आज़ादी का अमृत महोत्सव

G20 भारत 2023 INDIA

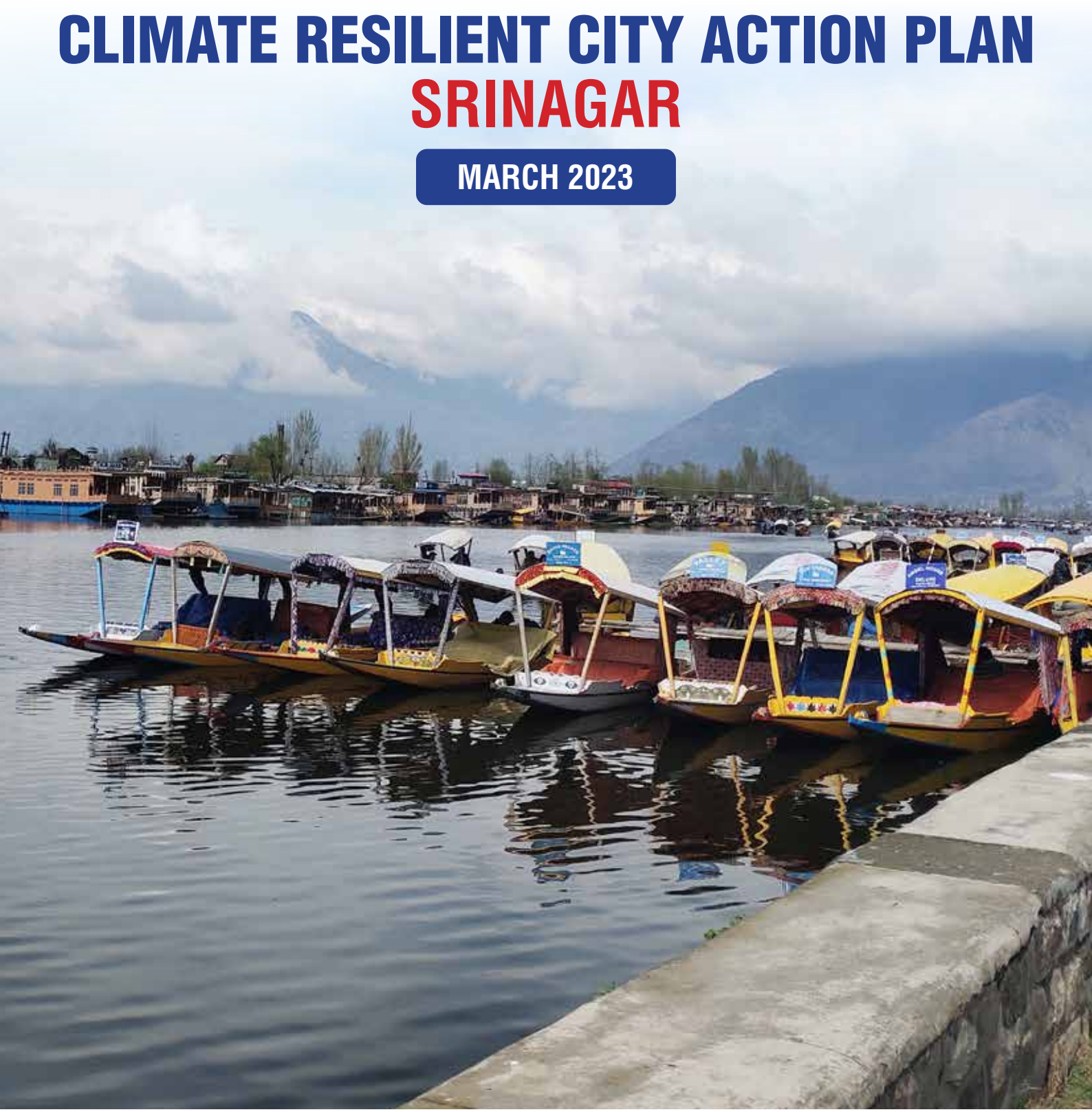
From the People of Japan

UNDP

CLIMATE RESILIENT CITY ACTION PLAN

SRINAGAR

MARCH 2023



25 Years TARU LEADING EDGE

VASUDHA FOUNDATION
Green ways for a good earth!

Copyright/Citation: Climate Resilient City Action Plan of Srinagar, Taru Leading Edge Pvt. Ltd. and Vasudha Foundation, 2023

Month & Year of Publication: March 2023

Research Leads: Binu Mathew, Jay Anil Shah, Rini Dutt, Shivika Solanki, Monika Chakraborty

Proofreading and editor: Srividhya Moorthy

Design and Layout: The Madre Designing

Source of photos: Flickr images of Srinagar city

Acknowledgement

The Climate Resilient City Action Plan (CRCAP) has been developed by UNDP with the support of Taru Leading Edge Pvt. Ltd. and Vasudha Foundation through guidance and collaboration with the Department of Ecology, Environment and Remote Sensing (DEE&RS), Government of Jammu & Kashmir (J&K).

The Climate Action Plan (CAP) was developed under the leadership of Mr. S. Rakesh Kumar, IFS, (Director, DEE&RS, Government of J&K) and Mr. Manish Mohandas, Programme Officer (Resilience), UNDP. Our sincere thanks are extended Dr Majid Farooq (Scientist, DEE&RS, Government of J&K) and Dr Fayma Mushtaq (Geospatial Analyst, DEE&RS, Government of J&K) for supporting and gathering data and sharing feedback for preparing an effective CRCAP document.

This document could not have been developed without the active involvement of a large number of city officials representing various city entities and departments. Though you are too many to mention individually, your contributions have been invaluable. Sincere thanks are also extended to the stakeholders from national and provincial governments, the private sector, youth, and non-governmental organizations who attended various consultations and provided written input.

Our sincere thanks to Ms Vayomini Khajuria, Consultant and Ms Nida Amin, Consultant, Taru Leading Edge Pvt. Ltd. for being stationed in Jammu and Srinagar and supporting in data collection, preparation of various reports, and composing the final CRCAP document.

This report was produced with the generous financial support of the Government and the People of Japan to collectively respond to the climate emergency and support the Government of India's effort in fulfilling its Nationally Determined Contributions (NDCs) to achieve net-zero emission and climate-resilient development.

Content

List of Figures

List of Tables

Acronyms

Acronym	Description
AFOLU	Agriculture, Forestry and Other Land Use
BUR	Biennial Update Report
CPP	Captive Power Plant
CRCAP	Climate Resilient City Action Plan
CVI	Composite Vulnerability Index
CMIP6	Coupled Model Intercomparison Project-6
CDP	City Development Plan
DDMA	District Disaster Management Authority
DEE&RS	Department of Ecology Environment and Remote Sensing
DDMP	District Disaster Management Plan
EVI	Economic Vulnerability Index
GHG	Green House Gas
GDP	Gross Domestic Product
GCM	General Circulation Model
GWP	Global Warming Potential
J&K	Jammu and Kashmir
JKHUDD	J&K – Housing and Urban Development Department
JKSPDCL	Jammu and Kashmir State Power Development Corporation Limited
JKRTC	Jammu & Kashmir Road Transport Corporation
JKPWDRB	J&K – PWD (R&B) Department
JKRTC	Jammu & Kashmir Road Transport Corporation
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
kt CO_2e	kilotonnes of Carbon dioxide equivalent
NVI	Natural Vulnerability Index
NATCOM	National Communication
PEG:	Public Electricity Generation
PVI	Physical Vulnerability Index
SVI	Social Vulnerability Index
SC	Scheduled Caste
ST	Scheduled Tribes
SSP	Shared Socioeconomic Pathway
SDG	Sustainable Development Goal
UHI	Urban Heat Island
ULB	Urban Local Body
UNDRR	United Nations Office for Disaster Risk Reduction
UT	Union Territory
UNEP	United Nations Environment Programme
WRT	with respect to

EXECUTIVE SUMMARY

Executive Summary

CClimate change is one of the most pressing issues facing the world today. The Paris Agreement is an international agreement that aims to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. India is a signatory to the Paris Agreement and has committed to reducing its greenhouse gas emissions by 33-35% below 2005 levels by 2030. India began by establishing eight national missions to combat climate change in 2008, and it has since regularly altered its own goal to quicken the delivery of Climate Justice. In response to the climate emergency, UNDP India has secured funding from the Japan Supplementary Budget (JSB) 2021 to leverage Nationally Determined Contributions (NDCs) to achieve net-zero emissions and climate-resilient development.

Climate Resilient City Action Planning for Srinagar

TThe Department of Ecology, Environment and Remote Sensing, Government of Jammu and Kashmir, and the United Nations Development Programme (UNDP) have prepared this Climate Resilient City Action Plan (CRCAP) for Srinagar City. The CRCAP aids the local government of Jammu city in estimating greenhouse gas emissions, identifying vulnerability hotspots, understanding critical infrastructure systems with respect to resilience, and developing specific climate change mitigation and adaptation plans while promoting sustainable development. The CRCAP for Srinagar typically includes a thorough analysis of climate change risks, and GHG emissions, identifying priority areas for action, and developing action plans that include specific measures to boost the resilience and adaptive capacity of Srinagar city.

Coordinates: 34.0837° N, 74.7973° E
Population: 15,50,342 (census 2021)
Area: 246 sq. km
Number of wards: 74

Climate of Srinagar

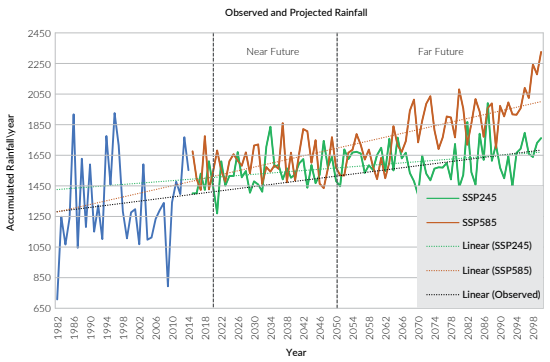
JSrinagar city's future climate under SSP-245 scenario suggests the accumulated rainfall is projected to increase by 55 mm/yr in near future and by 85 mm/yr in far future. In SSP-585 scenario the accumulated rainfall is projected to increase by 87 mm/yr and 225 mm/yr in near and far future respectively. Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 1.22°C and 1.25°C respectively. In far future, under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.51°C and 2.48°C respectively. Under SSP-585 scenario in near-future the maximum and minimum temperature are projected to increase by 1.42°C and 1.47°C respectively while as the upsurge is on higher end by 4.30°C and 4.51°C in far-future.

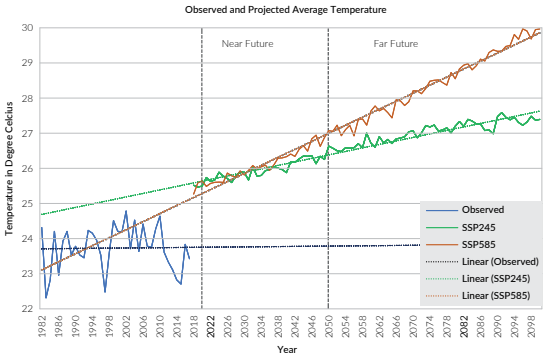
Table 1 Annual Accumulated Rainfall w.r.t to baseline period (1976-2005)

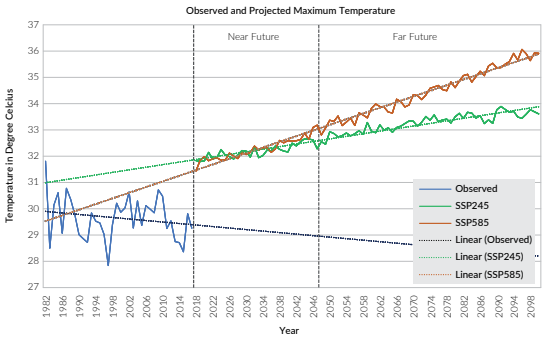
Change in R (mm) SSP 245 2020-2050	Change in R (mm) SSP245 2051-2100	Change in R (mm) SSP585 2020-2050	Change R (mm) SSP585 2051-2100
↑ 55 mm/year	↑ 85 mm/year	↑ 87 mm/year	↑ 225 mm/year

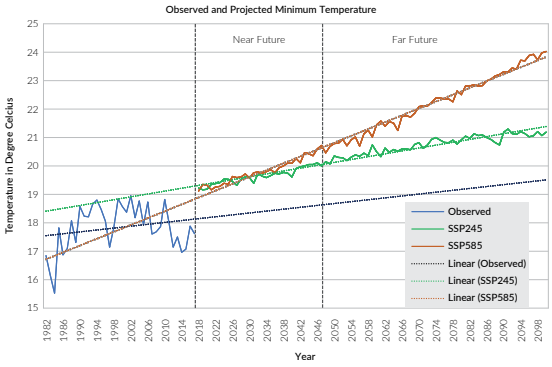
Table 2 Maximum Temperature Changes w.r.t to baseline period (1976-2005)

Parameter	Region	SSP 245 2020-2050	SSP245 2051-2100	SSP585 2020-2050	SSP585 2051-2100
Change in Max T (°C)	Srinagar Station	↑ 1.22°C	↑ 2.51°C	↑ 1.42°C	↑ 4.30°C
Change in Min T (°C)		↑ 1.25°C	↑ 2.48°C	↑ 1.47°C	↑ 4.51°C



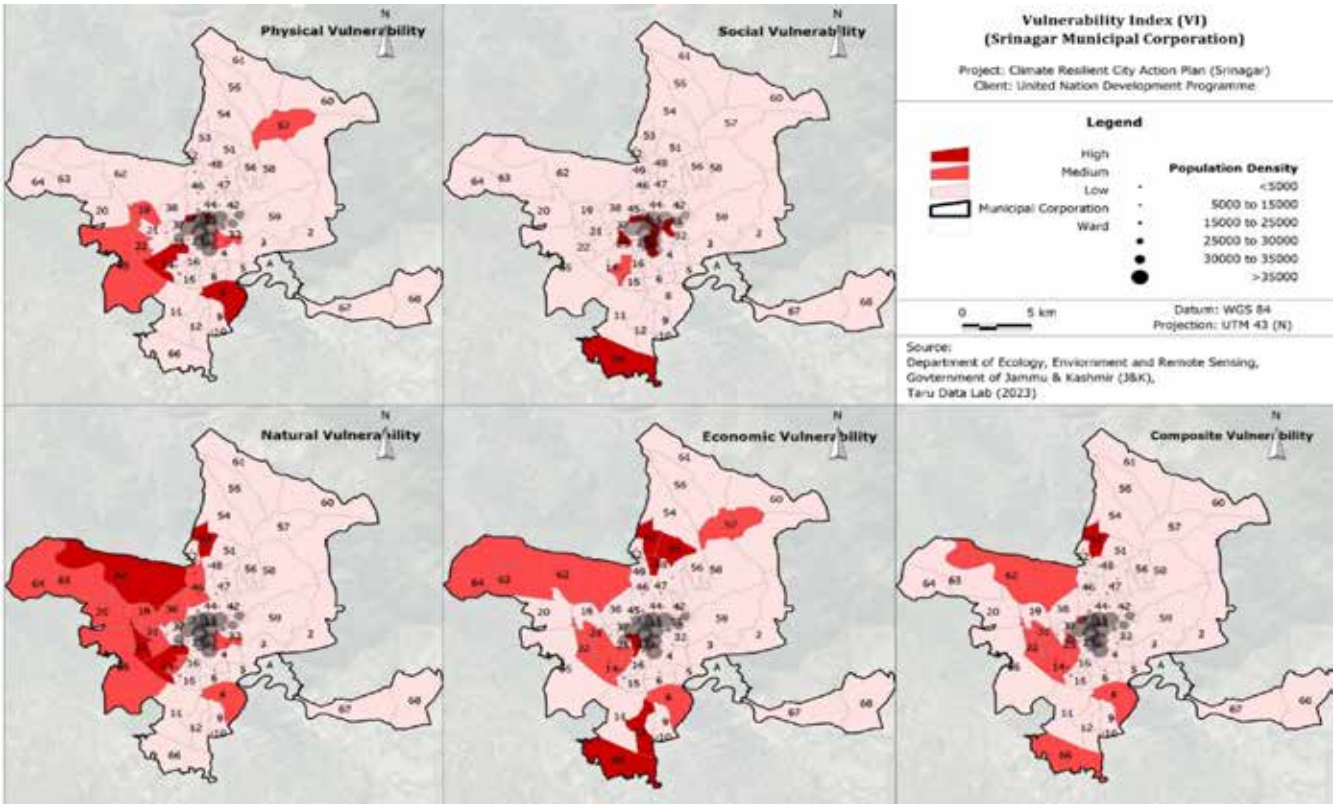






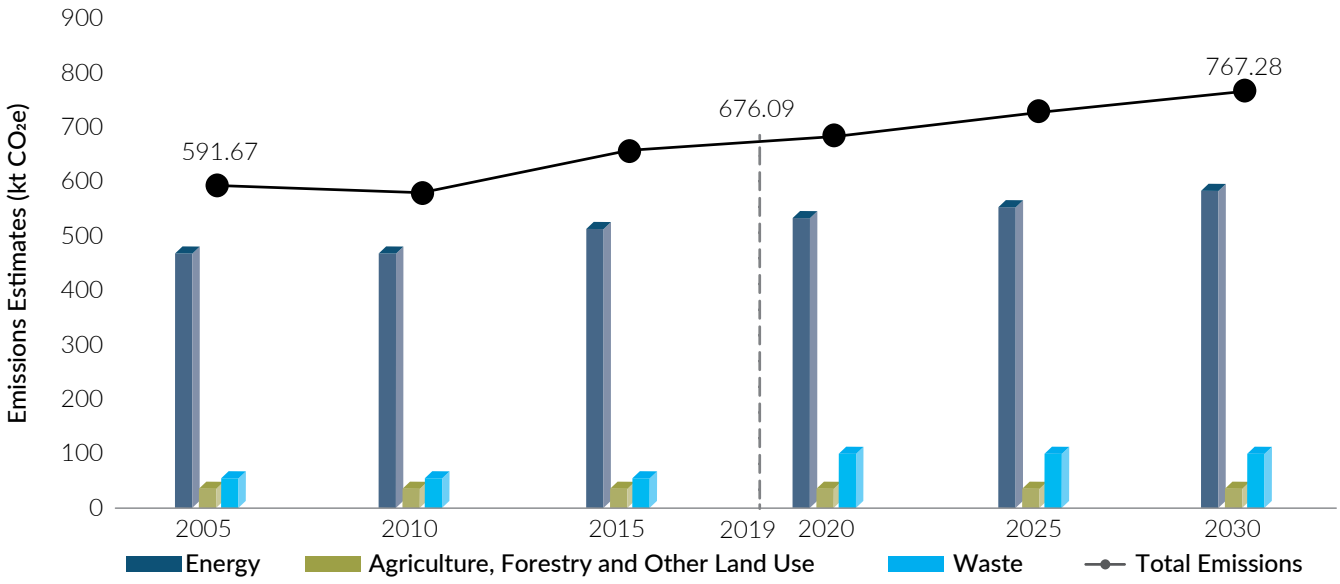
Vulnerability Assessment

Vulnerability assessment is conducted in two levels namely – City level and Ward level. City-level vulnerability assessment is based on understanding the climate-induced risk of various hazards and their exposure to critical urban services and populations spatially. The ward-level vulnerability assessment uses four dimensions (Natural, Social, Economic and Physical Vulnerability). Decision-makers need to understand the most vulnerable wards to focus on those wards towards improving services to make them more adaptive and resilient.



GHG emissions

Emissions of Srinagar city increased at an estimated CAGR of ~0.96% from 591.67 kilotons of CO_2 equivalent (kt CO_2e) in 2005 to 676.09 kt CO_2e in 2019. The Energy sector was the major contributor of GHG emissions in Srinagar city's total economy-wide emissions across all the reference years, contributing an average of 80% to economy-wide emissions. Emissions from the energy sector increased from 479.51 kt CO_2e in 2005 to 538.14 kt CO_2e in 2019 and emissions from waste sector increased from 67.11 kt CO_2e in 2005 to 108.77 kt CO_2e in 2019. In contrast, emissions from AFOLU sector decreased from 45.05 kt CO_2e to 29.18 kt CO_2e. Despite the increase in the total GHG emissions of Srinagar city, its per capita emissions decreased between 2005 and 2019, with a CAGR of 1.17% from 0.57 t CO_2e/capita in 2005 to 0.48 t CO_2e/capita in 2019. Under the BAU scenario, the emissions are expected to increase almost ~13% by 2030 from 2019 level. As per the projections, Energy sector will be the key driver of emissions in the city, accounting for ~78% of the total GHG emissions in 2030.



Climate Resilient City Action Plan for Srinagar city

Sectors	Key Interventions	Mitigation Potential	Overall Climate Resilience Impact
Power, Energy and Habitat	• Scale up Renewable Energy (RE) generation by promoting rooftop and ground-mounted installations of solar power plants (SPP) at households, institutions, government buildings, commercial buildings etc in the city.	106,657 t CO_2e /yr from households alone	Reduction of GHG emissions, Improved awareness among citizens regarding uptake of RE
	• Replacing Diesel Gensets in residential/ commercial/ institutional sectors with solar-powered or other RE + storage options.	1.34 t CO_2e /yr for each generator replaced.	
	• Encourage faster penetration of the Street Lighting National Programme (SLNP) and UJALA Scheme (Domestic Efficient Lighting Program). This will ensure all lighting fixtures are replaced with energy-efficient LED bulbs, tube lights and fans at domestic, public buildings and streetlights	LED bulb: 0.15 t CO_2 /bulb/yr LED tubelight: 0.036 t CO_2/tubelight/yr Fan: 0.076 tCO_2/fan/yr	
	• Encouraging the adoption of Energy Conservation and Sustainable Building Code (ECSBC) and Indian Green Building Council (IGBC) standards	Save 254 kg CO_2e per annum per household (Scenario: a household that consumes 6 cylinders of LPG in a year, shifts to cooking through electricity)	

Sectors	Key Interventions	Mitigation Potential	Overall Climate Resilience Impact
Sustainable Transport	• Promote wide-scale adoption of Electric Vehicles (EV) by increasing share in private passenger vehicles (cars and 2-wheelers), public transport (buses, mini-buses), intermediate public transport (3-wheelers, e-rickshaws), delivery service fleets, vehicle fleets owned by government departments etc	Replacing 30% of registered cars in Srinagar city can avoid 1,668 t CO_2e /year. For an average run of 22 km per day, 2100 kg CO_2 /year per bus can be avoided by switching to electric buses	Reduction of GHG emissions, improved air quality, reduced traffic congestion and improved public health
	• Replacing 30% of registered cars in Srinagar city can avoid 1,668 t CO_2e /year. For an average run of 22 km per day, 2100 kg CO_2 /year per bus can be avoided by switching to electric buses	Can be assessed by obtaining the current energy demand for all PT and IPT infrastructure of the city.	
	• A strong Public transport (PT) and Intermediate Public Transport (IPT) network in the city would discourage the use of private vehicles, helping curb GHG emissions and traffic congestion. Strengthening public transport (PT) and intermediate public transport (IPT) in Srinagar city	Shift from private to public transport can save emissions by 30-40% from the transport sector. Accurate mitigation potential requires passenger km travelled, current modal share and target modal share developed according to city needs.	
	• To increase the share of non-motorized transport in Srinagar city	Can be estimated from a reduction in trips made by vehicles for short-distance travel	
Agriculture and Green Spaces	• Enhancing green cover by increasing trees outside forests and green spaces through measures such as setting up urban parks, floating gardens etc.	Setting a target of increasing area under forest and trees in Srinagar city from 7.96% (19.58 km^2) to 10% (24.60 km^2) i.e. 3% increase by 2030, will contribute to sequestration of 44,616.7 t CO_2e per year.	Reduce GHG emissions. Provides much needed shade to reduce energy demand for cooling of buildings
	• Promote Sustainable and Zero Budget Natural Farming	Replacing 10% of the current use of chemical fertilizers with organic fertilizers can avoid 328 t CO_2e per annum.	
Waste	• Minimize landfill waste disposal	Extensive amounts of primary data and various fractions (like % of recyclable waste, and waste composition) are required to estimate the mitigation potential.	Highest potential to reduce GHG emissions . improved public health and safety. PPP models will lower financial impact on ULB
	• Establish composting facilities to prevent loss of carbon content in long-route organic waste transport	If 100% compostable waste is composted, the Srinagar city can avoid 7828 t CO_2e per annum.	

INTRODUCTION

VISION:

Towards a Net Zero & Climate Resilient Srinagar

Srinagar city is home to over 1.50 million people and thrives on a diverse economy due to its rich heritage, cultural heritage, scenic beauty and tourist influx. Tourists visit Srinagar city to see its scenic beauty. Srinagar is a bustling city with a rich cultural heritage and a vibrant way of life. It remains an important centre of tourism, trade, and commerce in the region as a large influx of tourists visit the city every year. The city itself is situated in a valley surrounded by the Himalayan range, and it is home to a diverse range of flora and fauna. Although, the city is increasingly at risk due to temperature rise which is projected to increase by 1.5°C and rise in precipitation. Over the millennium, the region's topography, including that of the city of Srinagar, has been shaped by glacial flooding and by the Jhelum River. In this context, DEE&RS has led the process of drafting the first-ever, Srinagar Climate Resilient City Action Plan (CRCAP).

The CRCAP is committed to a net zero and climate-resilient Srinagar by 2050. This means ensuring just transitions – towards net zero pathways; big significant investments– towards inclusive and transformative climate solutions; and coordinated and robust governance – to ensure a targets-based approach. We herein acknowledge that the climate crisis is already affecting us all, although in varying ways, and the time for action is now to secure a better future for all by 2050.

Mindful of the consequences of climate change to future generations living in Srinagar and its region, the CRCAP recognizes that actions must be prioritised across four sectors – power, energy and habitat sector; sustainable transport; agriculture and green spaces; waste management. The actions identified in each sector are framed on four pillars of success (Figure 1).

Tourism-centric Economy	Engagement	Environment	Inclusivity and Equity
Economic activity catering to tourism influx to serve to generate a better economy, while being sustainable and triggering more local employment opportunities.	Key stakeholders will include the citizens across vulnerable wards and prominent decision-makers. Herein the citizens engage in climate action planning and the effective implementation of climate actions envisaged and give their valuable inputs.	Stakeholders will take steps to reduce the vulnerability witnessed across the city while building natural assets and maintaining resources for future generations.	Equitable distribution of resources that would lead to improved health and address the needs of vulnerable groups across wards.

Figure 1: Four pillars on which actions and strategies are prepared

Need for Climate Resilient City Action Plan (CRCAP)– Srinagar

The initiative to develop CRCAP's in India started in 2009 as a part of the National Action Plan on Climate Change (NAPCC). The Government of India launched the NAPCC to address climate change issues in various sectors such as agriculture, forestry, and energy. Under the NAPCC, the Ministry of Environment, Forest, and Climate Change (MoEFCC) developed guidelines for preparing CRCAP's in urban areas. The guidelines provide a framework for cities to identify vulnerabilities and develop adaptation strategies to build climate resilience.

Adopting the Paris Agreement on Climate Change at the 2015 Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) and its subsequent acceptance by nearly 200 countries marked a significant milestone in climate action.

Climate change is already affecting poor and vulnerable people disproportionately. Climate action is thus not only an environmental issue but also a social justice imperative linked to poverty eradication and increased inclusivity. Adopted in 2015, the United Nations' 17 interconnected Sustainable Development Goals (SDGs) provide a holistic framework and vision for the world to address these issues. Each of these goals is closely linked to climate action mandated by SDG 13.

Srinagar city is vulnerable to climate change impacts such as floods, waterlogging, urban flooding, and water scarcity. These impacts have serious consequences for the city and its residents, including infrastructure damage, threats to public health, and economic disruption that highlight the critical need for CRCAP. Although the city does not have a comprehensive climate action plan, the Jammu and Kashmir government has taken some initiatives towards addressing climate change in the state, including the launch of the Jammu and Kashmir State Action Plan on Climate Change (JKSAPCC) in 2014. Some of the key initiatives under the plan include promoting renewable energy, energy efficiency, sustainable agriculture, and forest conservation. It is important to note that although these initiatives are steps in the right direction, they do not constitute a comprehensive climate action plan needed to assess and address the challenges posed by climate change in the city in the context of urbanization and vulnerability. Hence, it is imperative to identify actions to address existing and forecasted climate fragility and develop an implementation and monitoring plan, which will help the city adapt to existing and impending climate change impacts and steer the city's focus to climate change mitigation measures.

The department of ecology, environment, and remote sensing, Government of Jammu and Kashmir, in association with the United Nations Development Programme (UNDP), has prepared this Climate Resilient City Action Plan (CRCAP) for Srinagar city in collaboration with Taru Leading Edge Pvt. Ltd. and Vasudha Foundation. The CRCAP aids the local government of Srinagar city in estimating greenhouse gas emissions, identifying vulnerability hotspots, understanding critical infrastructure systems with respect to resilience, and developing specific climate change mitigation and adaptation plans, while also promoting sustainable development. The CRCAP for Srinagar typically includes a thorough analysis of climate change risks, identifying priority areas for action, and developing action plans that include specific measures to boost the resilience and adaptive capacity of Srinagar city. Developing a Climate Resilient City Action Plan for Srinagar city is crucial for building a sustainable and resilient city that can withstand the impacts of climate change. This plan is comprehensive, involves stakeholder engagement, and has a clear implementation and monitoring strategy.

Roadmap to prepare Climate Action Plan – Srinagar

To get the initiative started, the first round of kick-off meeting on 7th November 2022 was chaired by Mr. S. Rakesh Kumar (IFS), Director, DEE&RS, Government of J&K. Stakeholders, who would be involved in the development and implementation of the action plan, such as the line departments critical for data collection, were identified. The objectives and scope of the assignment were defined and followed up by an inception report and presentation. Subsequently, all essential data were collected to understand the city and its vulnerabilities. This step was supported by a stakeholder consultation workshop, as a part of which several team members/ consultants visited the city, and the ideation helped bring together all the stakeholders. This stakeholder consultation was held on 28th March 2023 at the Banquet Hall, Polo View, Srinagar.

Figure 2: Photograph of Stakeholder Consultation Workshop - Srinagar

During the workshop (figure 2), discussion was held with the stakeholder departments to assess the existing status of service delivery and validate data sets to be collected for vulnerability assessment, including ward-level data and GHG emissions inventory of the city to generate a carbon inventory. Also, the financial- and policy-level implications of the plan were deliberated upon. The impact of different mitigation and adaptation interventions were also discussed with the stakeholders. In order to get a better understanding of Srinagar city and to assess its vulnerabilities, a digital questionnaire was filled up by almost 30 participants who were in attendance at the workshop, giving us much-needed insights on the issues witnessed in the city. This consultation was an essential part of the development of CRCAP in Srinagar. It helped to identify key vulnerabilities, understand the needs and concerns of different stakeholders, and develop a shared vision for building climate resilience in Srinagar city.

An agenda was developed for conducting the consultation, which included determining the objectives, scope, and timing of the consultation. The aim was to gather information on the stakeholders' needs, priorities, and concerns related to climate change in Srinagar and build resilience in the city.

The consultation was designed to encourage active participation, while it ensured that diverse perspectives were represented. The information gathered during the consultation was analysed to identify common themes, priorities, and recommendations. This information was used to inform the development of the CRCAP in Srinagar city.

Structure of the CRCAP Document

To better understand the dynamics of the city, a description of the existing climate change hazards, vulnerabilities, and dangers to Srinagar city's communities, infrastructure, and economy has been prepared in this document. The CRCAP seeks to provide a statement of the city's desired future state, outlining the key goals and objectives of the action plan. An analysis of the city's exposure to climate change impacts, such as flooding, heatwaves, water logging, and an assessment of the risks to the city's population, infrastructure, and economy is undertaken. The process adopted for climate resilient city action planning and way forward is given in Figure 3.

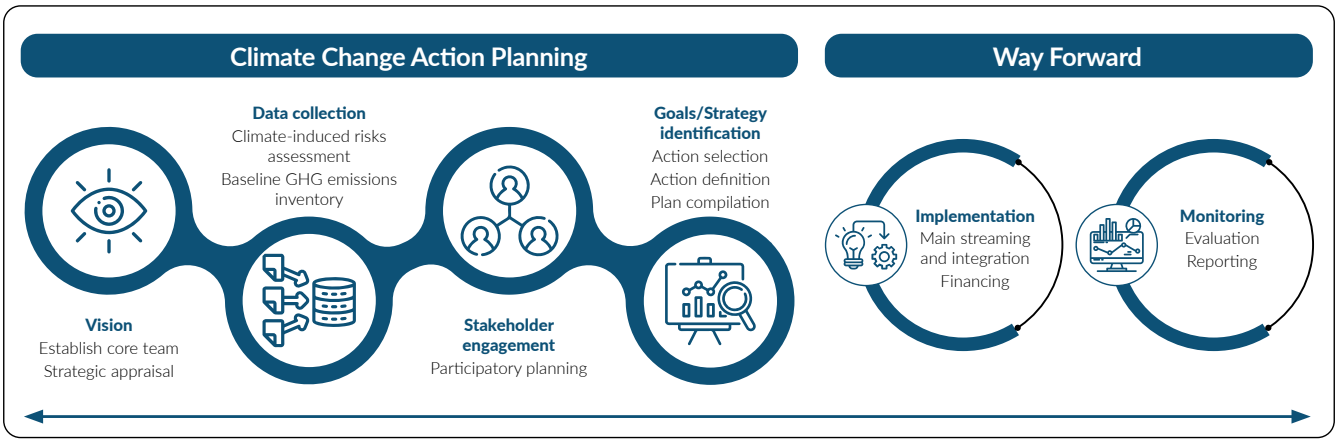


Figure 3: Process adopted for climate resilient city action planning and way forward

Chapter-wise priority actions have been devised as follows, where Chapter 1 gives a glimpse of Srinagar city, its connectivity and its landscape. The baseline evaluation of the city is covered in Chapter 2, along with information on climate change, a timeline of previous catastrophes, and the effects of disasters. Chapter 3 discusses climate risks and vulnerability assessment at city and ward levels, focusing on critical assets exposed to hazards. Chapter 4 states GHG baseline inventory. Chapter 5 gives the sectoral action plan with priority (short-term) and medium–long-term plans envisaged to make Srinagar city carbon-neutral and climate resilient. The concluding chapters 6 and 7, propose a way forward for the city's future and draw implications from the CRCAP.

CHAPTER

1 CITY CONTEXT

The city of Srinagar is located in the northernmost union territory (UT) of India, Jammu and Kashmir (J&K) (figure 4). The area of Srinagar city 246 sq km, which lies between 33°59′N and 34°12′N latitude and 74°41′E and 74°57′E longitude. Srinagar is about 876 km north of New Delhi and 300 km north of Jammu city, and it is the largest populated city in J&K. The history of Srinagar city dates back to the 3rd century BC. It was founded by Emperor Ashoka, who built several Buddhist stupas and monasteries in the area. Over the centuries, the city was ruled by various dynasties, including the Mauryas, Kushans, Guptas, Mughals, and the Dogras. The city is located on the banks of Jhelum River and is surrounded by the Himalayas.

Srinagar is known for its beautiful water bodies, including the famous Dal Lake. Other important water bodies in the city include Anchar Lake, Khushal Sar, and Gil Sar Lake. Srinagar is located in the heart of Kashmir Valley, surrounded by the natural mountains of the PirPanjal Range. The entire city is located in low-lying flood plains with an elevation of less than 1700 m, making it prone to flooding incidents (as have been recorded in the past). Ward no. 60 has the highest average elevation of 1651 m (as shown in table 3 and figure 4). Higher the elevation will have high vulnerability to landslides.

Table 3: Average elevation in various wards in Srinagar

Average DEM (Height (m))	Wards
1500-1600	4 – 43, 45-53, 56-59, 62-66
1600-1650	1, 2, 3, 44, 54, 55, 61, 67, 68
1650-1700	60

Today, Srinagar is a bustling city with a rich cultural heritage and a vibrant way of life. It remains an important centre of tourism, trade, and commerce in the region as a large influx (1 million per year) of tourists visit the city every year.

Srinagar is the 36th most populous city in India and the 1st in J&K. The city population is estimated to increase by 2.1 million in the year 2031 and will grow 0.53 times by the year 2051, having a projected population of about 3.2 million (JKHUDD, 2022). An overview of the city demographics is shown in Table 4

Table 4: Overview of Demographics of Srinagar City

Specifics	Year 2011 (Census, 2011)	Year 2021 (ICLEI, 2022)
Total Number of Administrative Zones	8	8
Total Number of Administrative Wards	68	74
Total Area	246 sq. km	246 sq. km
Total Population	11,80,570	15,50,342
Total Males	6,18,790	8,12,604
Total Females	5,61,780	7,37,738
Total Households	1,83,034	2,40,363
Average Household Size (Persons Per Household)	6.45	6.45
Total Slum Population	23,000	2016[1]
Total Slum House-holds	18,000	366[1]
Total Number of Tourists Per Year	6,33,161	10,00,000

[1] https://www.academia.edu/25276812/Socio_Economic --_Characteristics_of_Slums_in_Srinagar_City_J_and_K_India

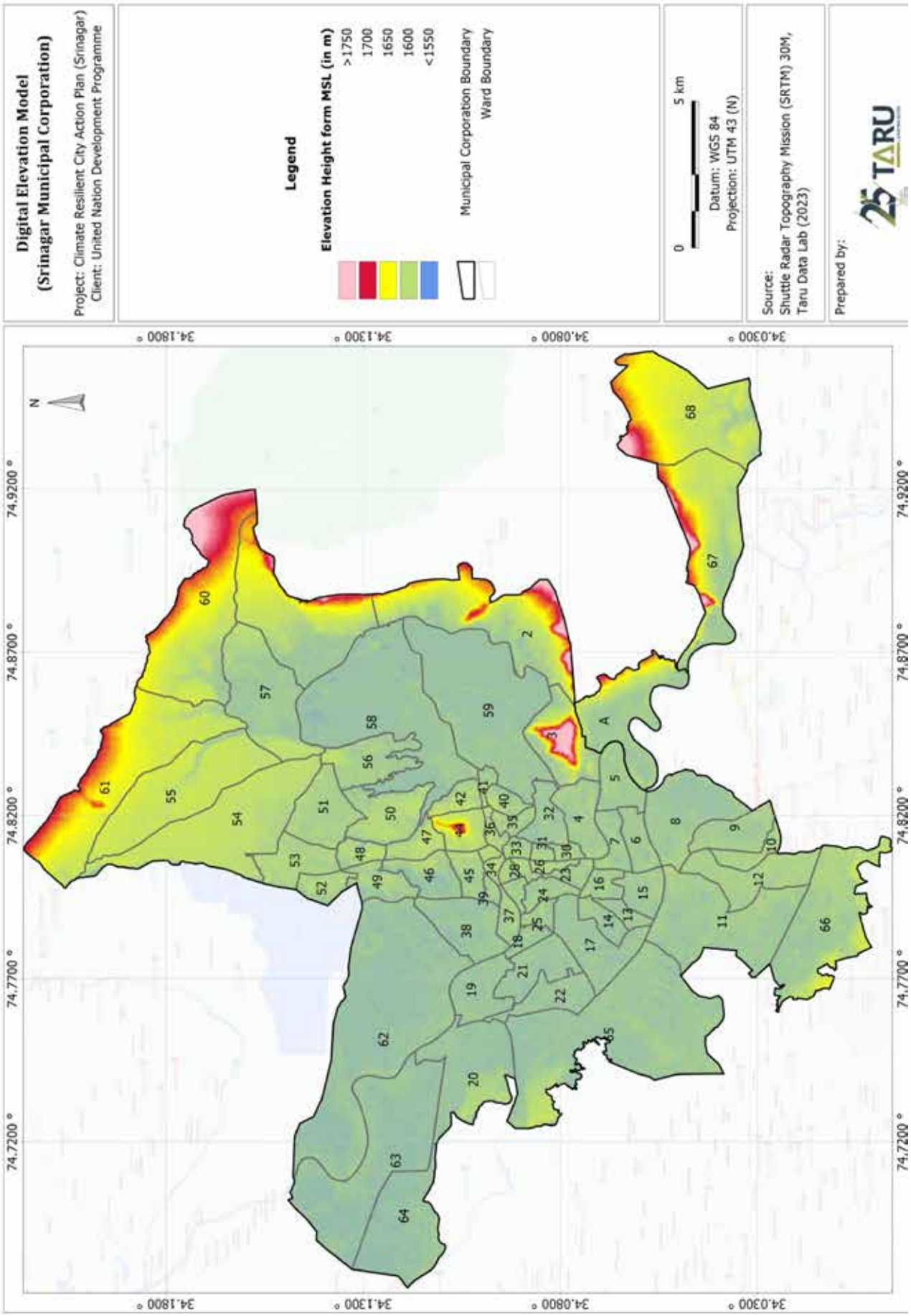


Figure 4: Location and Digital Elevation Model of Srinagar City

1.1. Connectivity

Srinagar city is well-connected to its surrounding areas by roads, railway, airport, and other local means of transport. A comprehensive mobility plan has also been prepared in the year 2020 which highlights a vision for the city of Srinagar, wherein an attempt to achieve a safe, efficient, reliable, and seamless mobility of people and goods is made, thereby making Srinagar a model city.

Transport continues to occupy a significant share of the land in the city, accounting for 15.63% in the landuse plan (Srinagar Master Plan, 2035). Given below are some details on connectivity.

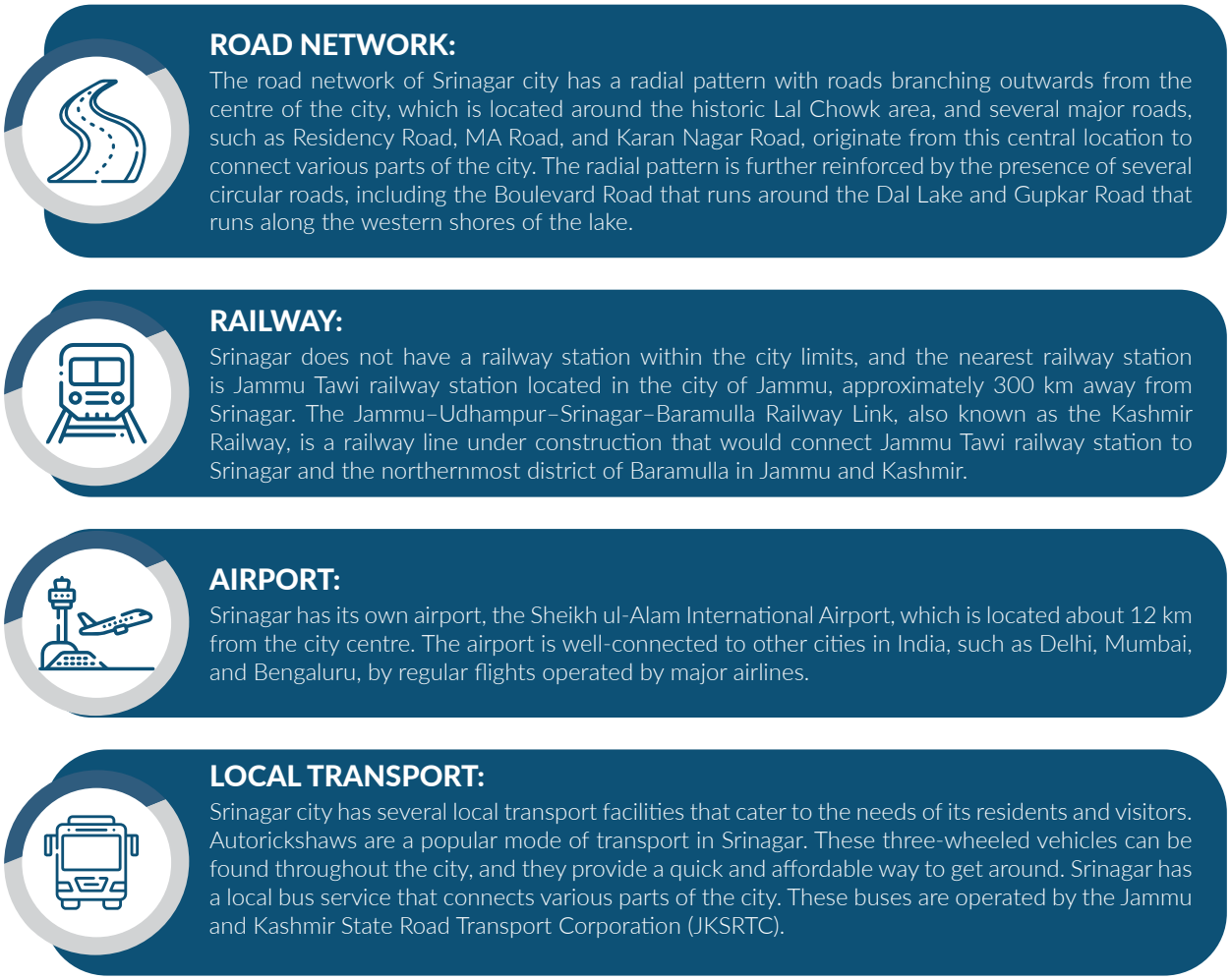


Figure 5: Srinagar city connectivity

1.2. Land Use Land Cover (LULC)

Land use is not static as it changes from time to time by both anthropogenic factors as well as natural interruptions(Lokinder, Hardev, & Sanjay, 2020). A detailed land use classification for the year 2022 (Srinagar city) is represented in figure 7. For the year 2022, the LULC statistics (figure 6) indicate that the majority of the municipal land was covered with crop land (28.1%). About 69.83 sq km of the area in the north-western part of the city (wards 62, 63, 64) , some areas in wards 55, 60 and 61 majority of the area in ward 68 is covered with crop-land. This is followed by core urban(comprising of residential, institutional and commercial built-up) of (21.9%) in the central part of the city close to the Dal lake. There is 1.53 sq km (0.62%) of Hamlet & Dispersed Household land scattered throughout the city. The other urban areas and peri-urban areas are in northern southern and central part of the city (wards 2, 3, 9, 19, 22, 53 and 56) comprising of 19.25 sq km (7.83%) and 10.70 sq km (4.35%). The agriculture plantation/ orchards land is mainly found towards the North of the city (wards 1, 53, 54, 56, 57, 60 and 61) comprises of 23,13 sq km (9.41%). The forest plantation land found in eastern part of city (wards 2, 3 and 8) comprises of 3.19 sq km (1.30%).

The lakes / ponds found in central part of city (going through wards 40, 42, 44 50, 57, 58 and 59) comprises of 18.65 sq km (7.59%). The dense scrub land is found

in scattered throughout the city and is mainly found in the outskirts of city comprising of 0.99 sq km (0.40%).. The industrial area land found in small pockets of the city comprises of 0.33 sq km (0.13%).The streams pass through many scattered parts in the city (some parts of wards 8, 16, 19, 21, 31, 62 and 64) comprises of 1.09 sq km (0.44%). The mixed village settlement land comprises of 15.14 sq km (6.16%) and is scattered across wards 1, 2, 53, 54, 55, 60, 61, 62, 64, 65, 66, 67 and 68. The other rural built-up areas(in some part of wards such as 1, 2, 20, 55, 60, 61, 62 and 68) comprises of 7.43 sq km (3.02%).The river land found scattered in the city comprises of 2.96 sq km (1.21%). The sparse scrub land found scattered in the city comprises of 3.32 sq km (1.35%). The transport infrastructure land found across the entire city comprises of 0.22 sq km (0.09%) and the transport network comprises of 1.55 sq km (0.63%).

Land use and Land cover category	Percentage of land use
Crop Land	28.4%
Core Urban	21.2%
Agriculture Plantation/ Orchads	9.4%
Other Urban Areas	7.8%
Lakes/Pond	7.6%
Mixed Village	6.2%
Peri -Urban	4.4%
Other Rural Built-up Areas	3%
Village Settlement	1.7%
Sparse scrub land	1.3%
Closed Forest	1.3%
Wetland	1.3%
River	1.2%
Waterlogged	1.2%
Canal/ Drain	1.0%
Transport Network	0.6%
Hamlet & Dispersed Household	0.6%
Stream	0.4%
Dense scrub land	0.4%
Fallow Land	0.4%
Barren Rocky	0.2%
Industrial area	0.1%
Mining/ Quarry/ Mining Dump	0.1%
Transport Infrastructure	0.1%
Stony Waste	0.1%

Figure 6: Classification of various land uses for Srinagar city

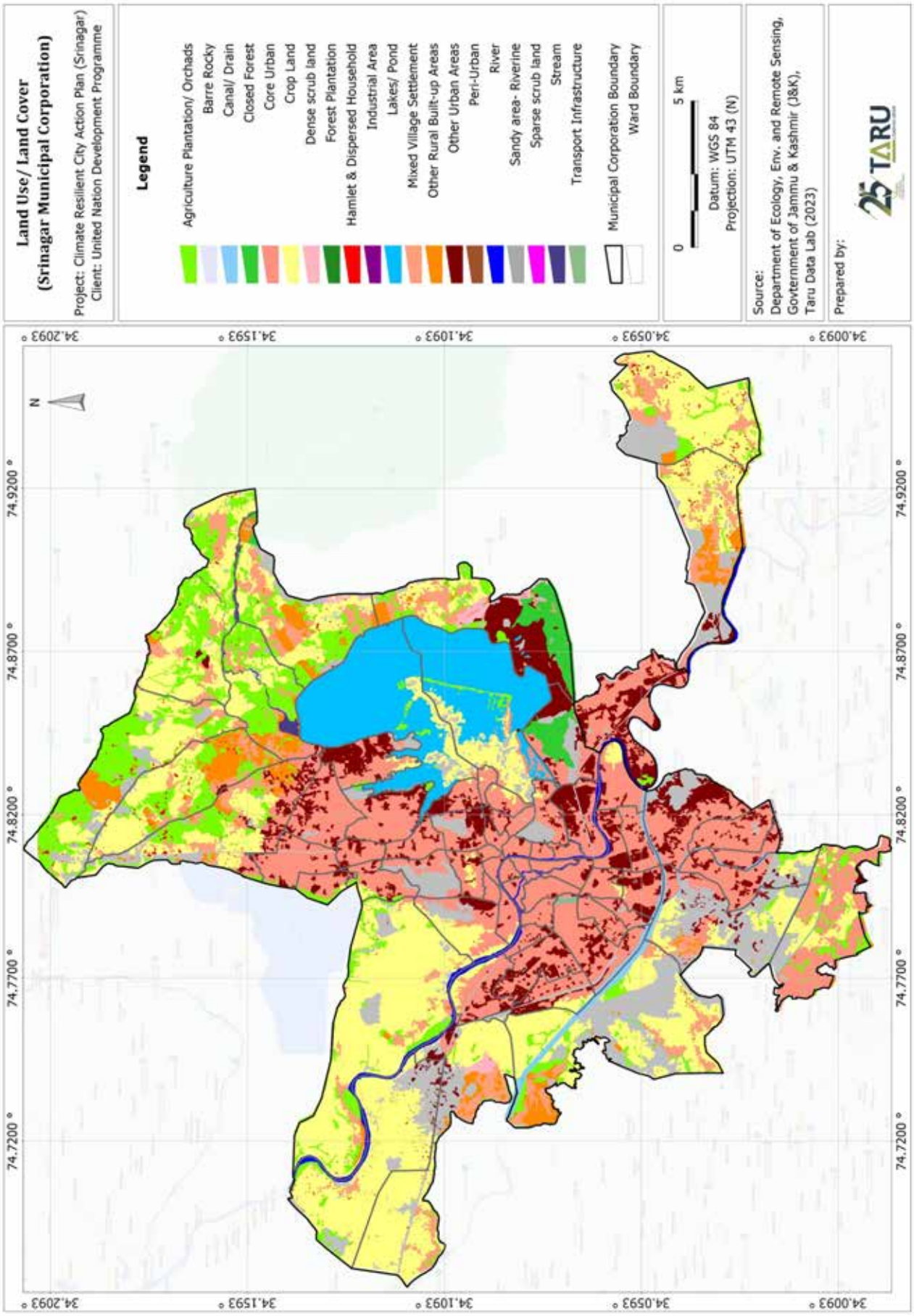


Figure 7: Land Use map of Srinagar city for year 2022

1.3. Economic Activities

The workforce participation rate in the district of Srinagar (which includes the city and its surrounding areas) was around 30% , with male participation at around 42% and female participation at around 13% (Census of India, 2011). These people were engaged in the service sector, followed by the manufacturing and agricultural sectors. In case of Jammu and Kashmir, the tourism sector contributes almost 7% to the total Gross State Domestic Product (GSDP) of Jammu and Kashmir and 5.6% to the Gross Domestic Product (GDP) of India, of whicha major contribution of J&K state comes from Jammu and Srinagar division (Aziz &Bashir, 2022). Srinagar city is home to several manufacturing industries, including textiles, pharmaceuticals, handicrafts, food processing, and construction materials. The city also has a thriving small- and medium-enterprise sector. Srinagar, being an urban area, does not have much agricultural activity within its limits. However, it is surrounded by agricultural areas such as Ganderbal, Budgam, Pulwama, and Anantnag and serves as a major market for agricultural produce. The major crops grown in the Srinagar region include rice, maize, pulses, vegetables, fruits, and saffron. The city is also home to several food processing industries such as pickles, sauces, jam, and some packaging units. Agro-based industries like horticulture concerned with the production of dried fruits, such as almonds and walnuts, apples, peaches, and sericulture also assist in enhancing the overall economic potential of the city as well as the UT of Jammu and Kashmir. The presence of water bodies in the city of Srinagar has also facilitated the fisheries sector in generating employment opportunities. These are just a few examples of the economic activities in Srinagar city. The city's economy is diverse and dynamic, and is driven by a range of sectors including tourism, agriculture, handicrafts, manufacturing, and trade.

1.4. Tourism

JTourism is a major contributor to the economy of Srinagar city. The city's scenic beauty, serene lakes, and the pleasant climate attract a large number of tourists every year. The tourism industry in Srinagar provides employment opportunities to a large number of people. On average, Srinagar city attracts around 1–1.5 million domestic tourists annually. However, this number can vary depending on the prevailing circumstances. Srinagar also attracts a significant number of international tourists, with tourists from countries such as the United States, United Kingdom, Australia, and Canada visiting the city. On average, around 20,000–30,000 international tourists visit Srinagar every year. The tourism industry in Srinagar faces a number of challenges, such as political instability, security concerns, and natural disasters. These challenges can impact the number of tourists visiting the city and the overall tourism industry in the region. Despite the challenges, tourism remains a key contributor to the economy of Srinagar city and the region as a whole. The government and tourism industry stakeholders continue to work towards promoting the city as a safe and attractive tourist destination, while also addressing the challenges facing the industry. Throughout the year, tourists from all over the world visit Srinagar. The city witnesses the maximum tourist influx in the months of March and April (due to opening of Tulip Garden) and May to September (due to Amarnath Yatra). In recent years a significant number of tourists, both domestic and international, can be seen during the winter months from December to February. The tourism infrastructure in Srinagar city is inadequate, and there is a lack of facilities such as proper roads, transportation, and accommodations. These, in some cases, discourages tourists from visiting the city and negatively impact the tourism industry. Addressing these challenges requires a concerted effort by the government and stakeholders in the tourism industry to improve the security situation, develop infrastructure, and preserve the environment of the city.

1.5. Biodiversity

Srinagar city is known for its rich biodiversity. The City Biodiversity Index of Srinagar has been developed, and with it, Srinagar has become the country's 10th smart city to have the index, which is a self-assessment tool, and the city must repeat the index every five years to compare its own progress. There are 23 indicators in total, divided into three categories: native biodiversity, ecosystem services provided by biodiversity, and governance and management of biodiversity. Srinagar received 45 points out of a total 72 (Dailyexcelsior, 2022).The city itself is situated in a valley surrounded by the Himalayan range, and it is home to a diverse range of flora and fauna. Over the millennium, the region's topography, including that of the city of Srinagar, has been shaped by glacial flooding and by Jhelum River. This has further led to the formation of a complex network of natural ecosystems in the region, including streams, lakes, rivers, wetlands, and forests. The Jhelum River, also considered as the backbone of the city's ecology, is connected to the Dal Lake. The Dal Lake outpours into BrariNumbal, Khushal Sar, and Gil Sar. The outlet water from Khushal Sar and Sindh Nallah goes into Lake Anchar. Sindh Nallah, one of the important water bodies of the region, ultimately joins Jhelum River. As a result, it is important that Srinagar's biological diversity is preserved for the future generations. To that end, a one-of-kind City Biodiversity Index for Srinagar has been developed to help the city's administration, stakeholders, and citizens better understand the city's rich assets while preserving and conserving Srinagar's biodiversity. It has been prepared with consistent efforts from the J&K Biodiversity Council, along with UNDP and ICLEI – local governments for sustainability, South Asia.

The city of Jammu is prone to several climate-induced risks, namely, floods, droughts, landslides, forest fires, and windstorms. Also, there is a risk of an increase in greenhouse gas (GHG) emissions, with an increase in city's population, use of vehicles, fuel consumption, etc. The average annual carbon dioxide emissions per person for Jammu and Kashmir (J&K) is 11663.89 Giga gram, which is 0.68% of total India's emissions (1727706.10 Giga gram) (DEE&RS, Govt. of J&K, 2013-14). GHG emissions and climate changes are inevitable and occur mostly due to anthropogenic factors. Reducing emissions and adapting to climate changes are must to make the city more liveable, sustainable, and tourism friendly.

CHAPTER

2 CITY BASELINE ASSESSMENT

2.1. Climate Change

Climate of Srinagar

Srinagar city has a sub-Mediterranean type of climate with warm summers from June to August and cold winters from December to February. The cold season is from November to mid-March. Temperatures begin to decrease from November. January is the coldest month with mean maximum temperature of about 6°C and mean minimum temperature of about -2°C. In association with cold waves, the minimum temperature may sometimes drop to below -18°C on individual days. The day and night temperatures both begin to rise from March and continue till July. July is the hottest month with mean maximum temperature of about 30°C and mean minimum temperature of about 18°C. There is no much variation in the day temperatures between summer and monsoon months, however nights in the monsoon months are warmer than summer months. On some days, during the period April to August the maximum temperature may sometimes reach 37°C. Both the temperatures are 10°C to 15°C lower over the places situated at higher altitudes in surrounding mountains. Weather is pleasant in months of April to June and October.

Observed and Projected Climate

The analysis carried out using Indian Meteorological Department (IMD) station data of Srinagar from 1980 to 2017 for a period of 37 years for maximum & minimum temperature and from 1980-2016 for precipitation which has been used to calculate the variability and trend in precipitation and temperature respectively.

The WorldClim CMIP-6 Ensemble modelled climate data on precipitation, maximum temperature, minimum temperature was used to derive the future climate projections with respect to baseline of (1976-2005). The projections were analysed for two scenarios SSP-245 (scenario with increased reliance on fossil fuel and no mitigation effort) and SSP-585 (scenario with mitigation efforts). The analysis was divided into two time frames the near-future from 2020 to 2050 and the far-future from 2051 to 2100.

Observed and Projected Rainfall

During the period of analysis, the average annual rainfall observed was 721.19 mm/yr. The analysis of accumulated rainfall per year from 1980 to 2016 showed a decreasing trend with highest accumulated rainfall in year 1986 (999 mm/yr), 1996 (986 mm/yr) and 2014 (1160 mm/yr). The least accumulated rainfall in year 1999 (457 mm/yr) and in year 2016 (471 mm/yr).

The analysis was carried out for accumulated rainfall per year SSP245 and SSP585 showed an increasing trend in both scenarios in near as well as far future. Under SSP245 scenario the accumulated rainfall is projected to increase by 55 mm/yr in near future and by 85 mm/yr in far future. In SSP585 scenario the accumulated rainfall is projected to increase by 87 mm/yr and 225 mm/yr in near and far future respectively.

Table 5 Annual Accumulated Rainfall w.r.t to baseline period (1976-2005)

Change in R (mm) SSP 245 2020-2050	Change in R (mm) SSP245 2051-2100	Change in R (mm) SSP585 2020-2050	Change R (mm) SSP585 2051-2100
↑ 55 mm/year	↑ 85 mm/year	↑ 87 mm/year	↑ 225 mm/year

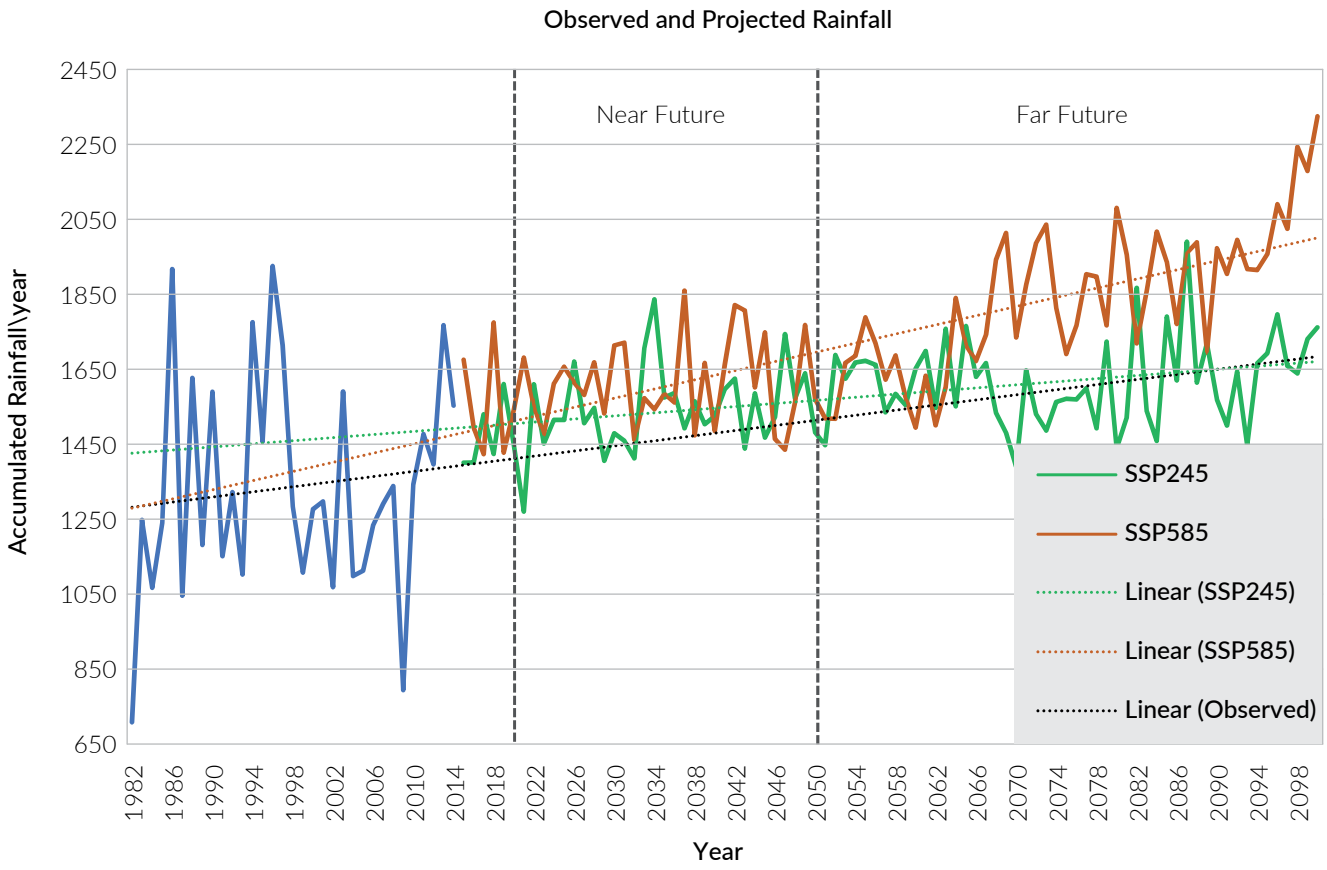


Figure 8: Observed and projected Rainfall

Observed and Projected Temperature

The average maximum temperature observed for the period of 37 years was 19.72°C and the average minimum temperature was 7.53°C. For the period of analysis, the maximum and minimum temperature is showing an increasing trend for Srinagar station. The annual average temperature is also showing an increasing trend over the period of analysis. In maximum temperature the highest recorded was in year 2001 (21.80°C) and year 2009 (30.72°C). The drop in maximum temperature upto 17.11°C was observed in year 1986 and in year 1991 (18.08°C). In minimum temperature the least recorded was in year 1993 (6.54°C).

On annual basis the average temperature showed an increasing trend under SSP-245 and SSP-585 scenarios in near and far future. The maximum as well as minimum temperature is showing a projected increase under SSP-245 and SSP-585 scenarios in near and far future. Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 1.22°C and 1.25°C respectively. In far future under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.51°C and 2.48°C respectively. Under SSP-585 scenario in near future the maximum and minimum temperature are projected to increase by 1.42°C and 1.47°C respectively while as the upsurge is on higher end by 4.30° C and 4.51°C in far future.

Table 6 Maximum Temperature Changes w.r.t to baseline period (1976-2005)

Parameter	Region	SSP 245 2020-2050	SSP245 2051-2100	SSP585 2020-2050	SSP585 2051-2100
Change in Max T (°C)	Srinagar Station	1.22°C	2.51°C	1.42°C	4.30°C
Change in Min T (°C)		1.25°C	2.48°C	1.47°C	4.51°C

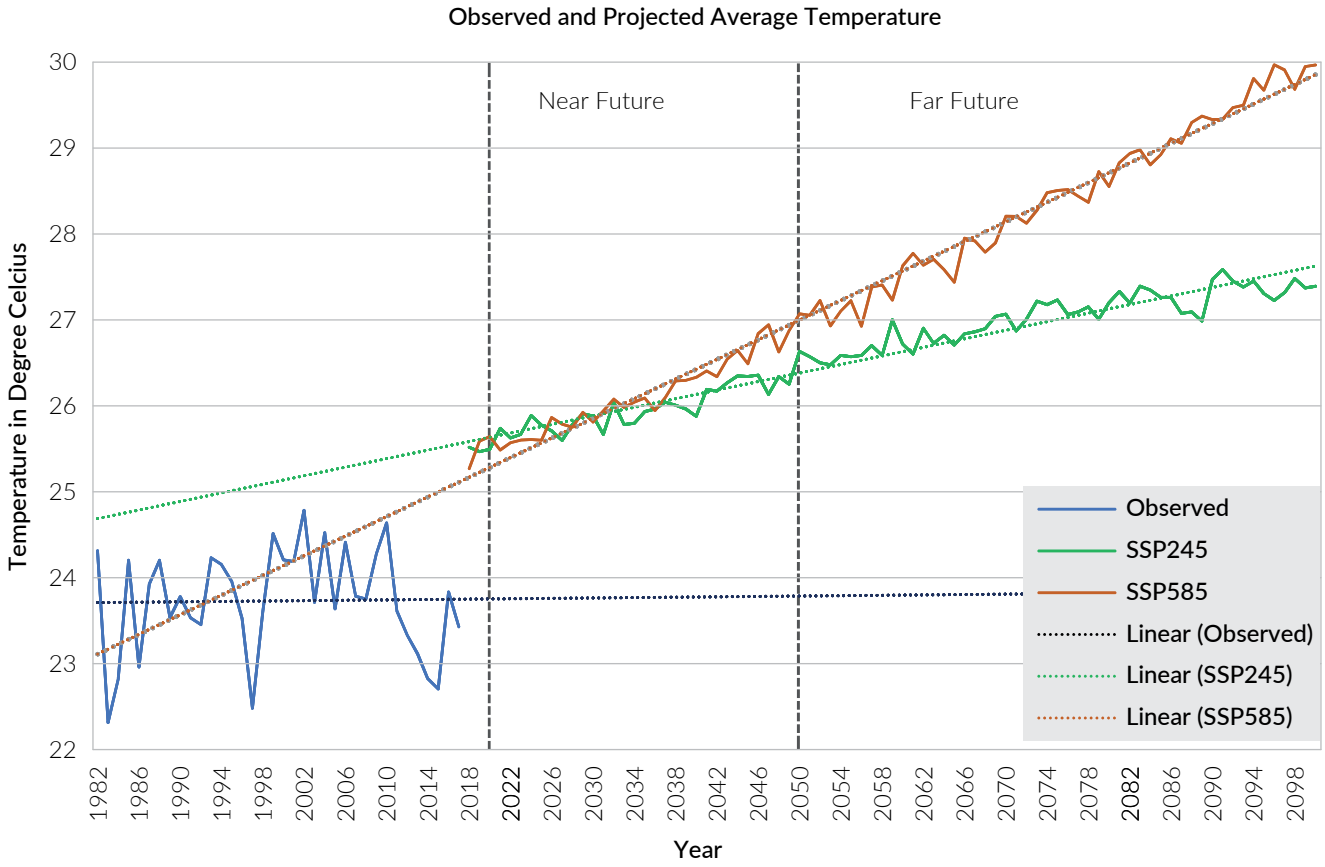


Figure 9: Observed and Projected Average Temperature

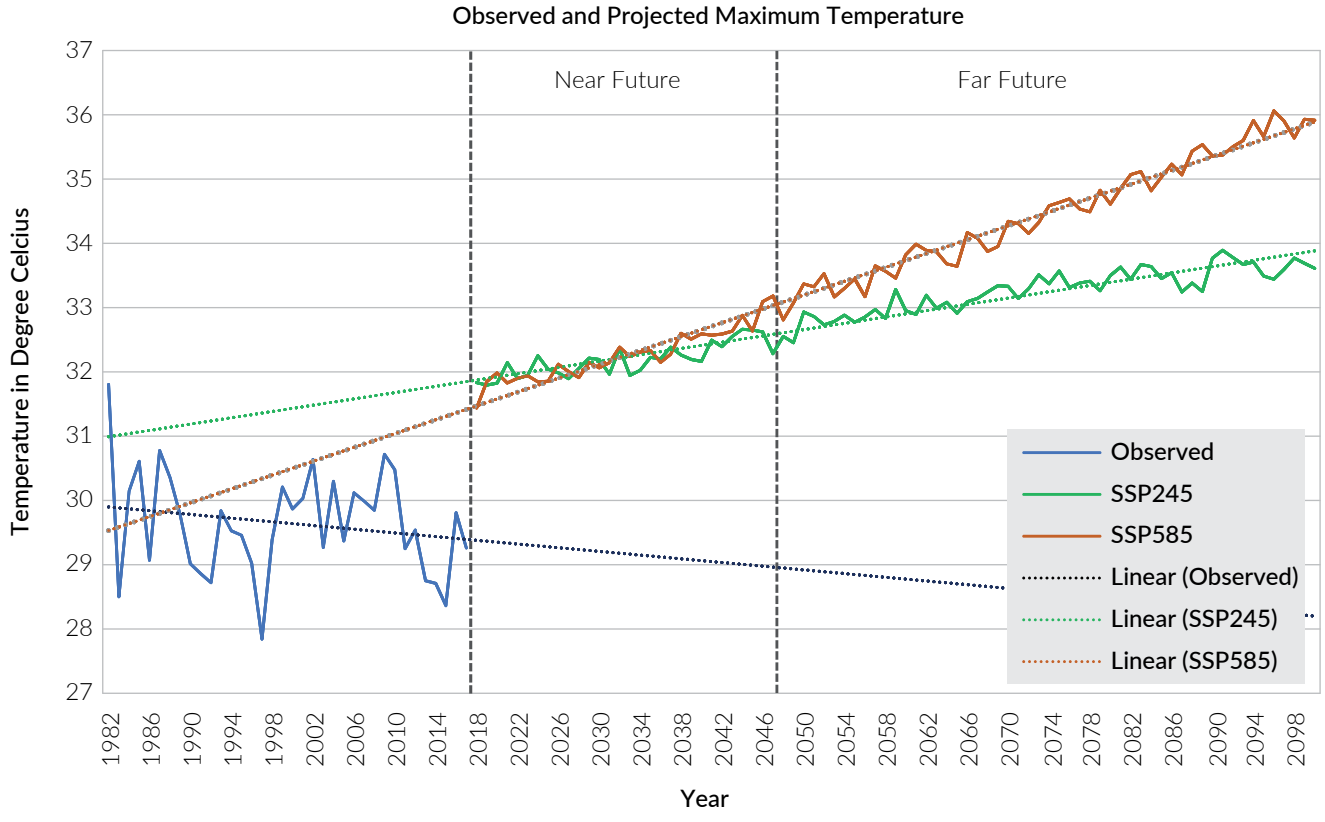


Figure 10: Observed and Projected Maximum Temperature

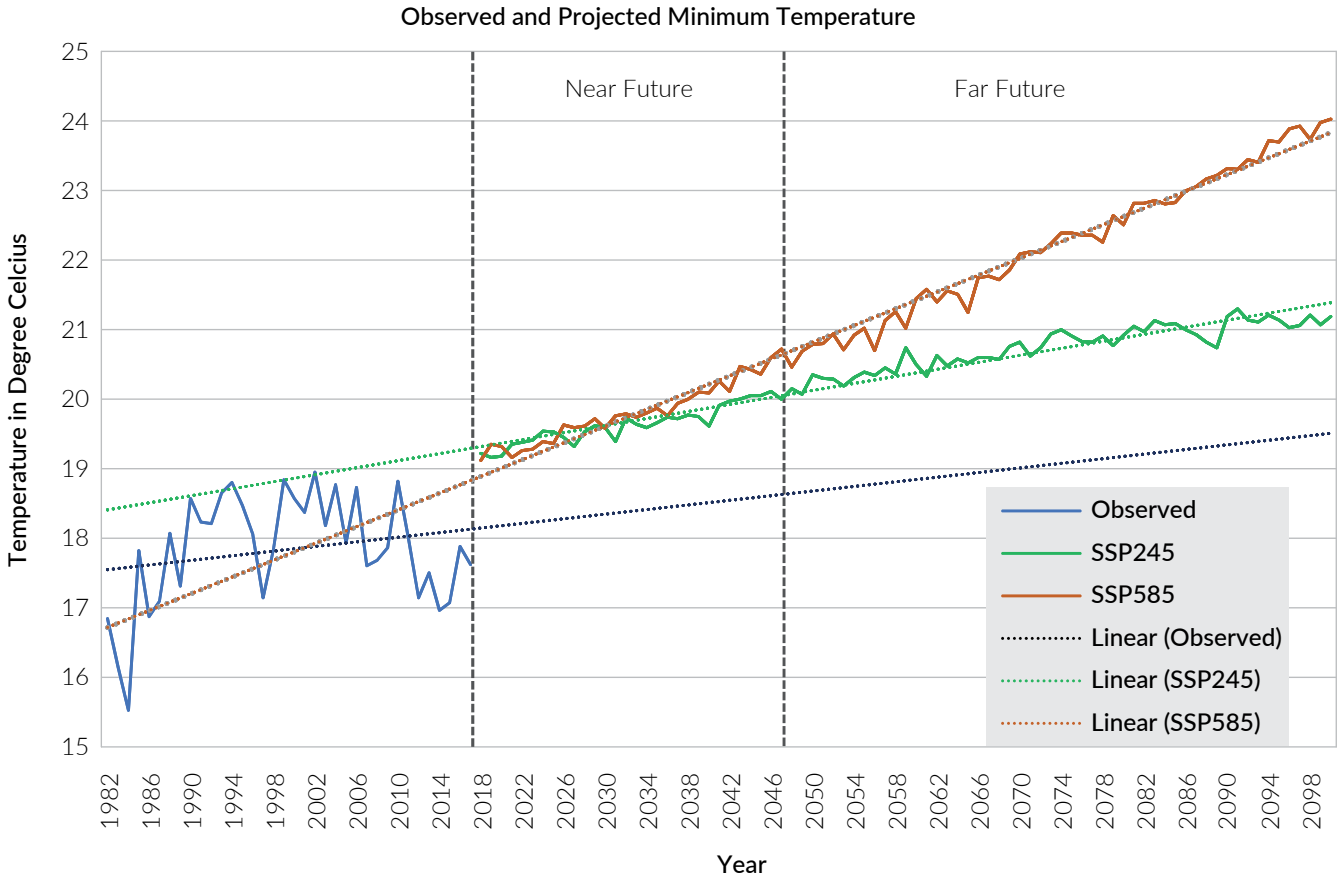


Figure 11: Observed and Projected Minimum Temperature

2.2. Timeline of past disasters

Due to the observed climate changes, it may be noted that there are several extreme events that impacted the city of Srinagar in the past and have chances of occurring in the future. The city is prone to such various extreme natural disasters (such as earthquake, floods, and landslides) and man-made emergencies (forest fire, fire accidents etc). Timeline of the witnessed disaster events is shown below:

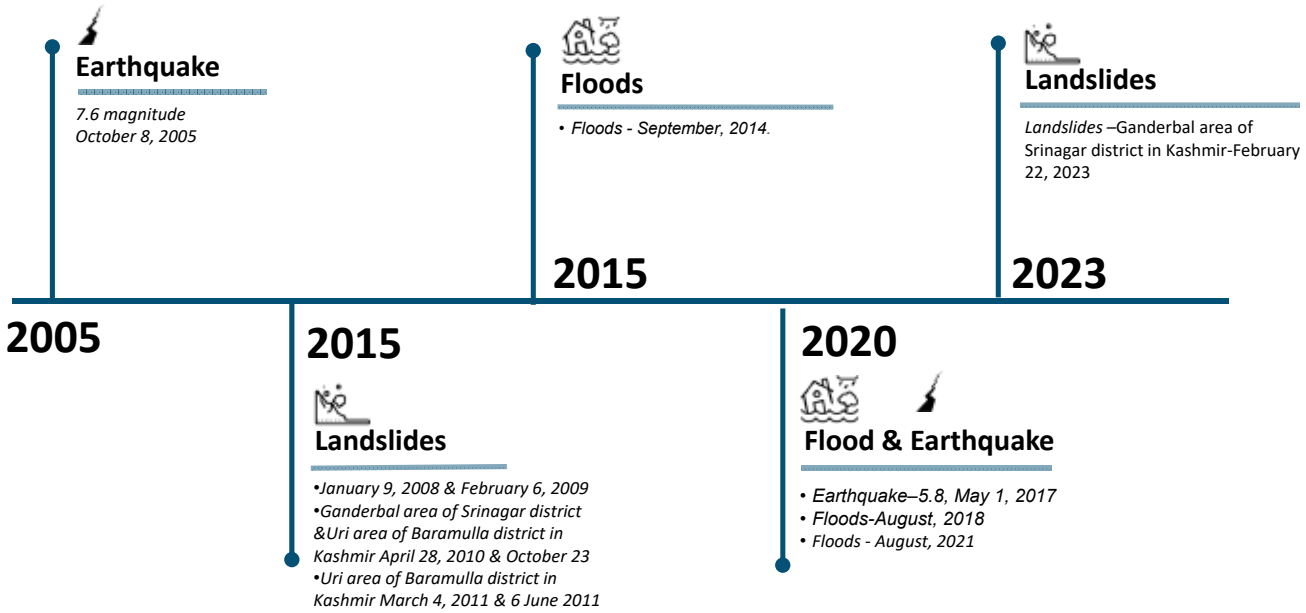


Figure 12: Timeline of Disasters in Srinagar Division

2.3. Climate-Induced Impacts on the City

Waterlogging remains a persistent problem in Srinagar city, particularly during heavy rainfall. The city's topography, which includes low-lying areas and inadequate drainage systems, exacerbates the problem causing a range of concerns such as traffic disruptions, damage to buildings, and public health hazards. A number of roads in Srinagar city almost turn into ponds immediately after a snowfall or rain. Waterlogging causes issues for both vehicular and pedestrian traffic. The scene is almost similar on most roads – be it at the city centre Lal Chowk, or the adjoining areas like Residency Regal Chowk, Polo View, Moulana Azad Road, and Budshah Chowk. It is no different at Exhibition Crossing and Jehangir Chowk. The waterlogging problem is not limited to these areas; it also affects a large number of other areas in Srinagar, including Bemina, Mehjoor Nagar, Rambagh, Natipora, and Chanapora interiors. Massive inundation can also be seen in the interiors of Parraypora and Sonwar. Shalteng, Usmanabad, Umerabad, Mustafabad, Zainakote, Maisuma, Indira Nagar, Iqbal Colony Sonwar, Aloocha Bagh, Shivpora, Rainawari, and Soura are low-lying areas and newly-built colonies on the flood channels, affected by waterlogging over the years.

Local residents complain that Srinagar's drainage system has become so clogged with silt over the years that a few hours of rain or snowfall turns the capital city's roads into rivulets. Most drains in the city have not been desilted for years, reducing their carrying capacity significantly. Following the devastating floods of 2014, the already inadequate drainage system was aggravated by additional silt accumulation brought on by the deluge, resulting in frequent waterlogging in the city. Shopkeepers from various markets complain that waterlogging hampers their daily operations, while others claim that water enters their stores. Waterlogging also affects the businesses of street vendors in the city centre, who struggle to find a place for putting up their stalls as a result of flooding.

Figure 13: Water Logging Due to Heavy Rainfall – Srinagar City (JK News Today, 2022)

Flash floods in Jhelum river is a matter of great concern in Srinagar city, particularly during the monsoon season. Jhelum river flows through the heart of Srinagar, and the city is vulnerable to flooding during heavy rainfall. In September 2014, the city experienced severe flash floods due to the overflowing of Jhelum river, which caused widespread devastation in the region. Floodwaters damaged homes, infrastructure, and agricultural lands, leading to the loss of life and property.

Figure 14: Flash Floods in Srinagar 2014 (Source: (Bukhari, 2014))

Dal Lake is a popular tourist destination and a vital source of livelihood for local residents, but the lake's water levels can rise dramatically during heavy rainfall, causing flooding in nearby areas. The lake also faces several other challenges, including siltation, pollution, and encroachment, which can exacerbate flooding. The build-up of silt reduces the lake's holding capacity, while pollution and encroachment can affect the lake's natural drainage system.

The local government, especially Srinagar Municipal Corporation (SMC) and other organizations have implemented several measures to mitigate the impact of floods and lake conservation in Srinagar city. The SMC takes several measures to reduce waterlogging and flooding in Srinagar city, which include the construction of embankments and bunds along the river, the establishment of early warning systems to alert residents of potential flood risks, and the implementation of evacuation plans to move people to safer areas during floods. The SMC has undertaken various projects to improve the drainage infrastructure in the city, such as the construction of culverts and the rehabilitation of the old drainage system. SMC has raised the levels of low-lying roads in the city to prevent waterlogging during heavy rainfall. Despite these efforts, floods in Srinagar city remain a significant threat, particularly without adequate preparedness and response mechanisms. It is essential for the government and local authorities to continue investing in flood control measures and preparedness to minimize the impact of future floods.

It is important to note that these hazards mentioned are not limited to Srinagar city alone but can affect the entire Srinagar region and the outskirts of Srinagar city. It is essential for residents and tourists to remain informed about potential hazards as early as possible and take appropriate measures to stay safe.

CHAPTER

3

CLIMATE RISK AND VULNERABILITY ASSESSMENT

Chapter 3: Climate Risk and Vulnerability Assessment

Vulnerability according to IPCC-AR6 is defined as *"the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC -AR6, 2022)"*. In other words, vulnerability is the inability to resist a hazard or respond to a disaster. For instance, people living on plains are more vulnerable to floods than those living higher-ups. In fact, vulnerability depends on several factors, such as people's age and state of health, local environmental and sanitary conditions, as well as on the quality and state of buildings and their location with respect to any hazards (RMSI, 2014). Families with low incomes often live in high-risk areas in the cities, because they cannot afford to live in safer (and more expensive) places. Similarly, a wooden house is sometimes less likely to collapse in an earthquake, but it may be more vulnerable in the event of a fire or a cyclone (RMSI, 2014).

Srinagar city's future climate under SSP-245 scenario suggests the accumulated rainfall is projected to increase by 55 mm/yr in near future and by 85 mm/yr in far future. In SSP-585 scenario the accumulated rainfall is projected to increase by 87 mm/yr and 225 mm/yr in near and far future respectively.

Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 1.22°C and 1.25°C respectively. In far future, under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.51°C and 2.48°C respectively. Under SSP-585 scenario in near-future the maximum and minimum temperature are projected to increase by 1.42°C and 1.47°C respectively while as the upsurge is on higher end by 4.30°C and 4.51° C in far-future.

3.1. Framework of Vulnerability:

Vulnerability assessment is conducted in two levels namely – City level and Ward level. The overarching framework of vulnerability assessment is shown in Figure 15.

1) City-level Vulnerability:

City-level vulnerability assessment is based on understanding spatially the climate-induced risk of various hazards and their exposure to critical urban services and population.

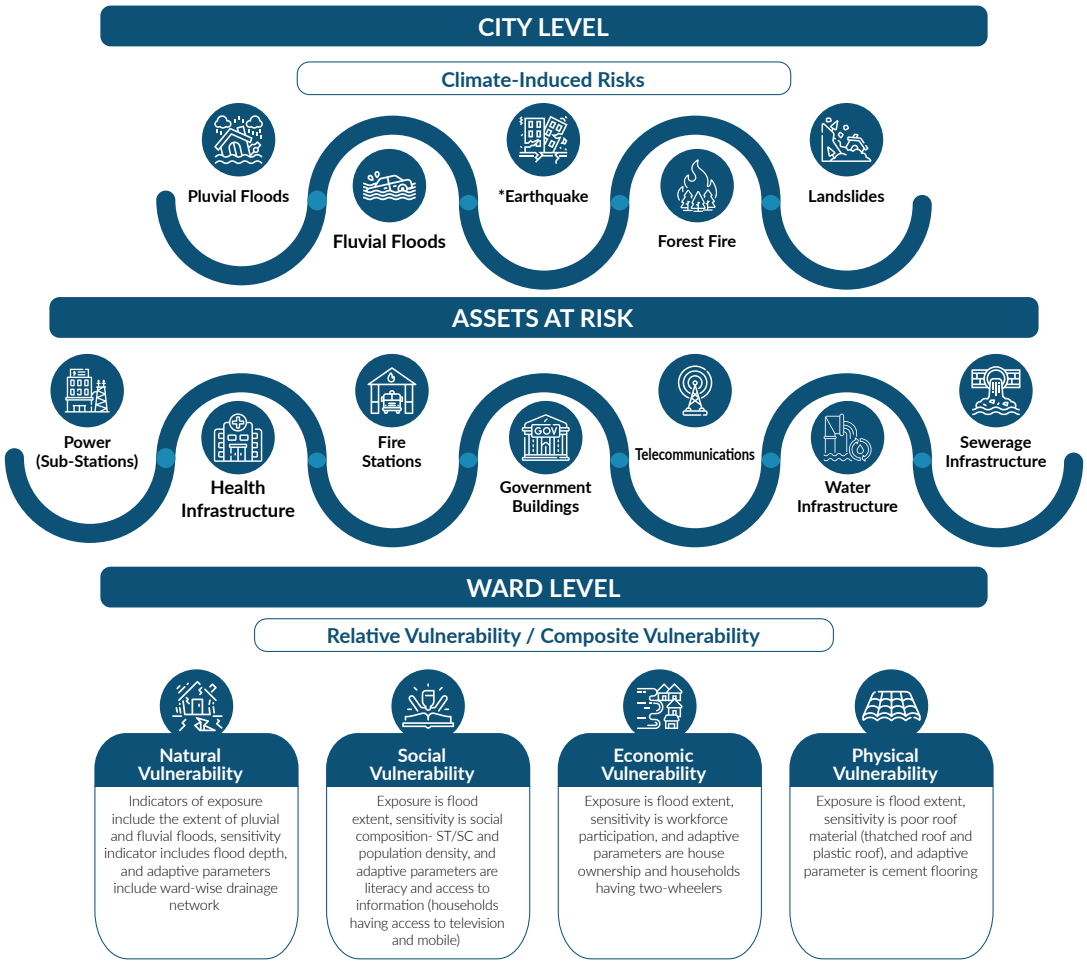


Figure 15: Framework of Vulnerability Assessment

The assessment is conducted using the Tier 1[2] approach, which mainly utilizes secondary data (such as GIS data for various urban services and IMD station data) collected from various departments.

2) Ward level Relative Vulnerability:

Most vulnerable wards are important to understand for decision-makers so that they can focus on those wards towards improving services to make them more adaptive and resilient. The ward-level vulnerability assessment uses four dimensions (Natural, Social, Economic and Physical Vulnerability) (Jha, Negi, Alatalo, & Negi , 2021).

The selection of suitable site-specific indicators is required to address multifaceted issues for vulnerability assessment. Therefore, the indicators (as shown in Figure 16 for the assessment of each dimension are classified into three functions (i.e. sensitivity, exposure and adaptive capacity) and have been selected post careful evaluation (Rationale of selection is as given in Table 7). Post the assessment of four dimensions composite vulnerability index has been calculated to understand the wards which need prior action to resilience. The detailed methodology is given annexure 8.5.

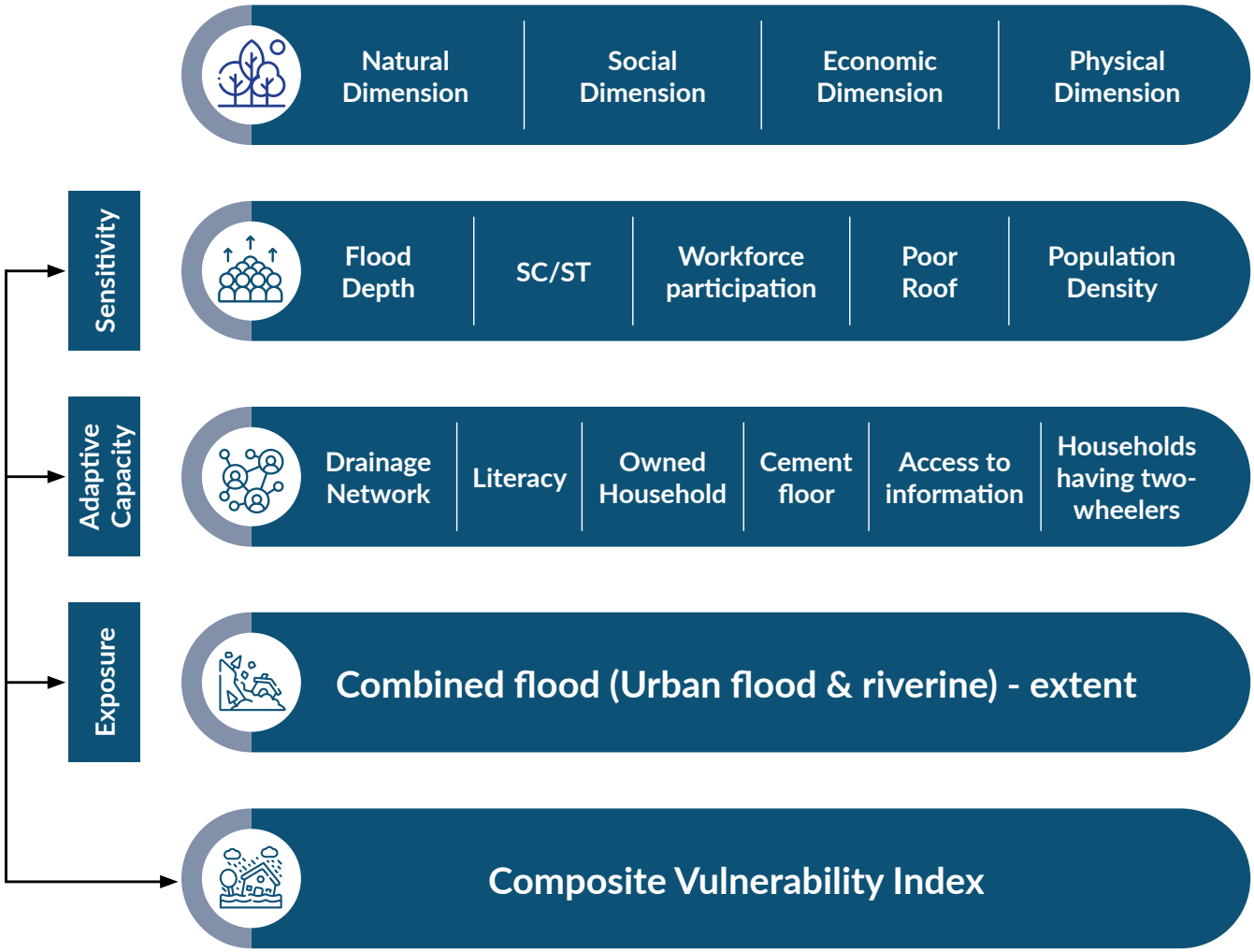


Figure 16: Ward-level vulnerability dimensions and indicators

[2] *Source: Climate Vulnerability Assessment for the Indian Himalayan Region Using a Common Framework, IIT Guwahati and IIT Mandi, 2018-19*

Table 7: Relative vulnerability indicators and rationale

Dimension	Sub-indicators	Rationale for selection	Functional relation with Vulnerability	Source of data
Natural	Flood depth	Higher the flood depth, higher the vulnerability of assets and population.	Positive	Exposure data received from DEE&RS
	Drainage Network	Household connected to drainage pipelines will be able to drain off flood easily. Hence, vulnerability will be less.	Negative	Data received from Urban Environmental Engineering Department (UEED)
Social	Population Density (Total population of a ward divided by the total geographical area)	Population density determines the extent of dependency and per capita availability of finite resources. Higher the density higher is the exposure of community to climatic hazards.	Positive	Calculated using Geographic Area (received from DEE&RS) and population data from Census of India (2011).
	Vulnerable group population- SC/ST, marginalized groups	The temperature and rainfall changes due to climate change pose a higher risk to the already stagnant or declining population of this group. Further, the population has weaker economic sections hence are more vulnerable.	Positive	Census of India (2011)
	Literacy	Literacy levels contribute directly to the mitigation and adaptive capacity towards the climate induced adversaries. Thereby lower the literacy, higher the sensitivity to the impact. Literacy capacitates the individuals and communities towards informed decision-making, higher awareness and thereby greater coping strength.	Negative	Census of India (2011)
	Access to information	Access to information refers to early warning system. It is critical that people are fully informed about the hazard, its possible impact, and preparedness measures during a catastrophic event. Citizens who are not aware will be negatively impacted by the tragedy, increasing their susceptibility.	Negative	Census of India (2011)
Economic	Main worker / Workforce participation	The availability of work opportunity or means of livelihoods through the year is essential to ensure economic resilience in any crisis situation. The less economically weaker will have greater capacity to response and restore resilience in any disaster situation	Positive	Census of India (2011)
	Land Ownership	Land ownership is a crucial indicator that ensures economic resilience during any disaster situation. It facilitates opportunities for high social and economic capital and thus reduces sensitivity and enhances adaptive capacity	Negative	Census of India (2011)
	House with two-wheelers	Household with two-wheeler are considered middle class and can easily cope with disasters.	Negative	Census of India (2011)

Dimension	Sub-indicators	Rationale for selection	Functional relation with Vulnerability	Source of data
Physical	House roof type	Type of dwelling unit determine exposure to hazards. Roof made of biomass, thatches are more sensitive to cyclone and high intensity rainfall and hence their susceptibility is higher.	Positive	Census of India (2011)
	House floor type	Dwelling with cement floor are less susceptible to natural hazards.	Negative	Census of India (2011)

3.2. City Level Vulnerability

3.2.1. Flood Vulnerability

Srinagar is prone to high flooding due to the combined effect of torrential rain and topographical changes induced due to weakly-regulated urbanization. The combined flood scenario for 1-in-100 year return period (Figure 17) is a combination of pluvial and fluvial floods assessment, where 74.05 sq km (30.18%) of municipal areas are likely to get impacted by flooding with water depth ranging from 0.66 m to 2.15 m. Flooding inundates the entire city, particularly the wards in low-lying areas spread across the flood channels. Wards 62, 63, and 64 include Sharifabad, Zainakote, Gori pora, Tengpora, Shalteng, and Laywaypora, which are located in low-lying areas on the city's eastern outskirts where flooding is a common occurrence even during light rainfall. These areas are submerged in water making it difficult for residents to move around and interfere with their daily lives. People in these areas sell or rent their property for commercial or other purposes in order to avoid the problem of flooding and relocate to other areas or districts within the state. These areas constitute 15% of the total area that is affected by flooding every year.

Areas such as Zonimar, Shunglipora, Zadibal, Noorbagh, Parimapora, Wazir Bagh, and Rajbagh in wards 13 to 28 on the city's south-eastern periphery, which are close to the Jhelum River, are always on high alert during heavy rains and attribute 9.2% of area to devastating floods almost every year. During the 2014 floods, these were the hardest hit areas where water remained in the establishment for over a month. In the northern part, low-lying areas such as Zakura, Gulab Bagh, Tailbal, Umer Colony, Soura, Anchar, and Bagwanpora in wards 47 to 58 are the hardest hit by flooding, accounting for 14.2% of the area inundated, with ward 57 having the highest flood depth.

The CBD and other business and tourist hotspots, such as Lal Chowk, Karan Nagar, Chattabal, Bemina, Dalgate, Sonwar, Indira Nagar, and Shivpora in wards 31 to 47 and wards 2, 3, 18, 37, and 59 are inundated by flooding because some of these areas are built on flood channels near Jhelum river and Dal Lake, causing inconvenience for daily commuters, particularly during the peak tourism season.

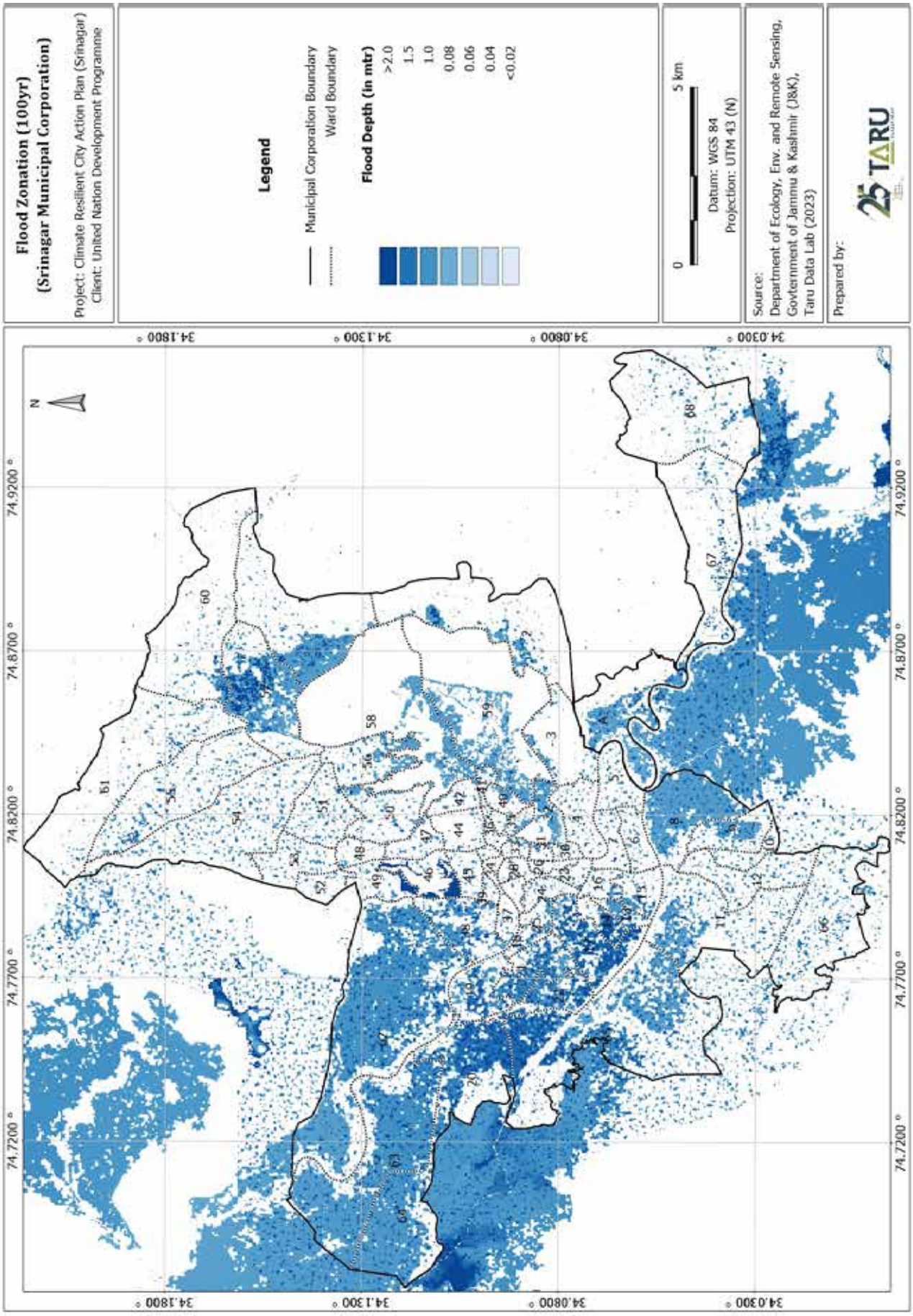


Figure 17: Combined (Pluvial & Fluvial) Floods (1 in 100 Year Return Period)

Critical assets vulnerable to flooding

For a city like Srinagar, it is important to understand critical urban assets (such as Power, telecommunication, water, sewerage, fire stations, health infrastructure and road network leading to essential infrastructures such as hospitals, government buildings etc.), which are most important during disaster management.

Power: According to the Jammu and Kashmir Power Development Department, the peak power demand in Srinagar in 2020 was around 850 megawatts (MW). This indicates that the average electricity consumption in the city would be somewhat lower than the peak demand, but is still likely to be significant. It is worth noting that electricity consumption in Srinagar city varies depending on a number of factors, such as the time of day, season, and the type of buildings and appliances in use. So, the average consumption may differ depending on the specific circumstances. Electricity consumption is extremely high during peak tourism seasons, and most areas have consistent power supply with very few power outages, such as Dal Gate, Indira Nagar, Sonwar, and Khayam.. The most power outages occur during and after snowfall, when all lines are damaged and can be seen lying on the streets, endangering people and putting their lives in jeopardy, particularly in Srinagar's old city, where houses are compactly placed in congested areas. Although J&K is heavily reliant on hydroelectric power plants on its own rivers for electricity generation, it suffers from frequent power outages.

Looking at the 1-in-100 year flood scenario, it is inferred that 15 of the 64 substation facilities will be exposed to floods due to their exposure to high flood areas. These are located in, wards 2, 4, 15, 20, 21, 23, 24, 30, 37, 45, 48, 57, 60, and 65. Also, the following substations are connected to critical infrastructure facilities, such as hospitals, fire stations, government buildings, etc. Wanganpora Substation in ward 48, Chandihar Substation in ward 47, Kawdara in Wanganpora –ward 45, Safakadal in Wanganpora SS –ward 37, Karan Nagar Substation in ward 24, Barbarshah Substation in ward 23, TRC in Chashmashahi Substation in ward 4, Buchwara in Chashmashahi SS in ward 2, and Burzahama in ward 60. These substations are part of the city's critical infrastructure, where power supply can be disrupted over a large area, affecting a greater number of people. It is extremely crucial to strengthen the resilience of these substations so that they can resist the adverse effects of severe flooding while remaining operational.

Telecommunication: During floods and other hazards, telecommunication services in Srinagar city are significantly affected. Floodwaters damage the infrastructure of telecommunication services such as telephone lines, mobile towers, and internet cables. This damage results in the disruption of telecommunication services, making it difficult for people to communicate with each other and access emergency services. These services are also disrupted during snowfall, when the internet and other mobile networks go down, making people's lives difficult. In some cases, when the temperature drops below 0 degrees, the lines become clogged.

In the past, during the 2014 floods in Srinagar, telecommunication services were severely disrupted due to the damage caused to the infrastructure. The floodwaters damaged a large number of mobile towers and telephone lines, causing communication networks to go down. This made it difficult for people to communicate with their families, friends, and emergency services. The degree to which the telecommunication sector in Srinagar is likely to get affected by flood is also found to be high. Mobile towers across almost all the wards are expected to get affected if the city is exposed to flood. About 27% of mobile towers are exposed to floods. Thus, it is essential to strengthen the emergency response systems of the city to reduce its vulnerability while avoiding such a scenario.

Fire Stations: Srinagar city has some essential services such as fire and emergency services. Their duties include rescue and firefighting, disaster management, and rescue from earthquakes, floods, landslides, avalanches, catastrophes, and conflagrations, as well as road and rail accidents, air crashes, and underwater rescue, in addition to man-made disasters such as war, air raids, and bomb blasts. There are 23 main fire stations located in Srinagar city. Srinagar, GawKadal, Dalgate, Habbakadal, Waniyar (Safakadal), Nowshehra, M.R.Gunj, Rainawari,Hazratbal, Raj Bhavan,New Secretariat, Syed Hamidpora, Brari Nambal (Babadem), Gupkar (temporarily relocated), Veer Chattabal, Rawalpora, Nowgam, M. A. Road, Soura, Shalimar, Hariniwas HCM's Residence, Rangreth, Brane Nishat. The city also has two river fire stations, namely, Nehru Park (I) and Nehru Park (II). There are six fire posts spread across the city namely, Khankah-e-Moula, Makhdoom Sahib, Zadibal, Shali Store, Pallapora, Noorbagh, and Central Jail Srinagar. The level of access also varies throughout the day depending on traffic and road conditions.

According to the analysis, most of the city's fire stations are vulnerable to floods and fire incidents, particularly those in wards 2, 46, and 57, which are in close proximity to high flood zone areas. These fire stations are an essential part of the city's critical infrastructure because they protect people when they are in danger. Even if one fire station goes out of service, it will affect a larger population, increasing their vulnerability to overlapping risks. As a result, there is an urgent need to establish more fire stations in the city and strengthen existing ones to avoid mishaps and fatalities in the event of any unforeseen hazard events. Fires are common in the Old City during the winter months. Because of the narrow lanes and congested buildings, it is difficult for the fire services to extinguish the fire, and most of the time the establishments are gutted to the ground due to lack of emergency services reaching on time. It is critical to propose some methods to avoid these incidents while causing the least damage.

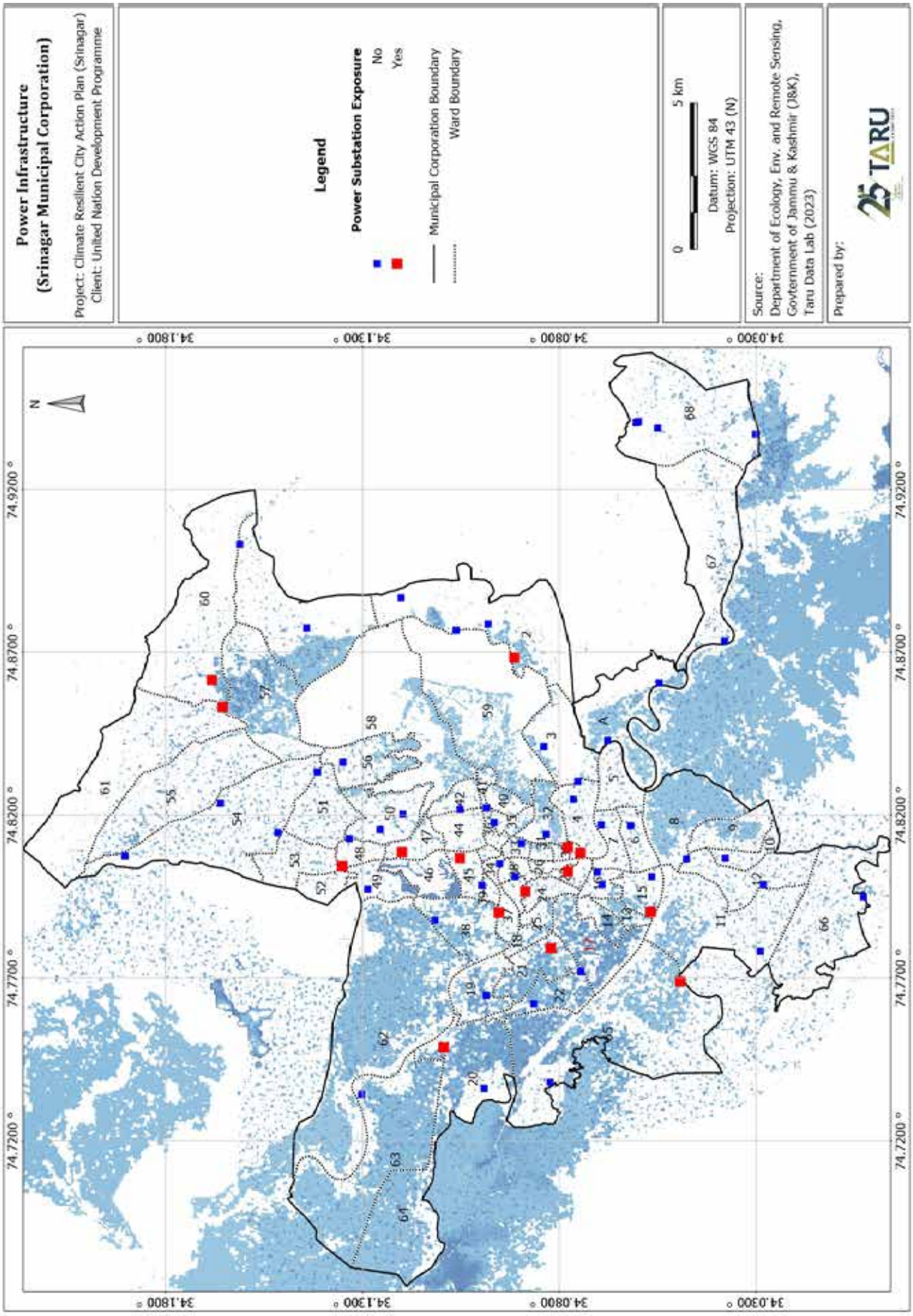


Figure 18: Exposed Power Infrastructure to floods (for 1 in 100 yr return period scenario)

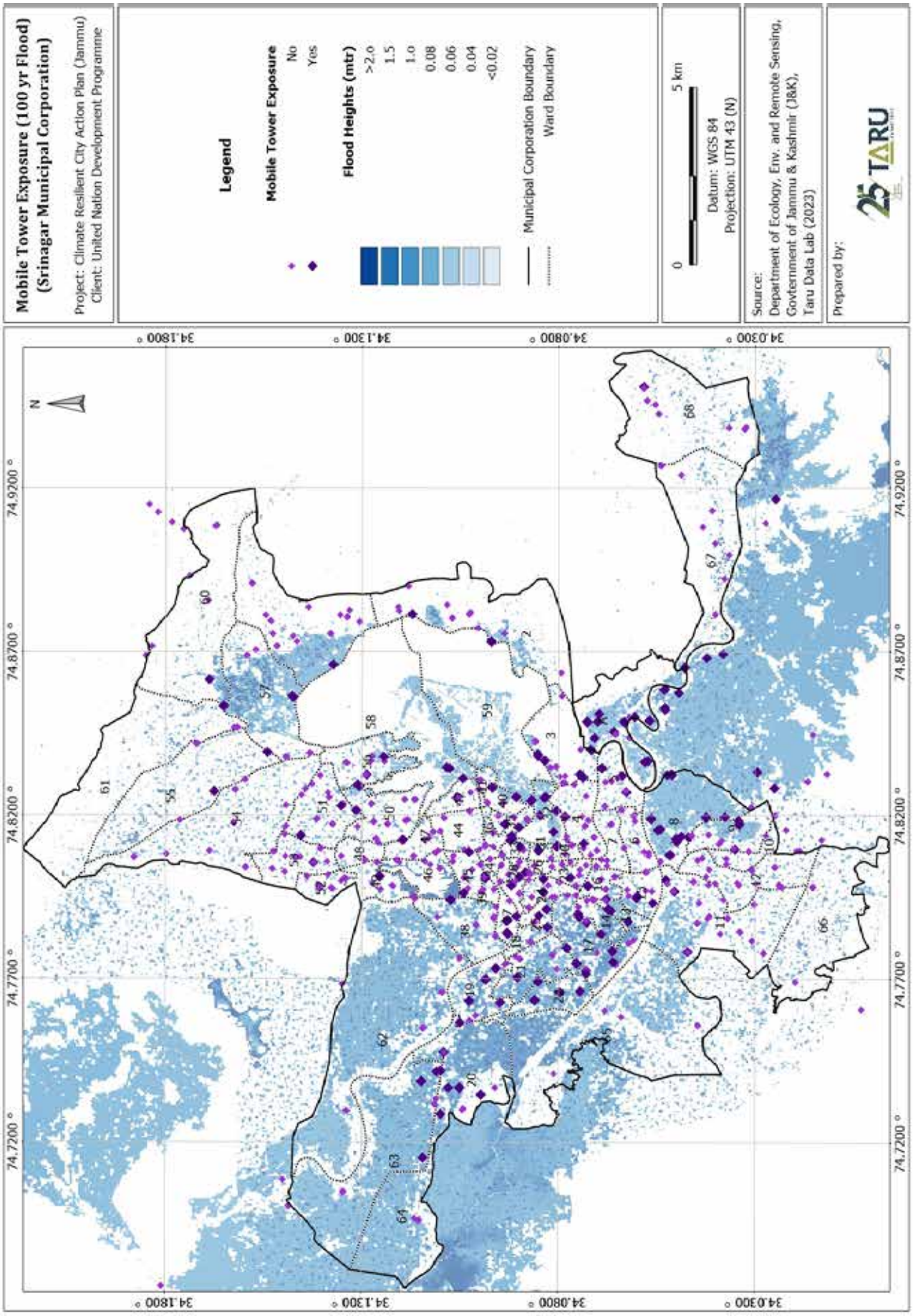


Figure 19: Exposed Infrastructure (Telecommunication, Fire Stations) to floods (for 1 in 100 yr return period scenario)

Water Supply : The supply of water in Srinagar city is being managed by the Department of Jal Shakti, Government of Union Territory of Jammu and Kashmir. Presently, the city is dependent on surface water sources (i.e., River Jhelum, Sindh extension canal, Sukhnag Nalah, and Dood Ganga Nalah) and ground water resources to fulfil existing water requirement from the city. About 97% of total water supply in the city (294 MLD) is made available through surface water sources, while 3% of total water supply (10 MLD) is through ground water resources. There are eight Water Treatment Plants (WTPs) having a cumulative treatment capacity of 298 MLD, against the total water supply of 304 MLD; water treatment capacity is somewhat below the city's current requirement. Although the WTPs located in the city don't come in the exposed area, yet there is a depletion of sources of water found in the city. Increased tourist activities within the city has led to an increase in water pollution in these water bodies due to illegal waste disposal, untreated wastewater disposal and illegal encroachments that require strategies to prevent the further deterioration.

Sewerage : The sewage network in Srinagar city has a capacity of approximately 200 million litres per day (MLD), which is designed to cater to the needs of the city's growing population. However, the actual capacity utilization of the sewage network is lower than the designed capacity due to various factors, such as leakages, blockages, and inadequate maintenance. The coverage of the sewage network in Srinagar city varies across different areas. According to the Srinagar Municipal Corporation (SMC), the Left Bank zone of the city, which includes areas such as Rajbagh, Jawahar Nagar, and Lal Chowk, has a higher coverage of sewage network compared to the Right Bank zone, which covers areas such as Batamaloo, Chanapora, and Bemina. In some areas of the city, particularly the old city, the sewage network is either absent or poorly developed, which leads to the discharge of untreated sewage into nearby water bodies. The sewage network in each zone consists of a series of underground pipes that carry wastewater to treatment plants, where it is treated before being released into the environment.

Maintaining an effective sewage network in Srinagar City presents several challenges. One of the most difficult challenges is the city's hilly terrain, which includes several bodies of water. This makes laying underground pipes and building treatment plants difficult. Furthermore, the city's ageing infrastructure and lack of maintenance have resulted in problems such as leaks, blockages, and overflows. It is concerning that only 18 to 20% of the city has a sewerage network, indicating the system's inadequacy.

If the city experiences heavy flooding, untreated sewage water flowing through storm drains would amplify the effects of untreated wastewater, as seen during rainy seasons. This surface runoff would become contaminated by the drainage system and eventually become waterlogged, resulting in serious health consequences.

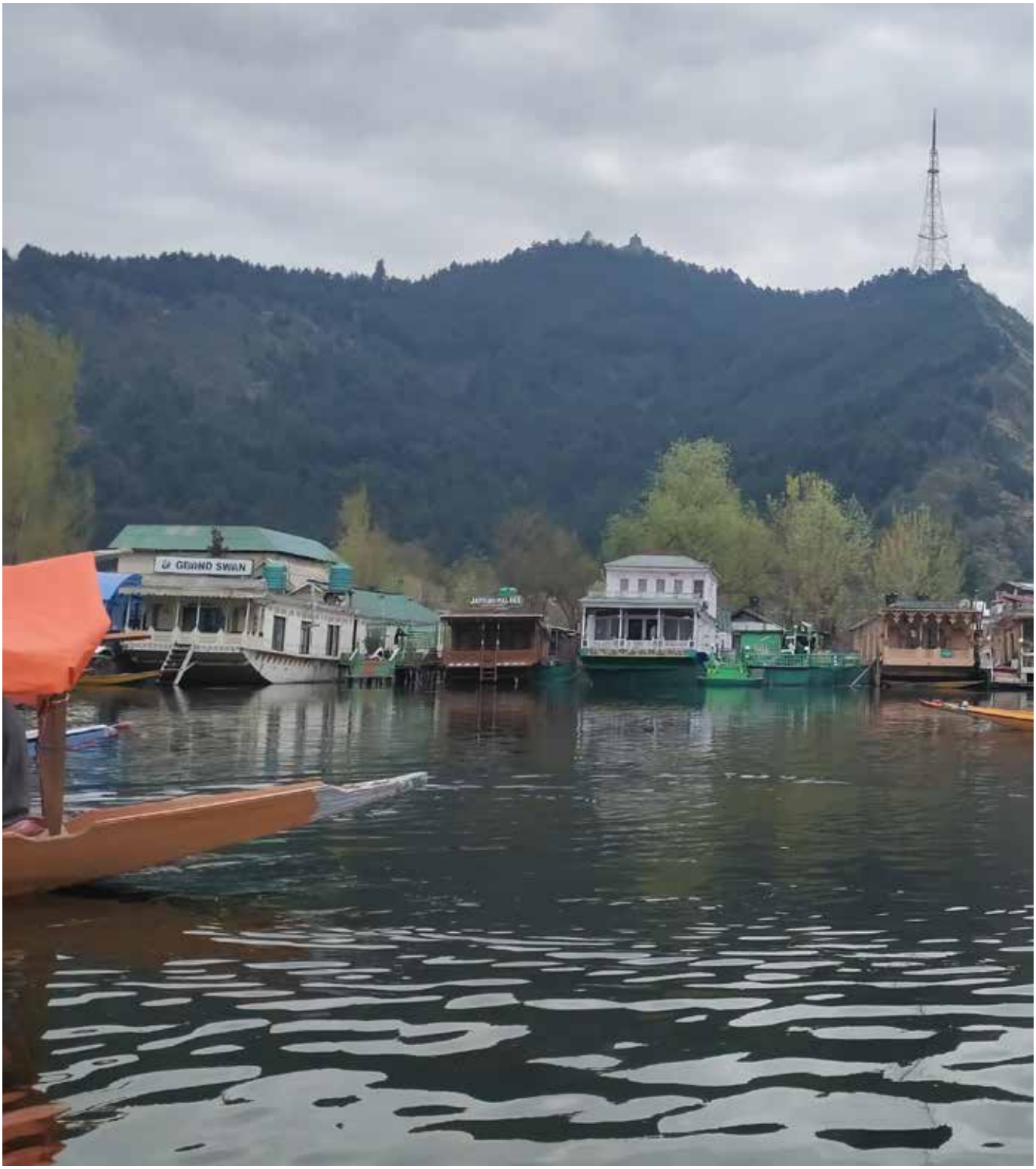
Health Infrastructure: The healthcare system in Srinagar city is mainly operated by the government, with some private hospitals and clinics also available. The government-run healthcare facilities in Srinagar include primary health centres, community health centres, and hospitals. The primary health centres are the first point of contact for patients seeking medical assistance in Srinagar. They provide basic healthcare services and referrals to higher-level health facilities if required. Community health centres are more specialized, offering a wider range of healthcare services than primary health centres. The major government hospitals in Srinagar are the Sher-i-Kashmir Institute of Medical Sciences (SKIMS), Soura, Shri Maharana Pratap Hospital (SMHS), and Jawahar Lal Nehru Memorial Hospital (JLNM). The privately run hospitals are also spread across the city namely, Modern Hospital, Medicare Hospital, Noora Hospital and many other super specialty hospitals. Srinagar has a total of 196 government and civic-run hospitals. There are 50 community health centres (CHCs), 34 primary health centres (PHCs), and 48 sub-centres (SCs) throughout the city, as well as 59 other general hospitals. These government hospitals serve the entire Kashmir division, as people from neighbouring districts visit these hospitals for better facilities, putting additional strain on the hospitals' capacity. These hospitals serve a large portion of the city's population as well as patients from surrounding districts, which can result in a lack of beds and poor service in some cases. Because the city's hospitals are unable to accommodate the large influx of patients, more bedded hospitals should be proposed for improved hygiene and safety.

The 1-in-100 year flood scenario estimates that 21.4% of healthcare facilities will be exposed to floods due to their exposure to high flood zone. They primarily consist of sub-centres and medical aid centres located in wards 3, 32, 34, 45, 48, 50, 56, 57, 59, 61, 13, and , and in wards located in the south-eastern parts of the city. It is critical to fortify these healthcare facilities, so that they can withstand the effects of intense flooding while remaining accessible to the public.

Healthcare facilities are vulnerable to floods, as evidenced by the 2014 floods when these facilities were submerged in water endangering the lives of in-house patients and were unable to provide services to flood victims during those testing times.

Road Network Putting Critical Infrastructure at Risk: Floods reduce accessibility and serviceability of the road transportation network, which is one of our most

valuable infrastructure assets. Disruptive effects on the road system are intimately related to the vulnerability and resilience of the transportation network. Thus, while looking at the 1-in-100 year scenario with respect to exposure of floods, it is deduced that 731.2 km of the road network in the city is affected by floods. This accounts to 27.6% of the entire road network in the city. An estimate of 32.5% of government buildings and 33.3% of schools are exposed to floods. In such a scenario, it is not only the road network that gets affected, but also the other critical infrastructure (CI) of the city that are put at risk, namely, health care facilities and fire stations. In case of a flood situation, accessibility to these CIs would get greatly affected as well, exacerbating the vulnerability of the road networks due to the overlapping risks. Hence, it is essential to assess the robustness of the transport network and take steps to make these more resilient, to avoid the degree of their vulnerability to floods in future.



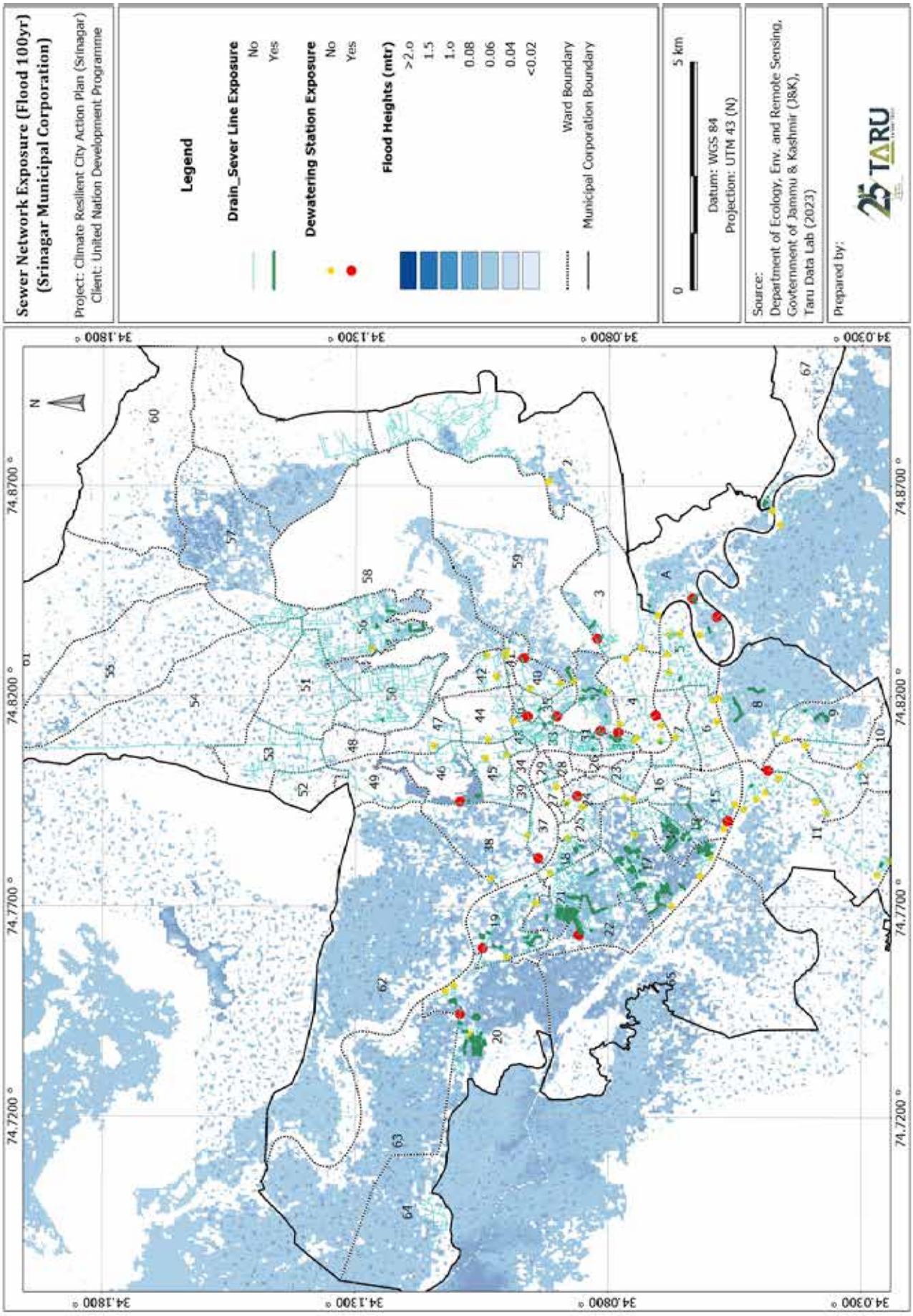


Figure 20: Exposed Transport Network to floods (for 1 in 100 yr return period scenario)

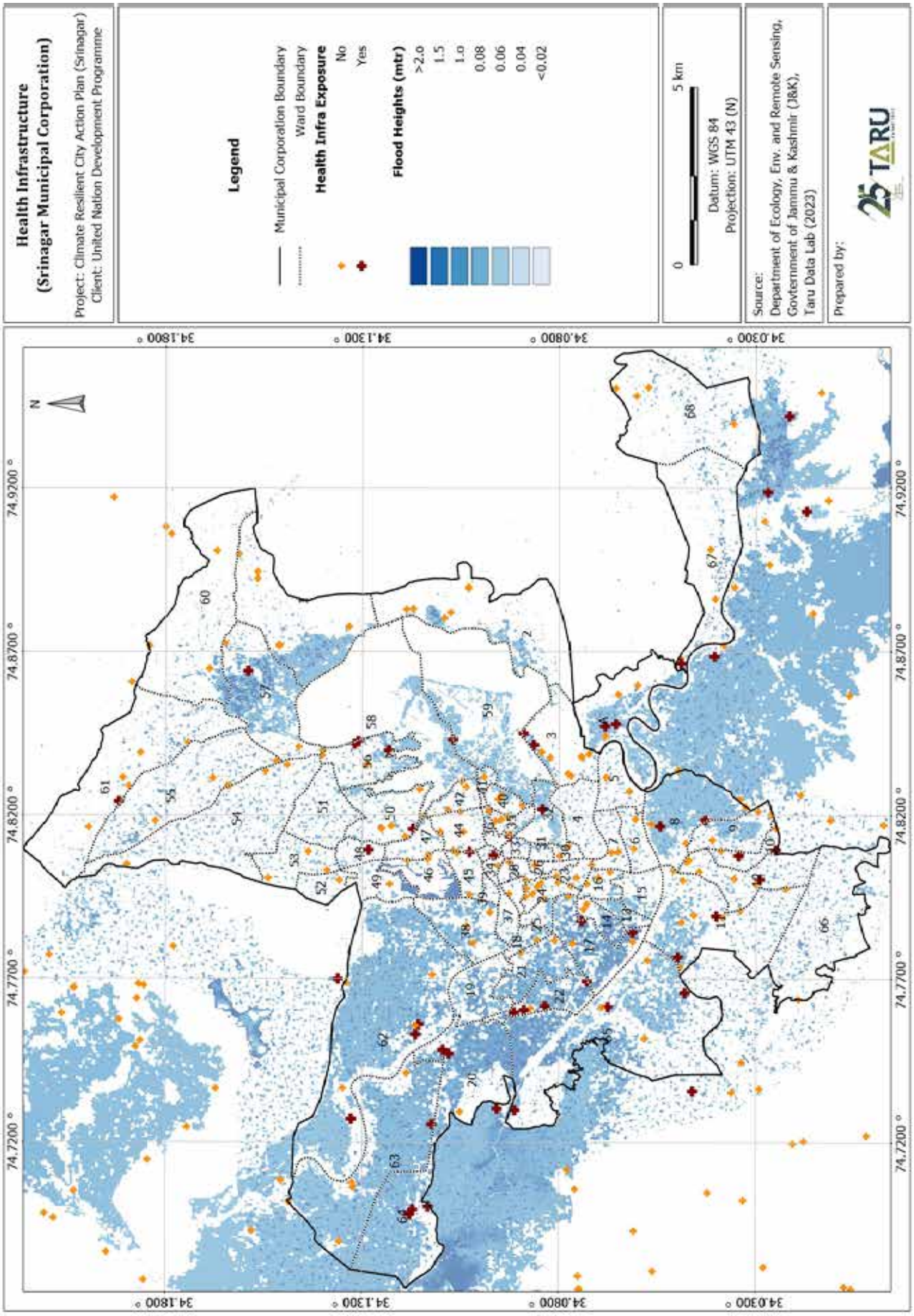


Figure 21: Exposed Health Infrastructure to floods (for 1 in 100 yr return period scenario)

3.2.2. Earthquake:

The ward-wise risk of buildings revealed that a total of 17 sq km area (7% of area in 23 wards) has very high-to-high vulnerability; moderate vulnerability affects 69 sq km of the city area (28% in 19 wards); 160 sq km area (65% of area in 27 wards) has vulnerability ranging from very low-to-low (Midhat Fayaz, 2022). Overall, the downtown is most vulnerable to earthquake damage due to high risk of pounding, high building density, and narrower roads, with little or no open spaces. The modern uptown city, on the other hand, has lower earthquake vulnerability, due to relatively wider roads and low building density (Midhat Fayaz, 2022).The old city area, which includes wards 40 to 50, has been severely impacted by earthquakes and is vulnerable to these incidents because the structures are somewhat dilapidated and cluttered, with very little space for evacuation due to its narrow streetscape and lack of open spaces. The 2005 earthquake in Srinagar occurred on 8th October 2005, with a magnitude of 7.6 on the Richter scale. The city of Srinagar suffered significant damage, particularly in the city's older parts, where many buildings were made of brick and mud. The newer constructions in Srinagar are in good condition, but they are not built in accordance with the building laws and codes that have been prescribed for Srinagar, which is located in seismic zone IV, a severe intensity zone. As per 2011 Census, about 25% of people in Srinagar live in dilapidated or overpopulated housing with inadequate access to light, ventilation and sanitation increasing the severity of disasters. The newer, outer city area has more recent constructions and is not as densely populated. However some of this new construction is in flood prone areas with incorrect plinth levels and will be chronically vulnerable to flooding. Many of the new buildings too, have not been designed to resist earthquake.The establishments in the newer colonies and residential areas, such as Natipora, BagiBarzulla, and Nowgamare are not detailed and designed with earthquake resistance in mind. Some areas of the city are sprouting up along Jhelum river and its flood plains, where the soil is loose and construction should be prohibited, increasing the city's vulnerability to earthquakes and potentially increasing the severity of the impacts on settlements and businesses.

3.2.3. Forest Fires:

Forest fires occur on the periphery of the hillocks and upper reaches of the urban forests, close to residential areas within the city limits. Every year, prolonged dry spells cause forest fires across Srinagar city, particularly in areas such as higher reaches of ward 2 comprising areas such as Brien, Nishat, Zabarwan Enclave, and Baba Shukar din Sahab village on the foothills of Zabarwan Hill. wards 55, 57, 60, and 61, namely Tailbal, Khaja Bagh, Wanihama, Burzahama, Gulab Bagh, and Dadina Bagh, are highly vulnerable to very high intensity forest fires on the outskirts of the main city. The reasons for these forest fires could be attributed to erratic and lower rainfalls. According to reports, fire is caused by dry foliage, particularly from June to September. These fires endanger wild animals, which migrate to cities in search of shelter and food, wreaking havoc and endangering the lives of people living near forests. As a result of these fires, leopards have attacked many people, claiming their lives. However, the areas vulnerable to forest fires are close to fire stations, and the fire department takes measures to guarantee that no lives are lost and that the horticulture farms on the forest's foothills suffer minimal damage. The nearest fire stations to forest fire-prone areas are Shalimar Fire Station in ward 57 (1.5 km distance), Brien Nishat Fire Station in ward 2 (1.2 km distance), and Hariniwas Fire Station in ward 2 (4 km distance).

3.2.4. Landslides:

Both earthquakes and floods have had a history of triggering landslides in the region, even though there are hardly any landslides in Srinagar. The Geological Survey of India (GSI) has identified fifteen highly unstable landslide zones in Jammu and Kashmir in the survey conducted in 2014-16. Based on the survey, a compendium of Landslide susceptibility Maps for Chenab river basin and major towns has been published identifying these areas with maximum geomorphic hazard. As per the report, the highest five highly vulnerable zones are located in Ramban District, including three along the Jammu-Srinagar highway, The Jammu-Srinagar national highway is often required to be closed to traffic during the rains as a result of landslides along the route.

3.2.5. Fires Accidents:

Fire hazard requires special attention in the city, because of its 'traditional building material, wood, and narrow streets that make access to fire brigades difficult, and the use of a large amount of flammable woven materials (especially cotton and linen) in each home, including carpets and blankets. The narrow, winding streets of Srinagar's old cities make it difficult for fire service and other emergency responders to get to the scene quickly. According to the Joint Director, Fire & Emergency Services, Kashmir Range, the highest number of fire incidents have been reported in Srinagar. The Fire and Emergency Services department received 143 fire-related calls, resulting in property damage worth Rs. 17.04 crore and goods worth Rs. 20.38 crore (Qureshi, 2022).

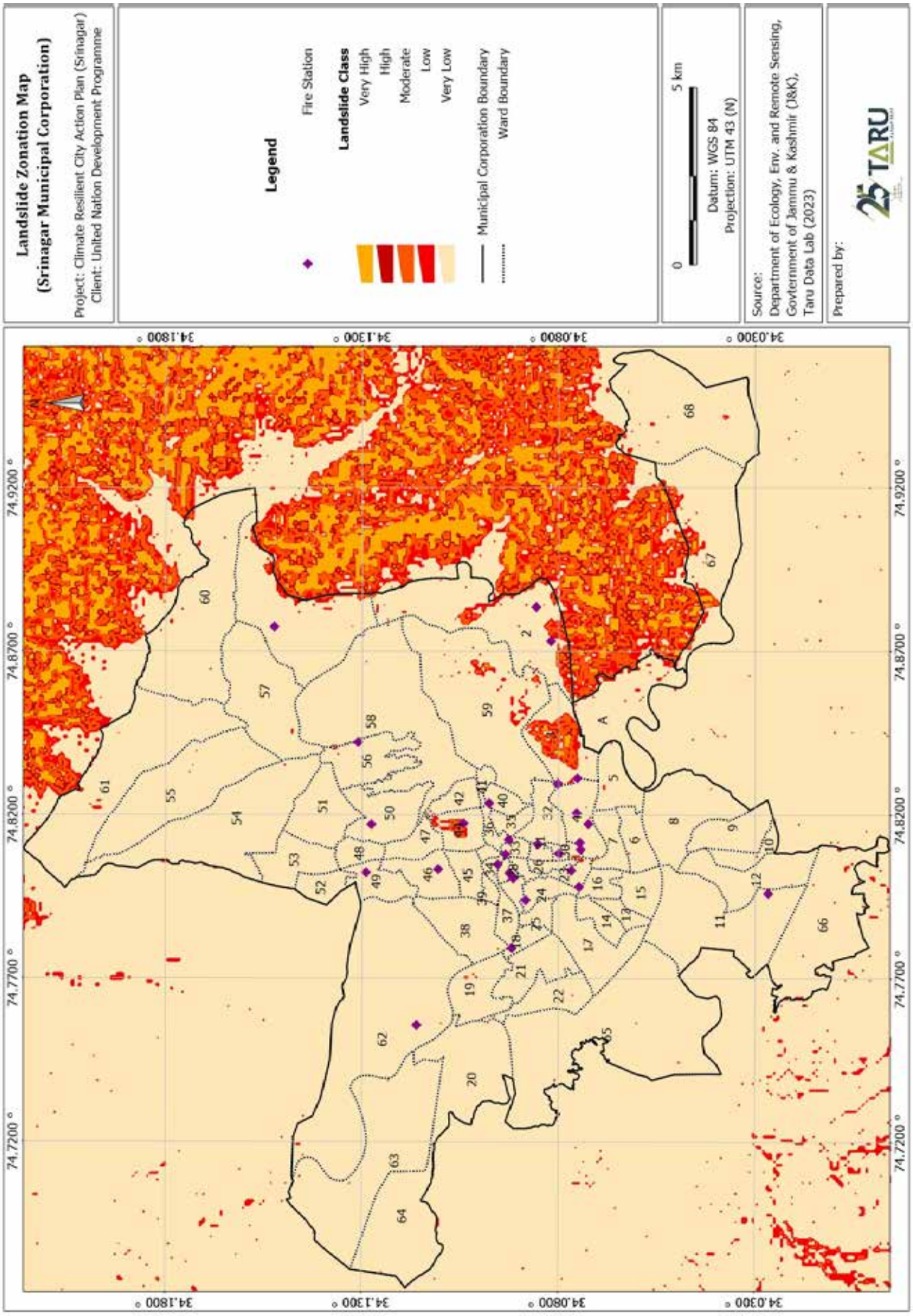


Figure 22: Exposure to Landslides

3.3. Ward-Level Relative Vulnerability

3.3.1. Natural Vulnerability

Natural Vulnerability: The hazard characteristics of that region highly influence natural vulnerability. 17, 22, 53, and 62, namely, Nundresh Colony, Bemina West, Buchpora, and Palapora, have a high natural vulnerability index. These wards have flooding exposure in this area of about 15.3 sq km (41% of total flood extent) affected and flood depth ranges > 2 m causing more water logging incidences in these wards Nundresh Colony, have been built on flood channels. Bemina ward was previously a flood basin that was converted into a residential area, which caused the natural drainage to stop, resulting in floods every year, hence adaptive capacity is less in these wards. Natural vulnerability is found to be high in 7.6 per cent of the total population.

3.3.2. Social Vulnerability

Social vulnerability is a factor of the social and economic capacity of the society, which otherwise are indicators of coping capacity. The social vulnerability is highly correlatable with the slums, SC/ST and marginalised groups of the city who are more prone to hazards. The total number of slum households in Srinagar city, according to the census of 2011 are 18,000.

3.3.3. Economic Vulnerability

Economic vulnerability of wards 12, 24, 48, 51, 53, and 66, namely, Rawalpora, Karan Nagar, Nowshera, Umer Colony, Buchpora, and Humhama is higher. These are the areas that are developing in tandem with new businesses and emerging commercial areas, and they are located in low-lying areas that are heavily impacted by floods, resulting in economic losses and increasing economic vulnerability. Approximately 9.2 per cent of the total population is found to be economically vulnerable.

3.3.4. Physical Vulnerability

Physical vulnerability evaluates exposure to ward-level physical parameters like poor roof material (thatched roof and plastic roof) and adaptive parameters like cement flooring in houses. Wards 8, 17, 39, and 43, namely, Mehjoor Nagar, Nundresh Colony, Tarabal, and Jamia Masjid, are highly vulnerable to physical due to their poor building materials. Because it is located in the old city, the building structures in and around Jamia Masjid Ward are in disrepair. Residential buildings in Mehjoor Nagar and Nundresh Colony were fairly recently constructed without regard for building codes, increasing their vulnerability to hazards. Approximately 4.7 per cent of the total population is found to be extremely physically vulnerable.

3.3.5. Composite Vulnerability

The composite assessment shows that ward 53, Buchpora, is the most vulnerable with 2 per cent of the total population. Wards 8, 14, 17, 21, 22, 25, 39, 62, and 66, which include Mehjoor Nagar, Batamaloo, Nundresh Colony, Bemina East, Bemina West, Chattabal, Tarabal, Palapora, and Humhama, are medium vulnerable, with a population of approximately 14.3%. Detailed values of CVI (Composite Vulnerability Index) are shown in Annexure 8.6. Figure 23 states various ward-wise and dimension-wise vulnerability maps.

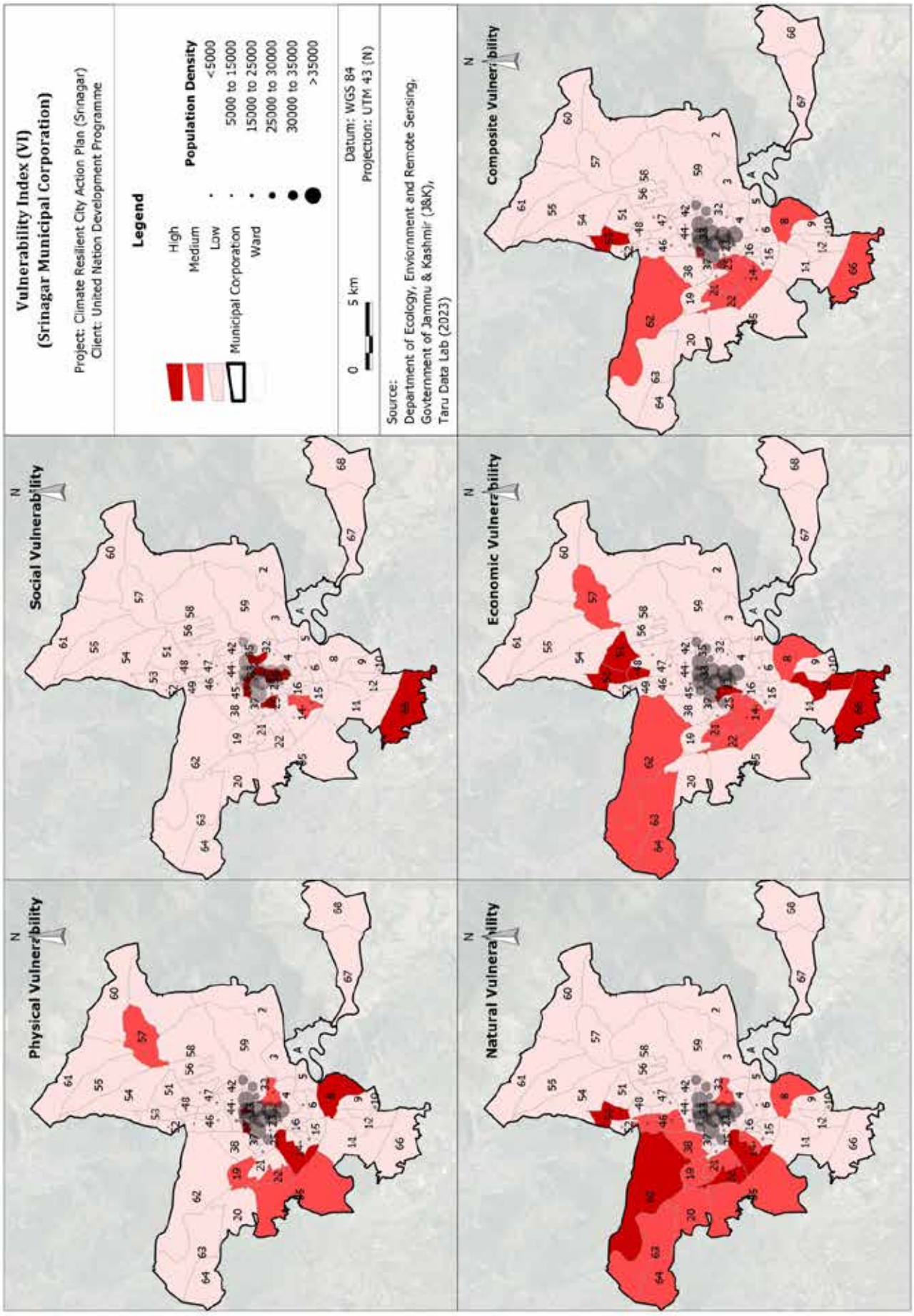


Figure 23: Vulnerability Indices - Srinagar

CHAPTER

4 GHG EMISSION INVENTORY

Chapter 4: GHG Emission Inventory

4.1. Baseline GHG Emission Inventory

Summary: A Quick Overview of Srinagar City's GHG Emissions

Srinagar city's greenhouse gas (GHG) emissions have been estimated for the Energy, Agriculture, Forestry, and Other Land Use (AFOLU) and Waste sector from 2005 to 2019. The year-on-year estimates help to understand the trends. As shown in figure 24, the economy-wide emissions of Srinagar city witnessed an increasing trend between 2005 and 2019. Emissions from the Energy sector progressively increased at a CAGR of ~0.83% between 2005 and 2019, contributing an average of 80% to economy-wide emissions. The drivers of the Energy Sector are transport and residential categories, the details are given in the sectoral description. Similarly, the Waste sector emissions also increased over the reference period with a CAGR of ~3.5% . Meanwhile, emissions from the AFOLU sector experienced a decreasing trend, with a CAGR of 3.05% due to decrease in livestock population and enhanced sequestration from a few categories of Land sub-sector. The economy-wide emissions and sectoral emissions are discussed in detail in the following sections and the year-on-year emissions estimated for this plan are given in table 8.

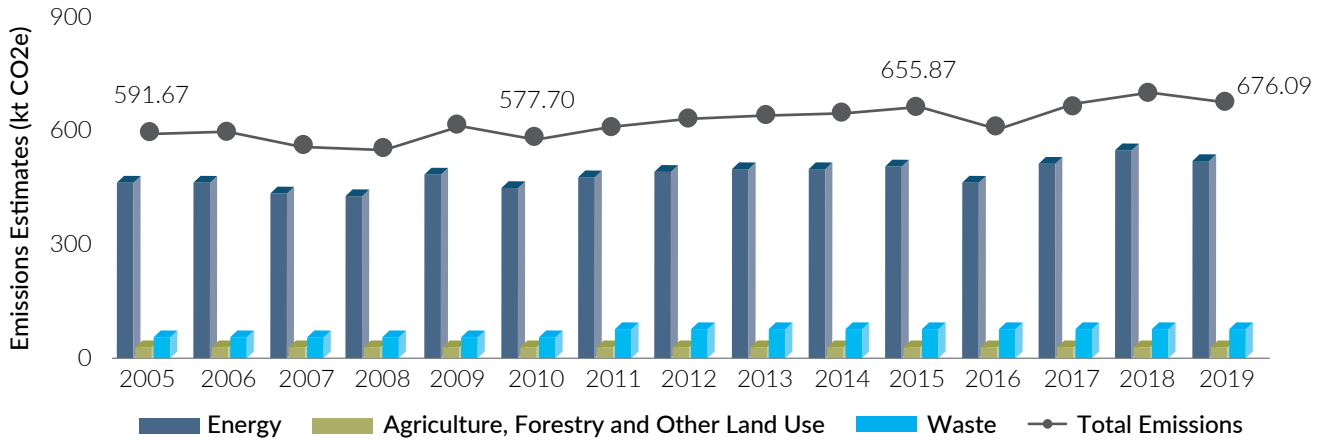


Figure 24: Economy-wide Emissions of Srinagar City (2005–2019)

Table 8: Year-on-Year GHG Emission Estimates of Srinagar City in kt CO_2e

Year	Energy	Agriculture, Forestry, and Other Land Use	Waste	Total Emissions
2005	479.51	45.05	67.11	591.67
2006	480.24	41.38	68.85	590.47
2007	450.68	37.72	70.64	559.04
2008	440.59	36.51	72.47	549.56
2009	499.53	35.20	74.71	609.44
2010	467.49	33.58	76.63	577.70
2011	493.47	31.72	90.76	615.95
2012	512.33	30.32	92.99	635.64
2013	514.94	29.97	95.18	640.09
2014	515.31	29.62	97.34	642.27
2015	526.45	29.95	99.47	655.87
2016	478.59	29.61	101.67	609.87
2017	534.10	29.61	104.05	667.76
2018	565.50	29.27	106.41	701.19
2019	538.14	29.18	108.77	676.09

4.1.1. Assessment Methodology

4.1.1a. Overview

Emissions estimates for the city of Srinagar cover key sectors and sub-sectors, as per the Intergovernmental Panel on Climate Change's 2019 Refinement to 2006 Guidelines for National Green House Gas Inventories (IPCC Guidelines). The GHG inventory for Srinagar city comprises of emissions from 11 categories across the sectors of Energy, Agriculture, Forestry, and Other Land-Use (AFOLU) and Waste for the years 2005-2019. Emissions from the industrial processes and product use (IPPU) sector are not included in the emission profile for Srinagar city, as the presence of industries that lead to IPPU emissions (as per IPCC Guidelines) was not reported. However, the energy used in industries from the consumption of fuels (diesel) and the corresponding emissions are reported in the energy sector as per the IPCC Guidelines.

Further, the GHG inventory of Srinagar city is in line with the national-level inventory preparation for National Communications (NATCOMs) and Biennial Update Reports (BURs) and, wherever available, India-specific emission factors (from the two NATCOMs, INCAA Report, and the three BURs)[3] were used in place of default emission factors. To understand the regional dynamics and to make appropriate methodological assumptions in the absence of specific activity data, inputs from sectoral experts were incorporated. Detailed notes on the formulae used for each category estimates and information on variables, emission factors, etc. are given in the Annexure 8.2 to 8.4.

4.1.1b. Activity Data

Activity data for all the categories was sourced from government-approved data sets and/or peer-reviewed papers. Emission sources of activity data is listed category-wise in table 9.

Table 9: Source of Activity Data for the Categories Under Consideration

Sector	Category	Source of Activity Data
Energy	Transport	PPAC (Petroleum Planning & Analysis Cell, Ministry of Petroleum and Natural Gas, GoI)
	Manufacturing Industries	
	Residential	
	Agriculture	
	Commercial	
Agriculture, Forestry, and Other Land Use (AFOLU)	Agriculture Soil	Ministry of Chemicals and Fertilizers APY Statistics of Farmer Welfare and Agriculture Development Department, GoI
	Enteric Fermentation	17th, 18th, 19th, and 20th Livestock Census Animal Husbandry Department, Jammu, GoJ&K
	Manure Management	
	Land Use and Land Use Change and Forestry	Khalid Omar Murtaza, M. A. (2015). Geospatial Mapping of Srinagar City. Journal of Geography and Regional Planning
Waste	Municipal Solid Waste	Census Data, Srinagar Framework Document for Srinagar City Climate Action Plan – Based on Urban System Gap Analysis June 2022, ICLEI, in collaboration with UNDP and GoJ&K
	Domestic Wastewater	

[3] India's First National Communication to the UNFCCC, 2004; India's Second National Communication to the UNFCCC, 2012; Indian Network for Climate Change Assessment – INCCA's 2010 Report 'India: Greenhouse Gas Emissions 2007'; India's First Biennial Update Report to the UNFCCC, 2016; and India's Second Biennial Update Report to the UNFCCC, 2018

4.1.1c. Emissions Factor

A summary of the methodological tier (of the IPCC Guidelines) used for emissions estimation is given in Table 10. This table also provides information on the type of emission factors used: India-specific (country-specific) or default (as given in the IPCC Guidelines).

Table 10: Tier of Estimation and Type of Emission Factor by Key Source Category

IPCC ID	GHG Source &Sink Categories	Tier	Emission Factor
1.	**Energy**		
1A3	Transport	T1	CS
1A2	Manufacturing Industries	T1	CS
1A4b	Residential	T1	CS
1A4c	Agricultural	T1	
1A4a	Commercial	T1	CS
3.	**AFOLU**		
3A	**Livestock**		
3A1	Enteric Fermentation	T2	
	Cattle	T2	CS
	Dairy Cows (Indigenous and crossbred)	T2	CS
	Other Cattle or Non-Dairy Cows (Indigenous and Crossbred)	T2	CS
	Buffalo (Dairy and Non-Dairy)	T1	CS
	Horses and Ponies	T1	D
	Pigs		D
	Poultry	T1	D
3A2	Manure Management	T2	
	Cattle	T2	CS
	Dairy Cows (Indigenous and crossbred)	T2	CS
	Other Cattle or Non-Dairy Cows (Indigenous and Crossbred)	T2	CS
	Buffalo (Dairy and Non-Dairy)	T1	CS
	Horses and Ponies	T1	D
	Pigs	T1	D
	Poultry	T1	D
3B	**Land**		
3B1	Forest Land	T2	CS
3B2	Cropland	T2	CS
3B3	Grassland	T2	CS, D
3B5	Settlements	T2	CS, D
3B6	Other Land	T2	CS, D
3C	**Aggregate Sources and Non-CO_2 Emission Sources on Land**		
3C4, 3C5	Agricultural Soils	T1	CS
4	**Waste**		
4A2	Solid Waste Disposal	T1	CS, D
4D1	Domestic Wastewater	T1	CS, D

Note: T1: Tier 1; T2: Tier 2; T3: Tier 3; CS: Country-specific; PS: Plant-specific; D: IPCC default

4.1.1d. Limitations and Assumptions

There were several limitations about the activity data and city-level information/data for multiple key source categories. Therefore, logical assumptions were used based on expert inputs and consultations. The limitations and assumptions are summarized category-wise in Table 11.

Table 11: Key Source Category-wise Limitations and Assumptions

Key Source Category (with IPCC Code)	Details	
Sector: Energy		
1A1ai Public Electricity Production	**Status**	No emissions occurred in this category
	Explanation	No fossil fuel-powered plants (supplying to grid) are present within the city limit
1A1cii Captive Power Plant	**Status**	Emissions from this category were not estimated
	Limitation	No data/information was available regarding captive plants within the city limit
	Assumptions	NA
1A2 Industrial Energy	**Status**	Emissions were estimated
	Limitation	Emissions were estimated only from diesel consumption; Lack of city-level data for other fuels (like LDO, NG, coal etc.)
	Assumptions	Total diesel consumed across all sectors within Srinagar city was derived from the fuel consumed in Srinagar district using the share of population living in Srinagar city with respect to Srinagar district 9.57% of total diesel consumed in Srinagar city is attributed to industrial energy (PPAC, 2013)
1A3 Transport	**Status**	Emissions estimated
	Limitation	Only road and aviation transport emissions were estimated. Railways could not be estimated due to lack of data Three fuels considered (diesel, petrol,& ATF) CNG data was not available
	Assumptions	Total diesel consumed across all sectors within Srinagar city was derived from the fuel consumed in Srinagar district using the share of population living in Srinagar city with respect to Srinagar district 63.3% of total diesel and 100% of petrol was attributed to road transport, and 100% of ATF was attributed to aviation in Srinagar city (PPAC, 2013)
1A4Other Sectors **1A4a** Commercial; **1A4b** Residential; **1A4c** Agriculture;	**Status**	Emissions were estimated
	Limitation	Fuels considered: diesel, LPG, and kerosene End-use (category-wise) fuel-wise consumption data was not available at city level
	Assumptions	Total diesel consumed across all sectors within Srinagar city was derived from the fuel consumed in Srinagar district using the share of population living in Srinagar city with respect to Srinagar district 21.96% of total diesel consumed in Srinagar city is attributed to agriculture, and 1.82% and 3.35% is attributed to commercial and residential categories, respectively (PPAC, 2013) 97% of total LPG consumed in Srinagar city is attributed to residential and 3% is attributed to commercial (GHGPI, 2022) 100% of kerosene in Srinagar city is attributed to residential

Key Source Category (with IPCC Code)	Details	
1B Fugitive Emissions from Fuels	**Status**	Emissions were not estimated
	Explanation	Major sources of emissions from this category (coal mines, oil refineries, pipelines etc.) are not present in Srinagar city
Sector: Agriculture, Forestry, and Other Land Use (AFOLU)		
3A1 Enteric Fermentation	**Status**	Emissions were estimated
	Limitations	City-level livestock population data was not available There are significant variations in body weight and size of livestock across India, along with variations of feed intake that could not be fully captured due to lack of information
	Assumptions	Livestock population of Srinagar city was estimated using the percentage of total livestock in Jammu city with respect to Jammu district (livestock population data was provided by the Department of Animal Husbandry, Jammu) Classification of livestock categories is based on the NATCOM reports. Details given in the AFOLU methodology annexure 8.2.
3A2 Manure Management	**Status**	Emissions estimated
	Limitations	City-level livestock population data was not available Information on manure management system in the city was not available (wet/dry system) There are significant variations in body weight and size of livestock across India, along with variations of feed intake that could not be fully captured due to lack of information
	Assumptions	Livestock population of Srinagar city was estimated using the percentage of total livestock in Jammu city with respect to Jammu district (livestock population data was provided by the Department of Animal Husbandry, Jammu) Classification of Livestock categories is based on the NATCOM reports. Details are given in the AFOLU methodology annexure 8.2.
3B Land (Land Remaining land and Land Converted to Other Categories for: **3B1** Forest Land **3B2** Cropland **3B3** Grassland **3B5** Settlements **3B6** Other Land)	**Status**	Emissions were estimated
	Limitations	City-level land use change matrix was not available from official sources Carbon stock of biomass and soil are considered, that of deadwood, litter, etc. are not covered
	Assumptions	Change in different categories of land use was obtained from literature review, therefore Tier 1 methodology was used
3C1a Biomass Burning in Forestland	**Status**	No emissions occurred in this category
	Explanation	No biomass burning in forest land reported for Srinagar city
3C1b Biomass Burning in Cropland	**Status**	No emissions occurred in this category
	Explanation	No biomass burning in crop land was reported in Srinagar city (based on inputs from stakeholder consultations)

Key Source Category (with IPCC Code)	Details	
Agricultural Soils **3C4** Direct N2O Emissions from Managed Soils; **3C5** Indirect N2O Emissions from Managed Soils	**Status**	Emissions were estimated
	Limitations	Emissions only from the use of fertilizers were estimated City-level fertilizer consumption data was not available
	Assumptions	City-level fertilizer consumption data was deduced by applying per hectare fertilizer used on the agricultural land of the erstwhile state of J&K to the total agricultural land of Srinagar city
3C7 Rice Cultivation	**Status**	Emissions were not estimated
	Explanation	Area under rice cultivation within the city boundary was not available Information on irrigation regimes/water ecosystem was not available
Sector: Waste		
4A Solid Waste Disposal	**Status**	Emissions were estimated
	Limitations	Year-on-year waste generation and waste treatment data was not available for Srinagar city Several factors/fractions required for computation of emissions were not available for the city, therefore, district-/state-level factions have been used, like, degradable organic carbon, proportion going to landfill etc.
	Assumptions	Population for the years in between those reported by the census is estimated using CAGR District-/state-level factions have been used, where required
4D1 Domestic Wastewater Treatment and Discharge	**Status**	Emissions were estimated
	Limitations	Year-on-year domestic wastewater generation data was not available for Srinagar city Several factors/factions required for computation of emissions were not available for the city, therefore, district-/state-level factions have been used, like protein intake, degree of utilization (toilet/ sewerage system types) etc.
	Assumptions	Population for the years in between those reported by the census is estimated using CAGR District-/state-level factions have been used, where required
4D2 Industrial Wastewater Treatment and Discharge	**Status**	Emissions were not estimated
	Explanation	Whether or not there are any industries (as defined by the IPCC) within the city limits is unknown. Year on year wastewater generation or even production data was not available for industrial units operating in city boundaries
Sector: Industrial Process and Product Use (IPPU)		
All categories of IPPU	**Status**	Emissions were not estimated
	Explanation	Whether or not there are any industries producing IPPU emissions (as defined by the IPCC) within the city limits is unknown No data was available on industrial production within the city boundary

4.1.2. Trend Analysis

4.1.2a. Energy Sector

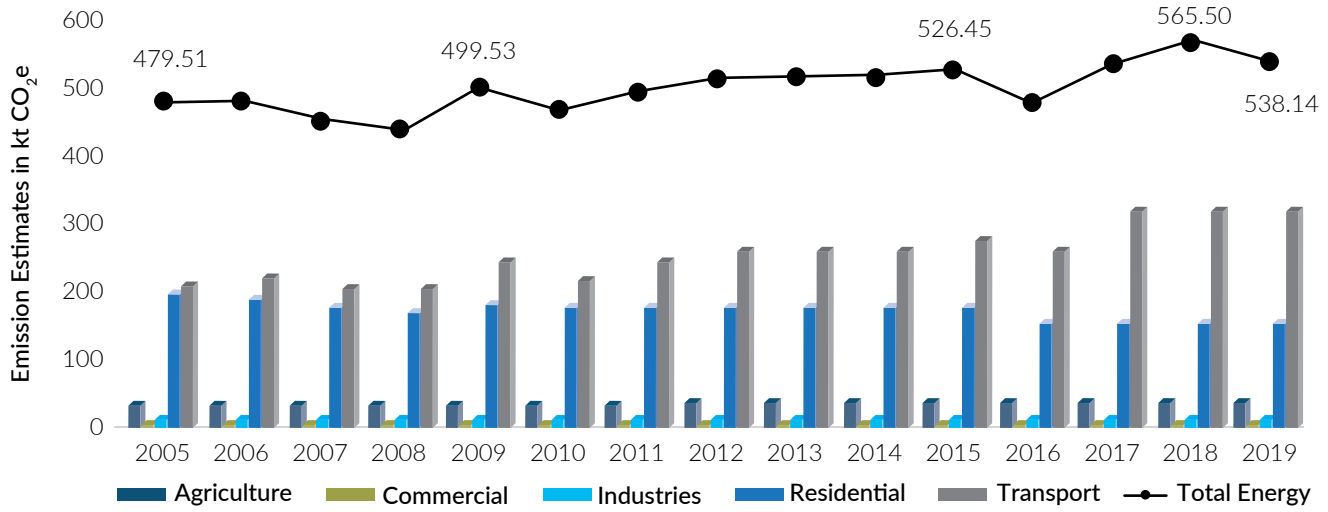


Figure 25: GHG Emission Estimates of Energy Sector (2005–2019)

The Energy sector typically comprises emissions from fuel combustion and fugitive emissions. Fuel combustion includes emissions from public electricity generation, transport, industries, captive power plants and agriculture, commercial and residential categories. Fugitive emissions are due to fuel production.

For Srinagar city, GHG emissions were estimated for direct fuel combustion from transport, industries, agriculture, commercial and residential categories. The energy sector of Srinagar city accounted for ~80% of the economy-wide emissions in 2019. Emissions from the energy sector increased at a CAGR of ~0.84% from 456.51 kt CO_2e in 2005 to 513.37 kt CO_2e in 2019 (Figure 25).

Within the energy sector, transport category was the major contributor to the GHG emissions with a share of ~62% in the total energy emissions in 2019. This was followed by residential and agriculture categories with shares of ~26% and ~8% , respectively (Figure 26).The peaks observed in 2009 and 2018 as well as the dip in 2016 are due to variation in diesel consumption within the city (as also can be seen in the activity data).

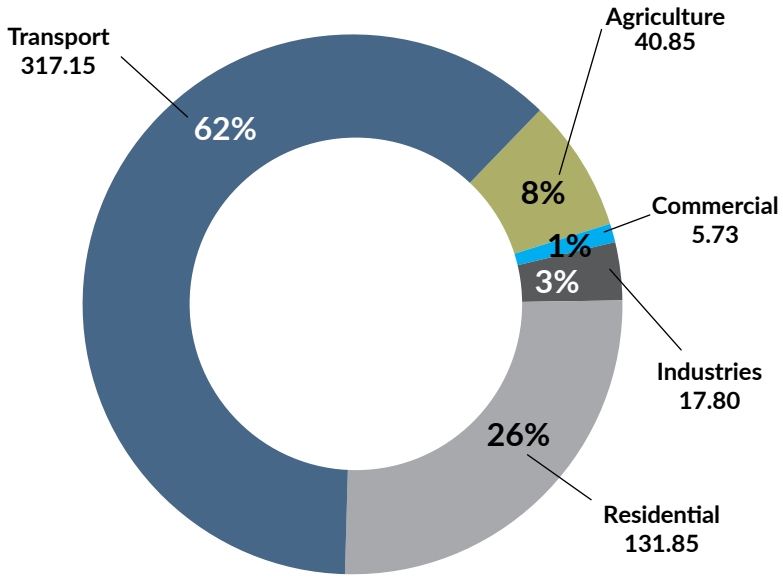


Figure 26: Percentage Contributions and Emissions Estimate (kt CO_2e) to Total Energy Emissions, 2019

4.1.2b. Agriculture, Forestry, and Other Land Use (AFOLU)

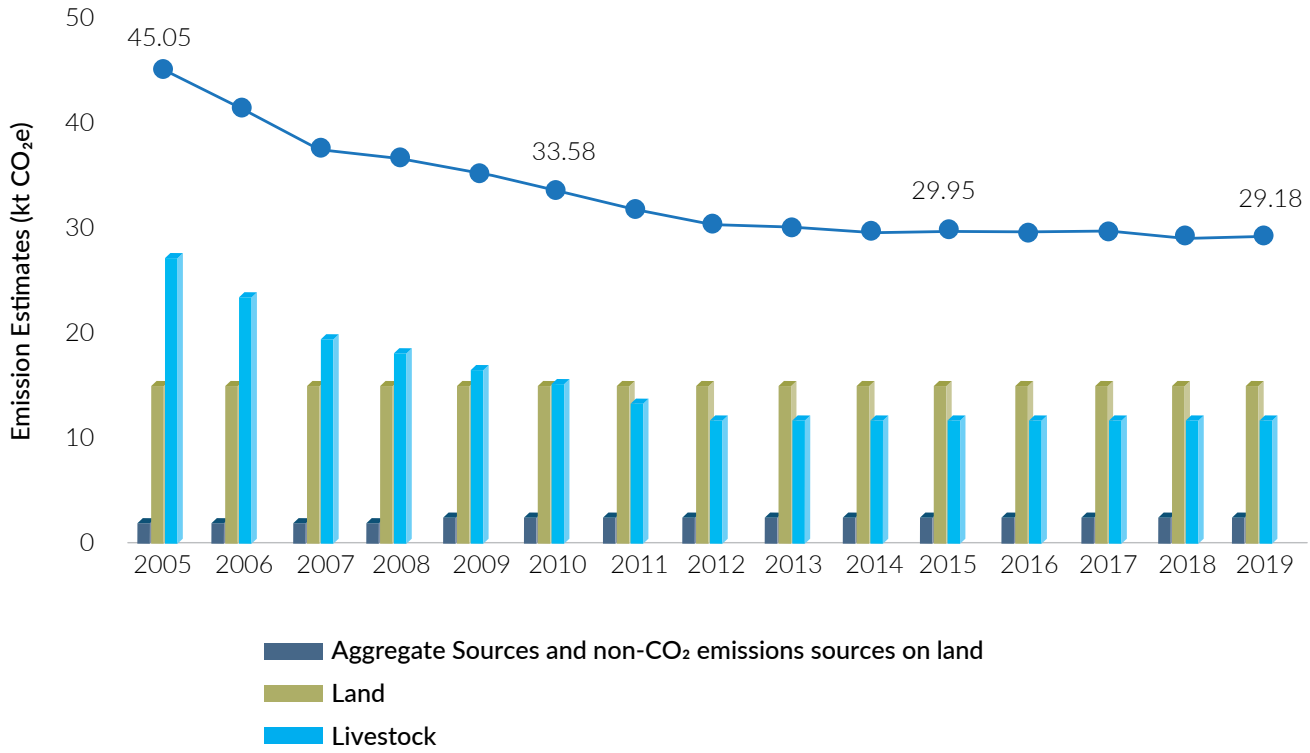


Figure 27: Emissions from AFOLU Sector (2005–2019)

Emissions from the agriculture, forestry, and other land use (AFOLU) sector arise from three main sub-sectors: livestock; land; and aggregate sources and non-CO_2emissions sources on land.

In Srinagar city, all the three sub-sectors were net emitters throughout the reference period. The AFOLU sector contributed to almost ~4% of the economy-wide emissions of Srinagar city in 2019[4]. The emissions from the AFOLU sector declined at a rate of ~3.05% (compounded annually) from 45.05 kt CO_2e in 2005 to 29.18 kt CO_2e in 2019. The decline in the emissions from the AFOLU sector is due to the decrease in emissions from the livestock sub-sector (figure 27).

The livestock sub-sector had a share of ~36% to net AFOLU GHG emissions in Srinagar city in the year 2019. Within the livestock sub-sector, enteric fermentation was a major contributor of emissions. The emissions from this category declined at a rate of ~6.74% (compounded annually) from 25.66 kt CO_2e in 2005 to 9.66 kt CO_2e in 2019.

From the aggregate sources sub-sector, the share of emissions from agricultural soils increased from ~5% in 2005 to ~11% in net AFOLU emissions in 2019, as illustrated in figures 28 and 29.

From the land sub-sector, the share of emissions from forest land in net AFOLU emissions increased from ~34% in 2005 to ~52% in 2019, whereas the share of emissions from settlements marginally increased from ~0.5% in 2005 to ~0.8% in 2019. There was a net sink in other categories (agricultural land, grassland, and other land) from the land sub-sector throughout the reference period.

[4] Note: Emissions from rice cultivation were not estimated due to lack of required data availability. Emissions from biomass burning from cropland and forest fires were not included, as biomass burning in crop land and forest land were not reported in Srinagar city (based on inputs from stakeholder consultations).

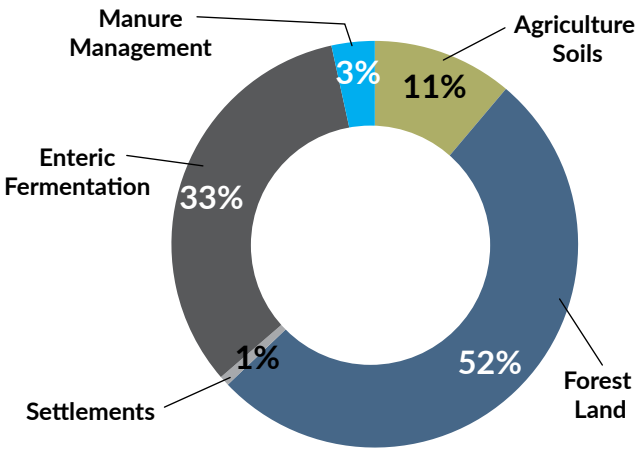


Figure 28: Percentage Share of Categories in Net AFOLU Sector Emissions, 2019

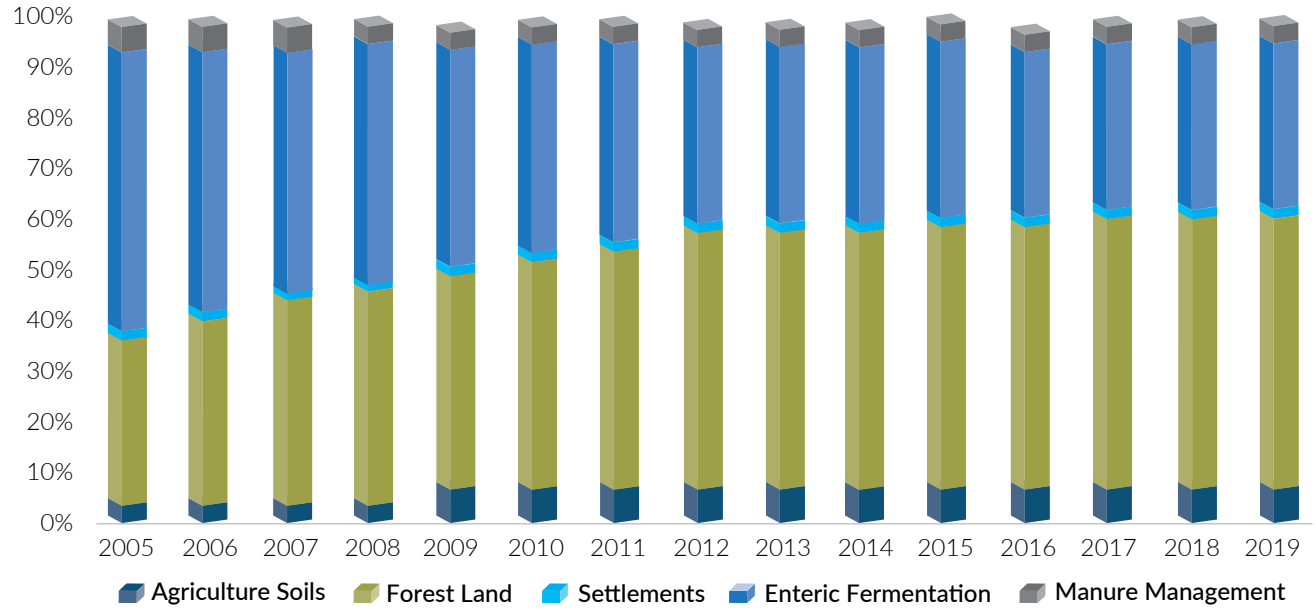


Figure 29: Category-wise Share of Net Emissions in the AFOLU Sector (2005–2019)

4.1.2c. Waste Sector

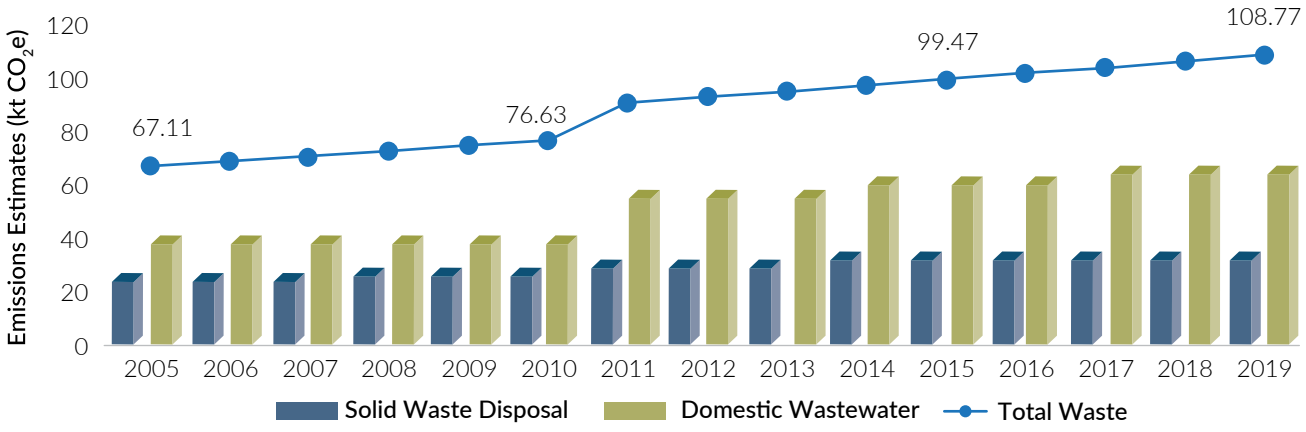


Figure 30: GHG Emission Estimates of Waste Sector (2005–2019)

Solid waste disposal, domestic wastewater, and industrial wastewater are the key sources of GHG emissions from the waste sector[5]. The waste sector contributed to almost 17% of the total emissions of Srinagar city in 2019. GHG emissions from the waste sector of Srinagar city grew at a CAGR of ~3.51% from 67.11 kt CO_2e in 2005 to 108.77 kt CO_2e in 2019, as illustrated in Figure 30. Notably, the waste sector emissions jumped after 2010, which can be attributed to an increase in emissions from the domestic wastewater sub-sector. A sudden jump in total waste sector emissions is seen between 2010 and 2011 due to changes in the degree of utilization (toilet/sewerage system types used), as reported in Census 2011.

Discharge of untreated wastewater and use of septic tanks are the key drivers of emissions due to the domestic wastewater sub-sector. Domestic wastewater had a share of ~64% in the total waste sector emissions of Srinagar city in 2019. Approximately 36% of the waste sector emissions were from solid waste disposal, which grew at an estimated CAGR of ~2.78% from 26.52 kt CO_2e in 2005 to 38.90 kt CO_2e in 2019. (Figure 31).

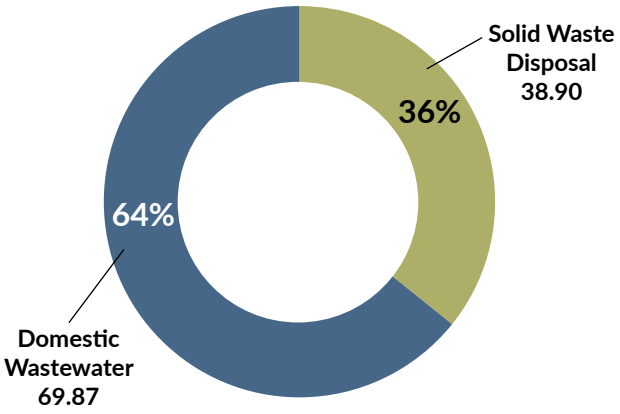


Figure 31 Percentage Share and Emissions Estimates (kt CO_2e) of Sub-Sectors in Total Waste Sector Emissions (2019)

4.1.2d. Economy-wide emissions

Emissions of Srinagar city increased at an estimated CAGR of ~0.96% from 591.67 kilotons of CO_2 equivalent (kt CO_2e) in 2005 to 676.09 kt CO_2e in 2019. As illustrated in Figure 32, the Energy sector was the major contributor of GHG emissions in Srinagar city's total economy-wide emissions across all the reference years, contributing an average of 80% to economy-wide emissions. Emissions from the energy sector increased from 479.51 kt CO_2e in 2005 to 538.14 kt CO_2e in 2019 and emissions from waste sector increased from 67.11 kt CO_2e in 2005 to 108.77 kt CO_2e in 2019. In contrast, emissions from AFOLU sector decreased from 45.05 kt CO_2e to 29.18 ktCO_2e during the reference period[6].

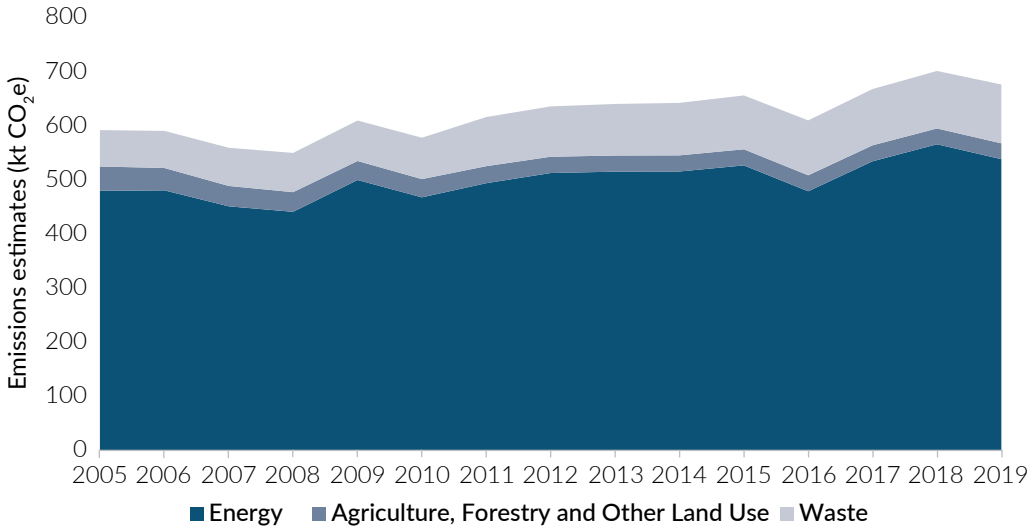


Figure 32: Economy-wide emissions of Srinagar city (2005-2019)

[5] Note: Emissions from industrial wastewater were not estimated because it could not be determined whether industry categories as listed in NATCOM/BUR (that lead to GHG emissions from industrial wastewater) were present in the city.
[6] Note: IPPU is not estimated in the inventory due to limited data available on industries within city limits.

4.1.2e. Sector-wise Contribution (kt CO_2e) and Percentage Share to Economy-wide GHG Emissions of Srinagar City

In 2005, the share of energy sector emissions to the total economy-wide emissions was ~81% . This was followed by waste and agriculture, forestry, and other landuse (AFOLU) sectors with shares of ~11% and ~8% respectively. In 2019, the share of energy sector emissions to the total economy-wide emissions marginally decreased to ~80% . However, the share of waste sector emissions increased to ~16% and that of AFOLU sector decreased to ~4% in 2019 (Figures 33 and 34).

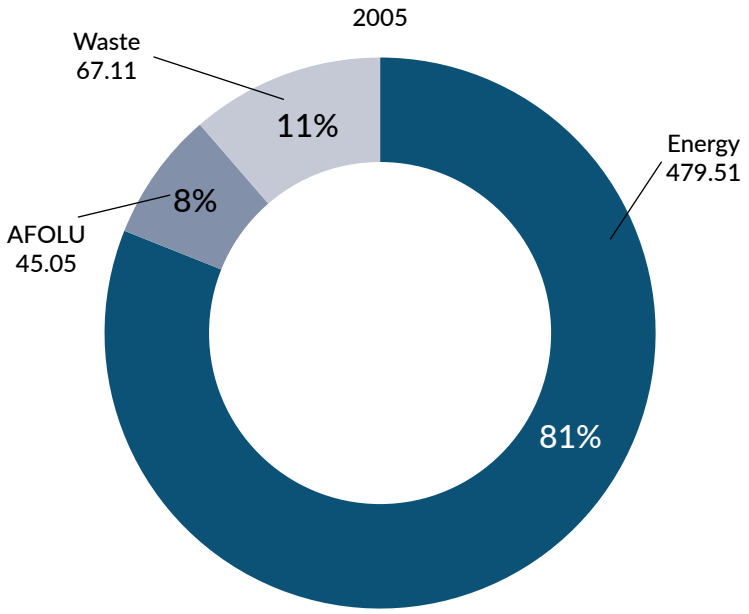


Figure 33: Sector-wise Contribution (kt CO_2e) and Percentage Share to Economy-wide GHG Emissions of Srinagar City, 2005

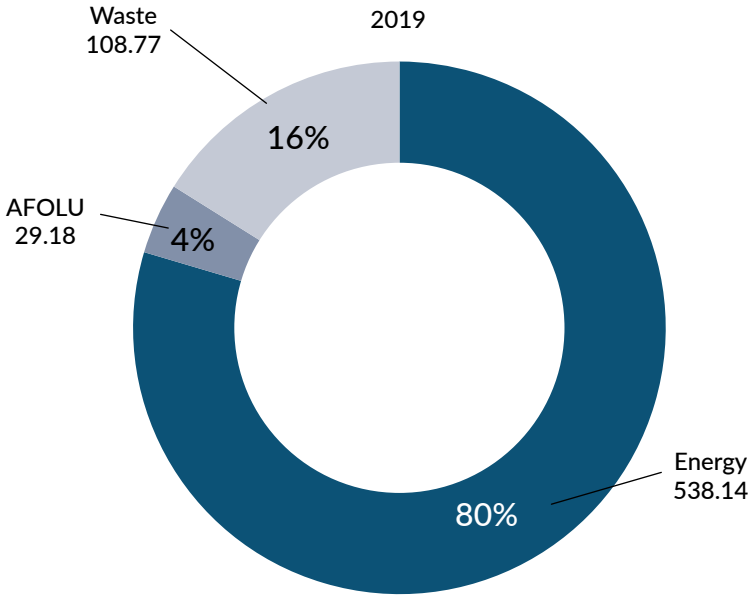


Figure 34: Sector-wise Contribution (kt CO_2e) and Percentage Share to Economy-wide GHG Emissions of Srinagar City, 2019

4.1.2f. Per Capita Emissions of Srinagar City

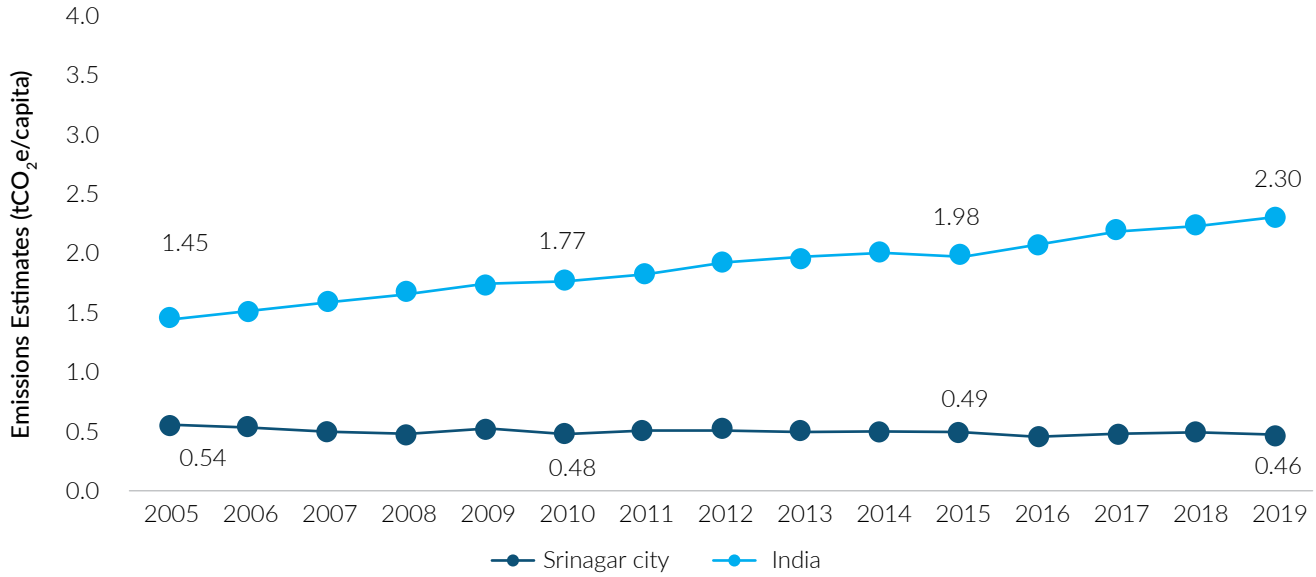


Figure 35: Per Capita GHG Emissions of Srinagar City and India

Despite the increase in the total GHG emissions of Srinagar city, its per capita emissions decreased between 2005 and 2019, with a CAGR of 1.17% from 0.57 t CO_2e/capita in 2005 to 0.48 t CO_2e/capita in 2019. This is because of significant increase in population of the city. Srinagar city's per capita emissions remained significantly low compared to India's per capita emissions throughout the reference period (Figure 35)[7].

4.1.2g Projection 2030

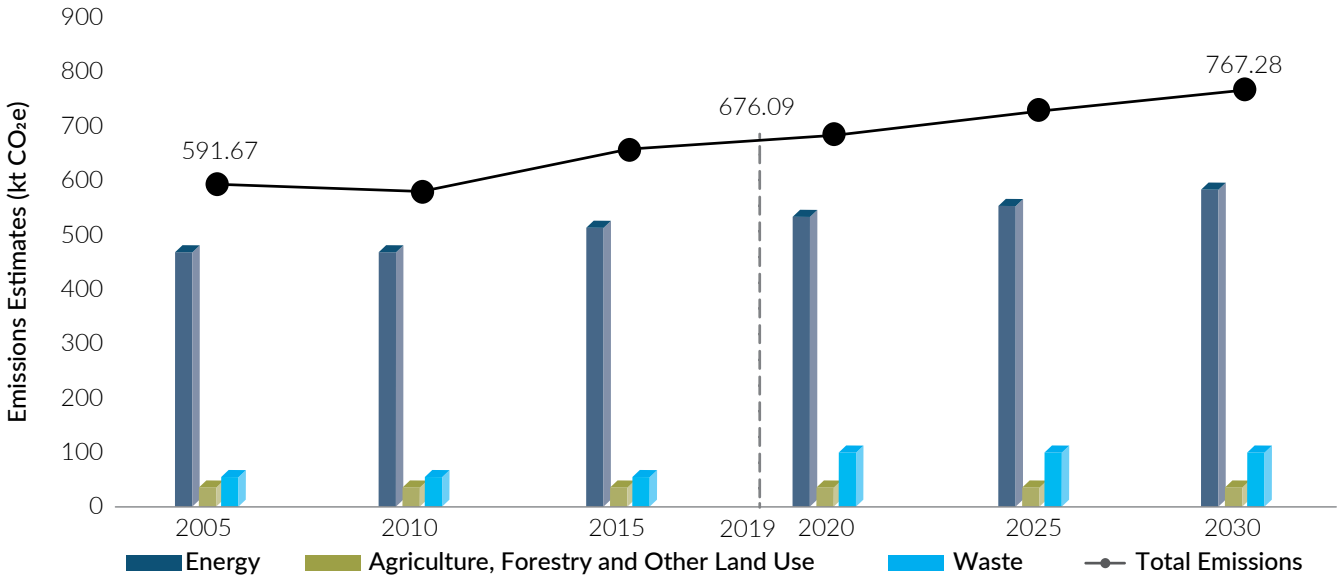


Figure 36: GHG Emissions Projection, 2030

GHG emission projections for Srinagar city from 2020 to 2030 are based on sectoral emissions trends between 2014 and 2019. Under the BAU scenario, the emissions are expected to increase almost ~13% by 2030 from 2019 level. As per the projections, Energy sector will be the key driver of emissions in the city, accounting for ~78% of the total GHG emissions in 2030. The emissions from Waste sector are projected to increase ~30% whereas almost 3.5% decrease in GHG emissions can be observed from AFOLU sector in 2030 from 2019 level (see Figure 36).

[7] Per capita emissions of India for 2019 are calculated using information/data of GHG Platform India.

4.1.2h. Gas-wise Inventory for Srinagar City (2019)

Gas-wise emissions of 2019 from all the categories are summarized in Table 12. This table provides the carbon dioxide equivalent of the emissions from all categories.

Table 12: GHG Inventory for Srinagar City (2019)

Greenhouse Gas Sources Categories[8]	CO_2 Emissions (Tonnes)	CH_4 (Tonnes)	N_2O (Tonnes)	Tonnes CO_2e[9]
Total Gross Emissions	**528788.74**	**NA**	**NA**	**676276.14**
Total Offset	**154.11**	**NA**	**NA**	**154.11**
Total Net Emissions	**528634.63**	**5663.29**	**94.19**	**676122.03**
Energy[10]	**513370.81**	**955.52**	**15.17**	**538140.37**
Transport	317147.49	65.85	14.07	322895.11
Agriculture	40845.71	5.51	0.330	41064.00
Commercial	5725.82	0.64	0.031	5748.96
Residential	131851.52	881.11	0.587	150536.90
Industries	17800.251	2.40	0.144	17895.37
AFOLU	**15232.30**	**494.24**	**11.54**	**29179.14**
Agriculture Soils	NA	NA	10.57	3278.71
Enteric Fermentation	NA	460.07	NA	9661.54
Manure Management	NA	34.17	0.971	1006.59
Agriculture Land	-108.57	NA	NA	-108.57
Settlements	236.61	NA	NA	236.61
Other Land	-45.54	NA	NA	-45.54
Forest Land	15181.32	NA	NA	15181.32
Waste	**NA**	**4183.53**	**67.48**	**108771**
Domestic Wastewater	NA	2331.05	67.48	69869
Solid Waste Management	NA	1852.48	NA	38902

NA – Not Applicable

[8] Global Warming Potential (GWP) AR2 values were used to estimate the CO_2e of CH_4, N_2O, and CO_2.AR2 GWP values are used because India's NATCOM and BUR reports use AR2 GWP figures to estimate national inventory emissions.
[9] Due to decimal rounding off, the total CO_2e (in tonnes) may slightly vary.
[10] Energy emissions pertaining to fuel combustion were estimated.

CHAPTER

5 CLIMATE RESILIENT ACTION PLAN

Chapter 5: Sectoral Plans – Actions & Implementation Strategies

The sectoral action plan focuses on power, energy and habitat sector, sustainable transport, agriculture and green spaces and waste management as the key sectors for Srinagar city. The resilience interventions included in the action plan are informed by the baseline sectoral GHG emissions and identified climate vulnerabilities. Sections 5.1 to 5.4 provide information on sectors that make up the CRCAP of Srinagar.

For each of the sectors, the specific timeframe, priorities (short and medium-long term), entities that are primarily responsible for the implementation and various schemes and programmes that can support the intervention, funding sources, mitigation potential, indicators and measure outcomes are indicated (as shown in figure 37).

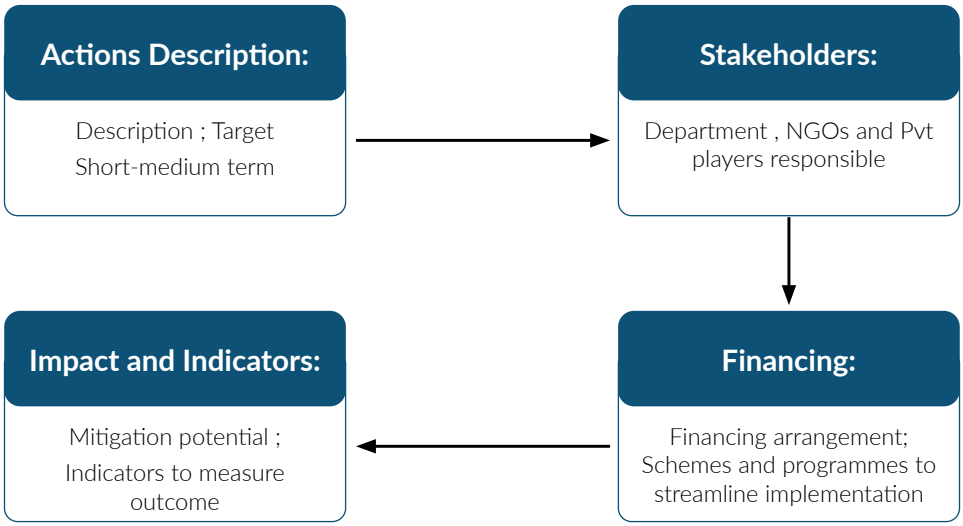


Figure 37: Flow of sectoral action plans

5.1. Power, Energy and Habitat sector: Recommended Actions

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
1.	Scale up Renewable Energy (RE) generation by promoting rooftop and ground mounted installations of solar power plants (SPP) at households, institutions, government buildings, commercial buildings etc in the city. **Target** **Short-medium term** → 50% households in Srinagar if installed with solar rooftop (solar potential of nearly 919 MW) by 2030. → targets for other categories can be set accordingly	Jammu and Kashmir Energy Development Agency (JAKEDA), Jammu and Kashmir Power Development Corporation Limited, Private Institutions	Explore Public-Private-Partnerships to enable solar deployment Incentivize solar rooftop for residential/ institutional uses through additional subsidies over and above the central/ state subsidies. **Schemes and programmes to streamline implementation:** J&K Rooftop Solar Programme, National Solar Mission	**Mitigation Potential:** 106,567 t CO_2e/yr from households alone **Indicators to measure outcome:** Number of installations, capacity addition, grid independence - reduced procurement of electricity from grid

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
2.	Replacing Diesel Gensets in residential/ commercial/ institutional sectors with solar powered or other RE + storage options. **Targets** **Short term** At least 40% of the diesel gensets existing in the city can be targeted to be shifted to RE and RE + storage-based backups by 2030. **Medium-term**, The target can be doubled or 100% conversion can be aimed.	Jammu and Kashmir Energy Development Agency (JAKEDA)	Commercial tax incentives can be offered to existing diesel genset owners willing to make the transition. **Schemes and programmes to streamline implementation:** J&K Rooftop Solar Programme, National Solar Policy	**Mitigation Potential:** 1.34 tCO_2e/yr for each generator replaced. Total mitigation potential can be estimated by setting a target of the number of diesel gensets to replace. **Indicators to measure outcome:** Number of diesel gensets replaced, RE capacity installed, reduction in residential/ commercial diesel consumption
3.	Encourage faster penetration of Street Lighting National Programme (SLNP) and UJALA Scheme (Domestic Efficient Lighting Program). This will ensure all lighting fixtures are replaced with energy- efficient LED bulbs, tube lights and fans at domestic, public buildings and streetlights. Awareness campaigns can encourage faster adoption. **Short Term** These interventions are short to medium terms	Energy Efficiency Services Limited (EESL); Srinagar Municipal Corporation	**Schemes/Programmes to streamline implementation:** Unnat Jyoti by Affordable LEDs Street Lighting National Program (SLNP)	**Mitigation Potential:** LED bulb: 0.15 t CO_2/bulb/ yr LED tubelight: 0.036 tCO_2/ tubelight/yr Fan: 0.076 tCO_2/fan/yr Total mitigation potential can be estimated by setting a target of the number of fixtures to be replaced under this scheme. **Indicators to measure outcomes:** Number of fixtures installed, number of beneficiaries, number of streetlights installed, reduction in sale of incandescent bulbs, CFL bulbs & tubelights
4.	Encouraging adoption of Energy Conservation and Sustainable Building Code (ECSBC) and Indian Green Building Council (IGBC) standards in: **Short-Medium Term** →Ensure deep electrification in residential heating, cooking uses. This will create a pathway for 'net zero energy' consumption buildings →50% of all new commercial and residential buildings with large built-up area (threshold value can be decided through consultations) **Medium-Long Term** →retrofitting existing buildings according to ECBC and IGBC standards	Jammu and Kashmir Energy Development Agency (JAKEDA), J&K Housing and Urban Development Department, ECSBC	Property tax rebates/tax-waivers can be offered to IGBC/ ECSBC compliant buildings.	**Mitigation Potential:** Save 254 kg CO_2e per annum per household (Scenario: a household that consumes 6 cylinders of LPG in a year, shifts to cooking through electricity) Net Zero Buildings can help reduce energy consumption by up to 30% annually. Data needed to estimate this potential is not available. **Indicators to measure outcomes:** number of compliant buildings, reduction in energy demand (reduced use of lighting, cooling, heating etc), reduction in LPG sales, increase in demand for electric cookstoves

5.2. Sustainable Transport: Recommended Actions

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
1.	Promote wide-scale adoption of Electric Vehicles (EV) by increasing share in private passenger vehicles (cars and 2 wheelers), public transport (buses, mini-buses), intermediate public transport (3 wheelers, e-rickshaws), delivery service fleets, vehicle fleets owned by government departments etc: → establish widespread EV charging infrastructure (at strategic locations such as commercial hubs, public parking, airport, railway station etc.) →free/subsidized parking spaces, → toll-free access in selected roads **Targets** **Short Term** For segment-wise EV share,[11] the following targets can be adopted for 2030: i) 30% for E-2W. ii) 70% for E-3W, iii) 30% for E-car MoP targets to be adopted,[12] such as: i) Having at least one charging station in a grid of 3kmx3km., and ii) one charging station to be set up every 25 km on both sides of highways/roads. **Long Term** Charging infrastructure for EVs should be 100% RE powered	Srinagar Municipal Corporation, Kashmir Power Distribution Corporation Limited, Energy Efficiency Services Limited (EESL), J&K Housing and Urban Development Department	Additional UT level subsidies on EV adoption/ registration can be provided. Charging infrastructure could be set up through competitive bidding. Operation of charging units can thus be handed over to private entities on, say, a Build-operate-own-transfer (BOOT) model. **Schemes/ programmes to streamline implementation:** Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME II), Srinagar Smart City mission	Mitigation Potential: Replacing 30% of registered cars in Srinagar city can avoid 1,668 t CO_2e /year For an average run of 22 km per day, 2,100 kgCO_2 /year per bus can be avoided by switching to electric buses Indicators for measuring outcome: increase in sale/ registration of electric vehicles, reduction in ICE vehicle demand, reduction in fuel sales, number of charging points set up by sector (residential, commercial, institutional etc)
2.	Integrating RE for enhancing PT and IPT infrastructure such as bus depots, bus stops, hoardings near bus stops, IPT parking's etc. **Short-Medium Term** By 2030, at least 40% of power usage for the public transport infrastructure can be targeted to be sourced from RE powered systems, including battery storage options.	Jammu and Kashmir Energy Development Agency (JAKEDA), Jammu and Kashmir Transport Department, Srinagar Municipal Corporation, ECSBC	Existing policies/schemes by the MNRE can be tapped into for solar powering public transport infrastructure, where applicable. **Schemes/Programmes to streamline implementation:** J&K Rooftop Solar Programme, National Solar Mission, ECSBC	**Mitigation Potential:** Can be assessed by obtaining the current energy demand for all PT and IPT infrastructure of the city. **Indicators for measuring outcomes:** reduced grid electricity procurement, solar capacity added, number of installations/ PT and IPT infrastructure upgraded across the city.

11 "ELECTRIC VEHICLE CHARGING INFRASTRUCTURE …." https://www.niti.gov.in/sites/default/files/2021-08/HandbookforEVChargingInfrastructureImplementation081221.pdf. Accessed 6 Apr. 2023.
12 "ELECTRIC VEHICLE CHARGING INFRASTRUCTURE …." https://www.niti.gov.in/sites/default/files/2021-08/HandbookforEVChargingInfrastructureImplementation081221.pdf. Accessed 6 Apr. 2023.

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
3	A strong Public transport (PT) and Intermediate Public Transport (IPT) network in the city would discourage use of private vehicles, helping curb GHG emissions and traffic congestion. Strengthening public transport (PT) and intermediate public transport (IPT) in Srinagar city by improving: **Short-Medium Term** i) numbers: national benchmark suggests having 400-600 buses per million inhabitants, the city service level can be compared against this. ii) frequency: based on the needs of the users, the frequency of buses along various routes needs to be optimized to make PT a viable and reliable option for the public. iii) expanding network: to cover maximum area of the city under PT, decreasing interchanges iv) last-mile connectivity: IPT such as tempos, jeeps, autos can ply on routes connecting key areas to PT, to decrease use of personal vehicles to the extent possible. v) introduce low-carbon mobility (electric and other alternate fuels) for PT and IPT	Jammu and Kashmir Energy Development Agency (JAKEDA), Jammu and Kashmir Transport Department, Srinagar Municipal Corporation, ECSBC	A contract model can be followed for a limited (evaluation) period by inviting Expression of Interests (EoI) from agencies interested in operating, say an EV transport fleet. FAME II scheme can be leveraged for increasing the share of Hybrid and EV buses plying in the city. **Schemes/Programmes to streamline implementation:** Srinagar Smart City initiative	**Mitigation Potential:** Shift from private to public transport can save emissions by 30-40% from the transport sector. Accurate mitigation potential requires passenger km traveled, current modal share and target modal share developed according to city needs. **Indicators to measure outcomes:** i) Interchanges free PT options available between two points, ii) reduced complaints/demand for last-mile connectivity iii) improvement in local air quality iv) change in modal share focusing on decrease in registration of private vehicles
4	To increase the share of non-motorized transport in Srinagar city, the following measures can be undertaken: **Short-Medium Term** → Constructing dedicated cycling/ pedestrian only pathways and roads in identified locations →Removing encroachments on existing cycle pathways and footpaths →Ensuring and maintaining well-lit, clean and safe pathways for pedestrians and cyclists →Encourage e-bike/cycle hire services and mobility-as-a-service models in the city. Key locations lacking end-to-end connectivity due to which public transport ridership in the routes are low must be identified. Efforts can be laid to set up shared mobility hubs for cycle/e-bike hiring. At least 40% of the potential locations identified in the city can be targeted for this service implementation in the short term.	Srinagar Municipal Corporation, Roads and Buildings Department	City development funds could be utilized for this purpose. Also, a proposal can be submitted to the Smart City authorities for allocation from the smart city funds. Potential public spots in the city can be identified and opened up for lease options. Agencies interested in offering shared mobility options can be selected based on the quotations submitted. **Schemes/Programmes to streamline implementation:** Srinagar Smart City initiative	**Mitigation potential:** can be estimated from reduction in trips made by vehicles for short distance travel **Indicators for measuring outcomes:** length of cycle/ pedestrian pathways developed,% road length covered by cycle/pedestrian pathways, increase in cycle ownership, increase in number of pedestrians, number of cycle/e-bike hiring kiosks, number of persons availing this service

5.3. Agriculture and Green Spaces: Recommendations Actions

Sr.	Action Description	Stakeholders	Financing	Indicators
1.	Enhancing green cover by increasing trees outside forest and green spaces through measures such as setting up of urban parks, floating gardens etc. **Short-Medium Term** →Developing urban forests through fast growing species/techniques (Miyawaki) →Census of Trees outside Forest for estimating carbon sequestration potential →Setting up a framework to evaluate the economic benefits of ecosystems/ biodiversity.	Jammu and Kashmir Forest Department, J & K Biodiversity Council, J&K Forest Department, Department of Social Forestry	Tapping into existing funds and schemes such as CAMPA and GIM to enable plantation activities. **Schemes and Programmes to streamline actions:** CAMPA, GIM, Updated NDC targets, National Afforestation Programme, J&K Forest Policy, 2011	**Mitigation Potential:** setting a target of increasing area under forest and trees in Srinagar city from 7.96% (19.58 km^2) to 10% (24.60 km^2) i.e. 3% increase by 2030, will contribute to sequestration of 44,616.7 t CO_2e per year. **Indicators for measuring outcomes:** Increase in area under urban forests, success rate of plantation activities undertaken,
2.	Promote Sustainable and Zero Budget Natural Farming by: → Use of non-chemical fertilizers → Subsidizing organic and natural fertilizers, pesticides and weedicides → Establishing agriculture market and or market links to ensure good prices for farmers producing ZBNF/ organic produce. →creating awareness on sustainable and ZBNF methods	Directorate of Agriculture Production and Farmers Welfare- Kashmir, Department of Horticulture, Department of Floriculture, Gardens and Parks	Fiscal incentives can be offered to farmers to transition to sustainable practices. Public Private Partnership, CSR funds can be tapped for the sustainable farming practices. **Schemes and Programmes to streamline actions:** Paramparagat Krishi Vikas Yojana (PKVY), National Mission on Sustainable Agriculture (NMSA), National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY)	**Mitigation Potential:** Replacing 10% of the current use of chemical fertilizers with organic fertilizers can avoid 328 tCO_2e per annum. **Indicators for measuring outcomes:** Reduction in demand of chemical fertilizers like Urea, DAP etc, increase in community composting facilities in/ around agricultural lands

5.4. Waste: Recommended Actions

Sr.	Action Description	Stakeholders	Funding/Financing	Indicators
1.	Minimize landfill waste disposal by: → Promoting 'at source reduction of waste' through product reuse, extending lifetime and right to repair → Ensuring efficient and 100% segregated waste collection from across the city by distributing color coded bins at subsidized prices. → Ensure 100% recycling of recyclables through measures such as a material recycling facility (MRF), refuse derived fuel (RDF), waste to energy (W2E), etc. **Short-Medium Term** → 100% of segregated waste collection from the commercial segment, and at least 50% from the residential segment. This must go hand-in-hand with imposing penalties on i) discarding waste in the open or undesignated areas, and ii) unscientific burning of dry waste, leaves, etc through active monitoring systems. In the short-term, instances of (i) and (ii) could be reduced significantly/ eliminated. **Medium- Long Term** Recycling capacity in the city can be increased, thereby significantly minimizing the waste sent to landfill.	J&K Pollution Control Board, Srinagar Municipal Corporation	Operational expenses for collection of segregated waste from households / commercial sites could be met by levying a fair fee from the beneficiaries based on the type and quantity of waste that is collected. (Example: pricing scale for quantity and organic/ inorganic fraction of waste generated by households and commercial establishments) The city development / smart city funds could be utilized to set up recycling plants or recovery facilities. Revenue recovery options from processed waste such as recycled plastic, RDF etc can be explored. **Schemes / Programmes:** Solid Waste Management Rules, 2016 and Amendment 2018, Swachh Bharat Mission Urban,	**Mitigation Potential:** Extensive amounts of primary data and various fractions (like % of recyclable waste, waste composition) is required to estimate the mitigation potential. **Indicators for measuring outcomes:** increase in % of segregated waste collection, % of waste treated, reduction in % of waste going to landfill, increase in business/ initiatives in the city which utilize recycled materials, reduction in number of non-designated dumping sites across the city
2.	Establish composting facilities to prevent loss of carbon content in long route organic waste transport, The compost generated can be utilized in corporation or development authority owned parks, gardens and nurseries and also be sold as a product to generate revenue. **Short-Medium Term** Centralized composting of 100% organic waste collected **Medium-Long Term** Promoting decentralized / community level composting facilities.			**Mitigation Potential:** If 100% compostable waste is composted, the Srinagar city can avoid 7828 t CO_2e per annum. **Indicators:** increase in number of community composting facilities, reduced % of compostable waste sent to landfills,

Sr.	Action Description	Stakeholders	Funding/Financing	Indicators
3.	100% domestic wastewater treatment can be achieved through following measures: → Shift domestic wastewater treatment (STP) to aerobic set ups by having only aerobic STPs for new constructions and transitioning the old anaerobic STPs to aerobic setup. → Operation and regular maintenance of sludge removal facilities of all STPs. The sludge can be used again for the bio-methanation of compost. **Short-Medium Term** → 100% treatment of collected domestic wastewater; with 40% aerobic treatment → Build infrastructure for ensuring 100% domestic wastewater collection **Long Term** Ensure 100% wastewater collection + 100% treatment; 70% aerobic treatment and 30% anaerobic treatment with methane capture and management	J&K Pollution Control Board, Srinagar Municipal Corporation, Srinagar Smart Cities Limited, Srinagar Development Authority, Jal Shakti Department	Encourage public-private-partnership to improve the Domestic Septage Treatment through innovative and affordable technologies. Department funds such as those allocated to Jal Shakti Department, Municipal Corporation, Development Authority and Smart Cities Mission can be utilized in addition to support from the state/central government. **Schemes:** Integrated Low-Cost Sanitation Scheme (ILCS), Swachh Bharat Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Pradhan Mantri Awas Yojana (PMAY)	**Mitigation Potential:** Extensive amounts of primary data and various fractions (like degree of utilization, status of STPs, coverage of sewage system, etc) is required to estimate the mitigation potential. **Indicators:** Reduced % of wastewater being discharged to water bodies, enhancement in capture and use of methane,

CHAPTER

6 CONCLUSION

In the face of rising global temperatures and more frequent extreme weather events over recent decades, the Government of Jammu and Kashmir has intensified its focus on mitigating climate change and increasing the climate resilience of the city of Srinagar. The city has a distinct character full of natural resources and scenic beauty, that needs to be in preserved and maintained. While preserving its biodiversity, it is essential to focus on the city's GHG emission and future climate vulnerabilities Srinagar city's future climate under SSP-245 scenario suggests the accumulated rainfall is projected to increase by 55 mm/yr in near future and by 85 mm/yr in far future. In SSP-585 scenario the accumulated rainfall is projected to increase by 87 mm/yr and 225 mm/yr in near and far future respectively. Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 1.22°C and 1.25°C respectively. In far future, under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.51°C and 2.48°C respectively. Under SSP-585 scenario in near-future the maximum and minimum temperature are projected to increase by 1.42°C and 1.47°C respectively while as the upsurge is on higher end by 4.30°C and 4.51° C in far-future.

The Department of Ecology, Environment and Remote Sensing, Government of Jammu and Kashmir, in association with the United Nations Development Programme (UNDP) have prepared this Climate Resilient City Action Plan (CRCAP) for Srinagar City. The initiative to develop CRCAP's in India started in 2009 as a part of the National Action Plan on Climate Change (NAPCC). The Government of India launched the NAPCC to address climate change issues in various sectors such as agriculture, forestry, and energy. Under the NAPCC, the Ministry of Environment, Forest, and Climate Change (MoEFCC) developed guidelines for preparing CRCAP's in urban areas. The CRCAP is a roadmap outlining the city's mitigation-adaptation strategies and actions to tackle this pressing global and local crisis. The CRCAP aids the local government of Srinagar City in estimating greenhouse gas emissions, identifying vulnerability hotspots, understanding critical infrastructure systems with respect to resilience, and developing specific climate change mitigation and adaptation plans while promoting sustainable development. The CRCAP builds on policies and plans developed at city, and ward levels with the goals at global (SDGs) level .The CRCAP- Srinagar envisions a city where its communities and citizens are safer, healthier, and thrive even in a changing and uncertain climate. The CRCAP is committed to a net zero and climate-resilient Srinagar by 2050. This means ensuring just transitions – towards net zero pathways; significant investments– towards inclusive and transformative climate solutions; and coordinated and robust governance – to ensure a targets-based approach.

The city of Srinagar is regarded as a multi-hazard-prone area, considering its vulnerability to floods, fire accidents, earthquakes, landslides, and forest fires. The climate risks were analyzed by performing a vulnerability assessment that looked into the city's vulnerabilities, w.r.t. these climate-induced disasters.. The analysis showed that 74.05sq km (30.18%) of municipal area is exposed to floods with water depth ranging from 0.66 m to 2.15 m. The assets that were exposed to floods were estimated to be 23 per cent of substations (power sector), 27 per cent of mobile towers (Telecommunication sector), 18 per cent of sewerage network and 27.6 per cent of road network are exposed leading to CIs at risk and other critical infrastructure such as health, schools, water, solid waste management and fire stations (the assets at risk are plotted on maps). lative ward-level assessment was also performed, According to the cumulative composite assessment, the most vulnerable ward is 53, Buchpora, with 2 per cent of the total population. To reduce these vulnerabilities, future growth strategies to facilitate a low impact development in these locations needs to be incorporated. along with a climate resilient and low carbon growth strategy to ensure minimum exposure to the people.

While considering the climatic and GHG emissions trends, adaptation strategies need to be undertaken with detailed vulnerability assessments to reduce weather events' impacts. To accomplish the same, energy sector emissions were estimated for fuel combustion from transport, industries, agriculture, commercial, and residential categories. It was found that emissions from the energy sector increased at CAGR of ~0.84% from 456.51 kt CO_2e in 2005 to 513.37 kt CO_2e in 2019 The energy emissions of Srinagar city accounted for ~80% of the economy-wide emissions in 2019. Within the energy sector, transport category was the major contributor to the GHG emissions with a share of ~62% in the total energy emissions in 2019. This was followed by residential and agriculture categories with shares of ~26% and ~8% , respectively. It was thus found that the emissions of Srinagar city increased at an estimated CAGR of ~0.96% from 591.67 kilotons of CO-2 equivalent (kt CO_2e in 2005 to 676.09 kt CO_2e in 2019 with the Energy sector was the major contributor of GHG emissions in Srinagar city's total economy-wide emissions across all the reference years, contributing an average of 80% to economy-wide emissions. Emissions from the energy sector increased from 479.51 kt CO_2e in 2005 to 538.14 kt CO_2e in 2019 and emissions from waste sector increased from 67.11 kt CO_2e in 2005 to 108.77 kt CO_2e in 2019. In contrast, emissions from AFOLU sector decreased from 45.05 kt CO_2e to 29.18 kt CO_2e during the same.

In order to mitigate GHG emission and reduce the climate risks, by 2050, the city aims to achieve its overarching goals of being carbon-neutral, through net-zero emissions and resilience as per the Paris Agreement and Sustainable Development Goals (SDGs). Further, the sectoral action plan focuses on power, energy and habitat sector, sustainable transport, agriculture and green spaces and waste management. The resilience interventions included in the action plan are informed by the baseline sectoral GHG emissions and identified climate vulnerabilities. The power, energy and habitat have approx. mitigation potential of 106,567 t CO_2e/yr from households alone, 1.34 t CO_2e /yr for each generator replaced, LED bulb: 0.15 t CO_2/bulb/yr ; LED tubelight: 0.036 tCO_2/ tubelight/yr; Fan: 0.076 t CO2 /fan/yr. Save 254 kg CO_2e per annum per household (Scenario: a household that consumes 6 cylinders of LPG in a year, Shifts to cooking through electricity). The sustainable transport has approx. mitigation potential of Replacing 30% of registered cars in Srinagar city can avoid 1,668 t CO_2e /year; For an average run of 22 km per day, 2100 kgCO_2 /year per bus can be avoided by switching to electric buses; Shift from private to public transport can save emissions by 30-40% from transport sector. Accurate mitigation potential requires passenger km travelled, current modal share and target modal share developed according to city needs; The agriculture and green spaces has mitigation potential with increasing area under forest and trees in Srinagar city 44,616.7 t CO_2e under forest and trees; Replacing 10% of the current use of chemical fertilizers with organic fertilizers can avoid 328 t CO_2e per annum. In the solid waste sector 100% compostable waste is composted, the Srinagar city can avoid 7828 t CO_2e per annum.

The success of CRCAP is dependent on the residents of Srinagar as their participation would be significant in creating resilient human settlements, implementing hazard vulnerability adaptation strategies to develop resilient infrastructure thereby enhancing their health and overall wellbeing. The citizens adopting sustainable choices in their daily lives will help achieve the CRCAP targets. The collaboratively developed vision and objectives in the CRCAP will provide tangible opportunities for the government/ municipality, civil society groups and private investors to be involved in improving the city, and city gatherings provide an opportunity to reflect, refocus, and make commitments of action towards this vision while aiming towards the success of Srinagar's first-ever climate-resilient action plan.

CHAPTER

7 REFERENCES

References

1. RMSI. (2018). J&K Data inventory Report.
2. Census. (2011). Retrieved from https://censusindia.gov.in
3. IPCC -AR6. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability . Retrieved from https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf
4. RMSI. (2014). Hazard Risk and Vulnerability Analysis (HRVA) of the City of Bhubaneswar (Odisha) . Retrieved from https://cms.bhubaneswarone.in/uploadDocuments/content/Bhubaneswar_Final_Report.pdf
5. Lokinder, S., Hardev, S., & Sanjay, S. (2020, August 19). Managing Natural Resources and Environmental Challenges in the Face of Urban Sprawl in Indian Himalayan City of Jammu.
6. Midhat Fayaz, S. R. (2022). Earthquake Vulnerability Assessment of the Built Environment in Srinagar City, Kashmir Himalaya, Using GIS.
7. Qureshi, A. (2022). Retrieved from https://news.abplive.com/
8. Srinagar Master Plan, 2035. (n.d.). Master Plan 2035, Srinagar Metropolitan Region.
9. Census of India. (2011).
10. Dailyexcelsior. (2022, May 06). Retrieved from https://www.dailyexcelsior.com/jammu-becomes-9th-srinagar-10th-smart-city-in-india-to-have-biodiversity-index/
11. Bukhari, S. (2014, September 11). Retrieved from BBC: https://www.bbc.com/news/world-asia-india-29137791
12. CLEI. (2022). Framework Document for Srinagar City Climate Action Plan

CHAPTER

8 ANNEXURES

8.1. Glossary

AFOLU: Agriculture, Forest and Other Land Use

Biological Oxygen Demand (B.O.D.): The amount of oxygen required by bacteria in decomposing organic matter under aerobic condition at 20°C for 5 days or 27°C for 3 days

CAGR: Compound Annual Growth Rate is calculated by the taking the nth root of the years in the period being considered

Carbon Dioxide or CO_2: A naturally occurring greenhouse gas. It is also emitted by combustion of fossil fuels and biomass, as well as land use changes and other industrial processes. Other GHGs are measured with reference to CO_2 , and therefore CO_2 has a Global Warming Potential of 1.

CO2 Equivalent: It is the sum total of all Greenhouse Gases in terms of their global warming potential. In this document the CO equivalent includes the sum of Carbon dioxide, Methane multiplied by its GWP (21) and Nitrous oxide multiplied by its GWP (310)

Country Specific data (CS): Data for either activities or emissions that are based on research carried out on-site either in a country or in a representative country

Default (D): Default emission factor/value as listed in IPCC

Decomposition: Decomposition or rotting is the process by which tissues of a dead organism break down into simpler forms of matter

Degradable Organic Carbon (DOC): It is the carbon content of paper and textiles; garden-park waste and other(non-food) putrescibles; food waste; and other organic biodegradable waste

Emission Factor: A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factor are often based on a sample of measurement data averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions

Emissions: The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and a period of time

Emission Intensity: Emission intensity is the average emission rate of a given pollutant from a given source relative to the intensity of a specific activity ; for example grams of carbon dioxide released per mega joule of energy produced, or the ratio of greenhouse gas emissions produced to GDP or total population

Energy: This category includes all GHG emissions arising from combustion of fossil fuel and fugitive release of GHGs. Emissions from the non-energy use are not included here and are reported under the industry sector

Enteric Fermentation: Methane is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animal's digestive system ferment the feed consumed by the animal.

Greenhouse Gases: Greenhouse gases are gases in an atmosphere that absorb and emit radiation within the thermal infrared range

Global temperature potential (GTP): The ratio between the global mean surface temperature change at a given future time horizon (TH) following an emission (pulse or sustained) of a compound x relative to a reference gas r (e.g., CO_2)

Global warming potential (GWP): The ratio of the time-integrated radiative forcing from the instantaneous release of 1 kg of a trace substance relative to that of 1 kg of a reference gas (IPCC, I990)

Key Categories: This concept is used to identify the categories that have a significant influence on a region's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals

Landfill: A method for final disposal of solid waste on land. The refuse is spread and compacted and a cover of soil applied so that effects on the environment (including public health and safety) are minimized

Manure: The term 'manure' is used collectively to include both dung and urine (i.e., the solids and the liquids) produced by livestock

Net Emissions: A total of GHG emissions from source categories adjusted by/including removals by sinks

Nitrous Oxide or NO_2: One of the six greenhouse gases to be mitigated under the Kyoto Protocol. Its emission is mainly caused by burning fossil fuels and manufacturing of fertilizer. It has a Global Warming Potential of 310 times that of CO_2.

Removals: Removal of greenhouse gases and or their precursors from the atmosphere by a sink

Tiers: A tier represents a level of methodological complexity. The Tier 1 method involves using default emissions factors or use of country specific emission factors with activity data which has been derived, while the Tier 2 method involves using country-specific information to calculate the emissions factors.

8.2. AFOLU sector methodology

1. 3A Livestock

1.1. 3A1 Enteric Fermentation

1.1.1 Category description

Enteric Fermentation, resulting in emissions of CH_4, arises out of the process of ingesting and digesting of food eaten by herbivores, primarily bovines and ovine. However, other animals such as camels, horses and mules etc. also emit small amounts of CH_4.

Methane emissions from Enteric Fermentation have been calculated using methodology prescribed in 2019 IPCC Refinement to 2006 IPCC Guidelines for National GHG Inventories. CO_2 emissions from livestock are not estimated because annual net CO_2 emissions are assumed to be zero – the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2 (Chapter 10, Volume 4, IPCC 2019). Similarly, as no nitrogen is released during the process of digestion in livestock, no nitrous oxide (N_2O) emissions are reported.

1.1.2. Methodology

Tier I methodology has been used for major methane emitting categories (i.e. bovines) and Tier I methodology has been used where country specific emission factors were not available.

The following steps were performed for emission estimation from enteric fermentation:

Step 1: Emission Factor

Methane emission factors for the livestock categories have been sourced from NATCOM II and IPCC 2019. Table A1 below provides emission factors for each sub-group:

Table A1: Emission factor of each sub-group in terms of kilograms of methane per animal per year

Category	Sub-category	Age group	Methane emission factor ($kgCH_4$/head/year)	Source
Indigenous Cattle	Dairy cattle	Indigenous	28.00	NATCOM II
	Non-dairy cattle (indigenous)	0-1 year	9.00	NATCOM II
		1-3 year	23.00	NATCOM II
		Adult	32.00	NATCOM II
Cross-bred cattle	Dairy cattle	Cross-bred	43.00	NATCOM II
	Non-dairy cattle (cross-bred)	0-1 year	11.00	NATCOM II
		1-3 year	26.00	NATCOM II
		Adult	33.00	NATCOM II

Buffalo	Dairy buffalo		50.00	NATCOM II
	Non-dairy buffalo	0-1 year	8.00	NATCOM II
		1-3 year	22.00	NATCOM II
		Adult	44.00	NATCOM II
Horses & Ponies			18.00	IPCC
Pigs			1.00	IPCC
Poultry			0.00	IPCC

Step 2: Emission Estimation

Emissions from the process of enteric fermentation are calculated by multiplying the selected emissions factors with the associated animal population (IPCC equation 10.19) and summed using IPCC equation 10.20 given below:

$$Emissions = EF_{(T)} \cdot \left(\frac{N_{(T)}}{10^6}\right)$$

Where,

Emissions = methane emissions from Enteric Fermentation, Gg CH_4 yr^{-1}

$EF_{(T)}$ = emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1}

$N_{(T)}$ = the number of head of livestock species/category T in the country

T = species/category of livestock

$$Total\ CH_{4_{Enteric}} = \sum_i E_i$$

Where,

Total $CH_{4Enteric}$ = total methane emissions from Enteric Fermentation, Gg CH_4 yr^{-1}

E_i = Emissions for the i^{th} livestock categories and subcategories

1.2. Manure Management

1.2.1 Category description

Manure management emissions arise from the process of animal manure decomposition. In general, emissions vary depending on the type of decomposition – aerobic or anaerobic. If manure is decomposed naturally i.e., aerobically, little or no emissions are produced. However, if manure is treated anaerobically, higher emissions are observed.

Manure management results in CH_4 and N_2O emissions. CO_2 emissions from livestock are not estimated because annual net CO_2 emissions are assumed to be zero – the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2 (Chapter 10, Volume 4, IPCC 2019).

1.2.2. Methodology

Methane emissions from manure management have been calculated using the methodology provided in the 2019 IPCC Refinement to 2006 IPCC Guidelines for National GHG Inventories.

The following steps were performed for estimating **CH_4 emission** due to manure management:

Step 1: Emission Factor Estimation

Methane emission factors for the livestock categories have been sourced from NATCOM II and IPCC 2019. The Table A2 mentioned below provides emission factors for each sub-group:

Table A2: Emission factor of each sub-group in terms of kilograms of methane per animal per year

Category	Sub-category	Age group	Methane emission factor ($kgCH_4$/head/year)	Source
Indigenous Cattle	Dairy cattle	Indigenous	3.50	NATCOM II
	Non-dairy cattle (indigenous)	0-2 year	1.20	NATCOM II
		1-3 year	2.80	NATCOM II
		Adult	2.90	NATCOM II
Cross-bred cattle	Dairy cattle	Cross-bred	3.80	NATCOM II
	Non-dairy cattle (cross-bred)	0-1 year	1.10	NATCOM II
		1-3 year	2.30	NATCOM II
		Adult	2.50	NATCOM II
Buffalo	Dairy buffalo		4.40	NATCOM II
	Non-dairy buffalo	0-1 year	1.80	NATCOM II
		1-3 year	3.40	NATCOM II
		Adult	4.00	NATCOM II
Horses & Ponies			2.19	IPCC
Pigs			4.00	IPCC
Poultry			0.00	IPCC

Step 2: Emissions Estimation

Emissions from the process of manure management are calculated by multiplying the selected emissions factors with the associated animal population (IPCC equation 10.22) as given below:

$$CH_{4_{Manure}} = \sum_{(T)} \frac{\left(EF_{(T)} \cdot N_{(T)}\right)}{10^6}$$

Where,

$CH_{4Manure}$ = methane emissions from Manure Management, Gg CH_4 yr^{-1}

$EF_{(T)}$ = emission factor for the defined livestock population, kg CH_4 head-1 yr^{-1}

$N_{(T)}$ = the number of head of livestock species/category T in the country

T = species/category of livestock

Step 3: Emissions from all livestock categories are added to get total methane emissions from manure management.

The following steps were performed for estimating **N_2O emission** due to manure management:

Step 1: Emission Factor

For calculating nitrogen excretion, IPCC values[13] were used for estimating nitrogen excretion, per animal. The values adopted were:

Dairy cattle - 60 kg N/ animal/ year

Non-dairy cattle - 40 kg N/ animal/ year

Pigs - 16 kg N/ animal/ year

Poultry - 0.6 kg N/ animal/ year

The following nitrogen emission factors were used as per IPCC:

[13] IPCC 2006 Guidelines, Chapter 10, Table 10.19, summarized from IPCC 1996 Guidelines, Chapter 4, Table B1, http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref8.pdf

Table A3: Nitrogen Emission Factors

Category of Livestock	Nitrogen emissions per animal (kg N_2O/head/year)
Dairy cattle	0.0006
Non-dairy cattle	0.0004
Pigs	0.0074
Poultry	0.0025

Step 2: Emissions Estimation

Total emissions were determined by multiplying the number of animals in each category with emission factor. Nitrogen emissions from manure management were calculated using the equation in step 3.

N_2O emissions were calculated in the following manner:

IPCC equation 10.25[14] that was used was the following:

$$N_2O_{animals} = N_2O_{AWMS} = \sum [N_T \cdot N_{ex(T)} \cdot AWMS_T \cdot EF_{3(AWMS)}] \cdot \frac{44}{28}$$

Where,

$N_2O_{animals}$ = N_2O emissions from animal production in a country (kg N/yr)

$N_2O_{AW\ MS}$ = N_2O emissions from Animal Waste Management System in the country (kg N/yr);

N_T = number of animals of type T in the country

$N_{ex(T)}$ = N excretion of animals of type T in the country (kg N/animal/yr)

$AWMS_T$ = fraction of $N_{ex(T)}$ that is managed in one of the different distinguished animal waste management systems for animals of type T in the country

$EF_{3(AWMS)}$ = N_2O emission factor for an AWMS (kg N_2O -N/ kg of in AWMS)

T = type of animal category

44/28 = conversion of (N_2O-N) emissions to N_2O emissions

Step 3: Emissions from all categories are aggregated and total emission expressed as Gg N2O/ year.

Emissions (Gg/ Year) = EF (kg/ head/ year) x population/ 10^6 kg/ Gg.

2. 3B Land

In this section, the category descriptions and the common methodology applied to estimate emissions from the following land use categories has been described

2.1 Category descriptions

2.1.1. 3B1 Forestland

Emissions originate from Forestland due to changes in biomass, dead organic matter and soil organic matter on Forest Land and Land converted to Forest Land. For GHG estimation from Forestland in India, the Stock-Difference Method is applied along with country specific estimates of activity data and emission factors, in-line with the choice of method in Volume 4, Chapter 4, 2019 IPCC Guidelines.

[14] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf - page 10.53

2.1.2. 3B2Cropland

Cropland includes arable and tillable land, rice fields and agroforestry systems where the vegetation structure falls below thresholds used for Forest Land. The amount of carbon stored in and emitted or removed from permanent cropland depends on crop type, management practices and soil & climate variable. Annual crops (cereals, vegetable) are harvested each year, so there is no long-term storage of carbon in biomass and hence, not accounted. GHGs from Cropland are estimated from perennial woody vegetation in orchards, vineyards and agroforestry systems and soil. Carbon stored in biomass, depends on species type and cultivar, density, growth rates, harvesting and pruning practices (Volume 4, Chapter 5, 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories).

2.1.3. 3B5 Settlements

Settlements are defined as including all developed land i.e., residential, transportation, commercial, and production (commercial, manufacturing) infrastructure of any size, unless it is already included under other land-use categories. The land-use category Settlements includes soils, herbaceous perennial vegetation such as turf grass and garden plants, trees in rural settlements, homestead gardens and urban areas. Soils and DOM in Settlements may be sources or sinks of CO_2, depending on previous land use, topsoil burial or removal during development, current management, particularly with respect to nutrient and water applications, and amount of vegetation cover spread among roads, buildings and associated infrastructure (Volume 4, Chapter 8, 2019 Refinement to 2006 IPCC Guidelines for National GHG Inventories).

2.1.4. 3B6 Other Lands

The sub-category 'other lands' includes wasteland, snow covered area, rocky surfaces, water bodies, etc.

Methodology

Inter-annual climatic variability is a crucial factor for consideration when estimating emissions from Land sub-sector. Substantial changes in standing biomass can occur from year to year that is associated with differences in annual rainfall or water availability. Inter-annual rainfall variability may also affect land management decisions such as irrigation or fertilizer application (Volume 4, Chapter 5, 2006 IPCC Guidelines for national GHG inventories) and thereby affecting emission estimates.

Steps followed

Step 1:

Emission estimation for various categories under Land sub-sector is done for Land Remaining Land category and Land Converted to other Land Use was not considered as activity data was not available for the same. This study uses the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories to estimate emissions from these categories. The steps followed in the estimation process for both the categories remain same with the only difference arising in choice/estimation of emission factors

The activity data, in the form of Land Use Change for the years 2005 to 2013 was obtained from Khalid Omar Murtaza, M. A. (2015). Geospatial mapping of Srinagar city. *Journal of Geography and Regional Planning*.

Step 2:

Change in Biomass Carbon stock in Land: Carbon stock change in Land remaining Land is estimated by taking the biomass change factor derived from BUR III (0.045 tC/ha/yr).

Step 3:

The total biomass carbon content for each land use category is calculated by multiplying the area within that land use sub-category with the respective change in biomass carbon for that particular sub-category.

3.1. Estimation of Emissions from Agricultural Soils, including from:

3C4 Direct N_2O emissions from managed soils and

3C5 Indirect N_2O emissions from Managed Soils

3.1.1. Category description

A portion of nitrogenous fertilisers applied in agricultural soils are lost into the atmosphere through direct emissions of N_2O through nitrification and denitrification. In addition, there are also indirect emissions of N_2O through volatilization losses, leaching and runoffs.

3.2. Methodology

Step 1:

Data on total N consumption for years 2007-08 to 2014-15 in the erstwhile J&K state was taken from Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt of India. For year 2004-05 to 2006-07 and 2015-16 the interpolation and extrapolation techniques were used using the CAGR of the above-mentioned period. The month wise data in the erstwhile J&K state on the actual sale[15] of urea was obtained from the annual report 'Indian Fertilizer Scenario' published by the Department of Fertilizers, Ministry of Chemicals and Fertilizers Government of India which was then added up to obtain the annual sales. For calculating the quantity of Nitrogen in Urea, the total urea consumption was multiplied by 46 percent as urea contains 46% Nitrogen[16]. So, N consumed by other fertilizers was found by subtracting the N consumed in urea from the total N consumption.

Step 2:

A factor for the fertilizer used per unit agriculture area in the state was derived for each year of the study period. This factor was then applied to the city-level agriculture area to estimate total N consumption in Srinagar city.

Step 3:

For the calculation of the nitrogen loss from volatilization of NH_3 and NO_x, a magnitude of 15 percent per kg of urea and other fertilizers was considered instead of IPCC fraction of 10 percent as most Indian soils are low in acidity and high in average temperature therefore resulting in more volatilization losses. The fraction of N lost through leaching is 10 percent of N applied to the soil. It should be noted that the above-mentioned factors have been sourced from BUR-II[17]

Step 4:

The default IPCC emission factor for N_2O emission for atmospheric NH_3 and NO_x is 1 percent; however, considering characteristics of Indian soils, 0.5 percent emission factor was used for N2O from volatilized N. Similarly, emission factor used for deposited N from leaching and runoff was 0.5 percent as stated in BUR-II[18].

[15] It was assumed that the sales were equal to the consumption of urea.
[16] Refer Table 5 http://fert.nic.in/sites/default/files/Full%20Book.pdf
[17] Refer Table 2.11 https://unfccc.int/sites/default/files/resource/INDIA%20SECOND%20BUR%20High%20Res.pdf.
[18] Refer Table 2.11 https://unfccc.int/sites/default/files/resource/INDIA%20SECOND%20BUR%20High%20Res.pdf `

8.3. Energy sector methodology

1. 1A Fuel Combustion

1.1. 1A3 Transport

A. Category description

Transport sector emissions are reported under four different modes: road transportation, railways, civil aviation, and water-borne navigation. For Srinagar city, road and aviation transport emissions have been accounted for in this exercise. Emissions from various fuels (diesel, petrol and ATF) have been estimated separately.

B. Methodology

To calculate emissions from the transport sector, the 2019 Refinement to the IPCC 2006 Guidelines for National Greenhouse Gas Inventories was used. According to this, emissions are a product of the activity data of fuel type and its corresponding emission factor, as represented in Equation 1. Table B1 presents the emission factors used. The calorific value and density of fuels have been sourced from the Indian Network on Climate Change Assessment (INCCA) (MoEFCC, 2010) and from the Ministry of Petroleum and Natural Gas (MoPNG, 2017).

$$Emissions_{Gas} = Activity\ Data_{Fuel}\ X\ NCV_{Fuel}\ X\ Emission\ Factor_{Gas} \quad \text{[Equation 1]}$$

The methodology for estimating emissions from the energy sector is consistent with a Tier I approaches specified by IPCC. Similarly, for calculating the CH_4 and N_2O emissions, the same equations for each fuel have been considered.

Step 1: Emission Factor

The emission factors for CO_2 and the specific emission factors with respect to road transportation for CH_4 and N_2O are given in detail in the table below:

Table B1: Net Calorific Values and Emission Factors used in the transport sector

Fuel type	Net Calorific Value (NCV) & CO_2 Emission Factor (MoEFCC, 2010)		Emission Factors - Road Transportation (IPCC, 2006)	
	NCV	CO_2 EF	CH_4 EF	N_2O EF
	TJ/kt	t/TJ	kg/TJ	kg/TJ
Diesel	43.00	74.10	3.90	3.90
Gasoline/Motor Spirit	44.30	69.30	33.00	3.20
ATF	44.10	70.00	0.50	2.00
Kerosene	43.80	71.90	10.00	0.60

Step 2: Emission Estimation

- Total fuel consumed in Srinagar district was obtained from PPAC for the years 2006-2019. For 2005, the fuel consumption was estimated using CAGR.
- Based on the fraction of population in Srinagar city vs the district and expert inputs, it was assumed that 90% of the total district fuel consumption can be attributed to Srinagar city (Census 2011).
- The share of diesel consumed in road transport was obtained from the PPAC, findings from Nielsen study (PPAC, 2013) - 63.3% was applied to the total diesel consumed in the city.
- The share of petrol consumed in road transport was also obtained from the PPAC, findings from Nielsen study (PPAC, 2013) - 100% was applied to the total petrol consumed.
- 100% of ATF consumed was considered to estimate the emissions from aviation
- Emissions from fuel consumption were estimated using Equation 1 and added for each fuel

1.2. 1A4 Other sectors

A. Category description

Other sectors include energy consuming activities in residential, commercial, and agricultural sectors. The activity data for this sector represents the fuel consumption used for specific applications such as cooking, lighting, heating, use of small (< 1 MW) Diesel Generator (DG) sets, drying of field produce, operation of tractors, diesel pump-sets, and other farm implements.

Tier I approach was applied for emission calculations in this sub-sector.

B. Methodology

The main source of activity data was PPAC, which gave the total annual fuel consumed in Srinagar district. The fuel types covered in this analysis include diesel, petrol and LPG.

1A4a Residential Sector

- The fuels considered under the residential sector are LPG, diesel and kerosene
- Fuel consumption in diesel sets was estimated based on data obtained from the PPAC, findings from Nielsen study (PPAC, 2013) – 3.35% applied to the total diesel consumed in the city.
- The share of LPG fuel consumption in Residential sub-sector was obtained based on GHG Platform India estimations for the erstwhile state of Jammu and Kashmir (GHGPI, 2022) – 97% applied to the total LPG consumed in the city.
- 100% of Kerosene used was attributed to Residential sector based on expert inputs.

1A4b Commercial Sector

- Diesel annual activity data was calculated using data on total diesel consumption, which was obtained from PPAC.
- The diesel consumption (commercial) was calculated from the information in PPAC's Nielsen report (PPAC, 2013). A weighted average of zonal share was used – 1.82% on the total diesel consumption in the city.
- The share of LPG fuel consumption in Commercial sub-sector was obtained based on GHG Platform India estimations for the erstwhile state of Jammu and Kashmir (GHGPI, 2022) – 3% applied to the total LPG consumed in the city.

1A4c Agriculture

Diesel (HSDO and LDO)

- According to the study conducted by Nielson for PPAC, the share of diesel consumed by tractors, agricultural pump sets and implements was 21.96% (Nielsen, 2013). This percentage share of diesel (retails) consumed in the agriculture sector was used to calculate the total diesel consumed in the agriculture sub-sector in Srinagar city.

8.4. Waste Sector Methodology

1.4A Solid Waste Disposal

1.1. 4A2 Unmanaged Waste Disposal Sites

A. Category Description

When solid waste is disposed of in landfills or in dumpsites and in the presence of anaerobic conditions, methanogenic bacteria break-down the degradable organic component in the waste, releasing CH_4 emissions. Decomposition of the organic content occurs slowly and the CH_4 emissions from a given mass of solid waste deposited continue to be released over a time period spanning a few decades.

This assessment covers the disposal of municipal solid waste in the city of Srinagar Municipal solid waste is generally defined as waste collected by local municipal governments or other local authorities, typically including residential, commercial and institutional waste, street sweepings, and garden and park waste in either solid or semi-solid form (excluding industrial, hazardous, bio- medical and e-waste). Industrial waste and other waste such as clinical waste and hazardous waste are not considered in the emission estimation, given the lack of reliable information for these waste streams and in accordance with India's Second National Communication and BUR reports.

B. Methodology

Tier 1 estimation methodology was used for this sub-sector following the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The urban population of Srinagar city was sourced from Framework Document for Srinagar city Climate Action Plan. This population was used to project population estimates for the years 1951 to 2019.

The following equations were used to estimate emissions due to solid waste in Srinagar city.

CH_4 EMISSION FROM SOLID WASTE DISPOSAL SITES

$$CH_4 \text{ Emissions} = [\square \ CH_4 \text{ generated}T - R_T] * (1 - OX_T)$$

Where,

CH_4 Emissions = CH_4 emitted in year T, Gg

T = inventory year

X = waste category or type/material

RT = recovered CH_4 in year T, Gg (default value of 0, IPCC)

OX_T = oxidation factor in year T, (fraction) (default value of 0, IPCC)

The amount of CH_4 formed from decomposable material is found by multiplying the CH_4 fraction in generated landfill gas and the CH_4 /C molecular weight ratio (16/12).

CH_4 GENERATED FROM DECAYED DDOCm

$$CH_4 \text{ generated}_T = DDOCm_{decompT} * F * 16/12$$

Where,

CH_4generated$_T$ = amount of CH_4 generated from decomposable material

DDOCm,$_{decompT}$ = Decomposable Degradable Organic Carbon (DDOCm) decomposed in year T, Gg

F = fraction of CH_4, by volume, in generated landfill gas (fraction) (default value of 0.5) (IPCC)

16/12 = molecular weight ratio CH_4/C (ratio)

The basis for the calculation is the amount of DDOCm. DDOCm is the part of the organic carbon that will degrade under the anaerobic conditions in the solid waste disposal site.

It equals the product of the mass of waste deposited (W) for the city, the fraction of degradable organic carbon in the waste (DOC), the fraction of the degradable organic carbon that decomposes under anaerobic conditions (DOCf), and the part of the waste that will decompose under aerobic conditions (prior to the conditions becoming anaerobic) in the solid waste disposal site, which is interpreted with the methane correction factor (MCF).

DECOMPOSABLE DOC FROM WASTE DISPOSAL DATA

$DDOC_m = W * DOC * DOC_f * MCF$

Where,

$DDOC_m$ = mass of decomposable DOC deposited,

Gg W = mass of waste deposited for the state, Gg

DOC = degradable organic carbon for the respective state in the year of deposition, fraction, Gg C/Gg waste

DOC_f = fraction of DOC that can decompose (fraction) (Default value of 0.5) (IPCC)

MCF = CH_4 correction factor for aerobic decomposition in the year of deposition (fraction) (default value of 0.4) (IPCC)

The DOC in bulk waste is estimated based on the composition of waste and can be calculated from a weighted average of the degradable carbon content of various components (waste types/material) of the waste stream. The following equation estimates DOC using default carbon content values:

ESTIMATED DOC USING DEFAULT CARBON CONTENT VALUES

$DOC = \Sigma(DOCi * Wi)i$

Where,

DOC = fraction of degradable organic carbon in bulk waste,

Gg C/Gg waste DOCi = fraction of degradable organic carbon in waste type i

Wi = fraction of waste type i by waste category

The default DOC values for various fractions in MSW are given in the table below. Since plastics, glass and metals do not contain degradable organic carbon they have DOC value as zero.

Table C1: Default DOC content of different MSW components

MSW component	DOC content in % of wet waste	DOC content in % of dry waste
Paper/cardboard	40	44
Textiles	24	30
Food waste	15	38
Wood	43	50
Garden and Park waste	20	49
Nappies	24	60

Source: IPCC Guidelines, Vol. 5, Chapter 2, Table 2.5

With a first order reaction, the amount of product is always proportional to the amount of reactive material. This means that the year in which the waste material was deposited in the disposal site is irrelevant to the amount of CH_4 generated each year. It is only the total mass of decomposing material currently in the site that matters.

DDOCm ACCUMULATED IN THE SWDS AT THE END OF YEAR T

$DDOCma_T = DDOCmd_T + (DDOCma_{T-1} \times e^{-k})$

DDOCm DECOMPOSED AT THE END OF YEAR T

$DDOCmdecomp_T = DDOCma_T - 1 \times (1 - e-k)$

Where,

T	= inventory year
$DDOCma_T$	= DDOCm accumulated in the SWDS at the end of year T, Gg
$DDOCma_{T-1}$	= DDOCm accumulated in the SWDS at the end of year (T-1), Gg
$DDOCmd_T$	= DDOCm deposited into the SWDS in year T, Gg
$DDOCm,decomp_T$	= DDOCm decomposed in the SWDS in year T, Gg
k	= reaction constant,
k	= $\ln(2)/t1_{/2}$ (y-1) = 0.17 (IPCC)
$t_{1/2}$	= half-life time (y) (IPCC)

2. 4D Wastewater Treatment and Discharge

2.1 4 D1 Domestic Wastewater Treatment and Discharge

A. Category Description

Domestic wastewater includes human sewage mixed with other household wastewater, which can include effluent from shower drains, sink drains, washing machines, etc. This source category refers to CH_4 and N_2O emissions generated due to the treatment and discharge of domestic wastewater. CH_4 emissions are generated from domestic wastewater on its treatment (on site through septic tanks, connected by sewer network to a centralized treatment plant) or untreated disposal via an outfall under anaerobic conditions (IPCC, 2019). The extent of CH_4 emission from wastewater depends primarily on the quantity of degradable organic material in the wastewater, the volume of wastewater generated, and the type of treatment system used

B. Methodology

Table C2: Type of Emission Factor and Level of Methodological Tier adopted for Domestic Wastewater Treatment and Discharge State-level Estimates

IPCC ID	GHG source & sink categories	CH_4		N_2O	
		Method Applied	Emission Factor	Method Applied	Emission Factor
4D1	Domestic wastewater treatment and discharge	T1	D	T1	D

Notes: T1: Tier 1; CS: Country-specific; D: IPCC default

CH_4 Emissions from Domestic Wastewater Treatment and Discharge

Calculation of CH_4 emission from treatment of domestic wastewater is largely based on the city population and the degree of utilization of the treatment system or discharge pathways relevant to urban residents. The total organics in wastewater determine the quantum of CH_4 emissions.

As per the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the following equation is used to estimate CH_4 emissions from domestic wastewater treatment and discharge.

$$CH_4 Emissions = \sum_{i,j}[(U_i \times T_i \times EF_j)](TOW - S) - R$$

Where,

CH_4 Emissions = Methane emissions in inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr (default value of 0) (IPCC)[57]

U_i = fraction of population in income group i in inventory year

$T_{i,j}$ = degree of utilization of treatment/discharge pathway or system, j, for each income group Fraction i in inventory year

i = income group: rural, urban residents for the respective state

j = each treatment/discharge pathway or system

EF_j = emission factor, kg CH_4 / kg BOD

R = amount of CH_4 recovered in inventory year, kg CH_4/yr (default value of 0) (IPCC)[58]

The emission factor EFj is applicable for the various type treatment systems or discharge pathways based on the corresponding MCF as per IPCC (Table C3). It is a function of the maximum CH4 producing potential (Bo) and the methane correction factor (MCF) for the wastewater treatment and discharge system (IPCC, 2019). The MCF indicates the extent to which the CH_4 producing capacity (Bo) is realized in each type of treatment and discharge pathway and system.

$$CH_4 \text{ Emission Factor } EF_j = B_O \text{ X } MCF_j$$

Where,

EF_j = emission factor, kg CH_4/kg BOD

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD (Default value 0.6) (IPCC)

MCF_j = methane correction factor (fraction)

The default MCF values for different types of domestic wastewater treatment and discharge pathways as available in the IPCC guidelines.

Table C3: Default MCF values by treatment type and discharge pathway

Type of treatment and discharge pathway or system	Description	MCF
Untreated system		
Sea, river and lake discharge	Rivers with high organic loadings can turn anaerobic	0.1
Stagnant sewer	Open and warm	0.5
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc.)	0
Treated system		
Centralized, aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.	0
Centralized, aerobic treatment plant	Not well managed. Overloaded.	0.3
Anaerobic digester for sludge	CH_4 recovery is not considered here.	0.8
Anaerobic reactor	CH_4 recovery is not considered here.	0.8
Anaerobic shallow lagoon	Depth less than 2 meters, use expert judgment	0.2
Anaerobic deep lagoon	Depth more than 2 meters	0.8

Type of treatment and discharge pathway or system	Description	MCF
Septic system	Half of BOD settles in anaerobic tank	0.5
Latrine	Dry climate, ground water table lower than latrine, small family (3-5 persons)	0.1
Latrine	Dry climate, ground water table lower than latrine, communal (many users)	0.5
Latrine	Wet climate/flush water use, ground water table higher than latrine	0.7
Latrine	Regular sediment removal for fertilizer	0.1

Source: IPCC Guidelines, Vol. 5, Chapter 6; Table 6.3

A key parameter for this source category is the total amount of organically degradable material in the wastewater (TOW). This parameter is a function of human population and Biochemical Oxygen Demand (BOD)[61] content of wastewater generated per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year).

The equation for TOW in domestic wastewater is

*TOW = P * BOX * 0.001 * I * 365*

Where,

TOW = total organics in wastewater in inventory year, kg BOD/yr

P = population in inventory year, (person)

BOD = state-specific per capita BOD in inventory year, g/person/day,

0.001 = conversion from grams BOD to kg BOD

I = correction factor for additional industrial BOD discharged into sewers

8.5. Ward-level Vulnerability Methodology

Methodology of calculating vulnerability indices : An aggregate composite score with equal weights of all four dimensions (NVI, SVI, EVI, PVI) are estimated to gather the information of composite vulnerability indices of the wards. The high CVI indices shows wards most vulnerable to hazards. The indicators for the assessment of each four dimension are in terms of exposure, sensitivity and adaptive capacity.

The indexing framework assumes that all the indicators are equally important for inducing vulnerability of the wards in the city. During the aggregation phase these indicators were normalized and added to obtain the arithmetic mean. Data ranges and scales used will be different among the indicators and in order to compare and perform arithmetical operations on them, they would be normalized (Gómez-Limón & Sanchez-Fernandez, 2010) during their integration into aggregate vulnerability index within a dimensionless range (0–1).

All the exposure and sensitive indicators are normalized with the formula/equation 1 :

$$Zi = \frac{Xi - Xmin}{Xmax - Xmin} \quad (1)$$

Zi = Normalised value

Xi = Actual Value

Xmin = Minimum value of total values

Xmax = Maximum value of total values

And all the adaptive capacity indicators parameters are normalized with the below formula, which is actually inversely proportional to vulnerability :

$$Zi = \frac{Xmax - Xi}{Xmax - Xmin} \quad (2)$$

Exposure indicators : Exposure indicators / maps derived from the flood modelling wherein the extend of flooding is

considered for flood exposure. The Exposure index is calculated using following algorithm.

$$Ei = \frac{\sum Xie}{\sum Xi \sum Xie} \quad (3)$$

where Ei refers to exposure index, ∑ Xi = sum of variables of exposure indicators; ∑Xie = total number of variables.

Sensitivity indicators : Sensitivity concerns with the extent to which the wards are affected by hazards. Sensitivity reflects the degree of tolerance in a social structure, population attributes, SC/ST, work force participation, poor roof. material Sensitivity index executed by:

$$Si = \frac{\sum Xis}{\sum Xi \sum Xis} \quad (4)$$

where Si refers to Sensitivity index; ∑ Xi = sum of variables of Sensitivity indicators; ∑Xis = total number of variables.

Adaptive Indicators : Adaptation has been used as nature and human adjustment to climate induced changes. It corresponds to the potentiality of people to adapt exposed event. The indicators include- drainage network, literacy, access to information etc. The adaptation index formula:

$$Ai = \frac{\sum Xia}{\sum Xi \sum Xia} \quad (5)$$

where Ai refers to Adaptive index, ∑Xi= sum of variables of Adaptive indicators; ∑Xia = total number of variables.

Vulnerability Index : The Vulnerability index for each of the four dimensions in this study is determined as the positive function of Ei and Si, but negative function of Ai following Li et al. (2015), as under :

$$Vulnearbility\ Index = \frac{Ei*Si}{Ai} \quad (6)$$

For each of the four dimensions (Natural, Physical, Social and Economic) of vulnerabilities the Vulnerability indexes are calculated known as NVI (Natural Vulnerability Index), SVI (Social Vulnerability Index), EVI (Economic Vulnerability Index), PVI (Physical Vulnerability Index).

Composite Vulnerability Index (CVI) : It is the combination of NVI, SVI, EVI and PVI indices, where we have allotted equal weights for the CVI calculations.

8.6. Composite vulnerability indices

Table 13: Composite Vulnerability Index – Srinagar

Wards	NVI	SVI	EVI	PVI	CVI
1	0.13	0.03	0.12	0.08	0.09
2	0.03	0.13	0.08	0.00	0.06
3	0.04	0.05	0.05	0.02	0.04
4	0.02	0.02	0.03	0.00	0.02
5	0.03	0.01	0.06	0.01	0.03
6	0.02	0.06	0.05	0.07	0.05
7	0.02	0.03	0.05	0.02	0.03
8	0.51	0.18	0.44	1.00	0.53
9	0.19	0.07	0.23	0.01	0.12
10	0.02	0.09	0.09	-	0.05
11	0.13	0.04	0.27	0.24	0.17
12	0.03	0.03	1.00	0.03	0.27
13	0.30	0.43	0.28	0.29	0.33
14	0.54	0.58	0.42	0.27	0.45
15	0.15	0.14	0.18	0.15	0.16
16	0.12	0.10	0.22	0.03	0.12
17	0.69	0.12	0.40	1.00	0.55
18	0.19	0.13	0.20	0.01	0.13
19	0.40	0.06	0.07	0.34	0.21
20	0.59	0.05	0.30	0.20	0.29
21	0.60	0.28	0.48	0.03	0.35
22	0.70	0.17	0.34	0.61	0.46
23	0.04	0.09	0.14	0.01	0.07
24	0.02	0.04	1.00	0.00	0.27
25	0.10	1.00	0.29	0.01	0.35
26	0.01	1.00	0.03	0.00	0.26
27	0.01	0.03	0.00	-	0.01
28	0.02	0.02	0.01	0.01	0.01
29	0.02	0.06	0.03	0.04	0.03
30	0.05	1.00	0.11	0.00	0.29
31	0.03	1.00	-	0.01	0.26
32	0.40	0.15	0.20	0.53	0.32
33	-	1.00	0.15	0.00	0.29
34	0.00	1.00	0.00	0.01	0.25
35	0.10	1.00	0.18	0.03	0.33
36	0.02	0.09	0.06	0.09	0.06

Wards	NVI	SVI	EVI	PVI	CVI
37	0.07	0.07	0.05	0.02	0.05
38	0.47	0.09	0.31	0.03	0.23
39	0.01	1.00	0.11	1.00	0.53
40	0.12	0.20	0.12	0.09	0.13
41	0.07	0.17	0.15	0.15	0.13
42	0.05	0.05	0.07	0.01	0.05
43	0.03	0.14	0.01	1.00	0.29
44	0.00	0.00	0.00	0.00	0.00
45	0.06	0.05	0.05	0.02	0.04
46	0.47	0.09	0.10	0.06	0.18
47	0.11	0.03	0.11	0.01	0.06
48	0.01	0.04	1.00	0.01	0.26
49	0.34	0.05	0.22	0.11	0.18
50	0.13	0.04	0.15	0.02	0.08
51	0.22	0.02	1.00	0.06	0.32
52	0.01	0.01	0.02	0.01	0.01
53	1.00	0.02	1.00	0.11	0.91
54	0.10	0.00	0.09	0.08	0.07
55	0.03	0.01	0.12	-	0.04
56	0.15	0.11	0.14	0.01	0.10
57	0.32	0.02	0.35	0.48	0.29
58	0.06	-	0.08	0.02	0.04
59	0.09	0.00	0.11	0.02	0.06
60	0.01	0.00	0.00	0.00	0.00
61	-	-	-	-	-
62	0.83	0.00	0.35	0.32	0.38
63	0.61	0.01	0.39	0.05	0.26
64	0.55	0.01	0.44	0.04	0.26
65	0.40	0.00	0.15	0.41	0.24
66	0.03	1.00	1.00	-	0.51
67	0.02	0.07	0.09	0.02	0.05
68	0.01	0.01	0.03	0.00	0.01
69	0.13	0.03	0.12	0.08	0.09
70	0.03	0.13	0.08	0.00	0.06
71	0.04	0.05	0.05	0.02	0.04

Vulnerability Index values: Low range- 0 to 0.33 (Green); Medium range (> 0.33 to 0.66) (Blue); High value range (>0.66 to 1) (Orange)


SEA HAWK

221, Ground Floor, Okhla Phase III, New Delhi 110020 (India)
+91 11 41580116/17 www.taru.co.in | info@taru.co.in