is a device used for measuring the speed of wind, and is also a common weather station instrument. It consists of four hemispherical cups mounted on horizontal arms, which are mounted on a vertical shaft. The air flow passes the cups in any horizontal direction turning the shaft at a rate that is roughly proportional to the wind speed. Therefore, counting the turns of the shaft over a set time interval produces a value proportional to the average wind speed for a wide range of speeds. It is also called a rotational anemometer.

Picture 1.2 Project team explaining the working of Hygrometer

Picture 1.3 Children viewing the instrument

Picture 1.4 Project team explaining the working of Hygrometer

Picture 1.5 Demonstration of instruments

Picture 1.6 Children viewing the Anemometer

Rain Gauge: This instrument is used to gather and measure the amount of liquid precipitation over a set period of time. The traditional copper rain gauge consists of a copper and brass funnel, copper collector and calibrated plastic measure. The rain is collected and funnelled into the inner plastic measure from which the contents can be measured. Any additional rainfall is collected in the large copper body of the rain gauge and can be measured by pouring it into the supplied measuring jar.

Aneroid barometer: The instrument is used to measure atmospheric pressure, as a method that does not involve liquid. The aneroid barometer uses a cell (capsule), which is made from an alloy of beryllium and copper. The evacuated is prevented from collapsing by a strong spring. Small changes in external air pressure cause the cell to expand or contract. This expansion and contraction drives mechanical levers such that the tiny movements of the capsule are amplified and displayed on the face of the aneroid barometer.

Results

The parameters recorded by the school include:

Maximum and Minimum Temperature: The highest and lowest ambient air temperature recorded daily in a specific location is the maximum and minimum temperature of that place. The students recorded temperature in the months of May, June, July and August.

Humidity: It is the amount of water vapour present in air. Humidity indicates the likelihood for precipitation, dew, or fog to be present. The amount of water vapour needed to achieve saturation increases as the temperature increases. Gangtok receives rainfall throughout the year. This is also reflected in the reading made by the school. The Relative Humidity recorded by the students is high.

Wind direction: Wind direction is reported by the direction from which it originates. For example, a northerly wind blows from the north to the south.

Wind speed: Wind speed, or wind flow velocity, is a fundamental atmospheric quantity. Wind speed is caused by air moving from high pressure to low pressure, usually due to changes in temperature.

Rainfall: Sikkim is one of the few states in India to receive regular rainfall and snowfall and receives an average annual rainfall of 135 inches. Rain is measured in units of length per unit time. The school measures it in millimeters per hour.

Atmospheric pressure: The hydrostatic pressure caused by the weight of air above the measurement point. As elevation increases, there is less overlying atmospheric mass, so that atmospheric pressure decreases with increasing elevation.

Picture 1.7 Students updating weather watch board

MAY-2018							
Date	**Max. Temp.**	**Min. Temp.**	**rainfall**	**Relative Humidity**	**Wind direction**	**Wind speed**	**Atmospheric pressure**
	(^{0}C)	**(^{0}C)**	**(mm)**	**(%)**		**(km/hr)**	**(mmHg)**
11	40.0	25.0	2.40	68.0	NE	Below 1	731
12	40.0	15.0	1.75	68.0	SW	Below 1	754
13	31.0	17.5	1.75	68.0			750
14	31.0	17.5	1.75	68.0	S	Below 1	746
15	22.0	17.5	1.10	70.0			746
16	21.0	17.5	3.05	69.0			746
17	20.0	20.0	5.00	68.0	EW	Below 1	746
18	39.0	13.0	3.05	67.0	SE	1	743
19	42.0	13.5	3.05	54.5			741.5
20	42.0	13.5	3.05	54.5			741.5
21	45.0	14.0	3.05	42.0	NE	1	740
22	42.0	13.0	1.1	60.0	SE	Below 1	737
23	41.0	12.0	5.0	52**.**	NW	4	735
24	27.0	23.0	9.2	62.0	S	Below 1	736
25	23.0	21.0	4.1	67.0	S	4	798
26	23.0	13.0	10.0	62.0	S	Below 1	735
27	25.0	14.0	10.0	62.0			766
28	27.0	15.0	10.0	62.0		Below 1	797
29	26.5	14.0	8.1	61.0			797.5
30	26.0	13.0	6.2	60.0	E	Below 1	798
31	23.0	14.0	0.0	46.0	S	Below 1	797

Table 1.1 Recorded readings of MAY 2018

JUNE-18							
Date	**Max. Temp.**	**Min. Temp.**	**Rainfall**	**RH**	**Wind direction**	**Wind speed**	**Atmospheric pressure**
	(^{0}C)	**(^{0}C)**	**(mm)**	**(%)**		**(km/hr)**	**(mmHg)**
1 June	27.0	14.0	10.0	60	S	Below 1	798
2	27.0	14.0	8.0	59	S	Below 1	799
3	26.0	15.0	5.0	58	E	Below 1	797
4	35.0	13.0	0.2	48	E	1	796
5	34.0	20.0	2.4	42	E	3	797
6	34.0	20.0	2.0	40	E	1	797
7	28.0	25.0	0.0	45	E	1	796
8	29.0	13.0	8.0	62	S	Below 1	796
9	25.0	21.0	2.0	42	E	Below 1	796
10	25.0	21.0	2.0	42	E	Below 1	796
11	25.0	21.0	2.0	42	E	Below 1	796
12	33.0	20.0	10.0	58	NW	Below 1	796
13	30.0	10.0	0.2	48	NE	Below 1	796
14	32.0	20.0	10.0	58	S	4	795
15 June	29.0	11.0	10.0	62	W	Below 1	797

Table 2. Recorded reading of JUNE 2018

Picture 1.8 School Principal with the Climate School team

Follow-up of the initiative

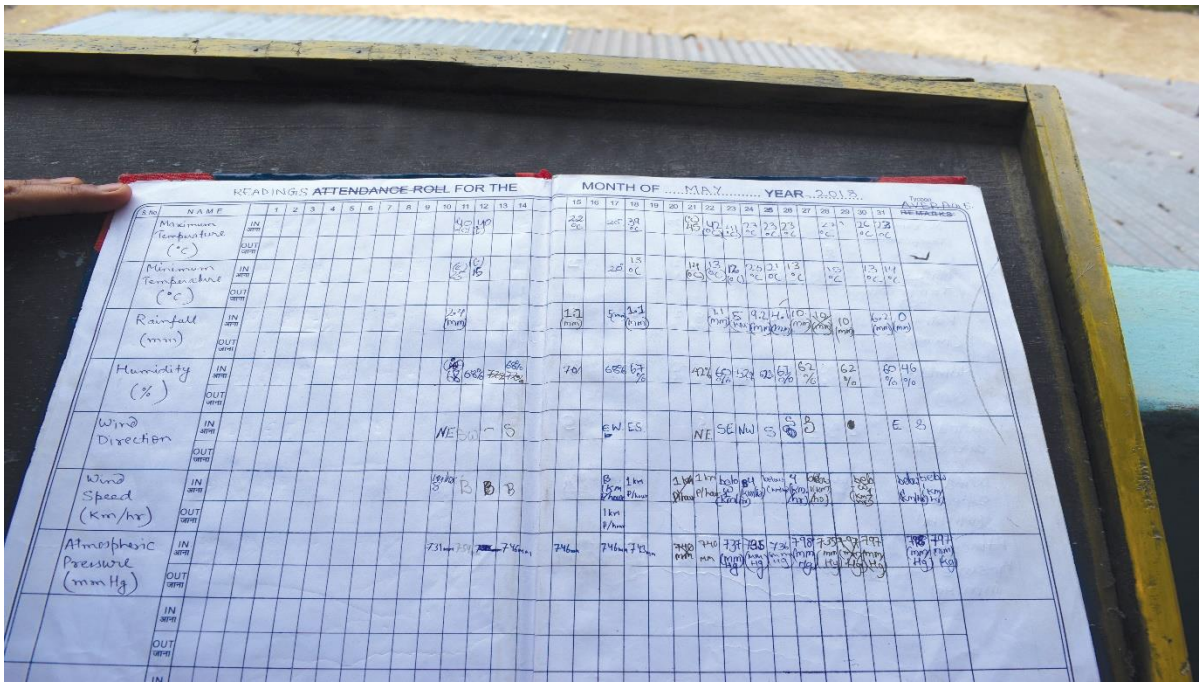
A visit to the established Climate School was done on 29 August 2018. In this visit, discussion with the school teachers and the teacher in-charge of the instruments and conducting the readings was done.

Picture 1.9 Instruments of Climate School

The teacher in-charge, the school's science teacher and has given a positive feedback regarding the establishment of the Climate School. The exercise of the taking the readings on daily basis and recording them daily on the board and the register is done by a group of four students, two new and two old. The old students train the new students in working of the instruments and this is done on rotation basis.

"This daily recording of the temperature has helped in sensitizing the students about climate and weather studies, which also happen to be in their course curriculum. Now the students better understand the phenomenon since they practically take the readings" Mrs. Aparna Chettri, teacher in-charge. The working of the instruments was discussed and it was reported that some instruments need to be repaired as they are not working effectively.

Picture 1.10 Daily recording on the board



Picture 1.11 Daily recording in the register

2. School Safety Exercise

The Nandu Gaon Secondary School, Poklok Denchung, South Sikkim was visited on 7th May 2018. An exercise regarding school safety was conducted in the school.

Picture 2.1 School Safety exercise

A small discussion on the prevalent risks in and around the school premises was carried out with the school students in a game format. The school students were given an activity to identify the different types of risk in their school premises. The following risks were identified by the school students:

a) Low hanging of high tension wires poses a threat of electrocution. One of the students got electrocuted 7 years back which led to the death of the student.

b) The fencing of the school premises is not complete. There is an open area beside the toilet where students play. The steep slope without a fence poses a threat of children falling and getting hurt. Student reported incidents of children falling and getting hurt.

c) The toilet area is not attached to the main school building. During rainy season, children often get wet in rain while going to the toilet.

d) The school building had minor cracks at multiple places. Small marks of dampness were also observed at specific locations.

e) There is no proper waste disposal system. All the waste is dumped at one place in an open area in front of the toilet. The waste is being collected on weekly basis by a waste collection truck. Sometimes the waste is burnt or disposed of in open if the waste collection truck does not come on time.

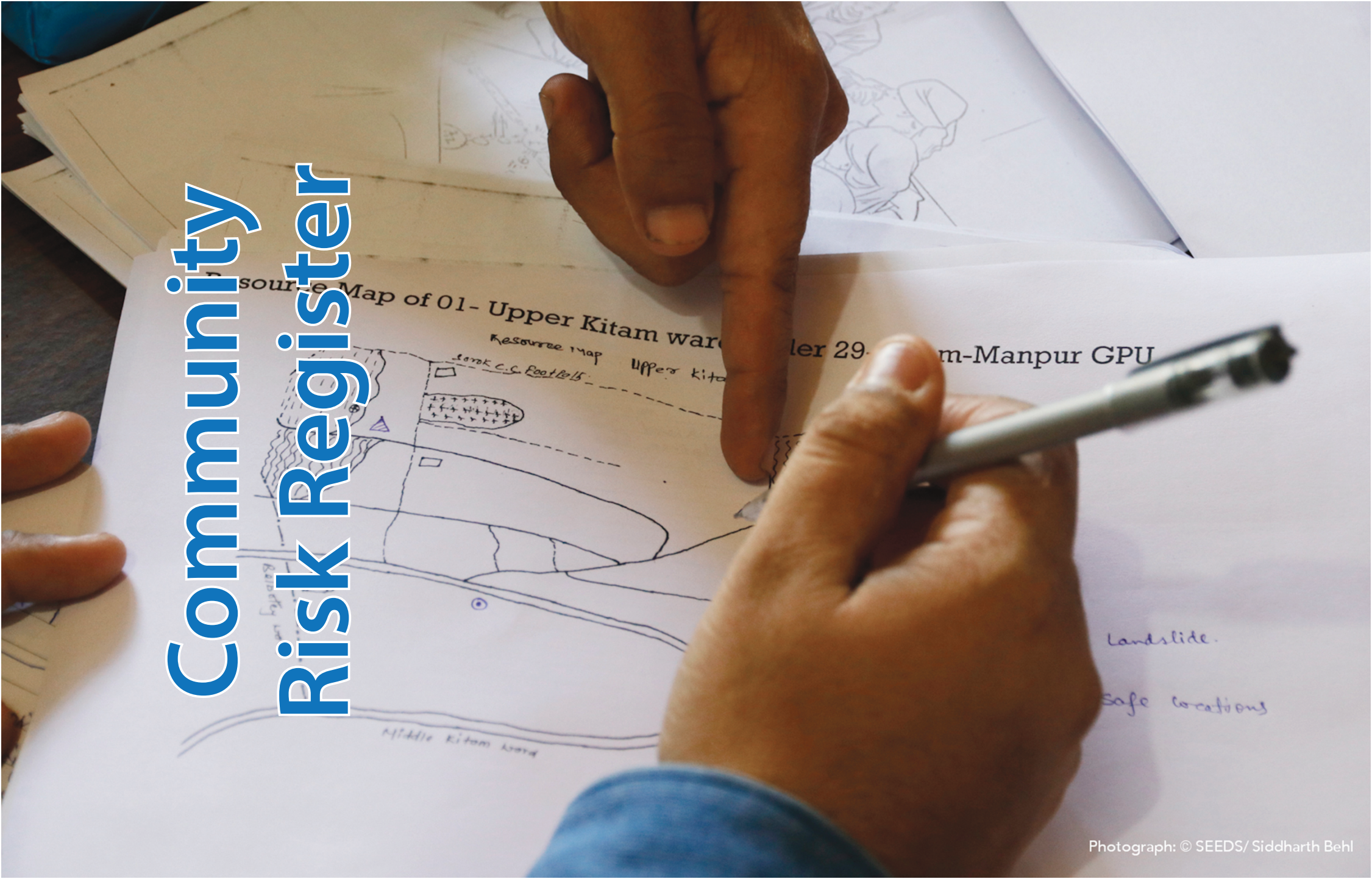
f) There is no direct access of school from the road as the school lies away from road downhill. Students have to walk down a staircase which does not have any railings for the safeguard of the students. In rainy season, the formation of algae on the staircase makes it slippery and students reported that they have slipped many times on the staircase.

Picture 2.2 High tension wire in close proximity

Picture 2.3 High tension wire around the school

Picture 2.4 Lack of railing

Community Risk Register



Photograph: © SEEDS/ Siddharth Behl

3. Community Risk Register

Community Risk Register (CRR) is a public document prepared by the local government which provides an overview of the potential risks in the community which can lead to a disaster. It provides information on the emergencies that can happen in the community, together with an assessment of how likely they are to happen and the impacts if they do. It is designed to inform people about the risks that could occur where they live, so they can think about what they can do to be better prepared in their homes, communities and businesses. The register also serves as a knowledge base for development planning works.

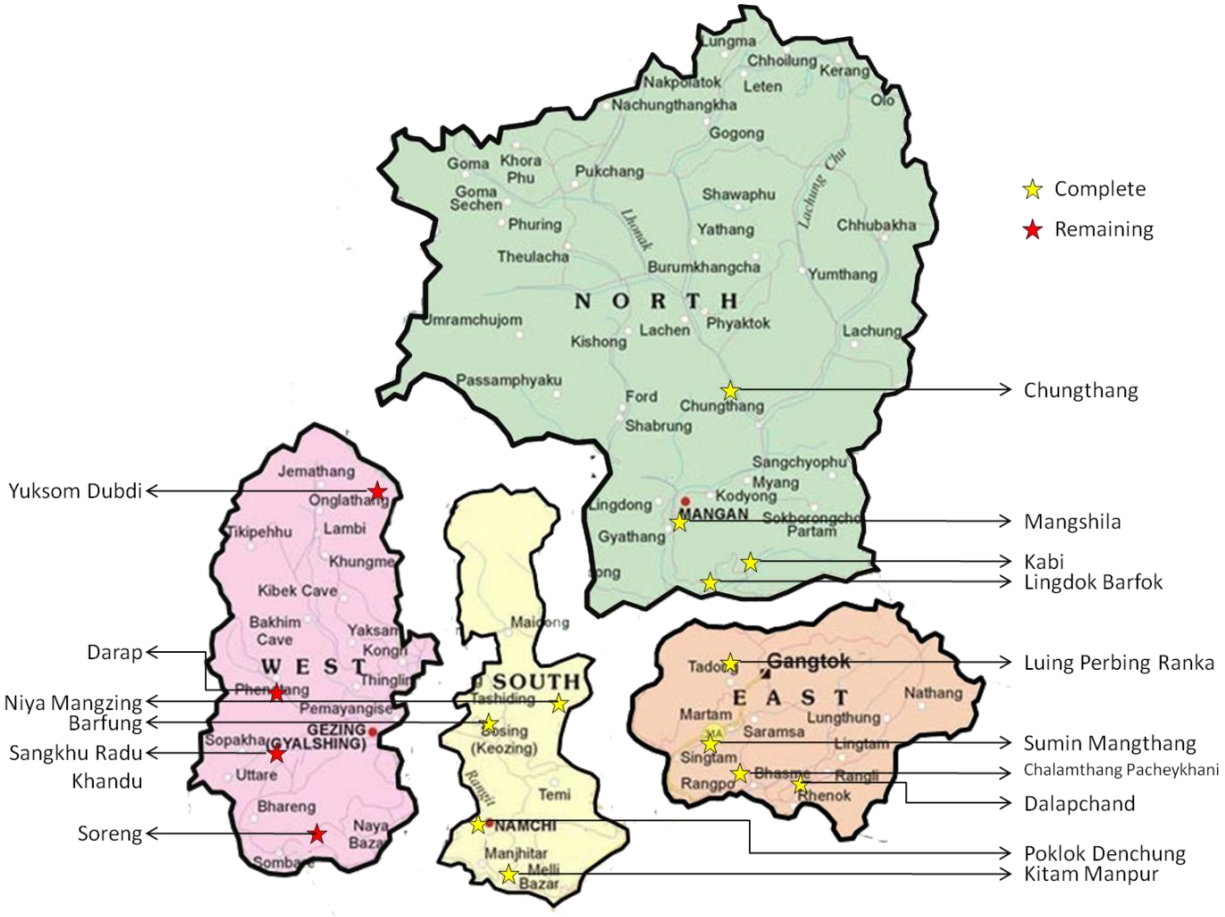


Figure 3.1 Locations of selected GPUs

Filling of CRR in Poklok Denchung Gram Panchayat Unit, South Sikkim

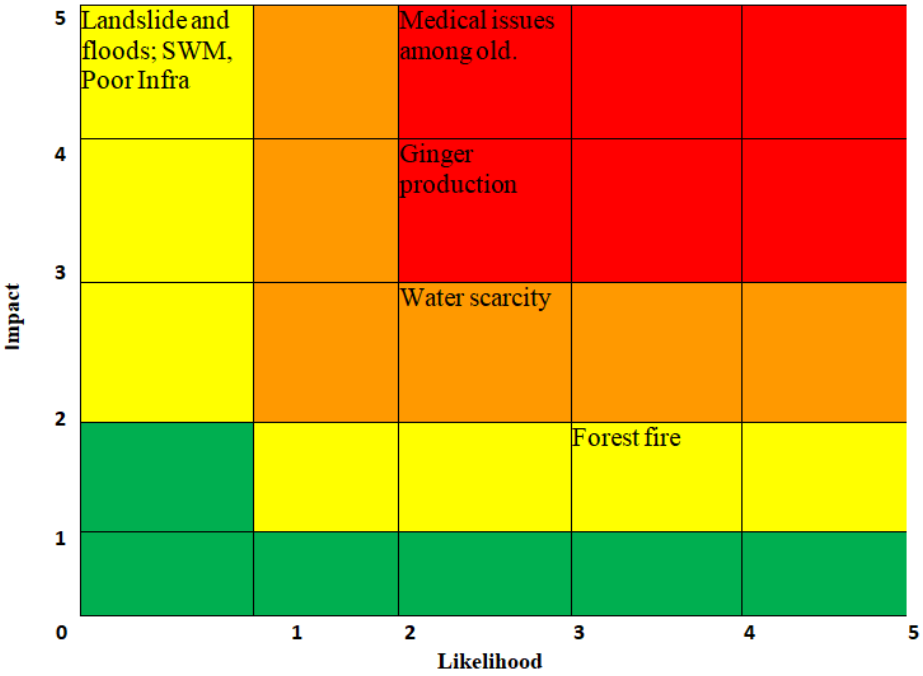
A visit to Poklok Denchung GPU was done on 07 May 2018. In this visit, discussion with PRI members including panchayat president, ward representatives and other panchayat officials was done on emerging issues due to prevalent hazards and climate change. The day to day shocks and stresses which the community felt were also discussed in the meeting. The template for filling of Community Risk Register (CRR) was demonstrated.

The concept of community risk register was discussed in detail and each section of CRR template was discussed. The prevalent hazards found during the discussion include landslide, earthquake and lightning. The day to day stresses included shortage of water, irregularity in rainfall and accidents due to high tension wires. The CRR template was handed over to the ward representatives for filling the same for their respective wards.

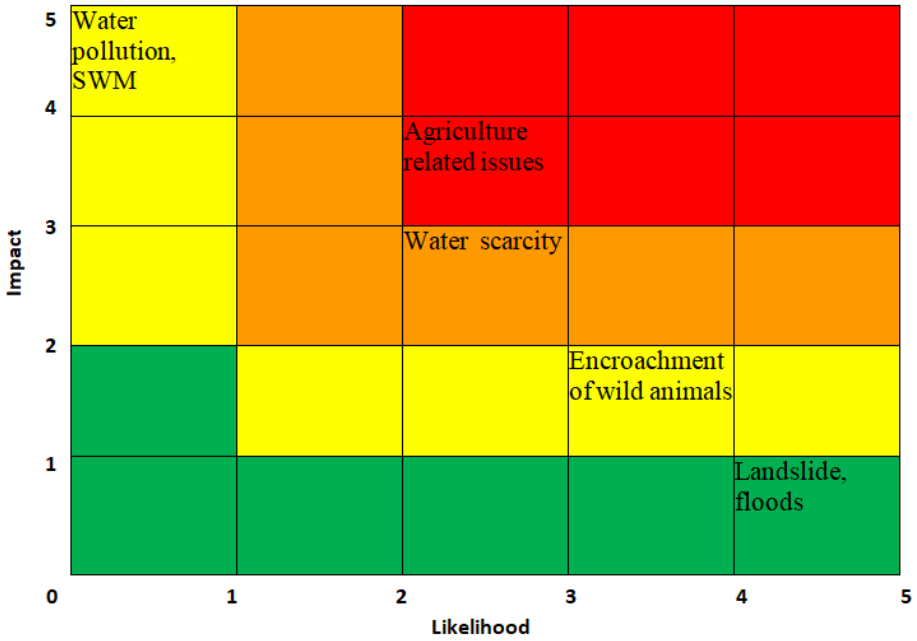
Picture 3.1 Interaction with the PRI members

1. CRR South district Poklok-Denchung (5 wards)

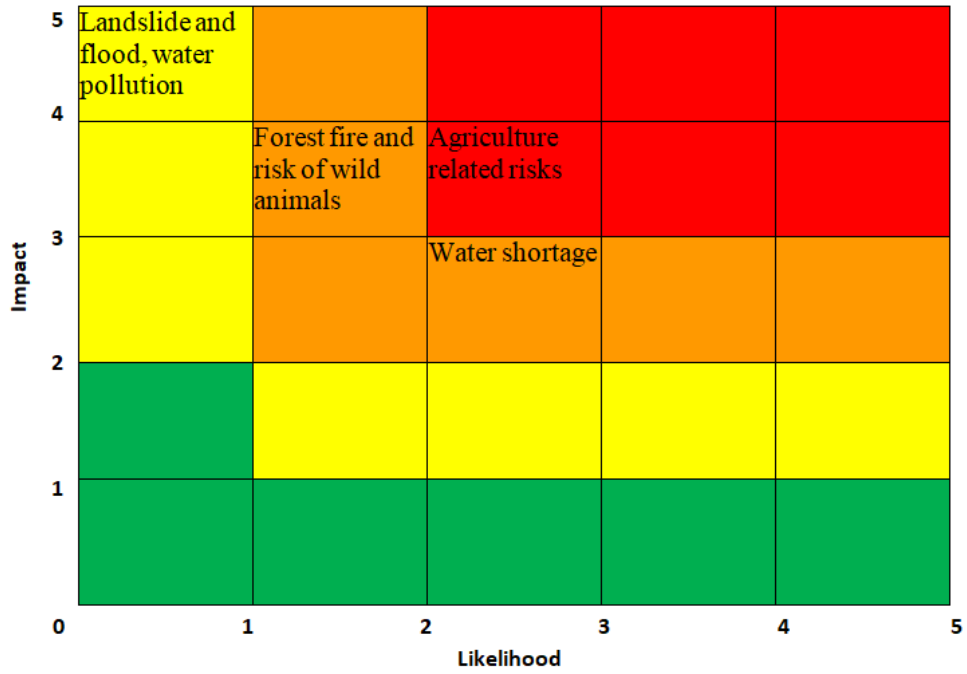
1.1 Risk Summary of Samseybong Ward of Poklok Denchung GPU (South)



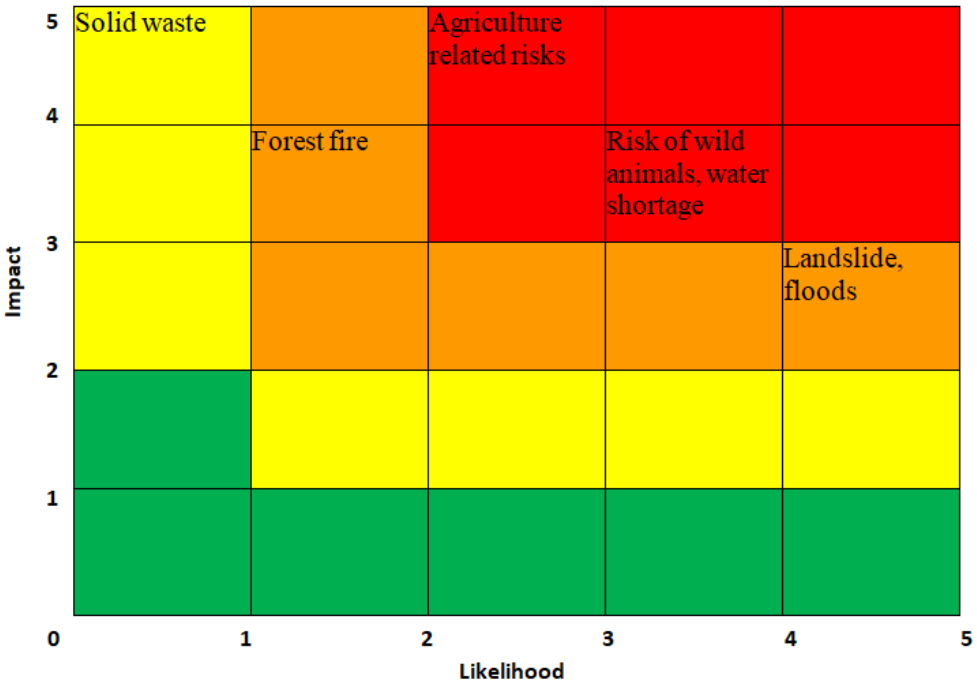
1.2 Risk Summary of Denchung Ward of Poklok Denchung GPU (South)



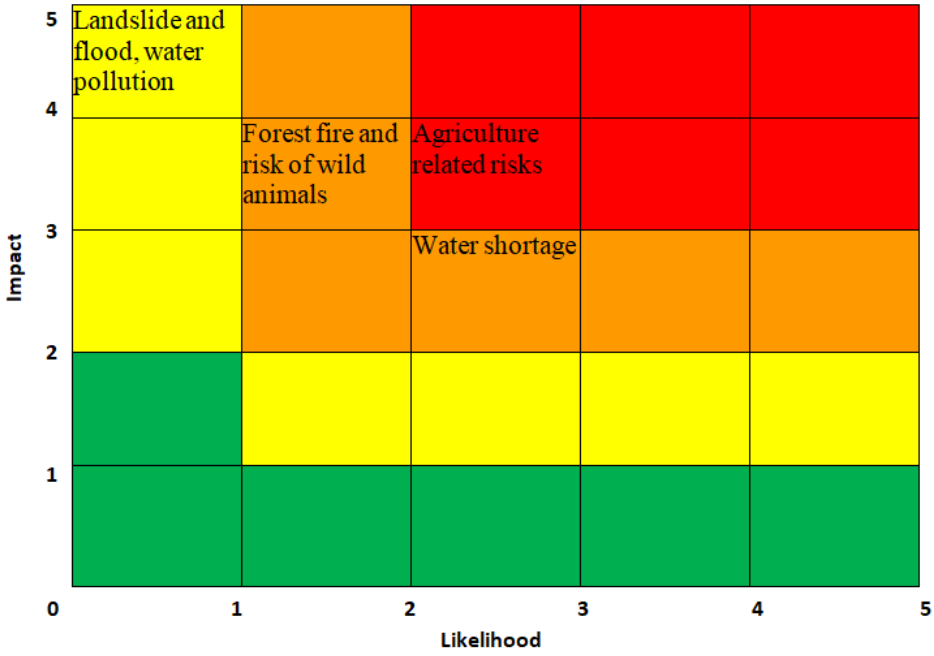
1.3 Risk Summary of Doncy Ward of Poklok Denchung GPU (South)



1.4 Risk Summary of Samtar Ward of Poklok Denchung GPU (South)



1.5 Risk Summary of Sirisey Ward of Poklok Denchung GPU (South)



Picture 3.2 Awareness at *Panchayat Bhawan*

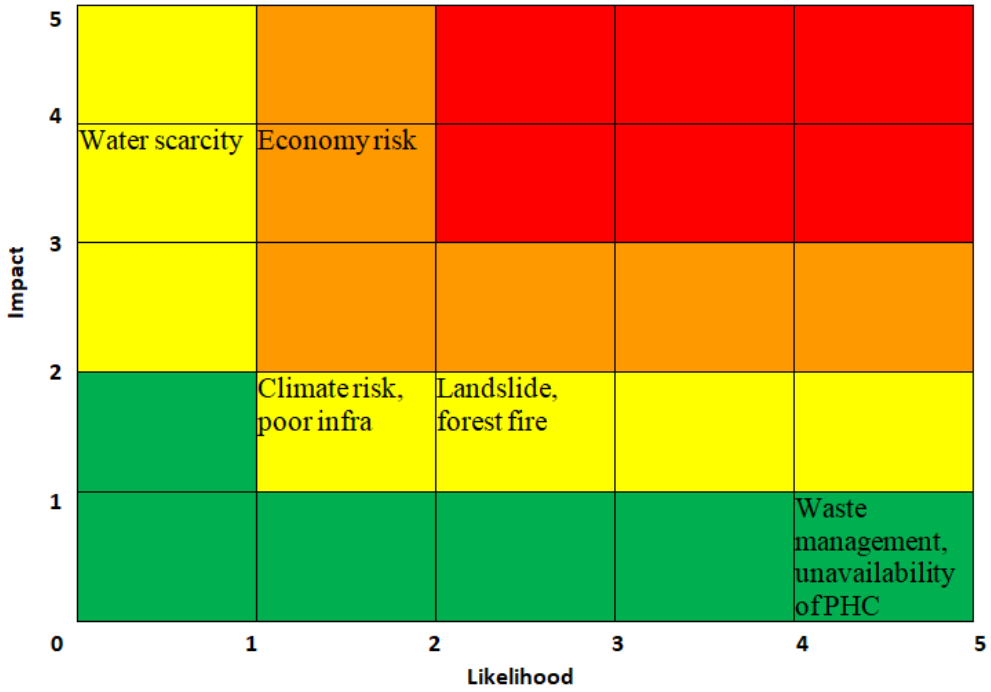
2. CRR South district Niya Manzing GPU (4 wards)

Passingkit Lepcha ward of the Manzing GPU was visited on 10th May 2018. In this visit, discussion with PRI members including Panchayat President, ward representatives and other panchayat officials was done on emerging issues due to prevalent hazards and climate change. The template for filling of Community Risk Register (CRR) was demonstrated. The concept of community risk register was discussed in detail and each section of CRR template was discussed.

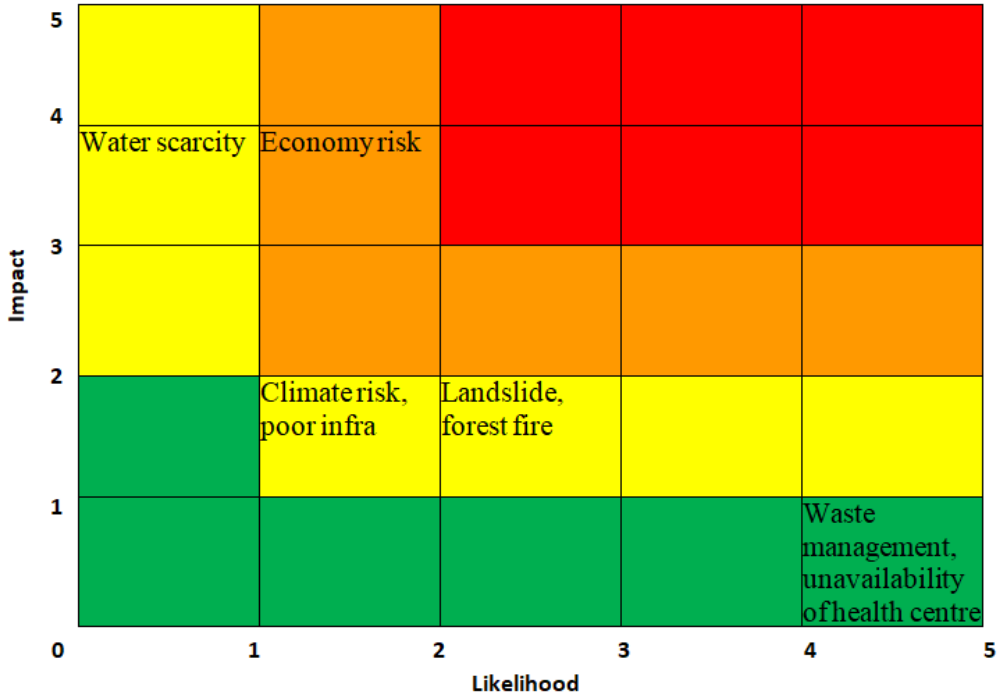
Picture 3.3 Filling of CRR in GPUs

The prevalent hazards found during the discussion include forest fire, hailstorms, drought, earthquake, landslide, depletion of perennial water sources and flooding in rainy season. The domestic issues included water scarcity, invasion of wild animals leading to destruction of crops, breaking of temporary bridges, hanging wires and land sinking. The community also identified increase in cases of water borne diseases. The CRR template was handed over to the ward representatives for filling the same for their respective wards for finalising and handing over to the field officer.

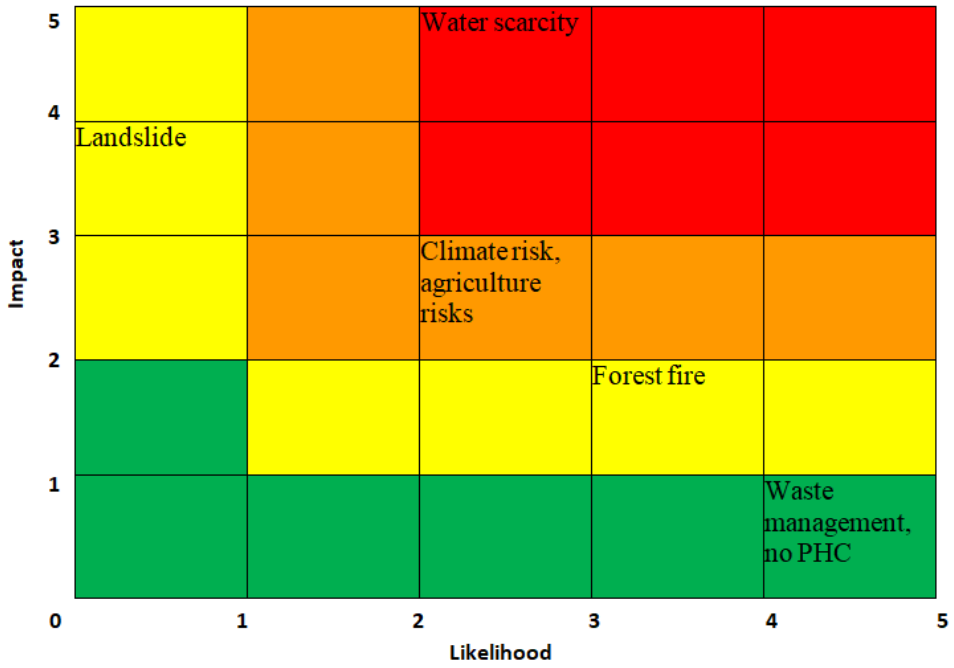
2.1 Risk Summary of Brum ward of Niya-Menzing GPU (South)



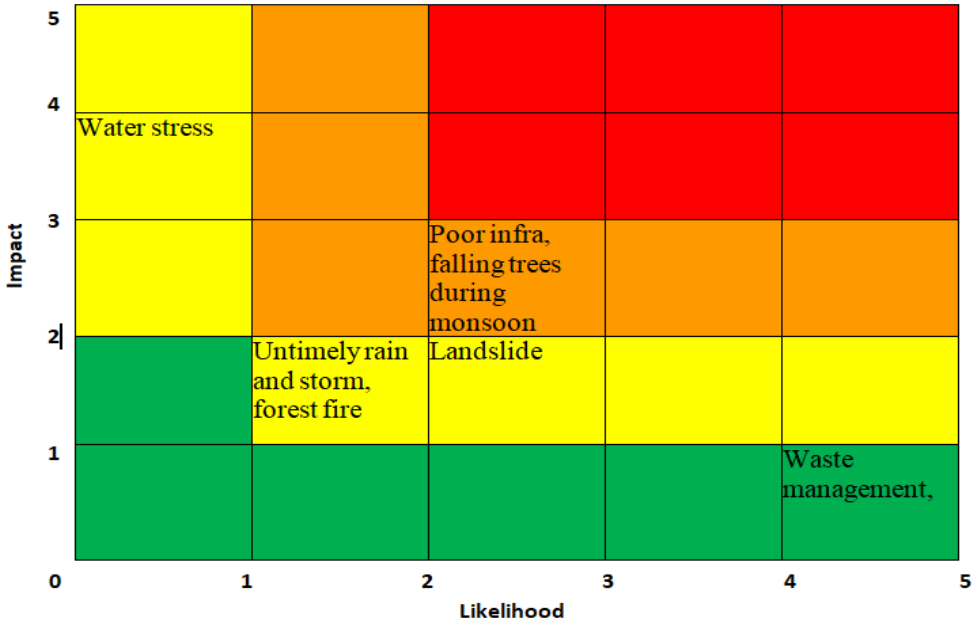
2.2 Risk Summary of Lower Manzing ward of Niya-Menzing GPU (South)



2.3 Risk Summary of Lower Niya ward of Niya-Menzing GPU (South)



2.4 Risk Summary of Upper Niya ward of Niya-Menzing GPU (South)

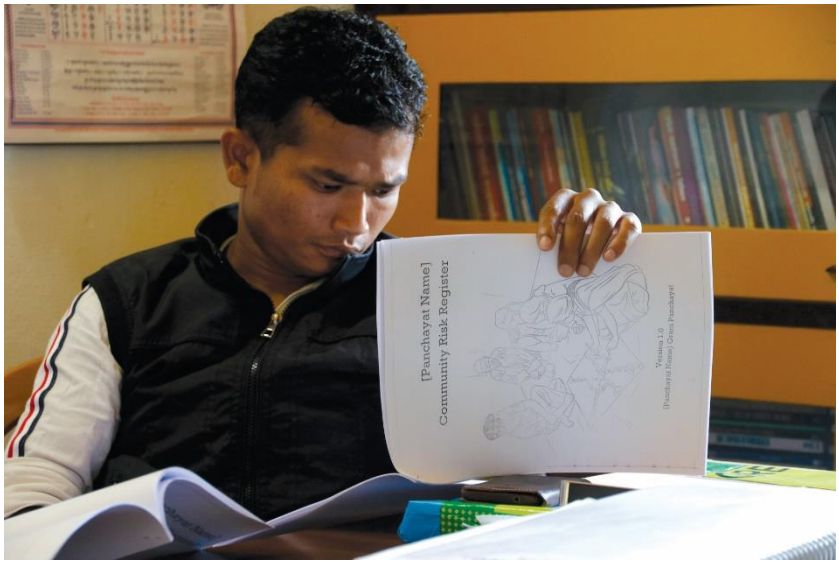


While conducting the transect walk, it was also assessed that the path to the Manzing ward passes through a landslide area and people follow the same because it is the shortest path. The walking trail is itself very dangerous and in rainy season it becomes even more slippery. There has been case of people falling and getting injured. A staircase is being constructed by the government, but the safety of the path still remains a question in this vulnerable location.

Picture 3.4 Transect walk

3. CRR South district Kitam Manpur (4 wards)

Kitam Manpur GPU was visited on 09 May 2018. In this visit, discussion with PRI members including panchayat president, ward representatives and other panchayat officials was done on emerging issues due to prevalent hazards and climate change. The day to day shocks and stresses which the community felt were also discussed in the meeting. The template for filling of Community Risk Register (CRR) was demonstrated. The concept of community risk register was discussed in detail and each section of CRR template was discussed.



Picture 3.5 PRI members going through CRR

The prevalent hazards found during the discussion include land subsidence, earthquake, landslide due to road construction and flooding in rainy season. The day to day issues included water scarcity, influx of large snails affecting crops, invasion of wild animals leading to destruction of crops and accidents due to high tension wires. The community also identified increase in cases of water borne diseases, diabetes and blood pressure. The CRR template was handed over to the ward representatives for filling the same for their respective wards for finalising and handing over to the field officer.

Picture 3.6 PRI members with field officer

Main Risks of the four GPUs of South District

ISSUES:

High Risk

Landslide, Flood	• Landslide is one of the major problem during monsoon • Highway gets blocked and source of water also get damaged and animals too suffer
Scarcity of Water Flood	• Shortage of water impacts • In agriculture and high • Flood risk in the river belt as during monsoon the river often gets flooded
Solid Waste Issues	• Waste created from the slaughter house are not properly managed and hence create a major health issue
Climate Change Risk	• Climate Change Risk is Likely To Be Seen In Agricultural Pattern And Hence Sometimes Shifts In agricultural practice is common
Water Scarcity	• Water scarcity is very common and hence is a big problem for agriculture

Table 3.1 High Risk in South District

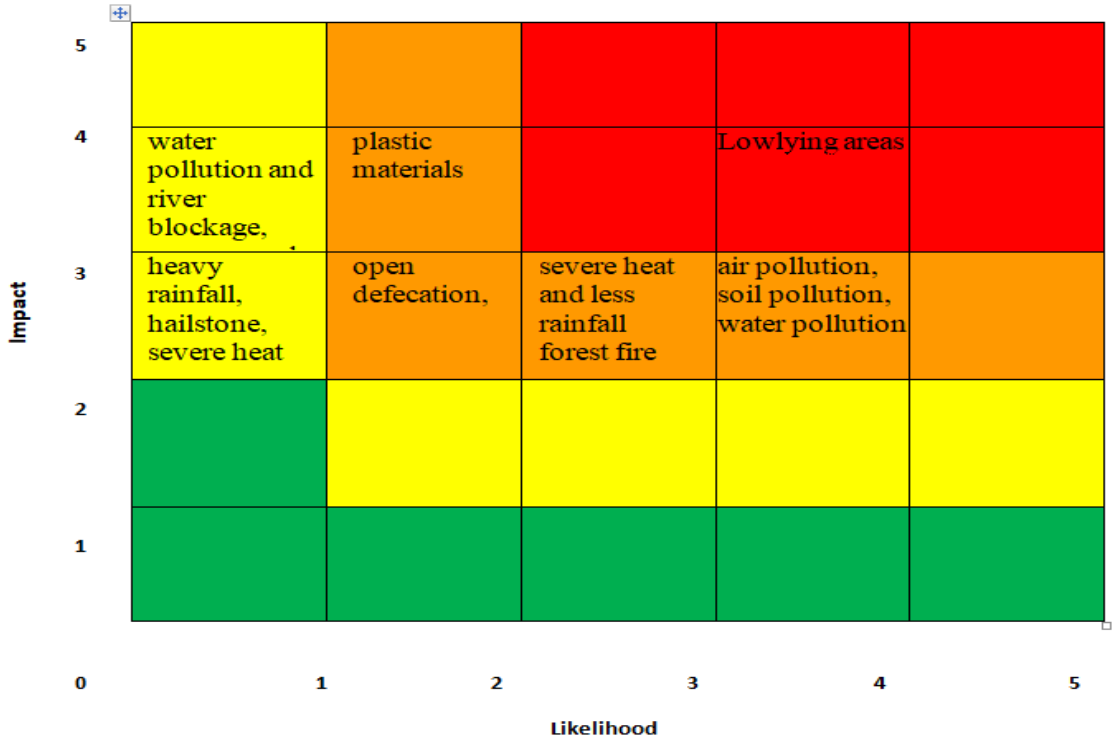
Medium Risk

Forest Fire	• During dry season forest fire occur as most of the area are surrounded by forest land
Landslide	• Most of the area are prone to landslide and in rainy season it is at very high risk

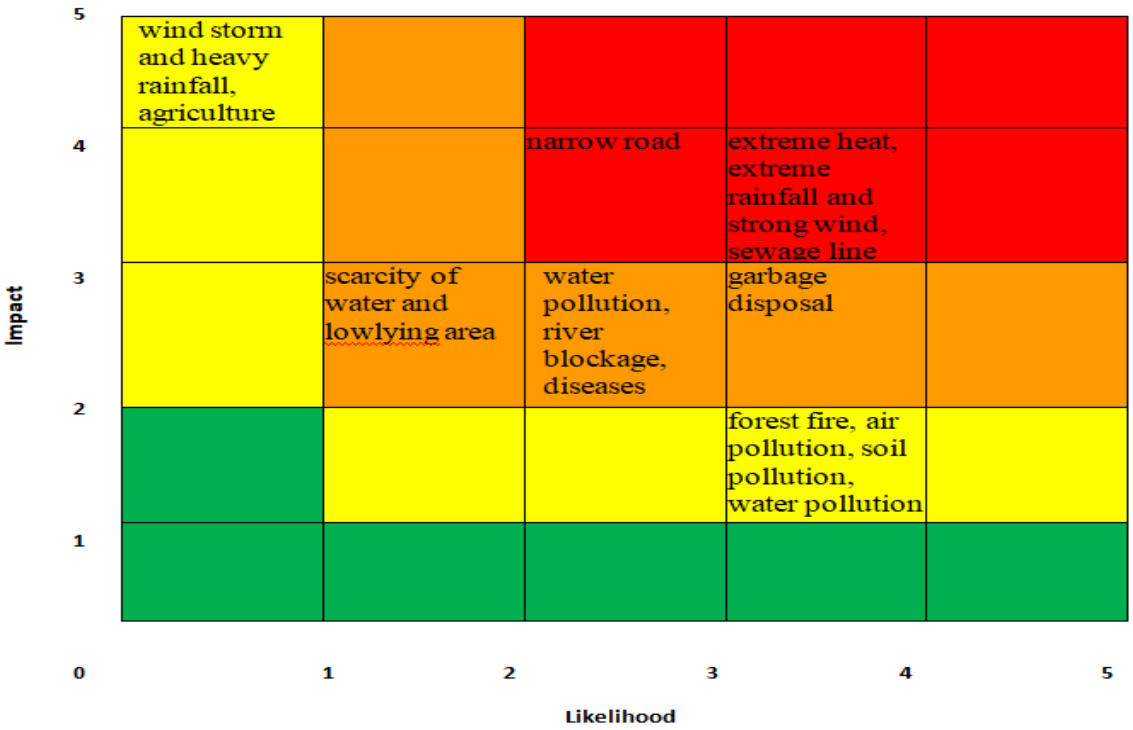
Table 3.2 Medium risk in South District

4. CRR East district Dalapchand (6 wards)

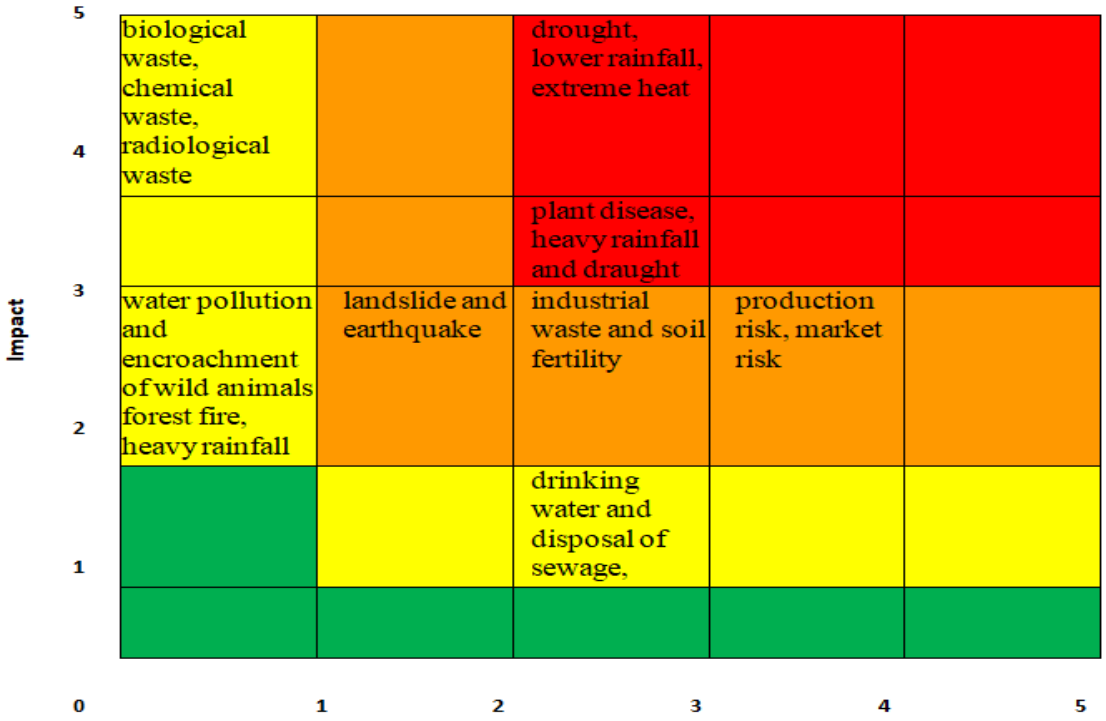
4.1 Risk Summary of Dara Gaon Ward of Dalapchand GPU (East)



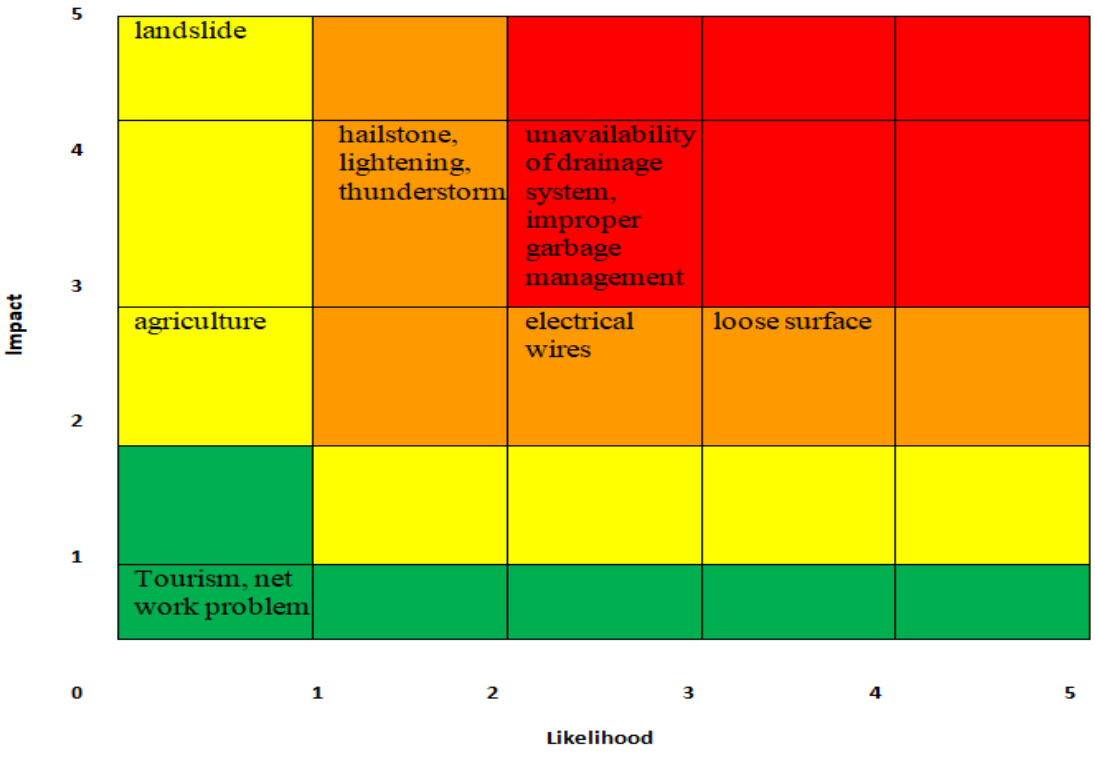
4.2 Risk Summary of Katahar Botey Ward of Dalapchand GPU (East)



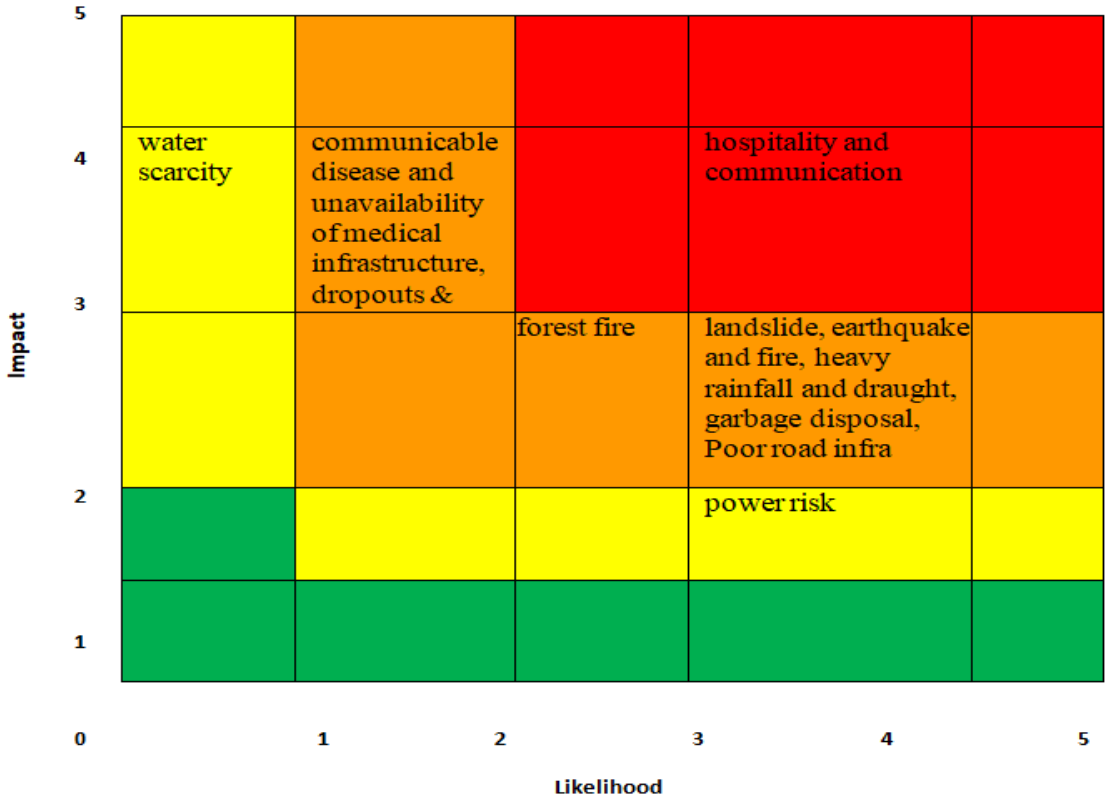
4.3 Risk Summary of Mandir Gaon Ward of Dalapchand GPU (East)



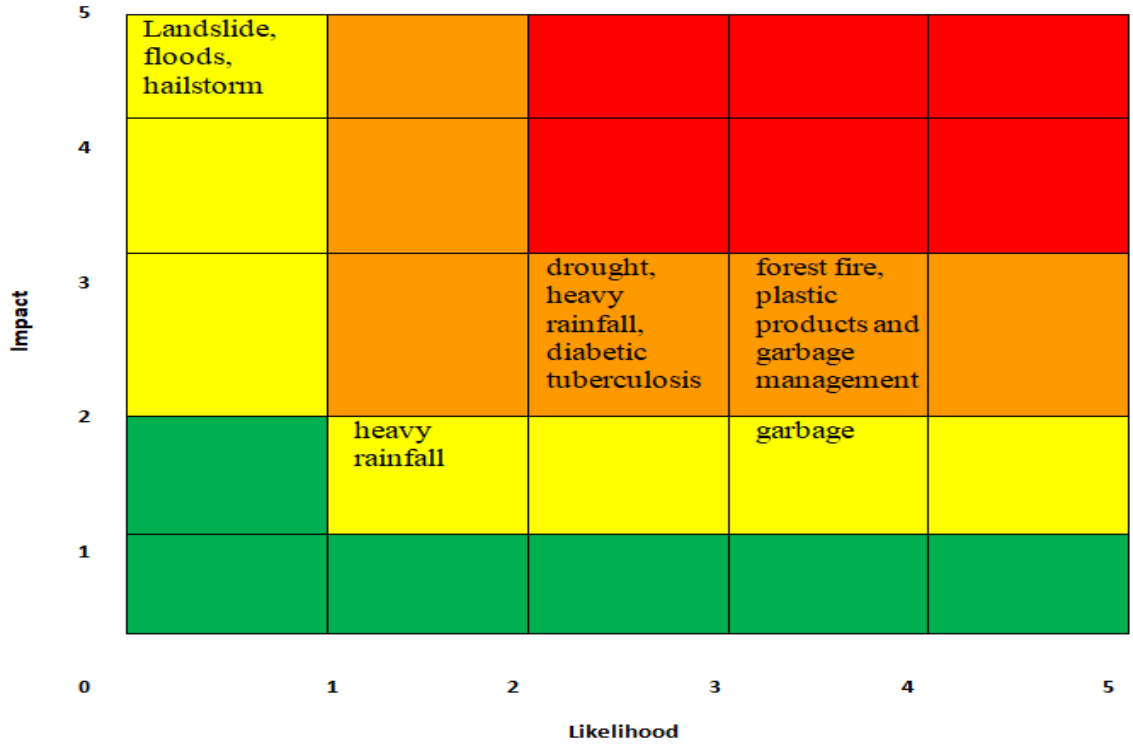
4.4 Risk Summary of Mangkhim Ward of Dalapchand GPU (East)



4.5 Risk Summary of Sadu Gaon Ward of Dalapchand GPU (East)

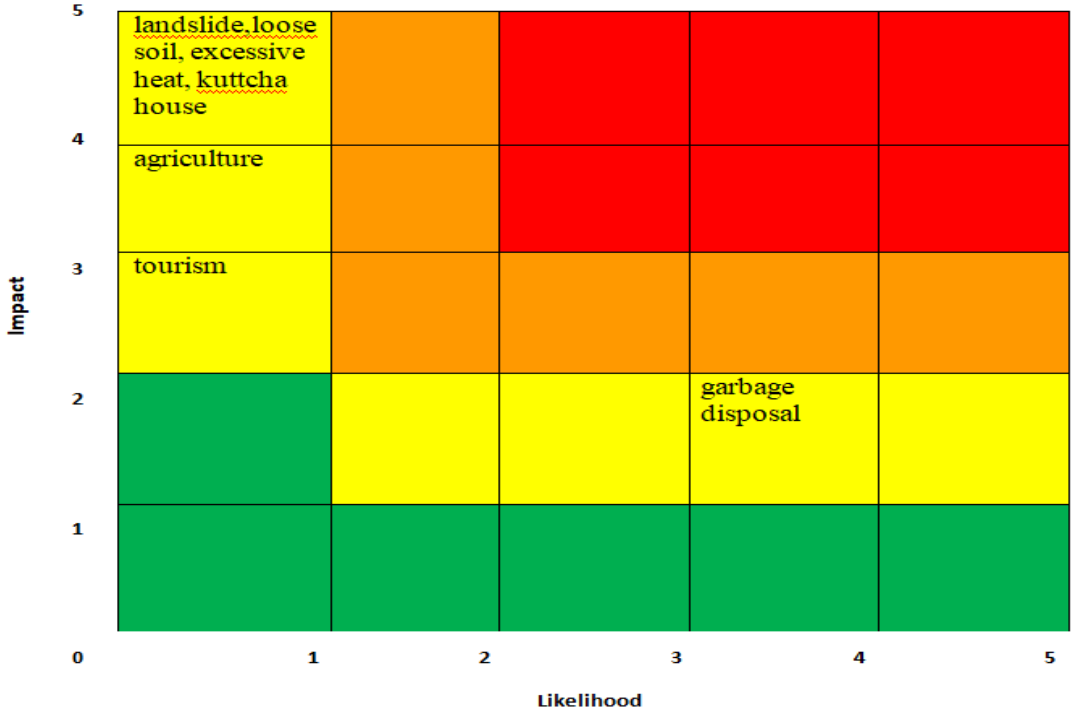


4.6 Risk Summary of Sewa Ward of Dalapchand GPU (East)

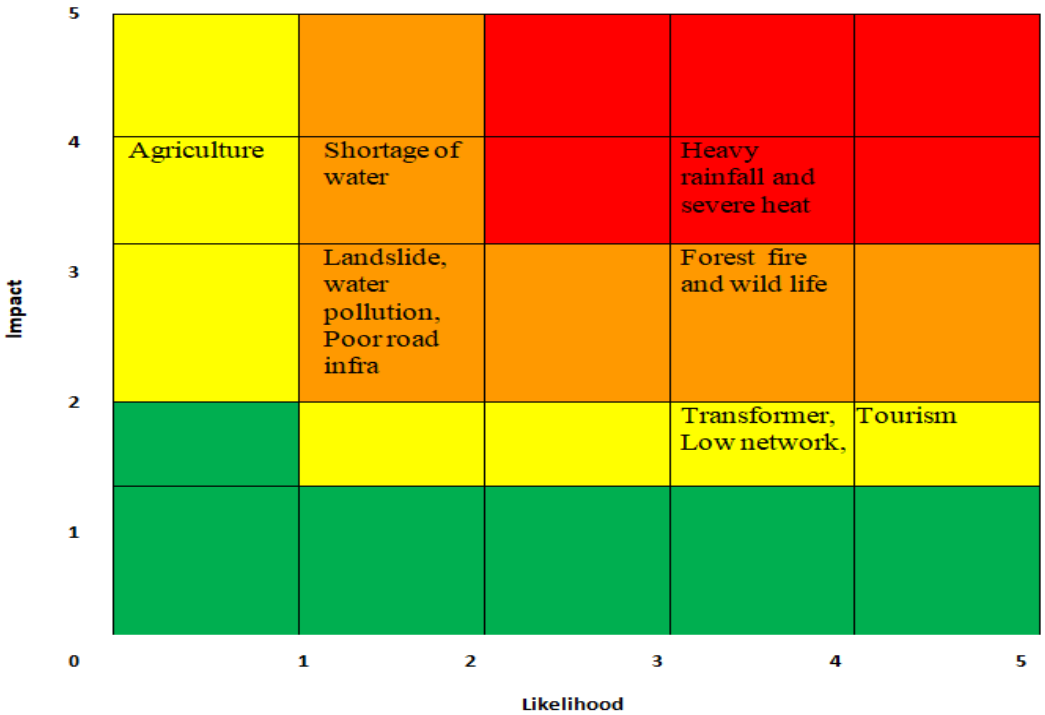


5. CRR East district Chalamthang- Pacheykhaney (6 wards)

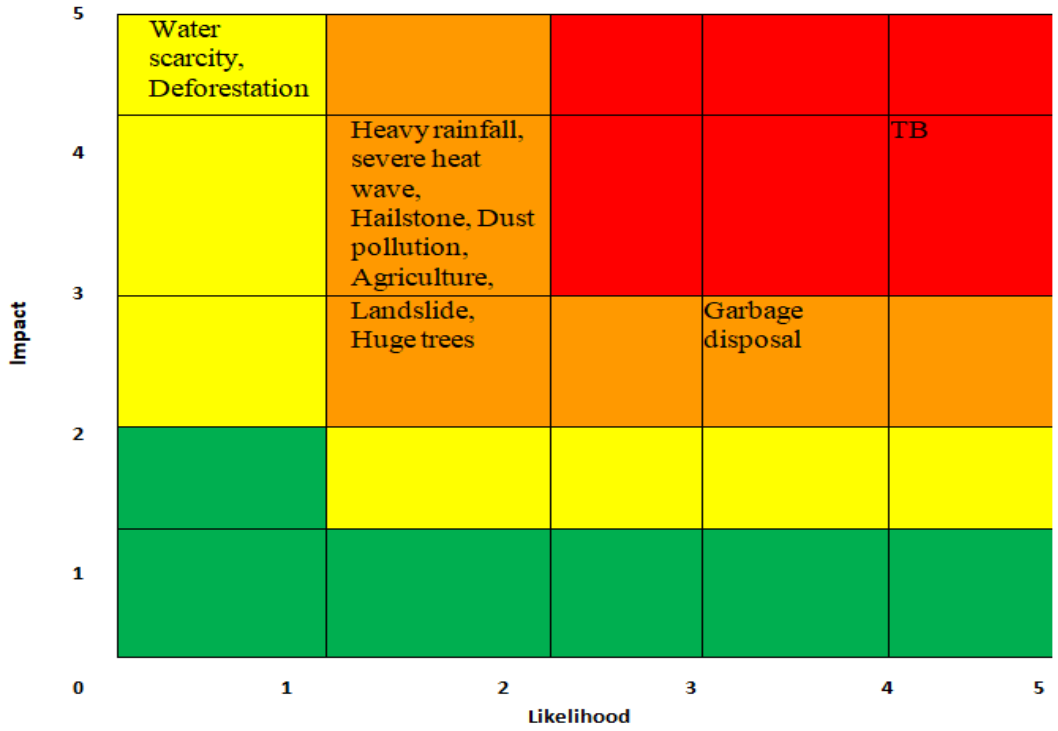
5.1 Risk Summary of Naya Busty Ward of Chalamthang-Pacheykhaney GPU (East)



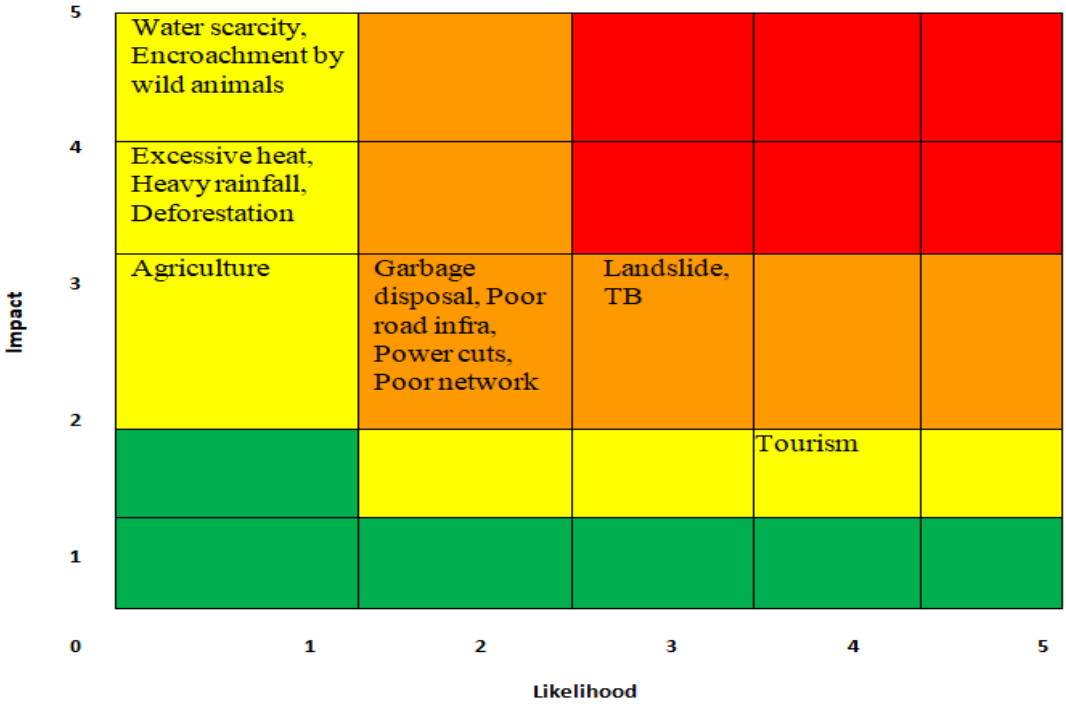
5.2 Risk Summary of Dikling Pachey Ward of Chalamthang-Pacheykhaney GPU (East)



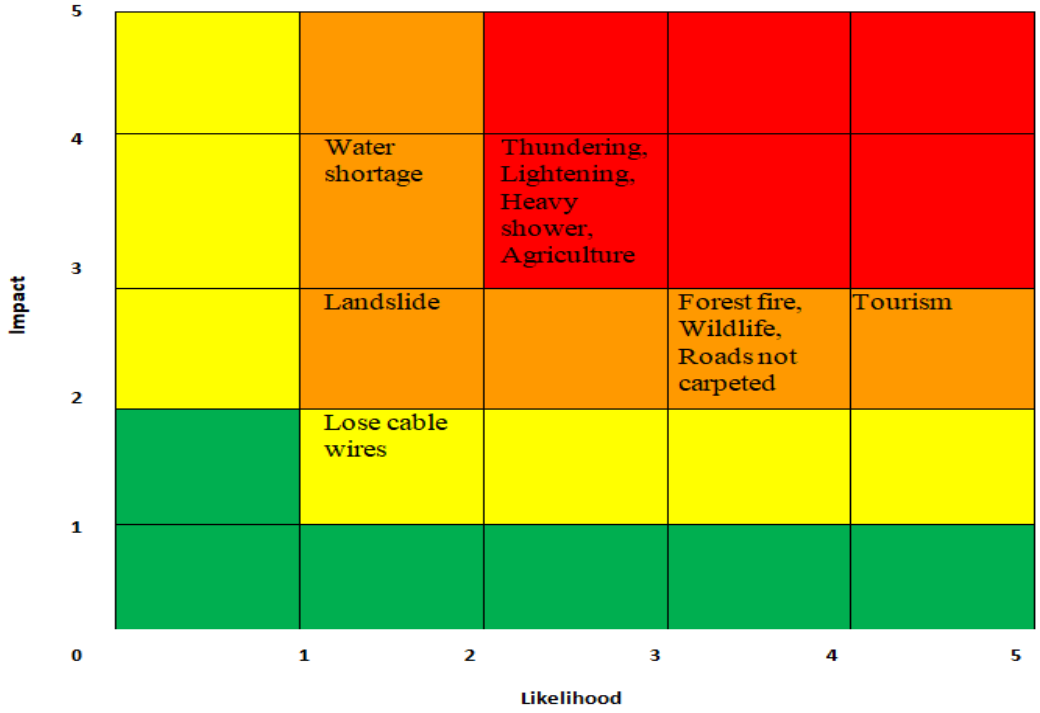
5.3 Risk Summary of East Dikling Ward of Chalamthang-Pacheykhaney GPU (East)



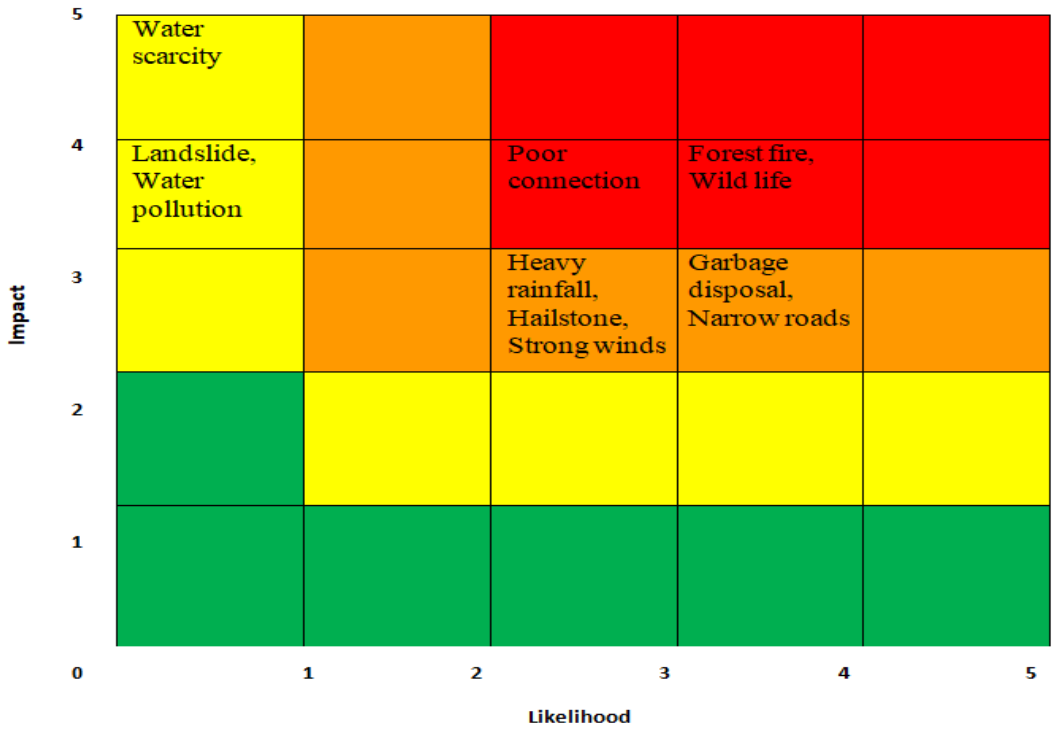
5.4 Risk Summary of Lossing Ward of Chalamthang-Pacheykhaney GPU (East)



5.5 Risk Summary of Pacheykhani Ward of Chalamthang-Pacheykhaney GPU (East)

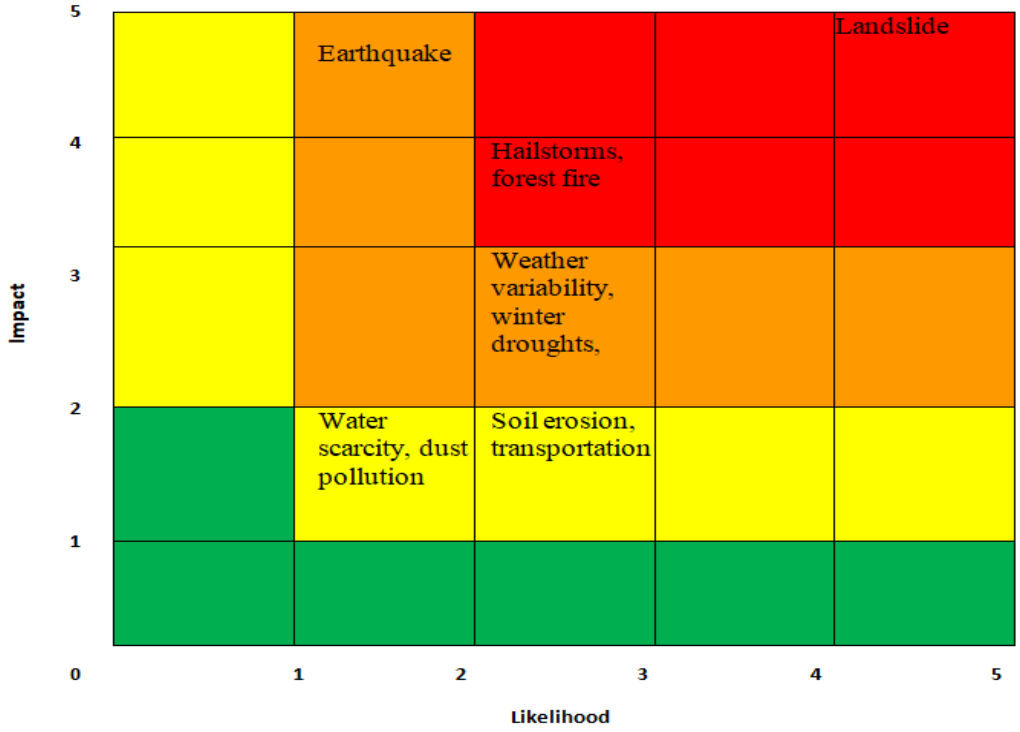


5.6 Risk Summary of Rorathang Ward of Chalamthang-Pacheykhaney GPU (East)



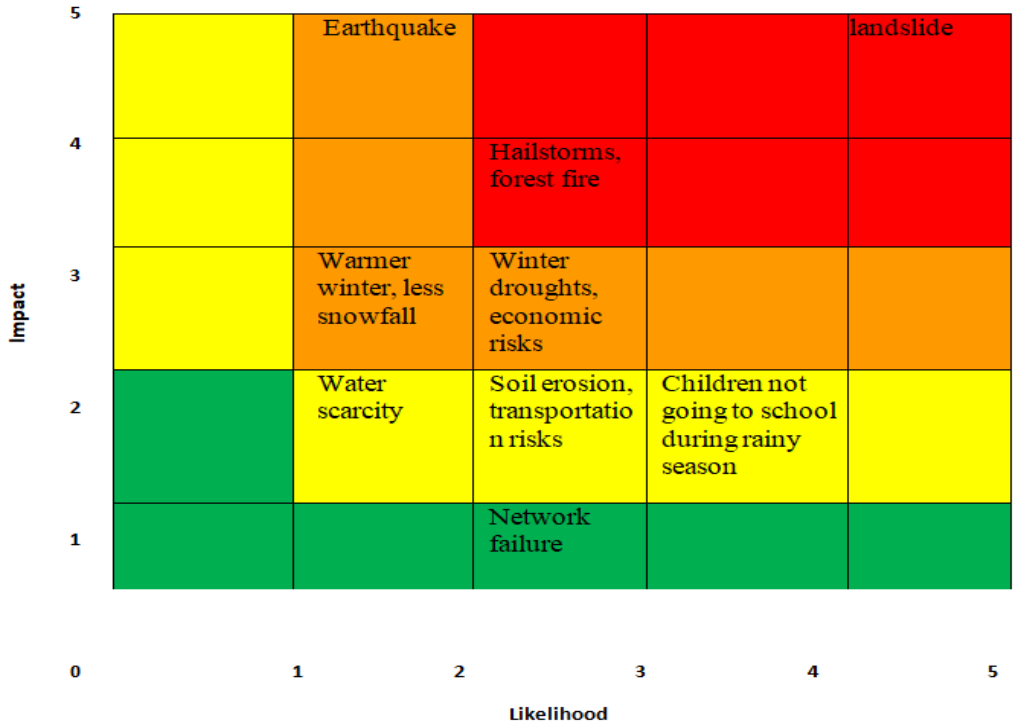
6. CRR East district Luing Perbing (1 ward)

6.1 Risk Summary of Themi Dara Ward of Luing-Perbing GPU (East)



7. CRR East district Sumin-Lingzey (1 ward)

7.1 Risk Summary of Upper Sumin Ward of Sumin-Lingzey GPU (East)



Main Risks of the four GPUs of East District

ISSUES:

High Risk

Landslide	• Several areas are prone to landslide during monsoon.
Erratic and Unpredictable rainfall	• Agriculture is the main livelihood but untimely climate change led to the destruction of the crops
Water Shortage	• Water shortage is severe and is thus difficult in farming. • Encroachment of wild animals and due to the severe shortage of water
Severe Heat	• Severe heat damages the crops and creates a drought like situation it dries up all the ponds and the streams.

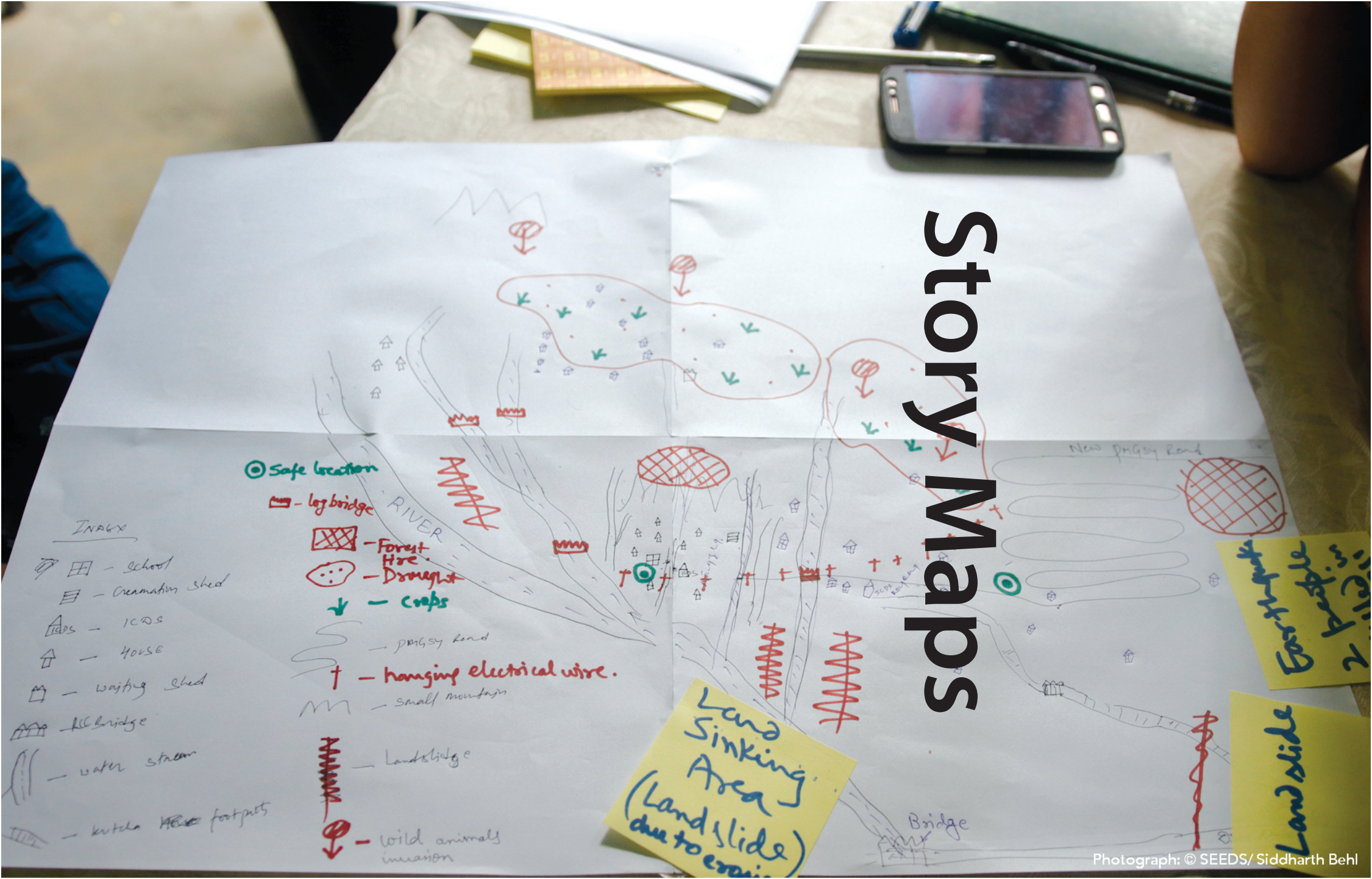
Table 3.3 High Risk in East District

Medium Risk

Forest fire and Wild life	• Forest fire and encroachment of wild animals often take place
Water pollution and River blockage	• Water is polluted by new construction and development taking place due to high tourist influx. • During monsoons the streams water get blocked due to improper drainage system

Table 3.4 Medium Risk in East District

Story Maps



Photograph: © SEEDS/ Siddharth Behl

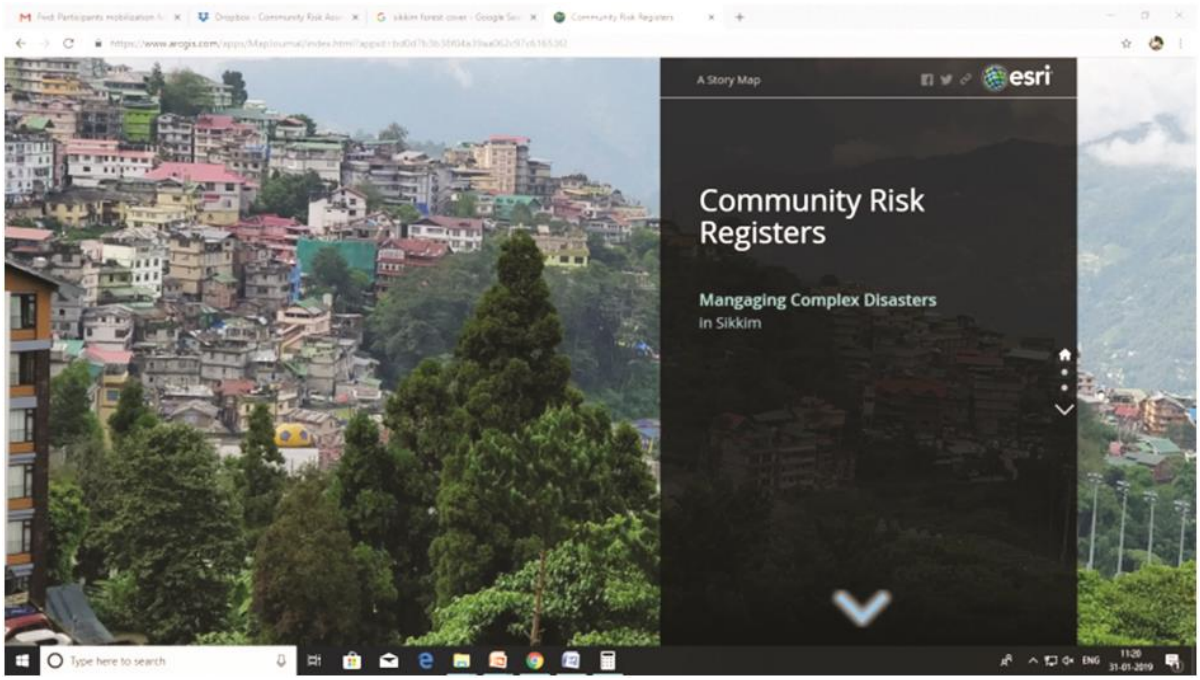
4. Story Maps

Story Maps are an efficient way to combine maps with narrative text and images, create compelling, user-friendly web apps. These Story Maps use interactive builders to create a Story Map Tour, a Story Map Cascade, and a Story Map Journal.

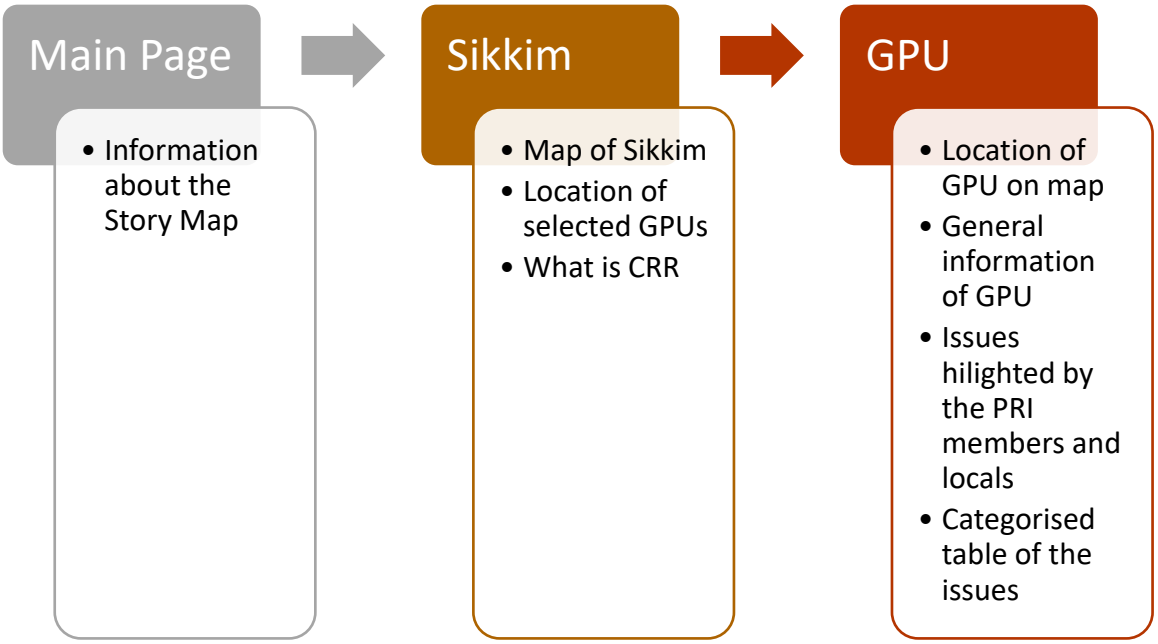
Hence the ESRI story maps are an appropriate way to represent the CRR exercise since the location of the GPU can be related to the content of the community risk register and at a glimpse we can identify the predominant issues common the nearby GPUs. Therefore we can identify if the GPU in a particular region has common issues.

Working

The page displayed in the start of the presentation is the designed as the main page of the CRR story maps. By scrolling down, an interactive map of Sikkim appears. This map has locations of all the selected GPUs. The user can click any GPU to get general information about it. On further scrolling down the map goes list wise to each GPU starting with North district's Chungthan GPU and displays the compilation of the risk matrix of this GPU. It also shows a categorized table of all the issues in the GPU. The table shows Environmental, infrastructural and managerial issues of the gram panchayat selected

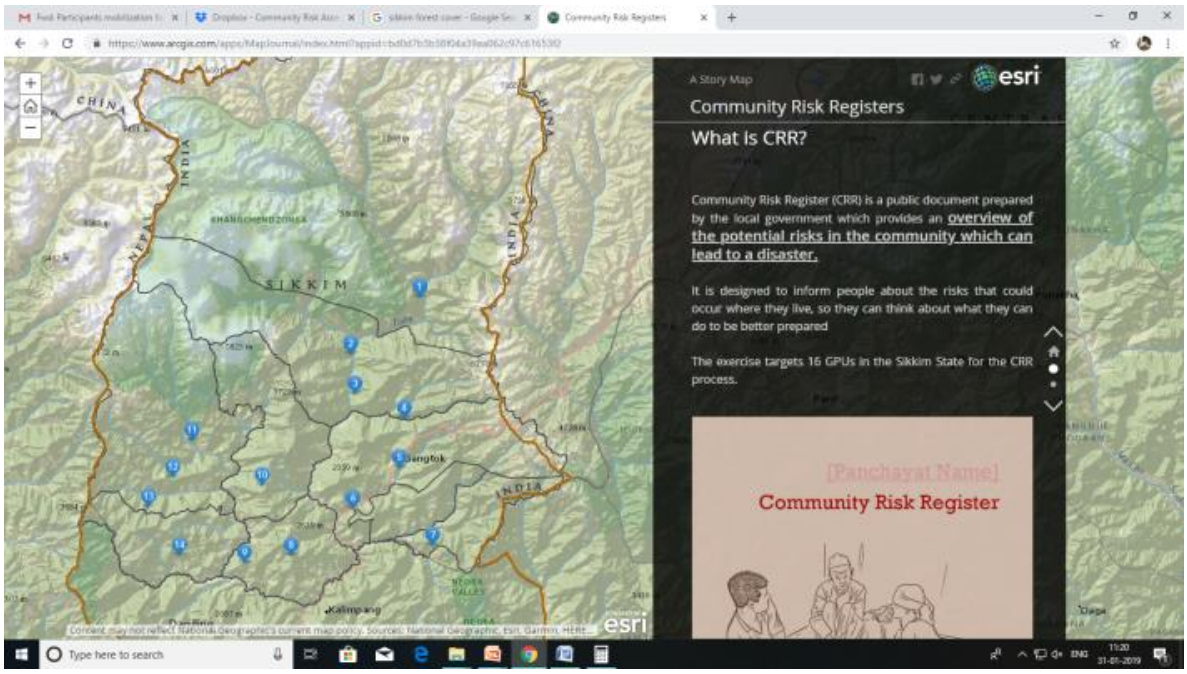


Picture 4.1 Home page of ESRI story maps

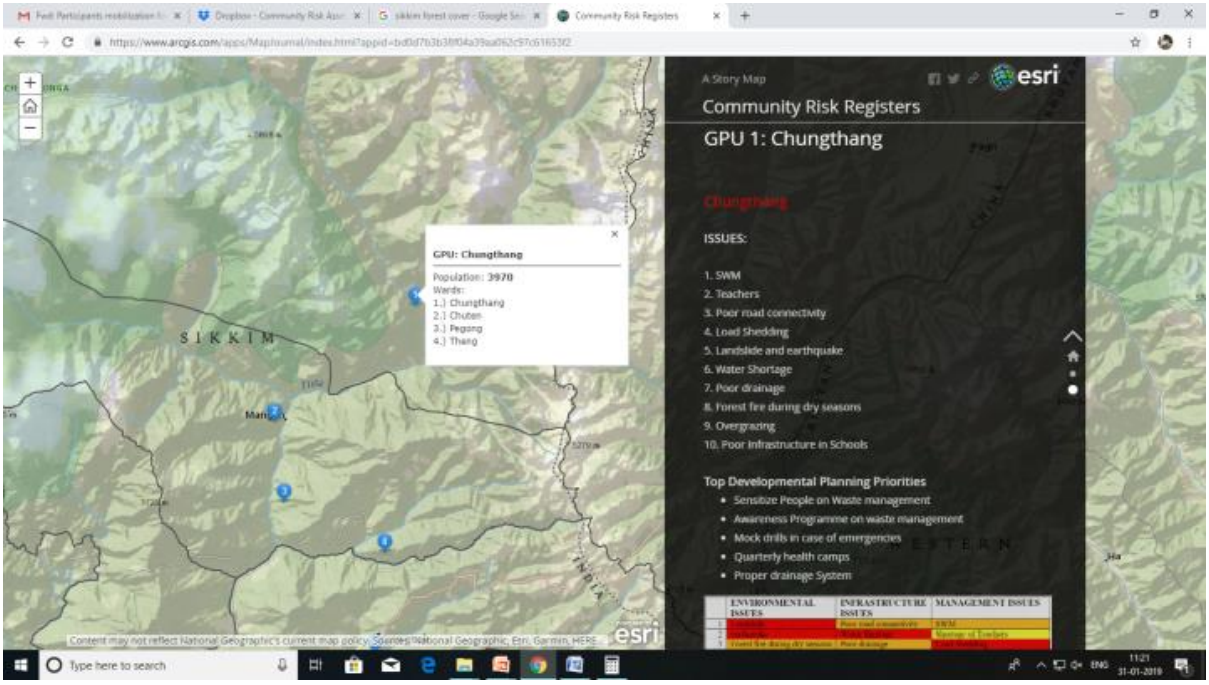


Picture 4.1 Working of Story Map

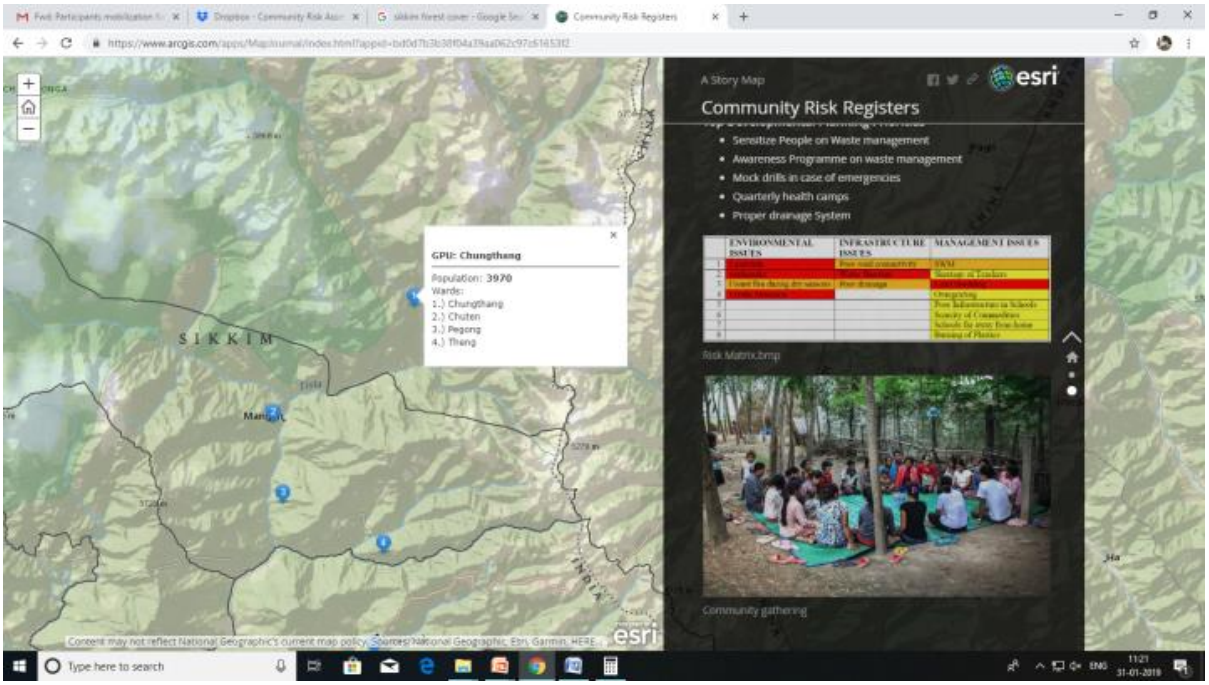
The story map gives the project an opportunity to bring the primary data being collected and analyses into a crisper format which is easy to access. The CRR of the second year (2018-19) will be update in the subsequent year, which will add to the information in the story maps and make it more accurate.



Picture 4.2 Location of CRR GPUs



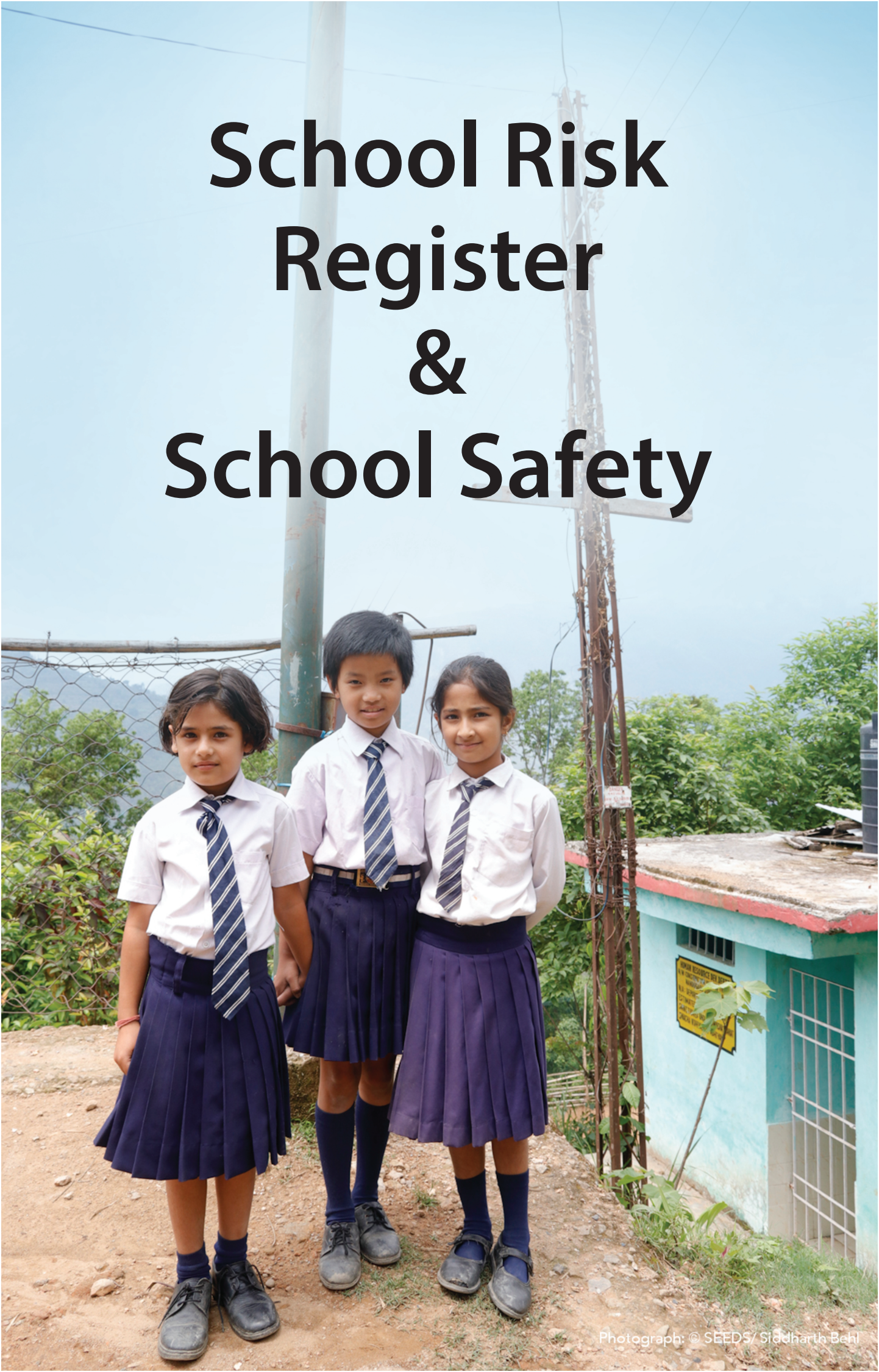
Picture 4.3 Common issues of Chungthan GPU (North District)



Picture 4.4 Issues separated into categories

Link ESRI Story Maps: https://arcg.is/0m1O0

School Risk Register & School Safety



Photograph: © SEEDS/ Siddharth Behl

5. School Risk Register Pilot

School Risk Assessment Committee

Name of the School: Upper Syari Junior High School

School Address: Kopibari, Upper Syari, East Sikkim

Principal Name: Pronita Subba

No. of Students: 214 Male: 127 Female: 87

No. of Disabled Students: 3 Kinds of Disability: Locomotive/ Physical/Mental

No. of Teaching Staff: 31 Male: 6 Female: 25

No. of Non-Teaching Staff: 1 Male: 1 Female: 0

Chairperson *(School Principal)*	Mrs. Pronita Subba
Assessment Teacher *(Male)*	Mr. Madan Kr. Sharma
Assessment Teacher *(Female)*	Mrs. Arpana Chettri
Non-Teaching Staff *(Male)*	Mr. Obed Lepcha
Non-Teaching Staff *(Female)*	-
School Head Boy	-
School Head Girl	Sonam Lhamu Sherpa
Student *(Senior-Male)*	Bittu Gaffar
Student *(Senior-Female)*	Dipika Chettri
Student *(Junior-Male)*	To be elected
Student *(Junior-Female)*	To be elected

Table 5.1 School Information

Risk Matrix

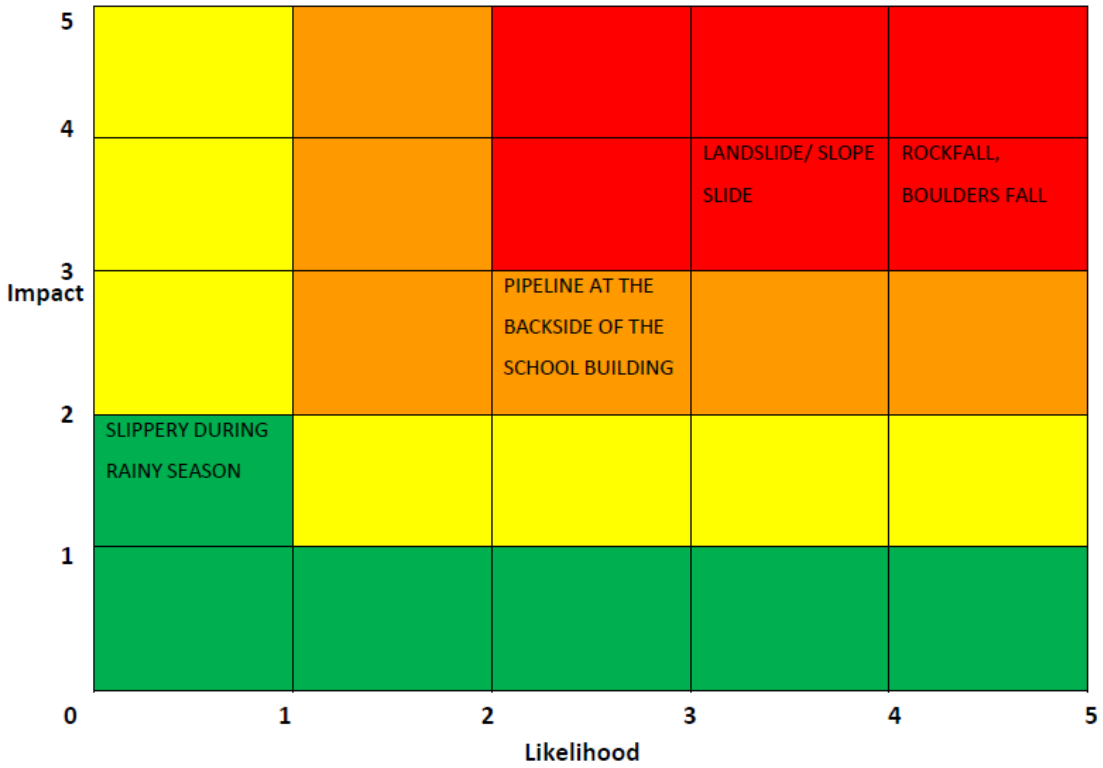
Sl. No.	Risk	Description	L	I	Risk Rating	Controls in Place
1	Location of the school is at the bottom of a vertical slope	There is a massive risk of landslide, which can cause damage to school infrastructure	4	4	very high risk	Awareness and plantation drive
2	Falling of boulders	Due to the very steep slope at the backside of the school, there is always a chances of fall rocks during summer as well as winter	5	4	very high risk	Nothing has been done till date/ however construction of skywalk in Namnag has helped a lot for the reduction of falling rocks in the area.
3	Placement of huge pipeline running along the backside	Water pipeline supply of the army area passes through the back side of the school. It is very risky in case of breakage of the pipeline. which may result in flood	3	3	high risk	No action has been taken till date
4	Slippery area during rainy season	The roads and stairs near school becomes slippery during rainy season which can cause minor harm to the students and faculty	1	2	low risk	School authorities try to handle the issue among themselves

Table 5.2 Risk Matrix of School

L- Likelihood

I- Impact

Risk Summary



Low Risk: slippery roads and stairs fall under this category of low risk

Medium Risk: there is no risk in this category in school area.

High Risk: pipelines built at the backside of the school building fall under this category.

Very High Risk: landslide, slope slide, falling rocks and boulders fall are in the very high risk category of the school area.

LANDSLIDE INVENTORY IN SIKKIM.

LAND-SLIDE NAME	TYPE OF SLIDE & MATERIAL	MAGNITUDE & INTENSITY	AREA IN DANGER	TRIGGERS	WARNING	STRIKE TIME	DAMAGE DONE
Deorali Gangtok	Mudslide (Shallow) Rock/Soil/ Construction	Localised Fast Mud flow &	Kopibari School Area Deorali	Water supply pipe burst and rain	No warning	9.30 PM 05/9/95	32 people dead, 08 houses completely

Source: Sikkim State Disaster Management Plan [2010-2011]

Picture Gallery- Vulnerable areas

Picture 5.1 Risk Description: Cracks in the school building during earthquake

Picture 5.2 Risk Description: Cracks in the school building still not repaired

Picture 5.3 Risk Description: School building and the picture with red circle shows skywalk which has reduced the boulders fall at the backside.

Picture 5.4 Risk Description: Back side of the school building

Picture 5.5 Risk Description: cracks in the school building

Picture 5.6 Classes in the new building after the hazard

Top Development Planning Priorities

Based on the risk matrix prepared, the following development priorities were discussed which needs to be addressed to make the school resilient:

- The school should in its capacity, increase awareness regarding the risk factors, organise a mock drill, sensitize, organise play and involve students and parents.
- Proper awareness and mock drill activities should be strengthened from the government.
- Awareness cum workshop should be provided to the school for combating major and serious disasters during emergence.
- Pipeline built at the backside of the school, needs to be checked time to time to reduce/prevent the harm.
- Time to time monitoring of the slope at the backside of the school should be done by the respective departments.
- Proposal about the shifting of school campus to a safer place**.**

Publications

6. Publications

Paper written for **National Seminar on Climate Change and its Impact on Himalayan Ecology and Food Security (13-14th March, 2019)**

Water Resource management in Hill settlements: Case study of Soreng, Sikkim

Dr. Shyamli Singh (Faculty), shyamli.env@gmail.com
Rini Reejonia (Research Officer),
Vinod K. Sharma (Sr. Professor),
(Indian Institute of Public Administration, New Delhi)

Abstract

The 57.8 million people residing in the Himalayan region depend on the Himalayan landscapes, glaciers and springs for water resources for irrigation, food, industry and for the functioning of many important ecosystem services (Apollo, 2017). The region being rich in glaciers and abundant in perennial snow cover is a source of many big rivers like the Indus, Ganges, and Brahmaputra, and have abundant seasonal and annual water supply. The mountain people depend largely on this region for their sustenance, in form of springs and rivers. The mountain springs, locally known as Dharas, are the natural discharges of groundwater from unconfined aquifers. In Sikkim, 80% of the rural households depend on spring water for their water security (Tambe, 2012). Traditionally, the state has always received good rainfall and has generally been a water surplus state. But recent years have witnessed unprecedented and erratic rainfall trends and longer and warmer summers. This has lead to rise in average temperature and shifting winter precipitation from snow to rain, leading to a change in the timing of the peaks of stream-flow which may be attributed to Climate Change. Glacial retreat causes an increase in the flow but only for short term and decreases as the glacier melts therefore changing the timing and quantity of the stream flow creating a huge impact on the settlements downstream. A prime example of this is the South Lhonak Glacier in the North district of Sikkim which has receded 2km in the past decade (Govindharaj, 2013). The situation is exacerbated due to the drying up of natural springs or turning of perennial springs into seasonal. This has added to the water shortage issue which is

fast becoming a regular occurrence in the state which is not used to dealing with water scarcity. Throughout the mountain region, springs are reported to be drying, and mountain agriculture has suffered from drought. The paper reflects this occurrence and the plight of the community through the case study of a Gram Panchayat Unit (GPU) in the West district of Sikkim, Soreng, which receives its water from the local spring, namely Chulidhara Chakmaki. In the recent years the water level of the spring has significantly reduced. This has created a lot of problem for the GPU residents who rely heavily on the spring for daily use consumption of water for day to day activities. Most of the residents in the GPU are farmers, and the spring and rainfall are the only two sources of water for irrigation the spring becomes even more important for the community. Furthermore the region being susceptible to landslides has often caused blockages and damaged to the water supply system. Such occurrences especially during the initial stages of sowing season are a cause of distress among the gram panchayat residents. As this problem poses a challenge which traditional agricultural practices cannot tackle, there is a need to develop new water management methods specific to the area and sensitize the residents to the usage of water. Methods such as, usage of the rainwater during the drought seasons and proper storage of the rainwater as to not cause local flooding, diverting storm drainage channels to a storage tank for the community etc. need to be studied and implemented for the specific area.
Key words Glacial retreat, Water Management, Hill Towns, Soreng, drying of spring

Introduction

Water has always been a chief element for human settlement, supporting the development of societies and evolution of agriculture. In recent times the threat to water resources has become more magnified due to the impacts of climate change. Thus the importance of water resource management has become more relevant especially for developing nations such as ours whose economy is powered by industrial and agricultural outputs. India has only four percent of the worl's renewable water resources but contains eighteen percent of the world's total population (Lahiry, 2017). There are about twenty river basins in the Indian Territory, but most of them are stressed due to large population, increased industrial development and agriculture. This creates a need to augment both water supply in water abundant regions lacking infrastructure and manage water demand in water scarce regions. National Water Policy (NWP) 2012 has several recommendations for efficient conservation and improved

water management resources. NWP stresses that "low consciousness about the overall scarcity and economic value of water results in the wastage and inefficient uses".

One of the primary sources of water in the Himalayan states of India is the Glaciers. The glacial regions are stores of potable water located at higher altitudes, in form of perennial ice features (Bryan G. Mark, 2015). Glaciers accumulate snow and ice to give freshwater downstream and have a cycle of discharge and accumulation seasonally. Another critical source of freshwater in the mountain region are the mountain springs which are discharges of naturally filters water from the unconfined aquifers of the region (Tambe, 2012). Himalayas are home to seven of the eighteen biosphere reserves in India (Biosphere Reserves, 2019). All these areas have an extremely fragile ecosystem and are more susceptible to effects of climate change, as compared to the urban areas in the plains.

Over the past few years there has been a shift in the overall climatic conditions, whose effect has been widely observed in all the different landscapes of the world. Himalayas too, have been observed to be vulnerable to these changing weather conditions. Hotter and longer summers, unpredictable rainfall patterns, winter droughts etc. are some of the tough situations that the people of the hilly states have been dealing with for the last few years. This change in the average temperature of the region can be attributed to be a causative factor in the receding glacial region, observed in the last few decades. Due to the rise in average temperature the glacial seasonal discharge has increased the flow and quantity. The spring snowmelt is brought forward and the winter flow increases.

Study Area

Sikkim state is one of the smallest Himalayan state of India located in North-East of India. The state is highly environment sensitive and declared as first 'Organic State' of India in 2016. The state is having maximum forest cover and very rich in biodiversity. By and large, Sikkim's income is highly depended on agriculture and forests. Initially the people residing in the state started a semi pastoral economy and sedentary farming on the scarcely available pieces of flat land in the mountainous regions of the state (Sikkim Economy agriculture, 2019). A with the progression of development in the state large tracts of woodland were cleared and made to fit for cultivation. The state is divided into four districts, North, East, South and West districts.

In west district of Sikkim lies the picturesque village of Soreng. It is surrounded by lush green hills. The area is famous for the wide variety of flowers and birds available here. Soreng is one of the three gateways to the Barsey Rhododendron Sanctuary. Soreng is known for its largest production of vegetables, oranges and flowers. The inhabitants are mostly dependent on agriculture, floriculture and tourism for their livelihood. It lies in the humid tropical zone of the state which constitutes the maize cultivation belt.

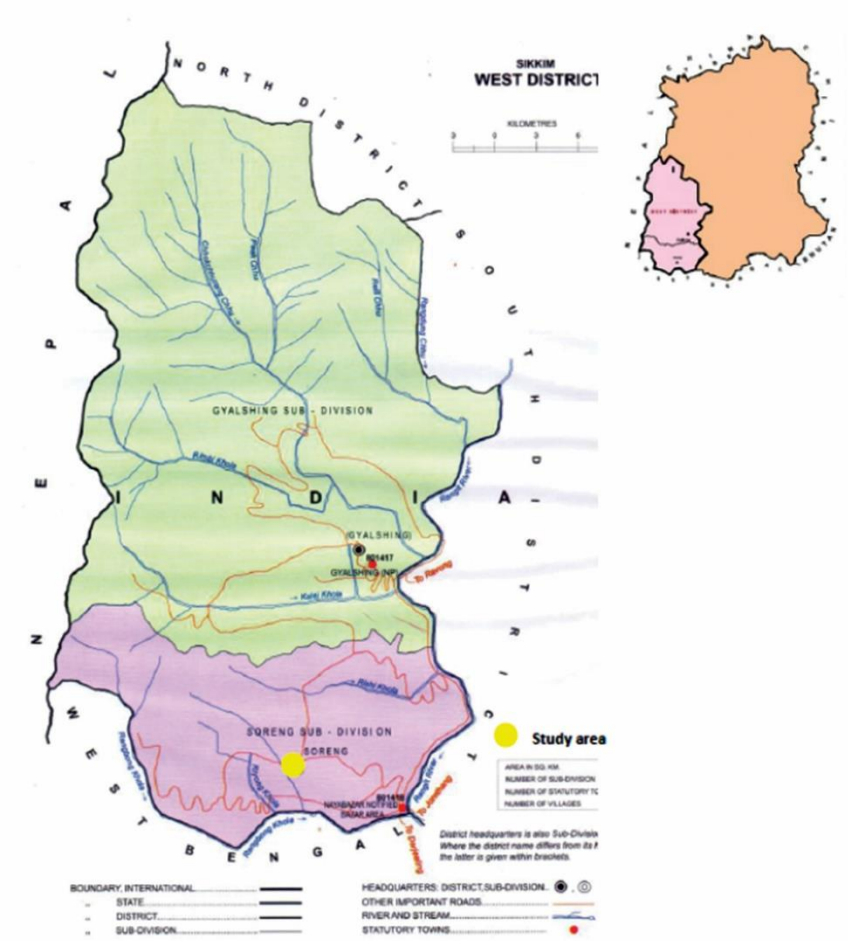


Figure 6.1 Location map of Soreng GPU

Soreng is a large village located in Soreng Sub Division of West Sikkim district, Sikkim with total 887 families residing. The Soreng village has population of 3818 of which 1937 are males while 1881 are females as per Population Census 2011. As per constitution of India and Panchyati Raaj Act, Soreng village is administrated by Sarpanch (Head of Village) who is elected representative of village. In Soreng village out of total population, 1261 were engaged in work activities. 83.27 % of workers describe their work as Main Work

(Employment or Earning more than 6 Months) while 16.73 % were involved in Marginal activity providing livelihood for less than 6 months. Of 1261 workers engaged in Main Work, 226 were cultivators (owner or co-owner) while 84 were Agricultural labourers.

The main activity of the people in the Soreng GPU is agriculture. Maize, paddy, wheat, barley and buck wheat are the main cereals grown in the area. Cardamom and potatoes are two important cash crops. Whereas maize is sown in early summer and harvested in September-October, wheat and barley are winter crops. The temperature and growing period during winter permit the cultivation of these crops. Farming is an all year round activity for the people if this GPU.

Water Management Issues

According to the Hydrome division of the IMD, New Delhi there has been a severe drop of rainfall during the winter months of November, December and January in the district.

District: WEST Sikkim

Note: (1) The district rainfall in millimeters (R/F) shown below are the arithmatic averages of Rainfall of Stations under the District.
(2) % Dep. Are the Departures of ranifall from the long period averages of rainfall for the district.
(3) Blank spaces show non- availability of Data.

YEAR	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.
2009																								
2010																								
2011													85.5	-83	449.0	5	241.0	-38	57.0	-78	38.0	-13	6.0	-73
2012	16.0	-74	5.0	-95	21.0	-89	126.0	-47	240.0	-32	486.0	-3	376.0	-23	520.0	21	548.0	41	81.0	-69	0.0	-100	10.0	-55
2013	8.0	-87	43.0	-56	79.0	-60	155.0	-35	354.0	0	241.0	-52	583.0	19	459.2	7	374.5	-4	153.0	-42	3.2	-93	8.7	-61
2014	0	-100	1.3	-99	41.3	-79	59.8	-75	204	-43	543.3	8	204.7	-58	439	3	109	-72	66.5	-75	6	-86	1.7	-92
2015	7.0	-89	23.5	-76	38.5	-81	121.0	-49	240.5	-32	446.6	-11	351.0	-28	273.0	-36	466.5	20	56.0	-79	1.0	-98	4.0	-82
2016	11.2	-82	4.5	-95	70.0	-65	84.5	-65	234.5	-34	401.7	-20	501.5	2	176.7	-59	585.1	50	110.5	-58	0.0	-100	0.0	-100
2017							77.1	-68	181.7	-49	278.0	-45	642.4	31	602.6	41	602.1	55	69.2	-74	6.2	-86	0.0	-100

Source: HYDROME DIVISION, INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI

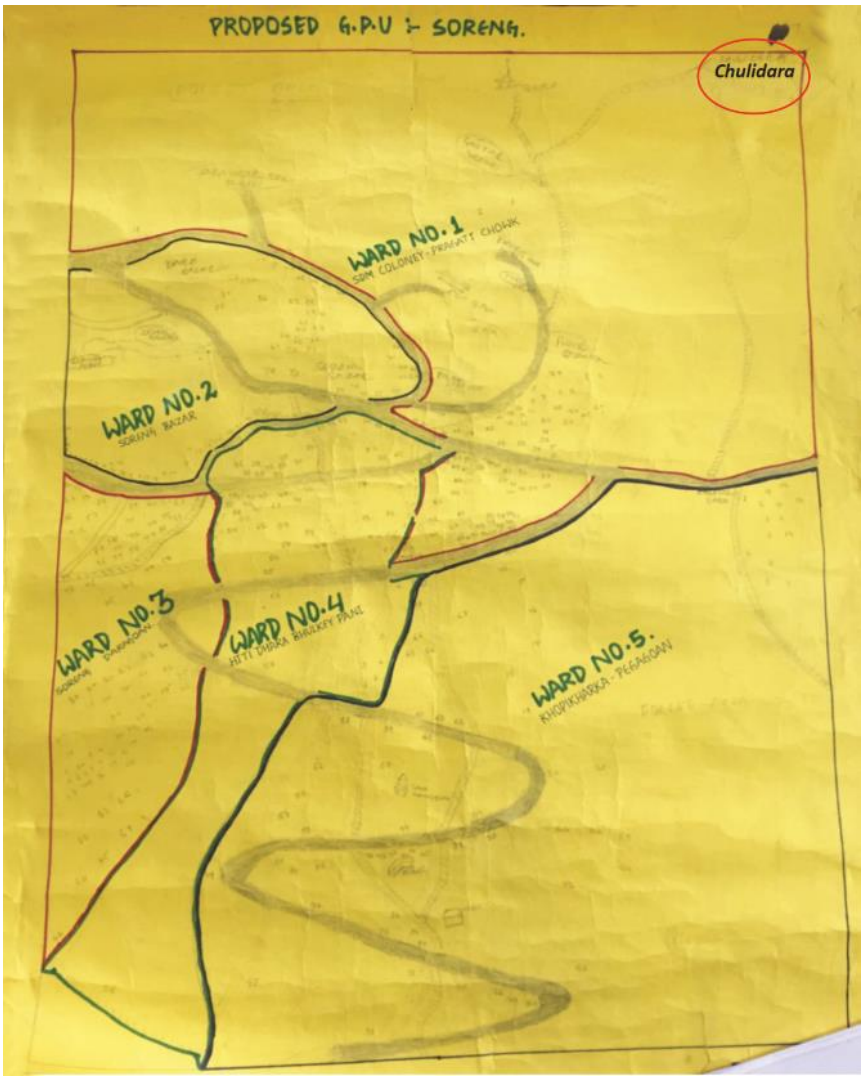
Data Hosted in ENVIS SIKKIM Website www.sikenvis.nic.in

Since most of the residents are dependent on agriculture as their main occupation any effect on the water resource on, which the farming activity is highly dependent, will have a huge impact directly on the residents' livelihood.

Under the project "Capacity Building strategies for managing Complex Disasters in the face on Climate Change" sponsored by NMHS- MoEF&CC, a survey of the GPU was conducted and an inventory of the issues relating to natural disasters was recorded in the Community Risk Register (CRR). The CRR is a public document prepared by the local government providing an overview of the potential risks in the community which can lead to a disaster.

The inhabitants of the GPU predominantly depend on the natural spring, Chulidara Chakmaki, which is located to the north of the GPU. The water from the spring flows downstream to forms a small lake, which is then used by the locals for their daily use.

Such springs are at risk as they are highly vulnerable to changes in seasonal climatic patterns and hydrological cycle. The increasing number of population and large demand of agricultural produce has put a stress on the already overused spring. Lately most of the spring have become seasonal or depleted due to ecological imbalance at local scale. The water table in foot hills has also lowered which calls for conservational solutions in the areas which traditionally did not have any conservation strategies.



Picture 6.1 Map of GPU used by the Panchayat

Susceptibility to natural disasters

The GPU is located in the high risk zone. The recurring occurrences of landslides have not only caused damage to the roads houses and agricultural fields but the water supply pipeline which connects Chulidara to the village. Repair and maintenance of the infrastructure is not hasty and has been delayed several times. The sowing and cultivation of the Rabi crops during the winter season depends highly on the water from the lake. Thus natural events such as landslides also strongly affect the water supply to the area.

Water Pollution

Due to the landslide and mudslides common in the region the large part of the water resource gets murky and unfit for drinking. Also misuse of the resource by the settlements upstream degrades the quality of the water and makes it non usable in it's supply form. Thus filtering the water and purifying it puts extra load on the GPU residents.

Possible Solutions

Though the requirement of the water in the district during the cultivation of Kharif crops is met with the seasonal rainfall, it is the non-availability of sufficient water for household activities and irrigation at critical stages of crop growth during the winter months, which adversely affected the agricultural productivity. Thus storage of water during the monsoons (July-September) for the water shortage months of winter (November-January) is an alternate solution. Since the state has always been a water abundant state, traditional methods of conserving water are not present, like in states of water scarce states like Rajasthan and Gujarat.

Therefore collecting and storing all forms of water resources available such as, direct surface runoff or overland flow, runoff through roof-tops of houses, and the discharge from natural water springs is essential. The flow from the natural spring largely go waste, it's collection and storage in suitably designed tanks/ ponds can make a huge water resource to solve the problems of house-hold water needs and irrigation in the region.

Conclusion

Although Sikkim is a water abundant state in recent times the shortage of water has posed a serious challenge which traditional agricultural practices cannot tackle, there is a need to develop new water management methods specific to the area and sensitize the residents to the usage of water. Methods such as, usage of the rainwater during the drought seasons and proper storage of the rainwater as to not cause local flooding, diverting storm drainage channels to a storage tank for the community etc. need to be studied and implemented for the specific area.

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Paper written under the project focuses on Flood Vulnerability of Rangpo town in East district of the state of Sikkim.

Case study of Rangpo in the eastern region of the Himalayan

Dr. Shyamli Singh (Faculty), shyamli.env@gmail.com

Rini Reejonia (Research Officer),

Vinod K. Sharma (Sr. Professor),

(Indian Institute of Public Administration, New Delhi)

Abstract

The Himalayan region is one of the most remarkable bio-diversity hotspots in the world. With its varied range of landscapes such as grasslands, forests, shrub lands and agricultural lands, the region is responsible for supporting a huge number of population for food, shelter and livelihood. However the Himalayan landscape is especially susceptible to natural disasters. The mountain range was formed due to the collision of Indian and Eurasian plates. The northward movement of the Indian plate causes continuous stress on the rocks, rendering them friable, weak and prone to landslides and earthquakes and GLOFs. In recent years the region has witnessed an increase in the number of natural calamities that could be due to the increasingly unpredictable climate variability. Increase in the number of irregular rainfall patterns causing flash floods or extended duration of summer months with higher temperatures and water scarcity during the winter months can all be attributed to Climate Change phenomenon. Such variability in the weather pattern causes huge losses to the agricultural production, which affects the economics of the region as agriculture is one of the main occupations in the Himalayan region which sustains 80% of the rural population.

Concurrently, the region has been developing at a faster rate in the last few decades due to rising demand in the tourism sector. This has lead to urbanization of large rural settlements into towns and population surge in these urbanized towns. Since these hill towns are preferred tourist destinations the tourism sector has become the main economic activity for many of these cities and towns instead of agriculture. The unprecedented development has resulted in expansion of unplanned built-up areas in for the ever increasing population. This

has increased the vulnerability of the area as increasing number of population is exposed to the hazards of the region thus inevitably increasing the risk in such places.

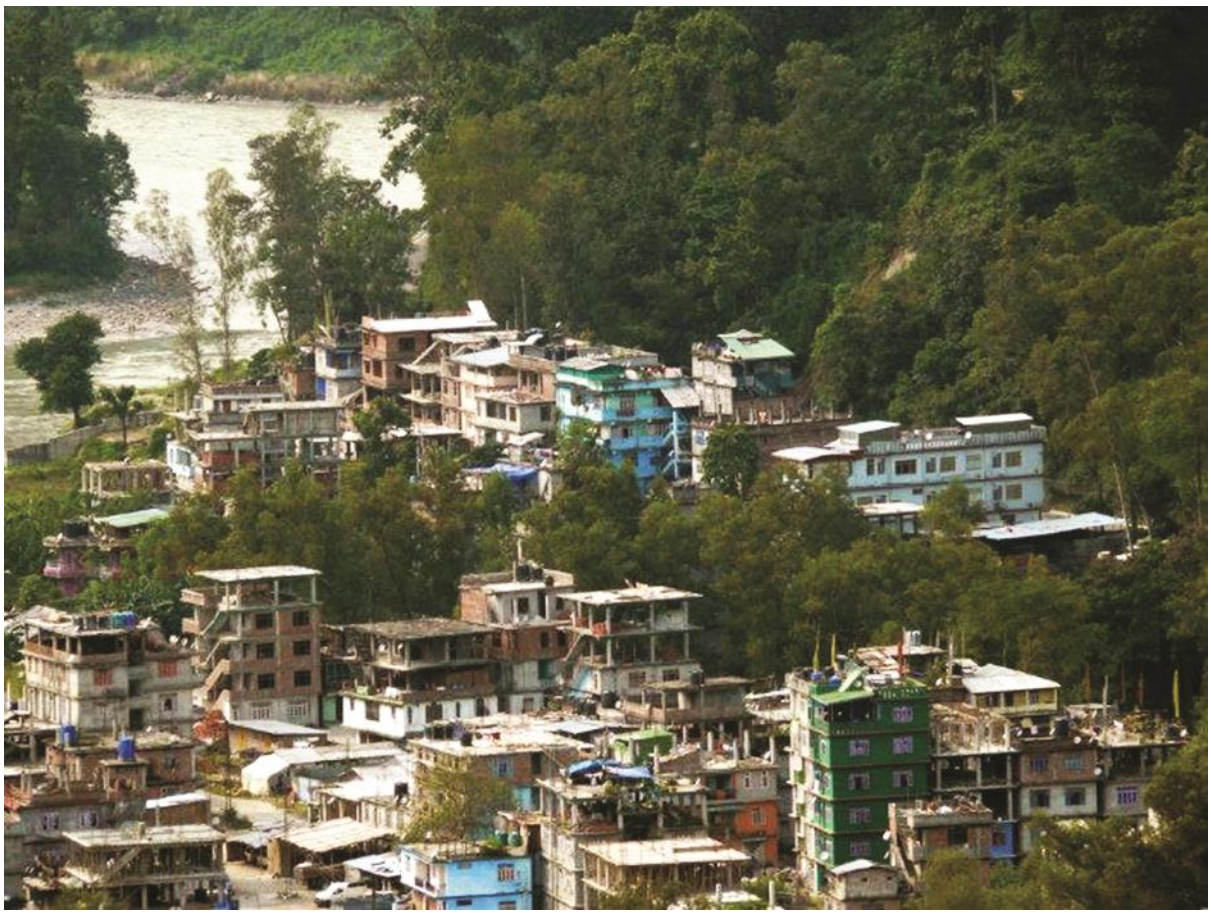
The paper deals with a case study of Rangpo in the eastern region of the Himalayan belt in the state of Sikkim. Rangpo is a town situated along the Teesta river in East Sikkim and is located at the confluence of two rivers the Teesta and the Rangpo river. The town has seen an increase in the population over the last few decades. The objective of the study is to analyze the development trend in the area and its rate of growth. The study also focuses on the exposure to natural disasters and vulnerability of the population.

Figure 6.2 Location map of Rangpo, Sikkim

The study is conducted on two types of data sets. The secondary data helps to observe the hydrological trends such as rainfall in the area in the past decades, maps of critical areas and inventory of landslides in the district. This helps to establish a level of likelihood in the case of geological and meteorological hazards. The GIS mapping and census data aids to study the vulnerability factors such as built-up ratio and population trend. This would also help in observing the effect of urbanization in a typical hill town and the changes to the environment which comes along with such a rapid growth of urban area.

The two sets of data were analysed and studied in relation with each other and the level of risk in the area was detected. Some critical risk elements of the city were also identified such as the stretch of National Highway 10 links Siliguri to Gangtok through the Rangpo city. The stretch is a critical risk element. It is a lifeline infrastructure as it is the only road that connects the city to the state capitol or other major cities and towns. In case of any major event/ disaster it is the key link for any escape route and is essential for any aid that will come to the city in the time of distress.

Keywords: Rainfall trend, Population trend, Rangpo, Complex Disasters



Posted by Vishva Bhraman (places to visit in Sikkim, www.blogspot.com)

Picture 6.2 Rangpo in the banks of the river

Indian Institute of Public Administration
Indraprastha Estate, Ring Road, New Delhi-110002