Prioritize and Strengthen Disaster Resilience Action

For

Gangtok city, Sikkim

20 YEARS Integrated Research and Action for Development

NESAC

G.B. Pant 'National Institute of Himalayan Environment'(NIHE)
(*An Autonomous Institute of* Ministry of Environment, Forest & Climate Change, Govt. of India)

सत्यमेव जयते
Ministry of Environment, Forest & Climate Change

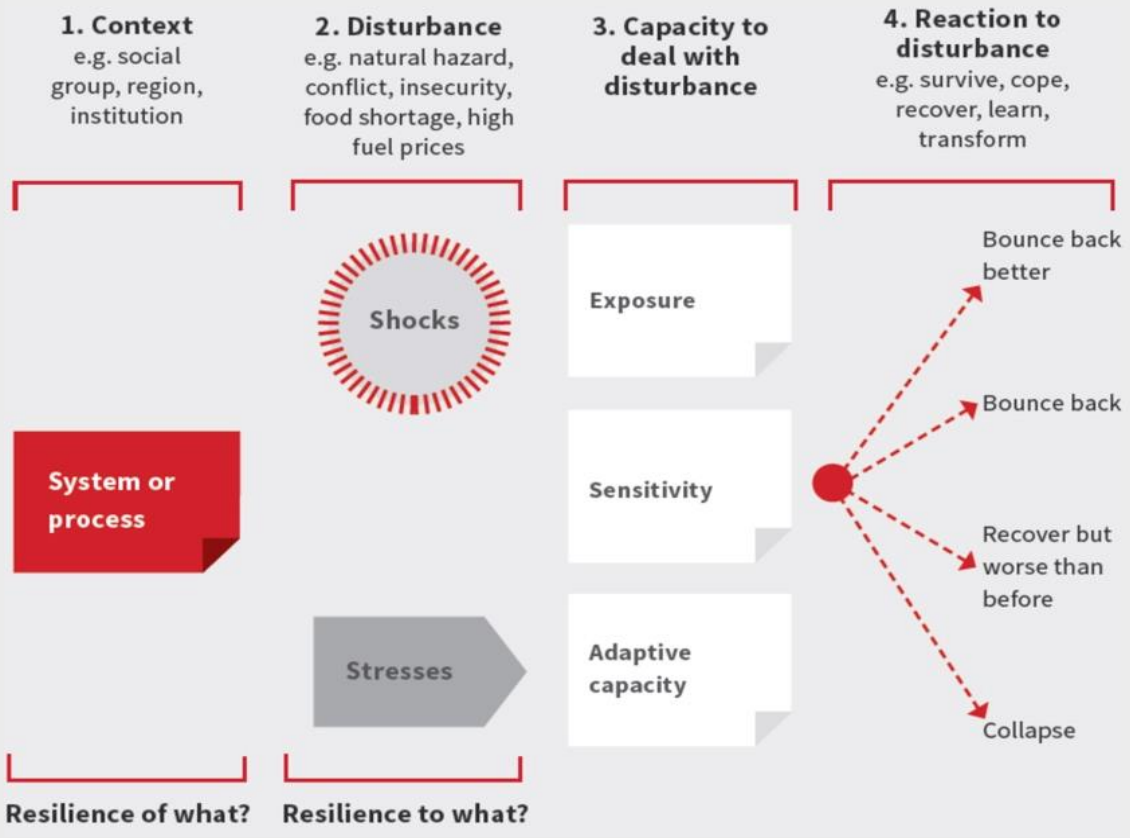
NMHS
National Mission on Himalayan Studies

Disaster Resilience Action Plan

Need

Himalayan cities are particularly vulnerable to disasters and extreme events like earthquakes, landslides, flash floods, thunderstorms and cold waves. The magnitude of hazards and extreme events in the region may vary depending on the risk exposure of the city. Physical risks and vulnerabilities in the Himalayan cities are often accompanied by difficult terrain, lack of necessary resources – *financial, human and institutional* – as well as lack of access to relevant scientific information on the coping mechanism.

This necessitates a thrust on improving the knowledge base and adaptive capacity of the cities by integrating disaster risk reduction measures in the urban planning. In addition, rapid urbanization and climate change could exacerbate environmental stress in the region. Thus, there is a need to collect and review evidence to assess the vulnerability and likely impact of disasters in the region. IRADe, with support from Ministry of Environment, Forests & Climate Change (MoEFCC) , under National Mission on Himalayan Studies (NMHS) aims to develop Disaster Resilience Action Plans for Shillong and Gangtok cities.



Model of Resilience

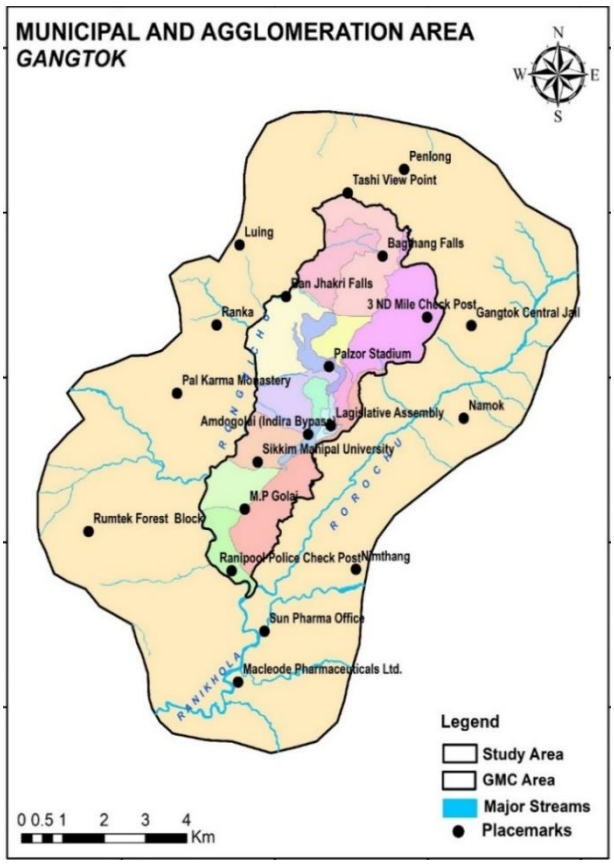
Source: DFID, Defining Resilience: A DFID Approach Paper (London: DFID, 2011), reproduced in J. Twigg, Disaster Risk Reduction, Good Practice Review 9, Revised Edition (London: ODI, 2015)

Composite Hazard and vulnerability maps on the **scale 1:4000** are developed for Gangtok indicating **High, Medium and Low** risk hazards for the city. This helps in analyzing the city vulnerability and provide decision-making tools to assist the city for better disaster management. Based on the vulnerable zone mapping of the two cities, actions are prioritized for disaster risk reduction. **The action plans suggest hazard/disaster wise (floods, landslides, earthquake) measures for mainstreaming disaster risk resilience for the identified cities which can be integrated with the master plans and proposed smart city plans of the identified cities.**

Policy Brief - Disaster resilience Gangtok

Gangtok is a Municipal Corporation, the capital and the largest town of the Indian state of Sikkim. It is the headquarters of the East Sikkim district and is located in the eastern Himalayan range. It is flanked on east and west by two streams, namely Roro Chu and Ranikhola, respectively. The Gangtok Municipal Area comprises of 17 municipal wards and has an area around 19.2 sq km

The unplanned urbanization and rapid construction on hill slopes have aggravated and increased the risk of environmental degradation in Gangtok. Urban sprawl and urban expansion followed by extensive tourism activities has led to the rapid destruction of the green infrastructure. The city has witnessed a substantial change in the land use pattern due to rapid urbanization which has increased to four times over a span of almost 30 years (2.94181 sq. km to 12.8144 sq. Km from 1978 to 2014). It is therefore, most prone to multi-hazards like earthquake, floods and landslides.



Hazard Exposure

Total Hazards Affecting the city every year			
No	**Hazard Type**	**Exposure**	**Key Disasters**
1	Flash Flood	**Y**	✓
2	Drought/ Heat Wave	**N**	-
3	Earthquakes	**Y**	✓
4	Landslides	**Y**	✓
5	Forest Fires	**Y**	-
6	Heavy rainfall	**Y**	-
7	Hailstorm/thunderstorms	**Y**	-

Hazard Timeline

Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Landslides												
Flash Flood												
Hailstorm/thunderstorms												
Forest Fire												
Earthquake												

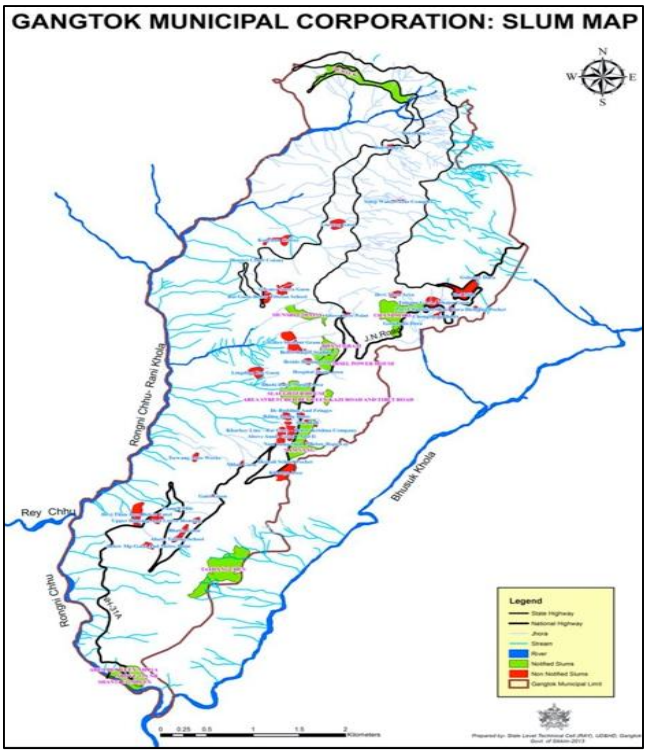
HAZARD AND EXTREME EVENTS	
Temperature Projections	• By 2030s, the avg. annual temp. will rise by 1.8 to 2.1°C with respect to 1970s (SSDMA & GMC , 2015)
Rainfall Projections	• Expected decrease in precipitation (3%) in 2030 w.r.t. 1970 (SSDMA & GMC , 2015)
Landslide	• Almost 71 landslide cases registered in the city (1990-2017, highest recorded between 2001-2017
Earthquake	• Sikkim is in Zone IV/V of the earthquake • September 2011 earthquake killed 70 people.
Urban Floods	• 22 people killed in 2012 flood , triggered series of landslides.

Disaster Vulnerability

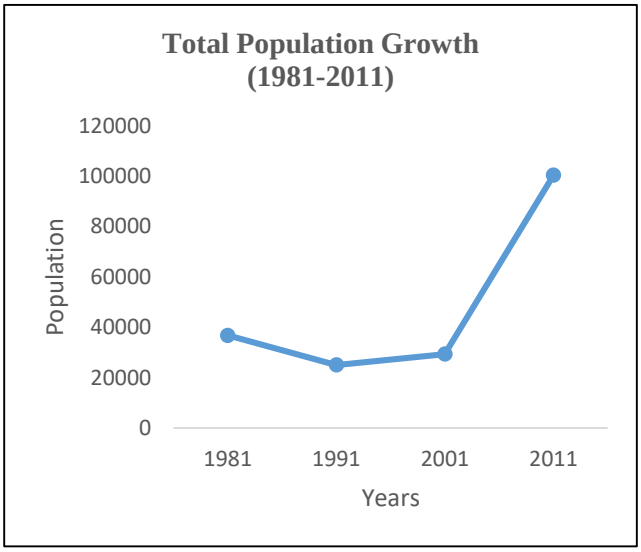
Physical Vulnerability

The high population growth in any city makes the impact of the disaster excessively worse.

- The total population of the city is 100,286 (Census 2011).
- The population growth rate has increased rapidly from 17% (2001) to over 271% (2011), creating pressure on the land and simultaneously increasing the population exposed to disasters and its direct and indirect impact.



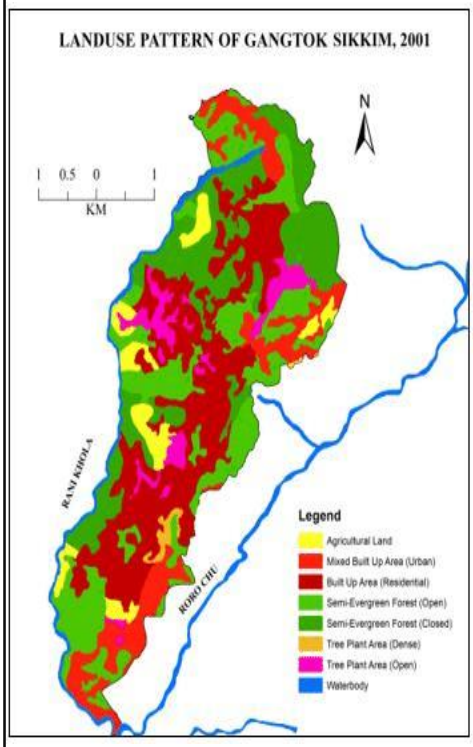
SOCIO-ECONOMIC CHARACTERISTICS		
Population	•	100,286 (2011 Census)
Density	•	257 persons per sq. km
Slum Population	•	15012 (3780 HHs), (RAY scheme, UD&HD govt. of Sikkim, 2013)

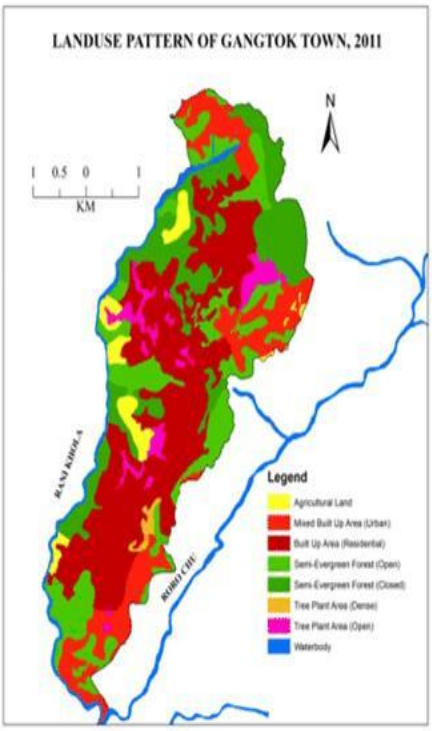


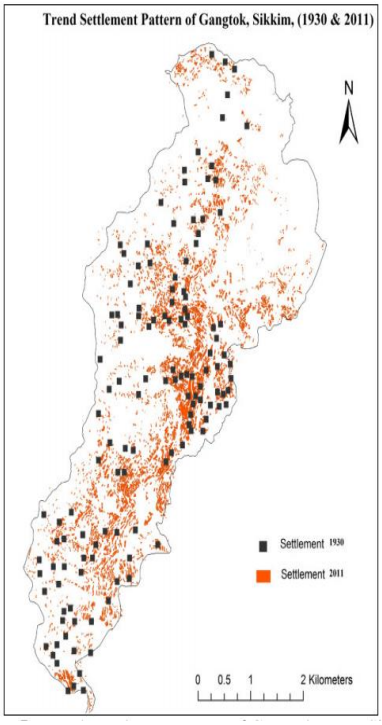
Social Vulnerability

- There are nearly 58 slum pockets -12 notified and 46 non-notified, across the city
- The slum pockets are distributed at the central or core area of the city, wherein the population density is also recorded high. The number of slums in the Fringe Area is only about 34%, while the percentage of slum-households in fringe areas to total slum households in Gangtok is even less, 31.3%. (UD&HD, 2013).

Land Use Land Cover



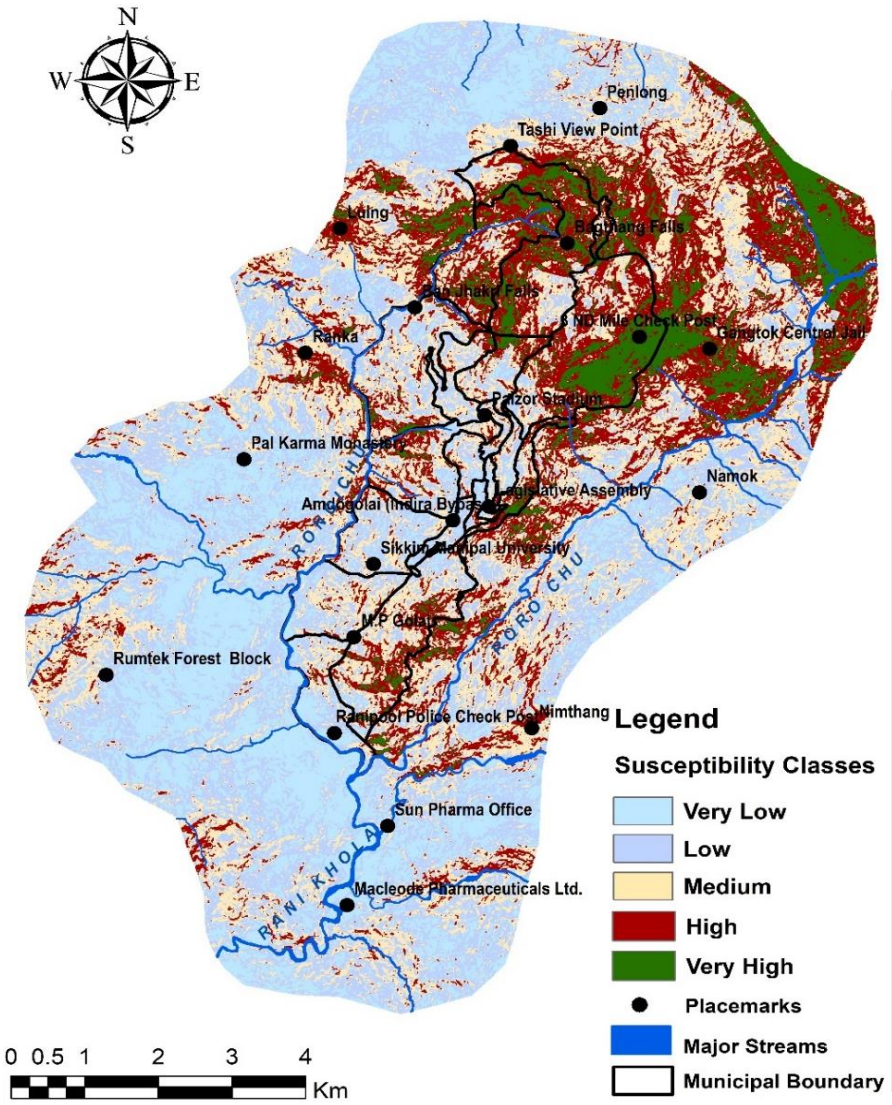




Land-use Categories	Total Land Area Share (%)				
	1975	1985	1995	2006	2011
Residential	65.5	54.8	49.6	43.0	36.0
Commercial	6.9	6.4	4.6	4.0	3.5
Public & Semi Public	0.6	1.7	4.2	15.0	21.4
Transportation	13.4	12.2	10.6	19.0	20.1
Recreational	12.6	17.7	22.0	13.5	14.1
Industrial	1.1	7.3	9.0	5.5	4.9

Source: DST, Gangtok Sikkim

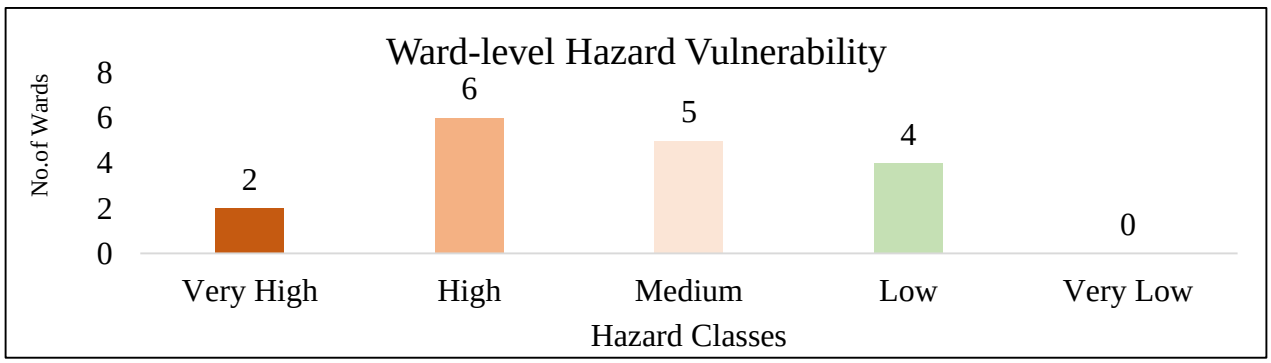
Landslide Susceptibility



Landslides:

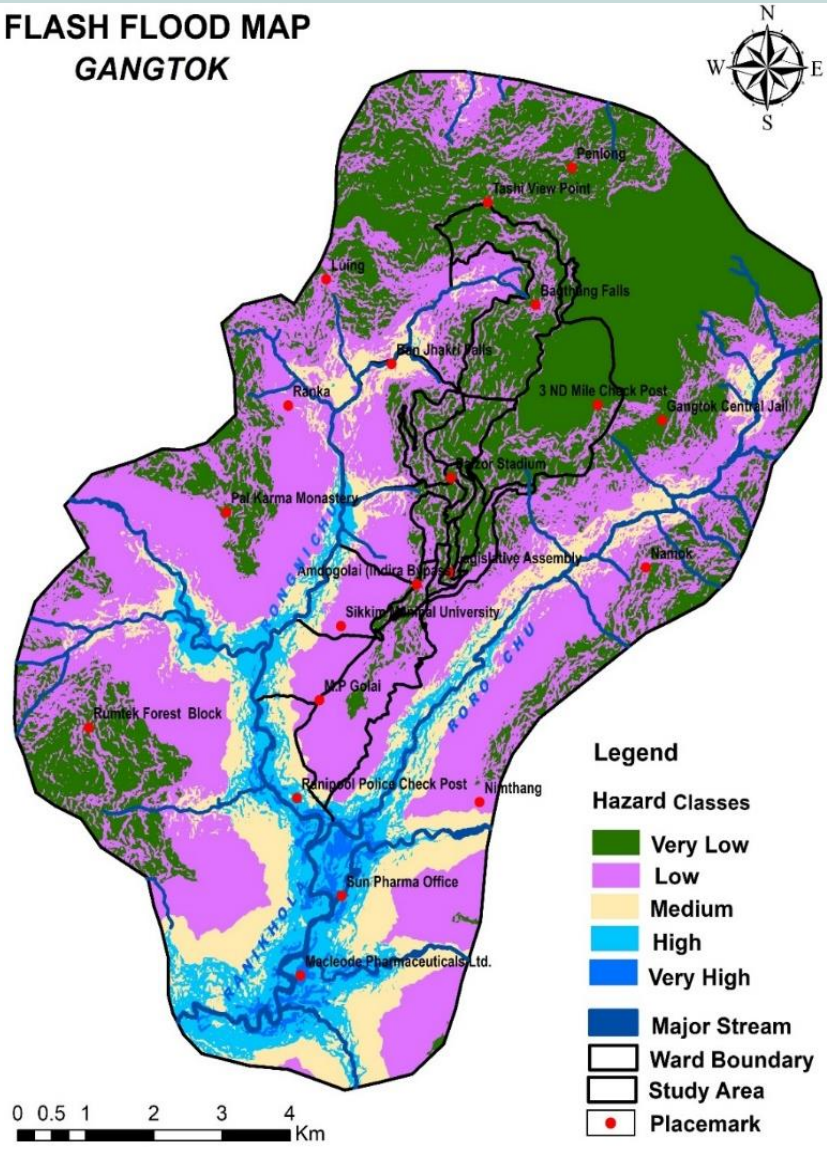
- ***Highly vulnerable Wards*- Upper Burtuk, Chandmari,** inhibiting 14% of total population and 27% of Slum population of the city.

- ***Highly Vulnerable Wards* - Lower Burtuk, Sichey I, II, Development Areas, Tibet Road and Dara Gaon** inhibiting 28% of total population and 10% of Slum population of the city.



Hazard Classes	Ward	Number
Very High	1, 6	**2**
High	2, 3, 4, 7, 12, 14	**6**
Medium	8, 9, 15, 16, 17	**5**
Low	5, 10, 11, 13	**4**
Very Low	Nil	**Nil**

Flood Susceptibility



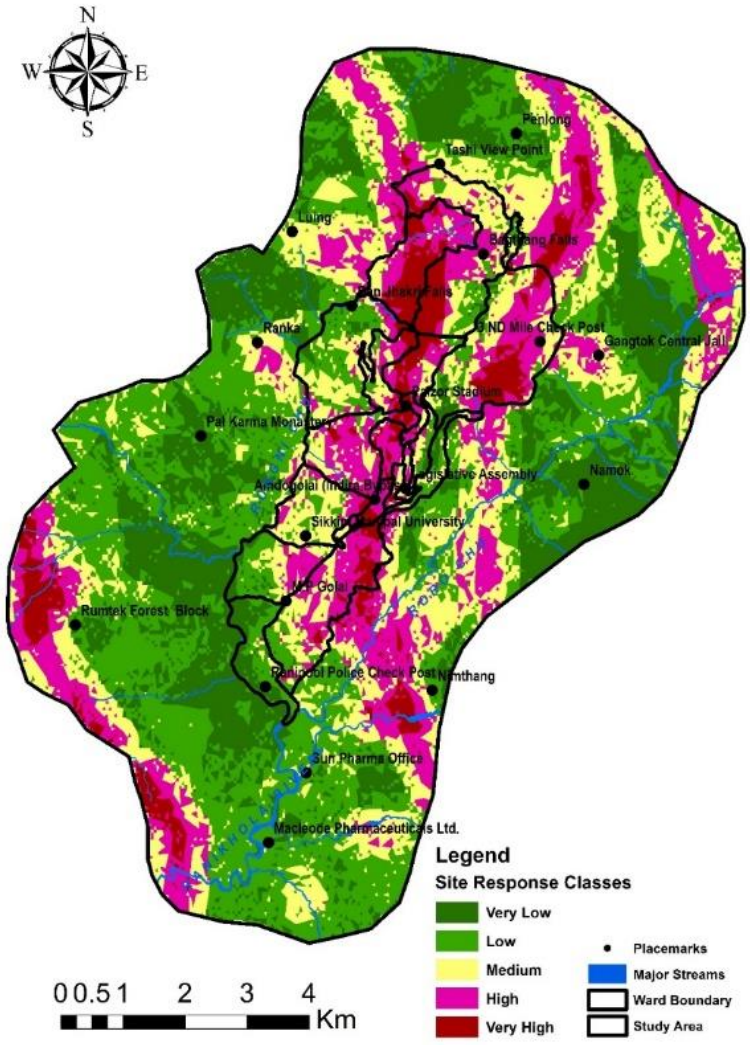
Flash Floods:

- ***Highly Vulnerable Wards*** **- Sichey II, Dara Gaon,Tadong and Ranipool** inhibiting 26% of the the population and 22% of the slum population

Hazard Classes	Ward
Very High	Nil
High	4, 14, 15, 16
Medium	3
Low	1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17
Very Low	Nil

Earthquake Susceptibility

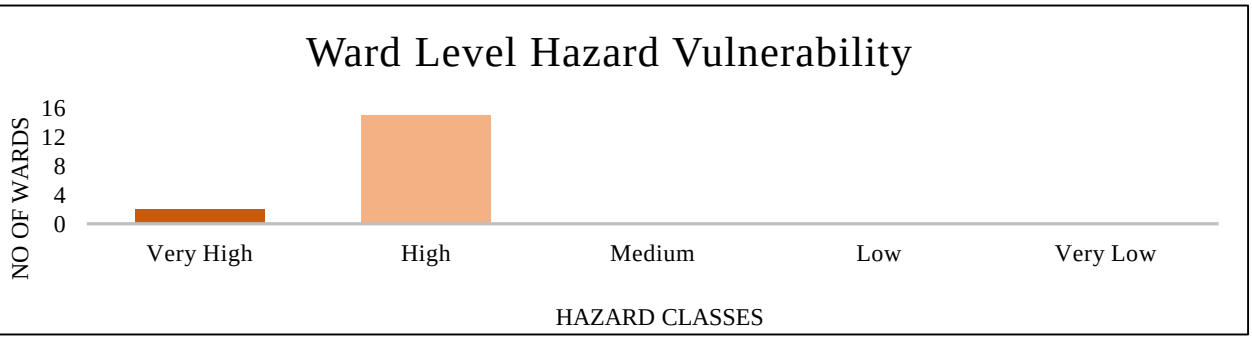
EARTHQUAKE SUSCEPTIBILITY MAP



Earthquake:

- ***Very highly Vulnerable Wards*- Sichey II and Arithang** inhibiting 11% of the total population and 2% of Slum population

- ***Highly Vulnerable Wards* - Almost all the wards** are to earthquake inhibiting over 90% of the total and slum population



Hazard Classes	Ward
Very High	4, 9
High	1, 2, 3, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17
Medium	Nil
Low	Nil
Very Low	Nil

Hazard Vulnerability

Landslides					
Hazard Classes	**Ward No.**	**Ward Name**	**Total Population**	**Total %**	**Slum Population %**
Very High	**1**	Upper Burtuk	**8225**	**14.36**	**27.28**
	6	Chandmari	6177		
High	**2**	Lower Burtuk	1732	**27.12**	**9.73**
	3	Lower Sichey I	3495		
	4	Lower Sichey II	2378		
	7	Developed Area	6723		
	12	Tibet Road	3266		
	14	Dara Goan	9605		

Urban Floods					
Hazard Classes	**Ward No.**	**Ward Name**	**Total Population**	**Total %**	**Slum Population %**
Very High	Nil				
High	**4**	Lower Sichey II	2378	**25.75**	**22.21**
	14	Dara Goan	9605		
	15	Tadong	9325		
	16	Ranipool	4520		

Earthquake					
Hazard Classes	**Ward No.**	**Ward Name**	**Total Population**	**Total %**	**Slum Population %**
Very High	**4**	Lower Sichey II	2378	**10.56**	**2.59**
	9	Arithang	8212		
High	**14**	Dara Goan	9605	**89.44**	**1.69**
	15	Tadong	9325		
	16	Ranipool	4520		
	3	Lower Sichey I	3495		
	1	Upper Burtuk	8225		
	2	Lower Burtuk	1732		
	5	Upper Sichey	7979		
	6	Chandmari	6177		
	7	Developed Area	6723		
	8	Diesel powerHouse	3987		
	10	Lower MG Marg	4032		
	11	Upper MG Marg	2664		
	12	Tibet Road	3266		
	13	Deorali	6936		
	17	Syari-Tathangchen	11028		

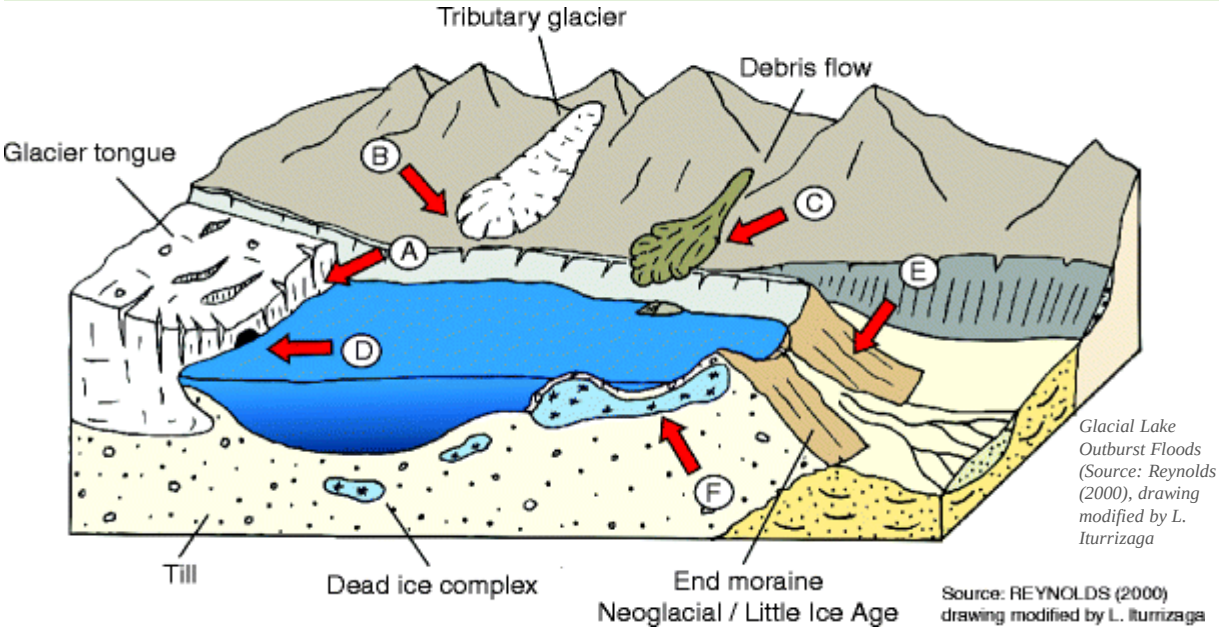
Multi-Hazard Susceptible Wards

Hazard Type	Ward No.	Ward Name	Total Population	% Population	Total %	Total Slum Population	Slum Population %	Total %
L & E	**1**	Upper Burtuk	**8225**	**8.2**		**1362**	**9.07**	
L & E	**2**	Lower Burtuk	**1732**	**1.73**		**-**	**-**	
L & E	**3**	Lower Sichey I	**3495**	**3.49**		**-**	**-**	
L, F & E	**4**	Lower Sichey II	**2378**	**2.37**		**-**	**-**	
L & E	**6**	Chandmari	**6177**	**6.61**	**55.75**	**2733**	**18.21**	**57.53**
L & E	**7**	Developed Area	**6723**	**6.7**		**1207**	**8.04**	
L & E	**12**	Tibet Road	**3266**	**3.26**		**-**	**-**	
F & E	**14**	Dara Goan	**9605**	**9.58**		**253**	**1.69**	
F & E	**15**	Tadong	**9325**	**9.3**		**756**	**5.04**	
F & E	**16**	Ranipool	**4520**	**4.51**		**2325**	**15.48**	

- **Total 10 wards are among the most vulnerable wards, susceptible to disasters - landslides, urban floods and earthquakes**
- **Total Vulnerable population – 55446 persons (55.75 % of total city population**
- **Total vulnerable slum population - 8636 (57.53 % of the total slum population of city)**

Glacial Lake Outburst Flood (GLOF)

The flash flood due to sudden burst of a glacial lake produce the violent flow of water and associated debris and is known as a Glacial Lake Outburst Flood (GLOF). Fast melting of glacier or an extreme weather event can trigger glacial lakes to burst and cause damage to people and property in the valleys.



Glacial Lake Outburst Floods (Source: Reynolds (2000), drawing modified by L. Iturrizaga

Sikkim

Since 1965, expansion up to ~**24% in the size of glacial lakes has been observed which pose a great threat to the valley** in the form of glacial lakes outburst floods (Debnath, M. et al, 2018), (Shukla, A., Garg, P. K. & Srivastava, S. 2018) **, including parts of Eastern Sikkim, Gangtok faces risk of flash floods.**

South Lhonak Glacial Lake, situated in north western part of Sikkim, is vulnerable as earthquakes of magnitude 4.9 and 6.9 were reported near the parent glacier on September 21, 1991 and September 18, 2011 respectively (Soma Basu, 2013)

SSDMA since 2014, is working to implement mitigation measures around the lake. They have successfully employed three heavy duty pipelines **of 8 inch** diameter to siphon out water from the lake to avoid the threat of GLOF

Source : SSDMA officials employing pipelines to siphon out water from South Lhonak lake (Source: http://www.ssdma.nic.in/Uploads/PdfFiles/glof.pdf).

Service Level Benchmarks – Gangtok City

	INDICATOR	BENCHMARK	GANGTOK STATUS
	WATER SUPPLY		
1	Coverage of Water Supply Connections	100%	82.7%
2	Per capita availability of water at consumer end	135 lpcd	129 lpcd
3	Extent of metering of water connections	100%	
4	Extent of non-revenue water	20%	50%
5	Continuity of Water Supply	24 Hours	37%
6	Adequacy of Treatment and Disinfection and Quality of water supplied	100%	75%
7	Efficiency in redressal of customer complaints	80%	NA
8	Cost recovery in water supply services	100%	NA
9	Efficiency in collection of water supply related charges	90%	NA
	SEWAGE MANAGEMENT		
1	Coverage of Toilets	100%	100%
2	Coverage of Waste sewerage Network Services	100%	42%
3	Collection Efficiency of Waste Water Network	100%	85%
4	Adequacy of waste water treatment Capacity	100%	40%
5	Quality of sewage Treatment	100%	NA
6	Extent pf reuse and recycling of sewage	20%	NA
7	Efficiency in redressal of customer complaints	80%	NA
8	Extent of cost recovery in sewage management	100%	NA
9	Efficiency in collection of sewerage charges	90%	NA
	SOLID WASTE MANAGEMENT		
1	Household level coverage of Solid Waste management services	100%	90%
2	Efficiency of collection of municipal solid waste	100%	90%
3	Extent of segregation of municipal solid waste	100%	55%
4	Extent of Municipal solid waste recovered/recycled	80%	60%
5	Extent of scientific disposal of municipal solid waste	100%	60%
6	Efficiency in redressal of customer complaints	80%	100%
7	Extent of cost recovery in solid waste management services	100%	52%
8	Efficiency in collection of SWM charges	90%	70%
	STORM WATER DRAINAGE		
1	Coverage of Storm Water Drainage Network	100%	55%
2	Incidence of water logging/flooding	0%	4.72%

Source:
Gangtok Municipal Corporation
Smart Cities Challenge (Stage 2) Smart City proposal
State Annual Action Plan, AMRUT

Traditional Knowledge

Housing Structural Knowledge

Chaukat Housing

This type of house is generally made up of stones, soil and woods material. There is no use of nails for jointing any window, doors or any part of the house.

Ikra/Icra Housing

Sikkimese traditional structure, built of a stone foundation and bamboo wall normally plastered with mud or cement. These houses effectively work as anti-seismic structures.

Tibetan Buildings

These types have demonstrated some of the basic principles of earthquake-safe construction of non-engineered buildings like appropriate sitting and location on firm soils and good building configuration

Vegetal cover

To stabilize the soil and protect it from landslides and mass movement, the local residents have opted for soil binding species like Thysanolaena spp, Dendrocalamus spp., Alnus nepalensis, Erythrina spp and Jatropha curcas, etc.

Preserving and Maintaining Chaals

Recharge pits in local parlance are maintained for improving spring yield, with the interrelationship of the increasing pore water pressure and the consequent (Rautela P & Paul SK, 1998) land destabilization.

Jotrapa & Thysanolaenaspp and Astilbe plants

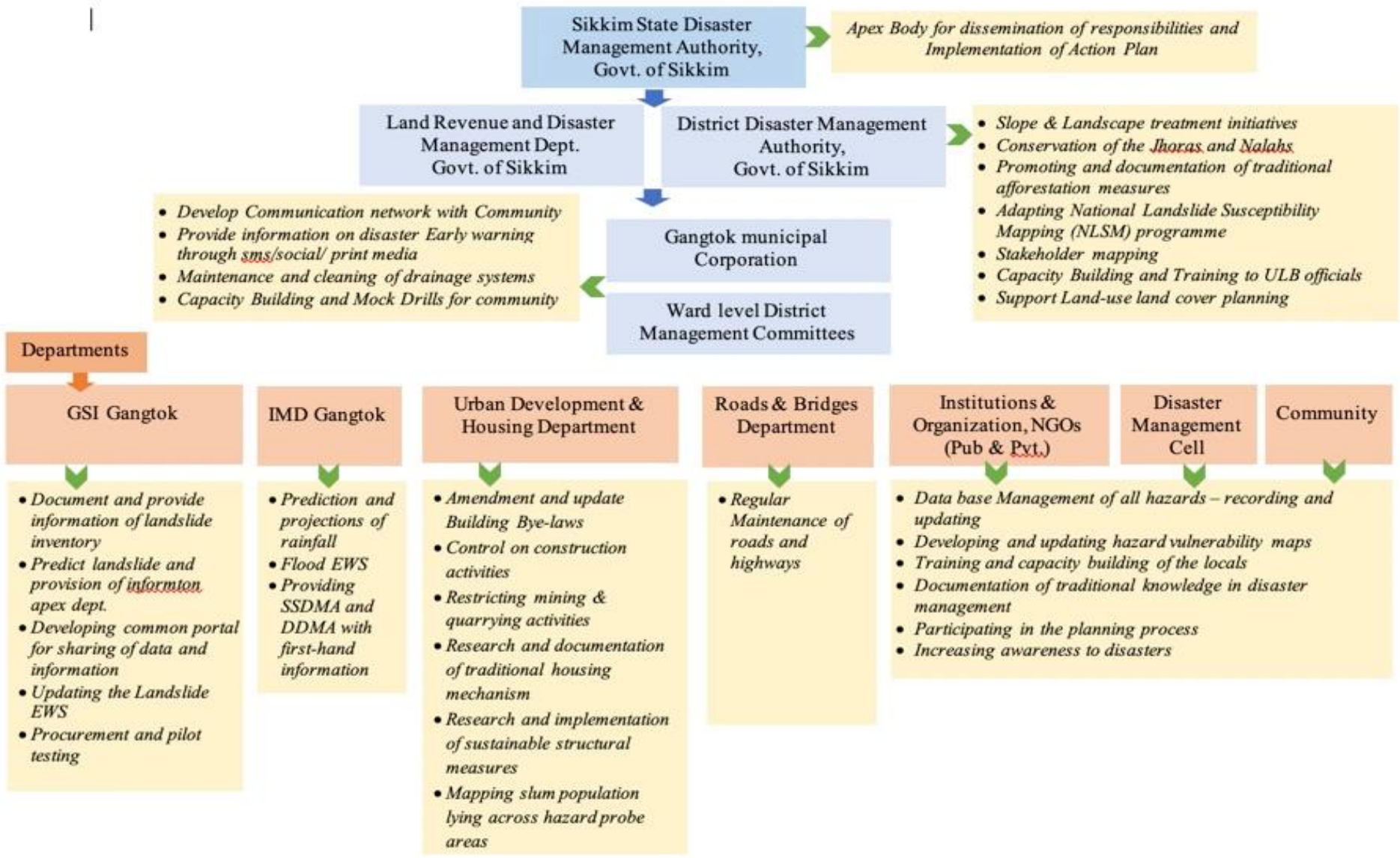
Early Warnings

The Lepcha community possess knowledge of the annual timing around when such natural disasters are expected to occur.

- Famine is indicated when bears (Ursusthi betanus) begin to raid villages, as well as when langurs (Presbytis entellus) move around in smaller groups. Also wolves (Canis lupus chanco) according to them, do not breed at these times, in anticipation of such conditions
- If the birds are silent, rain and storms are due. Alternately, if the birds are singing loudly and flocking together happily on the ground, good weather will continue
- The Lepchas say that when bamboo flowers start blooming, it may be a bad signs like warning of famine, scarcity of food, disaster etc (Sudin Pal, 2011).
- The Lepcha people believe that the behaviour of various pheasants (cries and nervousness) are displayed right before a major earthquake as an important indicator

KEY INTERVENTIONS IDENTIFIED FOR GANGTOK CITY	
1	**Construction and Building Bylaws – Structural Measures**
	• Restricted constriction along 35-60 degree slope. • Nature based construction technology adaption. • Change from prescriptive to form based/ performance based/site specific, and formulation of a new enforcement mechanism. • Plan and implement appropriate anti-erosion measures.
2	**Hazard susceptible zonation**
	• Map using Satellite imageries and GIS tools to produce at the scale of 1: 50,000-1:4,000 map landslide hazards and create a knowledge /database • Clearing of culverts and Jhoras and stabilization of road side drain along all important roads • Rehabilitation and stabilization of landslides affected sites
3	**Land-use and Land Cover Planning**
	• Development activities (road, bridge, canal, tunnel) should be integrated with existing disaster management policy • Quantification of environmental degradation, cost of loss of land and agriculture produce • Integration of Land slide Management with Development/ Urban Planning • Preparation of a large-scale maps (1:10,000/1:15,000) of flood vulnerable areas with contours at an interval of 0.3 m or 0.5 m. (NDMA) • Developing Flood Plain regulation Plan • Regulation of Land Use in Flood Prone Areas
4	**Slope Landscaping**
	• Prohibition of Hill cutting Installation of sustainable structural measures such as retaining wall • Vegetation standards (native plants with strong, deep root systems) • Use of Soil Improvement Techniques
5	**Community Capacity Building**
	• Training of first responders in search, rescue and Medicare • Establish a Landslide Disaster Knowledge Network • Rehabilitation and provision of Shelter for poor people living in the landslide-prone areas • Defining role and responsibility at large before, during and after a disaster, Bigger investment on research • Participatory flood-risk mapping • Developing effective traditional/ indigenous coping strategies
6	**Early Warning System**
	• Training of skilled technical human resources and adequate allocation of financial resources • Landslide Early Warning System (LEWS) (NIDM Guidelines) installation • Develop hydrometeorological observation network including stage and discharge management, (WMO, 2008) • Developing regional Flood Information system – based on HKH Hydrological Cycle Observing System (HYCOS) WMO • Generating Flood Outlooks

Resilience Action Plan Implementation Framework



Implementing Agencies

Sl.N	Action Plan Implementing agencies	Key Roles/Responsibilities
1	**Indian Meteorological Department (IMD)**	• Weather forecasting and disseminating weather information • Procuring and pilot testing Early Warning System • Providing SSDMA and DDMA with first-hand information
2	**Geological Survey of India (GSI)**	• Document and update hazard inventory database • Landslide prediction and provision of information through common portal
3	**Department of Land Revenue and Disaster Management – Sikkim State Disaster Management Authority (SSDMA)**	• Mapping multi-hazard risk • Installation of Landslide Early Warning Systems (LEWS) and Flood Information System • Hazard database management • Coordination of other departments
4	**Urban Development & Housing Department, Govt. of Sikkim**	• Amendment of building bye-laws • Assisting and guiding ULBs in terms of its functioning and execution of duties
5	**Public Health Engineering Department, Sikkim**	• Provision of Adequate safe water and sanitation • Functioning of city sewerage treatment plants
6	**District Disaster Management Authority**	• Guidance and corporation with ULB disaster mitigation
7	**Ward Level Disaster Management Committees**	• Work in coordination with DDMA
8	**Urban Local Bodies: Gangtok Municipal Corporation**	• Relief & Rehabilitation of City slums/ Urban poor

Infrastructure Implementing agencies	Funding Linkages
• Urban Development & Housing Department (UDHD), Govt. of Sikkim • Gangtok Municipal Corporation • Water Security and PHE Department • Municipal WASH Team • PHE Department • PWD • Transport Department • Road and Bridge Department • Building and Housing Department.	• AMRUT – CBUD • PPP mode funding (Private and Public Partnership) • Smart city • MLDAA (ADB) • Users/Citizens • Swachh Bharat Mission SBM • MLDAA (ABD) • Users/ Beneficiaries • Pradhan Mantri Awas Yojana