DRAFT

Asian Cities Climate Change Resilience Network (ACCCRN)

Shimla: Climate Resilience Strategy

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1. Climate research

1.1 Climate change and climate change adaptation

Although climate change occurs naturally over relatively long periods of time, the global climate is now changing at a much more rapid rate primarily as a result of anthropogenic emissions of greenhouse gases (GHG). In the past two decades or so, global efforts have been stepped up to curb the sources of GHG emissions and enhance the sinks of GHGs through international dialogues and agreements, national policies and programs, as well as actions at the local level. These efforts are critical in controlling and reducing the levels of GHGs in the atmosphere. However, with the levels of GHGs that are already present in the atmosphere, changes in climatic patterns are taking place with impacts at the local level. Therefore, alongside mitigation initiatives, adaptation to climate change needs to be undertaken to safeguard the interests and well being of local communities, especially the poor and vulnerable.

There is inter-dependency between adaptation and mitigation, which emphasizes the need to undertake both these measures simultaneously. In order to cope with the impacts of climate change caused by increased concentrations of GHGs in the atmosphere local governments and communities have to identify potential threats and adapt to them. Further, the development pathways that they choose for the growth of their cities have to balance their socio-economic needs with the global responsibility of reducing emissions (mitigation actions) while securing the well being of their citizens against potential climate events (adaptation). The idea therefore is to identify interventions that provide multiple benefits (co-benefits), including reduced emissions and increased adaptive capacities.

1.2 Climate change impacts on cities

Cities, being the engines of economic growth, are a very critical part of our system. Climate change poses several threats on the ecosystems and cities being such vital parts of the world are also affected.

The world is urbanizing rapidly, and with this urbanization there is increased consumption and ecological degradation across the globe. The cities face multi dimensional pressure of rapid economic growth, grossly inadequate infrastructure, social amenities and the disturbances due to climate change. Hence, urban populations are vulnerable to climate change.

Climate adaptation is needed in cities primarily because of the following:

- Climate change adaptation ensures the functionality of urban systems in changing climate scenarios and their corresponding impacts
- Adaptation does not only address the risks associated with climate change impacts in the future but also reduces risks associated with current climate variability
- Climate change adaptation improves disaster risk management practices for instance early warning systems and evacuation plans developed for areas currently prone and/or likely to be prone to floods or storm surges will significantly help in reducing damages and loss of assets and lives
- Climate change adaptation ensures sustainability of development trajectories
- Climate change adaptation safeguards current and future well-being of all social groups as well as investments in infrastructure

Climate impacts and vulnerabilities hinder the process of development. The cross-sectoral and inclusive characteristics of climate change adaptation helps counter these impacts and supports sustainable development by reducing vulnerabilities, enhancing adaptive capacities and helping in securing investments.

This Climate Resilience Strategy document aims to address these issues and build the resilience of the city against the changing climate. This strategy has been developed in association with ICLEI South Asia and Oceania with support from the Rockefeller Foundation under the Replication and Dissemination phase of ACCCRN. Under ACCCRN the partners have been working to develop climate change resilience strategies for the cities and implement them. The project also focuses on reaching out to other cities, and contributes to knowledge and experience sharing.

1.3 Objectives of the development of Climate Resilience Strategy

The primary objectives of the development of the Climate Resilience Strategy for Shimla includes:

1. Assessment of past and future climatic trends to determine possible climatic impacts that could be faced by the city.
2. Assessment of risks to identified fragile urban systems that could be impacted by climate change
3. Assessment of vulnerability of fragile urban systems and vulnerable population of the city
4. Identification of resilience strategies to overcome the impacts of climate change on the fragile urban systems.
5. Serve as a guiding document for the city to introduce the concepts of climate change to urban planning and development.

1.4 Methodology of the assessment

The ICLEI ACCCRN Process (IAP) has been used to develop the Climate Resilience Strategy for Shimla. The methodology has been developed by ICLEI by drawing from the experiences of the previous phase of ACCCRN and other ICLEI methodologies to ease the process of resilience planning for local governments.

IAP consists of phases where each phase comprises of a series of steps which have been developed in the form of tools. The whole process is iterative in nature with increased detail in each iteration.

Engagement: Phase 1 begins with gaining political support in the city. This is important in order to carry out the project activities in the city. This is followed by a scoping exercise which helps in gaining insight about the various city services and the problems faced by the city. Further, a climate core team involving of the key officials from the city government is formed. The climate core team is responsible for the execution of project activities in the city. A stakeholder group is formed from the citizens of the city with representatives from various relevant institutions and organisations of the city. The climate core team then forms a communication plan for the city highlighting the key messages to be conveyed to the public and the ways for doing so.

Climate Research and Impact Assessment: A shared learning dialogue with the stakeholder group is organised. This interaction aims to have a mutual learning and sharing of experiences from the city. Further an assessment of the past climatic trends and future climatic projections is conducted. This assessment can be conducted with the help of local university or research institution or any pre existing assessment can be consulted. In the absence of either of the two any significant regional or national level assessment may be consulted. Further the fragile urban systems of the city are indentified. The reasons for the fragility of these urban systems are determined and the impact of the anticipated climatic changes on these already fragile urban systems is estimated. Later a risk assessment is conducted in order to prioritise these urban systems in terms of their likelihood to be impacted by the changing climate and the consequence of these impacts.

Vulnerabilities Assessment: This phase helps in indentifying the key vulnerabilities of the each fragile urban system. It determines the spatial vulnerability of the city for each fragile urban system. It also identifies the vulnerable population and the potential supporting actors for each system. This information is gathered in consultation with the stakeholder group through shared learning dialogue.

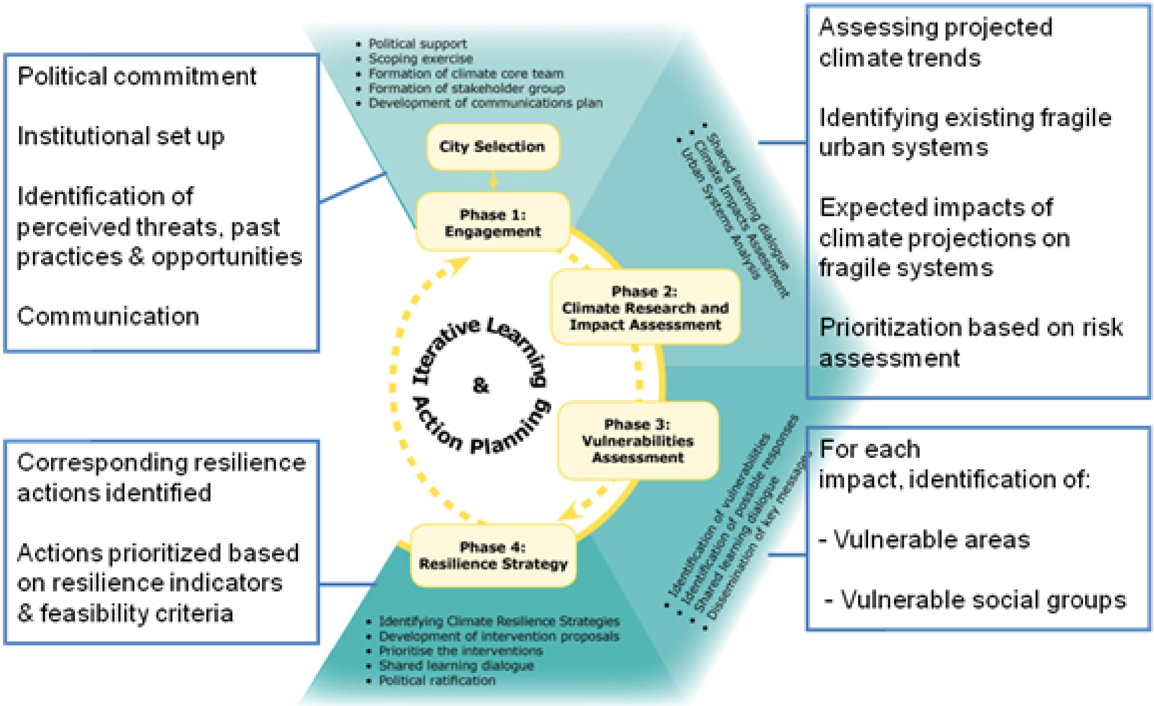


Figure 1: ICLEI ACCCRN Process

Resilience Strategy: The relevant resilience interventions for the city are identified. These interventions re prioritised on the basis of their feasibility and applicability to the city. The resilience strategy is then developed and is ratified through political support.

Implementation and Monitoring & Review: After identifying the resilience interventions for the city, concrete project implementation plans can be prepared. Opportunities for financing and implementing these projects need to be explored. These projects can then be implemented and further monitored and reviewed.

2. City profile

Shimla is the capital town of Himachal Pradesh in Northern India. It is located in the lap of lesser Himlayan range. It is also known as the 'Queen of Hills'. This name was given to Shimla by the British who used to retire to Shimla during the summers. During the British rule Shimla was known as the summer capital of the country. It still continues to be a summer relief for the whole country and is one the most famous tourist destination of Himachal Pradesh. The picturesque mountains of Shimla make it a must travel destination and brings solace to many during the summers to escape the heat of the plains. Shimla can be called 'a Wonder of Colonial Era'. The British established many architectural masterpieces such as Vice Regal Lodge, Gorton Castle, Railway Board Building, Gaiety Theatre, Town Hall, Auckland House, Ellerglie, Barnes Court, Bungalows, Churches and Challet Day School.

Location and Geography

The town of Shimla is built over several hills and connecting ridges. It is situated in the North-West Himalayas. The city occupies and area of 19.99 sq. km[1]. It is located at an altitude of 2,205 m in the lower Himalayan range between 31°06' North and 77°13' East. Jhakhoo hill is the most elevated spur of Shimla. The city has been divided into 25 wards. It is a Zone IV (High Damage Risk Zone) as per the Earthquake hazard zoning of India. In Shimla the sediments eroded from Himalyas 30 million years ago have been deposited. The shape of the city is said to be an irregular crescent[2] (City Disaster Management Plan, Shimla). The city is connected by rail, road and air with the rest of the country. Shimla district is covered by the catchment area of the rivers Sutlej, Pabbar and Giri. The district drains itself into these rivers. The Sutlej is the principal river of the district for water supply, which is about 21 km from the city. Shimla is covered by the thick forest of pine, rhododendron and oak.

Climate

Shimla has a sub tropical highland type of climate. The temperature in peak winters falls below 0°C. The weather in Shimla is cold in winters and moderately cool in summers. The average temperature during summer is between 19 °C and 28°C and between −1 ° C and 10 °C in winter. The snowfall is Shimla drives tourists to the city in its chilly winters. Snowfall earlier used to be in the month of December in Shimla but has lately shifted to January or even February. The total annual precipitation of the city is 1520 mm.

District	**Shimla**
Area	20 sq. Kms
No. of Wards	21
Height above mean sea level	2205 m
Demographics[3]	
Total Population	169758
Male	93364
Female	76394
F/M ratio (per 1000)	818
Household size	5
Number of Households	37756

[1] http://www.shimlamc.gov.in/page/General-Profile.aspx, accessed on 7 December 2012

[2] City Disaster Management Plan, Shimla, http://hpsdma.nic.in/disastermanagement/CDMP_MCShimla.pdf, accessed on 22 December 2012

[3] Census of India, 2011

Population Density	4197 per sq. km
Slum population[4]	10185
Literacy[3]	
Average literacy rate	94.67%
Male literacy rate	95.75%
Female literacy rate	93.35%
Employment[5]	
Employment rates (%)	38
Main worker population	54404
Marginal worker population	1595
Nature of occupation	The economy is mainly dependent on government and tourism. The government jobs account for almost 47% of the employment of the city
Occupational pattern	Primary – 1.1%
	Secondary – 0.9%
	Tertiary – 98 %

[5] City Development Plan, Shimla

3. Situational analysis

3.1 City Scoping

According to a city scoping exercise carried out for the city, the city is mainly impacted by two climatic hazards – increase of temperature, and increase in precipitation. These hazards impact several sectors in the city.

Further, shortage of water has been identified as a key issue in the city. Water supply is handled by Shimla Municipal Corporation and Irrigation and Public Health Department (I&PH). 90% of the community has access to safe-drinking water.

Shortage of water supply is a common problem in the city. During the summer monsoon season the problem becomes worse. Due to existing shortage of water supply following key social, economic and environmental impacts are being faced by the city:

- Loss in number of working days
- Decrease in productivity
- Depletion of the water table
- Increase in water pollution

Shimla Municipal Corporation (SMC) has been taking a number of measures for improved water supply and other sectors which directly or indirectly help the city in adapting to climate change. Some of these measures have been mentioned below:

Water Supply

- In the process of implementing 24x7 water supply
- Extension of water supply pipelines to uncovered areas

Solid Waste Management

- Waste composting plant is under trial run
- Engineered landfill to be constructed soon
- Door to door collection of solid waste is being carried out
- Use of non biodegradable polythene carry bags has been banned
- Carrying out a zero waste management project

Environment and DRR

- Awareness raising campaigns regarding DRR
- Hazard, Risk and Vulnerability Assessment of urban areas
- Community risk assessment and preparation of community response and preparedness plans
- Integration of disaster risk reduction features in urban planning
- Training and capacity building of engineers, architects, masons on safe construction practices
- Strengthening of compliance mechanism to ensure structural safety. Creation of DM cells in MC
- School safety and awareness programme

Following is a list of the main plans and policies for Shimla integrating social, environmental and economic elements:

- City Development Plan
- Solar city master plan
- City Sanitation Plan
- City Mobility Plan
- City Environment Plan (under development)
- City Disaster Management Plan (under development)
- City Climate Change Policy (under development)

3.2 Past hazards in the city

Earthquakes: The North-Western fringe of Himalayas is bounded by two major thrusts namely Main Central Thrust and Main Boundary Fault running parallel to the axis. Himachal State therefore, falls in most active seismic zones-IV and V. Shimla city and the region have experienced various earthquakes causing damage to the city infrastructure and further leading to other disasters like landslides.

Landslides: Landslide is the most common disaster in Himachal Pradesh and Shimla which causes immense loss of infrastructure, property and life. The fragile nature of rocks forming the mountains along with climatic condition and various anthropogenic activities has made the city vulnerable to the landslides.

Storms: Severe Storms, including lightning & high winds (Thunderstorms): Every year severe storms, lightning and high winds cause huge loss to the economy of Shimla City. It results in uprooting of trees, damage to electricity supply wires, telephone cables, street lights, etc. Uprooting of trees causes loss to life, buildings or vehicles[6] (City Disaster Management Plan, Shimla).

Flash floods: Shimla district has faced numerous flash floods in the past. These floods have resulted in major losses in the area. They cut the communication channels of the area to the outside world. They resulted in loss of infrastructure, life and livelihood, caused various health issues and left the people in a state of horror. Some of the major floods that have affected the area in the past are August 1997 flood and July 2005 flood[7] (Floods and Flash Floods in Himachal Pradesh: A Geographical Analysis).

[6] City Disaster Management Plan, Shimla, http://hpsdma.nic.in/disastermanagement/CDMP_MCShimla.pdf, accessed on 22 December 2012

[7] Floods and Flash Floods in Himachal Pradesh: A Geographical Analysis, http://nidm.gov.in/idmc/Proceedings/Flood/B2-%206.pdf, accessed on 7 November 2012

4. Climate scenario in the city

4.1 Past climatic trends

Climatic data trend analysis and projections at City level are rarely available. Hence, in order to better understand the past trends in temperature and precipitation for Shimla city, preliminary analysis of climatological parameters was undertaken based on historic data available with India Meteorological Department.

Climatological data for Shimla from Indian Meteorological Department was used for assessment of past trends and preliminary trend assessment for future. Data from 1992 to 2004 (16 years) was used for this purpose. The data was checked for missing values and since the data was complete with no missing values, no correction factors were applied to the data set. There are two sets of data, 1992-2004 and 2001-2012. The analysis has been done for both the data sets on two key parameters: Temperature and Rainfall.

Temperature: Data for Maximum and minimum temperature for the past 49 years was analysed separately and annual averages were also calculated.

a. **Annual Maximum Temperature**: Annual Maximum temperature for the period of 1992 to 2004 was plotted against time and it was observed that the maximum temperature showed a fluctuating trend. The maximum temperature during the study period varied from approx. 26.8^{0} C to 21.78^{0} C.

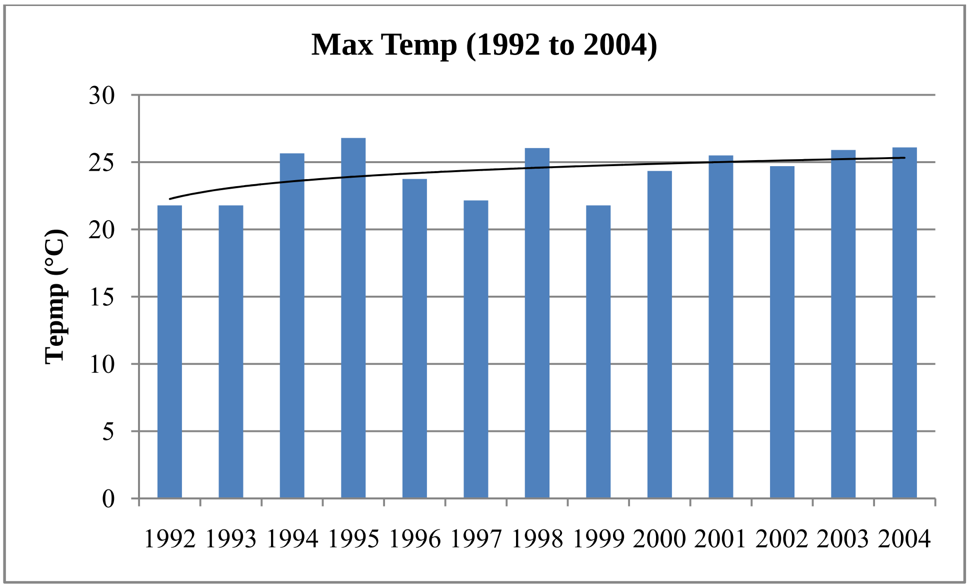


Figure 2: Annual Maximum Temperature (1992 to 2004)

b. **Annual Maximum Temperature:** Annual Maximum temperature for the period of 2001 to 2012 was plotted against time and it was observed that the maximum temperature showed a fluctuating trend. The maximum temperature during the study period varied from approx. 14.9^{0}C to 21.4^{0}C.

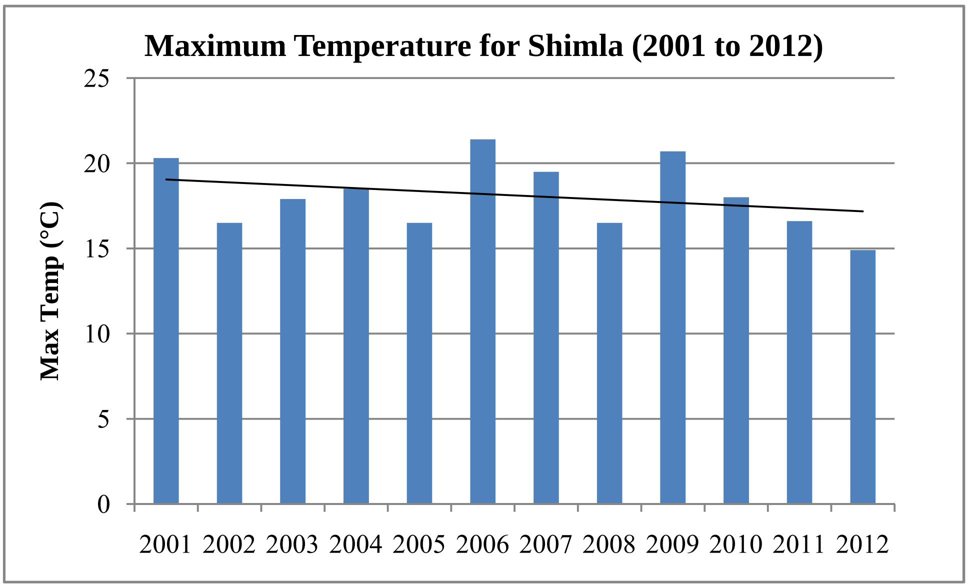


Figure 3: Annual maximum temperature (2001 to 2012)

c. **Annual Minimum Temperature**: Values for Annual Minimum temperature for the study period of 1992 to 2004 were plotted against time and it was observed that the minimum temperature showed a declining trend. The minimum temperature during the study period ranged between approx -0.1^0 C to 5.51^{0}C.

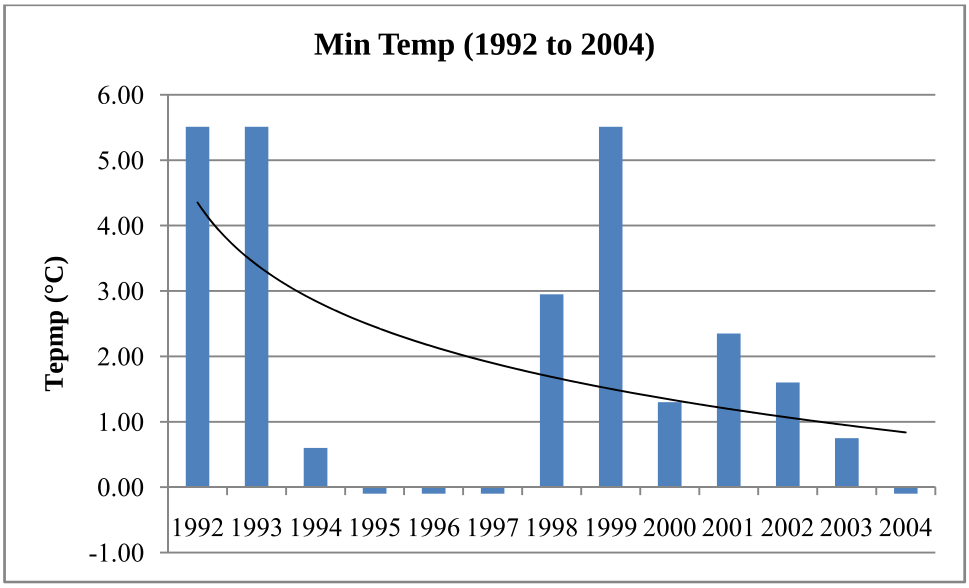


Figure 4: Annual Minimum Temperature (1992 to 2004)

d. **Annual Minimum Temperature:** Values for Annual Minimum temperature for the study period of 2001 to 2012 were plotted against time and it was observed that the minimum temperature showed a declining trend. The minimum temperature during the study period ranged between approximately –0.5^{0}C to 1.2^{0}C.

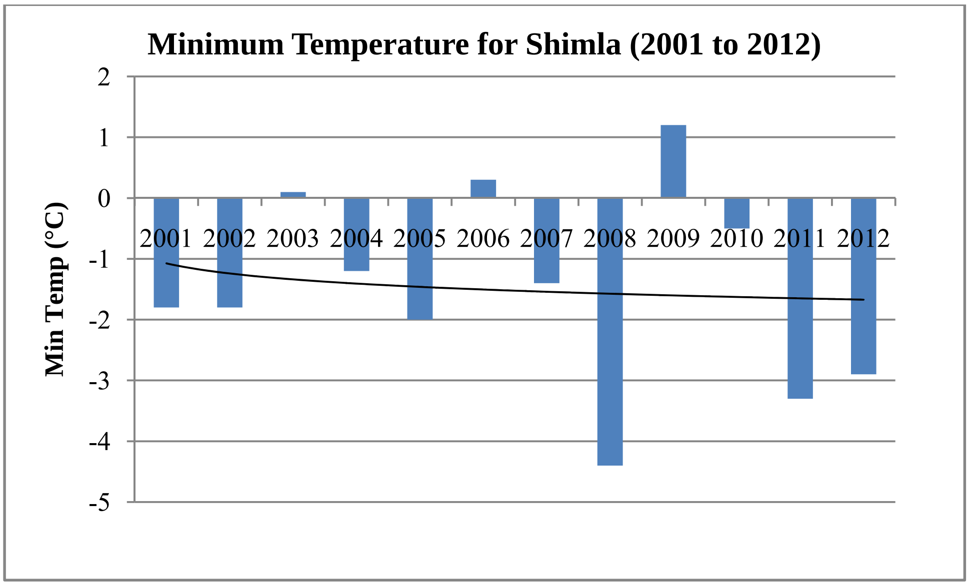


Figure 5: Annual minimum temperature (2001 to 2012)

e. **Average Annual Temperature**: Minimum and maximum monthly temperature values were used to get the annual average temperature for the study period of 1992 to 2004. The annual average temperature for Shimla showed a clear trend of increase in temperatures over time

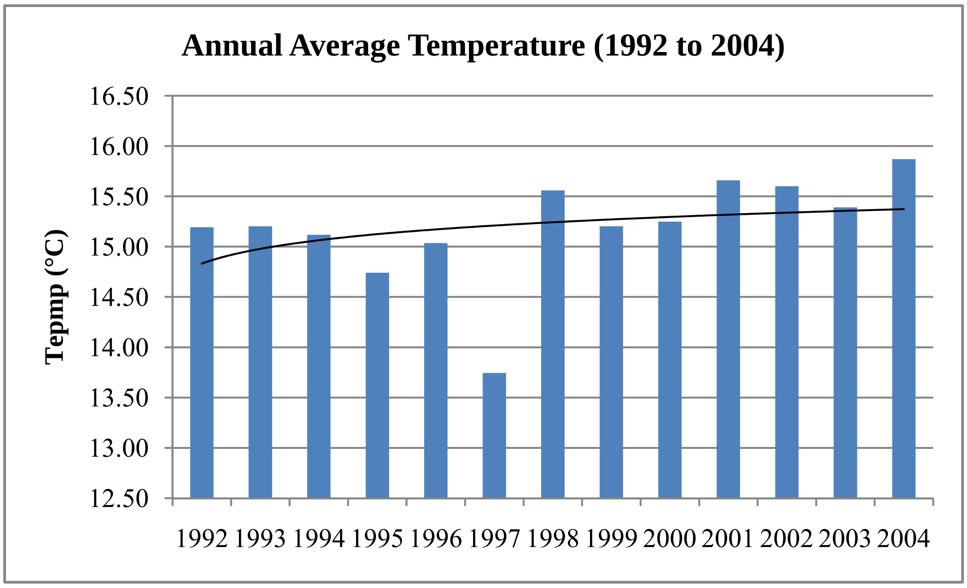


Figure 6: Average annual temperature (1992 to 2004)

Average Annual Rainfall: Monthly rainfall data from 1992 to 2004 (16 years) was analyzed to understand the trends in rainfall over the study period. The average annual rainfall showed low variability with exception of a couple of years. The trend analysis for rainfall data showed an increase in average annual rainfall over the study period.

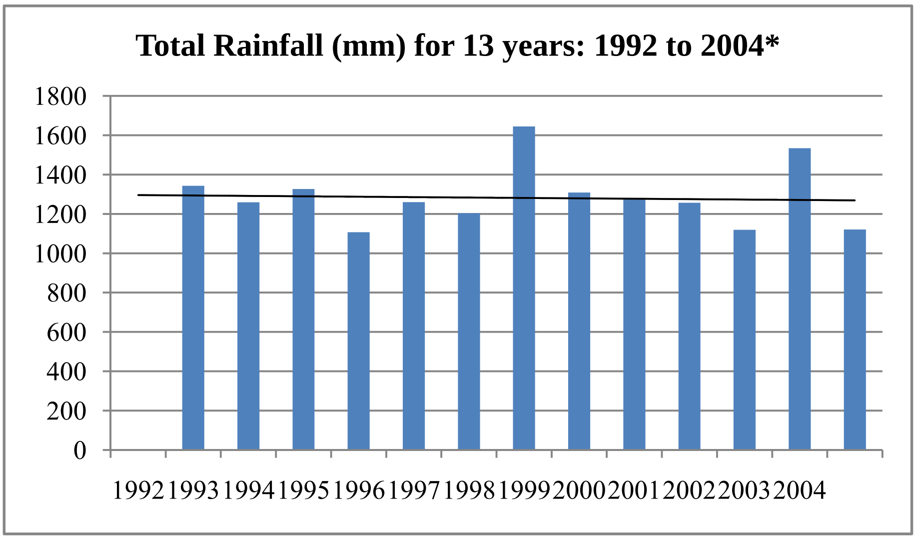


Figure 7: Average annual rainfall (1992 to 2004)

The graphs depict clearly the variation in temperature and rainfall that is already occurring over time. It is likely the climate change will exacerbate these variations and impact the different urban services in the city in future.

4.2 Future climatic projections

In order to plan for increasing the climate resilience of a city it is crucial to know how the climate of that city would be in the planning years. Therefore it is important to have the projected climate for the cities. Though climatic projections have started gaining a lot of attention of the scientific community however the projections that are being made are mostly national or regional. We still do not have city level projections available for many cities. In the absence of such climatic projections for the city of Shimla regional projections have been used for this assessment. In this study, a Government of India report called 'Climate Change and India: A 4*4 Assessment' has been referred. Following are the projections made in this report for the Himalayan region of India[8].

Changing Climate Condition	Amount of Expected Change	Geographical Area	Rate of Change	Extent of Variability
Precipitation change	The projected precipitation shows a net increase of 60 to 206 mm in 2030 as compared to 1970	Himalayan region	Annual rainfall is likely to increase by 5% to 13% in 2030 with respect to 1970	All seasons indicate an increase in rainfall: **JJAS** - showing the maximum increase in rainfall by 12 mm **JF** – showing an increase by 5mm **OND** – minimum increase

[8] Climate Change and India: A 4*4 Assessment, http://chimalaya.org/2010/11/17/report-climate-change-and-india-a-4x4-assessment-in-india/, Accessed on December 14, 2012

Temperature change	The net increase in annual mean temperature is ranging from 1.7°C to 2.2°C as compared to 1970	Himalayan region	Minimum temperatures are projected to rise by 1°C to 4.5°C, and the maximum temperatures may rise by 0.5°C to 2.5°C in 2030	Seasonal air temperatures show an increase in all seasons. **OND** - show a decrease by 2.6°C in 2030 with respect to 1970

Precipitation change:
There is a high probability of an increase in Average Annual Rainfall in the range of 60 to 206 mm in the Himalayan Region by the year 2030. The projected change of an increase of 5% to 13%, is expected to show an average increase of 12 mm rainfall in June, July, August and September; an increase on an average by 5 mm in January and February; and a minimum increase in rainfall in October, November and December.

Temperature change:
There is a high probability of a rise in Average Annual Temperatures by 1.7 to 2.2°C in the Himalayan Region by the year 2030. The projected change is expected for all seasons, except October, November and December showing a decrease by 2.6°C.

4.3 Urban systems analysis

In the previous section we saw the impact of climate change on Shimla city. This section focuses on the management and functioning of the urban systems. It tries to bench mark the condition of the urban systems in the city and determines their fragility. It therefore, helps in identifying the urban systems which are critical for the city and also explains the reasons for this. The critical urban systems are then analyzed against the climatic impact identified in the previous section. Further, the risk associated with the fragility of these systems is calculated through a risk assessment exercise.

The urban system analysis carried out for Shimla identified the following urban systems as fragile:

Water Supply: The city of Shimla is situated at an elevation. It draws water from the nearby streams. Surface water from rivulets is pumped and supplied at varying elevations. The water supply system of Shimla dates back to 1875. The authorities responsible for water supply in Shimla are the Irrigation and Public Health (I&PH) department and the Shimla Municipal Corporation (SMC). The I&PH looks after bulk supply and treatment of water while the SMC is concerned with distribution and pumping, metering and billing of potable water to domestic and commercial connections. Since the water supply infrastructure is very old it is not capable of supporting the current population. The current water losses are very high. At times of shortage of water, tankers are used to supply water. This is a money intensive process and involves increased diesel consumption. The identified possible climatic changes in Shimla would exacerbate the problem. Increased precipitation (snow) can disrupt/ damage water supply infrastructure. It can also cause the water in the pipelines to freeze. Increased temperatures will lead to increased demand for water. This would put additional stress on the supply system.

Transport: Traffic congestion is a major problem in the city. A single road connects the city to nearby areas. The city has many major bottle neck points which cause traffic jams for several hours. Many roads are extremely narrow and due to road encroachment their usage is further limited. There is a major shortage of parking facility. Further, the road infrastructure is impacted severely due to the inflow of tourists and landslides. The roads need significant maintenance and repair. Increased precipitation can disrupt/damage the road and transport infrastructure leading to increased traffic congestion. It can cut off the city from rest of the area leading to shortage of food supply etc.

Tourism: Shimla is a famous tourist attraction of North India. Increased temperature in neighbouring areas can lead to an increased influx of tourists to Shimla. This would lead to additional stress on the urban services of the city.

4.4 Risk assessment

Having identified the fragile systems and the impact of climate change on them, now we prioritise them based on an assessment of the degree of risk that each poses for the city. In this report risk is defined as a combination of the likelihood of an event to occur and the consequences faced if the event does occur.

Risk = Likelihood x Consequence

The idea behind this assessment is to identify the fragile systems facing a higher risk to the changing climate. This would help in the prioritization of the most fragile urban systems. This assessment provides a variety of combinations for likelihood and consequence. The approach helps in determining a risk score for each fragile urban system.

The assessment is carried out through a scoring mechanism. In terms of the likelihood of an event to occur the scoring is done on a scale of 1-5 with 1 being ‘rare’ and 5 being ‘almost certain’. Similarly, for the consequence of that event the scoring is done on a scale of 1-5 with 1 being ‘insignificant’ and 5 being ‘catastrophic’. The consequence of the event is evaluated on the system as well as on the city government. Based on the final risk score generated for each fragile statement they are categorized as extreme, high, medium and low risk.

Table 1: Risk Assessment

Urban system	Impacts of climate change	Likelihood	Consequence	Risk score	Risk status
Water supply	Increased precipitation disrupts/ damages water supply infrastructure	4	4	16	**High**
	Increased precipitation can cause water to freeze in the pipelines	4	4	16	**High**
	Increased temperatures will lead to increased demand for water thereby posing additional stress on the supply system	3	3	9	Medium
Transport	Increased precipitation can disrupt/damage the road and transport infrastructure	4	4	16	**High**

	Increased precipitation can lead to increased traffic congestion	4	4	16	**High**
	Increased temperature can cut off the city from rest of the area leading to shortage of food supply etc.	2	2	4	**Low**
Tourism	Increased temperature can lead to an increase in tourism industry causing additional stress on city services	4	3	12	**High**

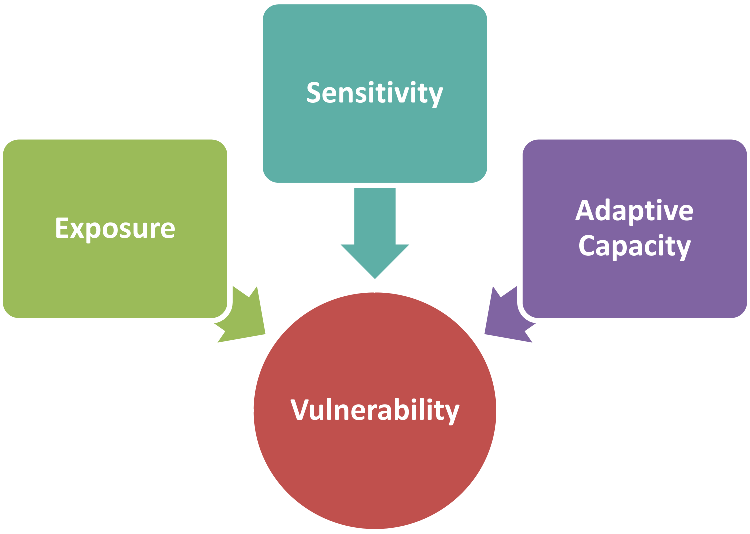
This step helps in prioritizing the urban systems on the basis of their fragility. These systems may fall (completely or partially) or may not fall under the purview of the city government. As observed from the assessment, the additional stress on water supply system, transport of the city has the highest risk.

- Disrupted/ damaged water supply infrastructure due to increased precipitation
- Frozen water in the pipelines due to increased precipitation
- Disrupted/damaged road and transport infrastructure due to increased precipitation
- Increased traffic congestion due to increased precipitation

It is interesting to notice here that increased precipitation is perceived to have more severe impacts than increased temperature. These fragile urban systems may further impact other urban systems thereby increasing the city's vulnerability to climate change. These secondary impacts have been identified in the next section. The urban systems with a high or medium risk have been considered for further assessment.

5. Vulnerabilities assessment

Intergovernmental Panel on Climate Change defines vulnerability as a function of three parameters of the character, magnitude, and rate of climate variation to which a system is exposed - in other words, the exposure of the system to climatic variation, its sensitivity, and its adaptive capacity[9].



Exposure: The nature and degree to which a system may be exposed to climate events, such as temperature increases, rainfall variability and change (including extremes), or changes in the frequency or intensity of tropical cyclones and storms.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. It is often measured by the system's response to what has happened to past events.

Adaptive Capacity: The ability of a system to adjust to climate - including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

To build a resilient set up there is a need to know to what extent are the cities susceptible to the climate change. This susceptibility will vary from city to city depending on their geographical location, demographic condition, infrastructure, socio economic condition etc. Hence we need to have a robust analysis of all these parameters in order to assess the overall susceptibility of a city. This can be done in the form of vulnerability assessment. This section tries to capture all these components of vulnerability. It takes into account both the current and the future vulnerability of the city. This assessment identifies the vulnerable areas, relevant actors and the adaptive capacity of the urban systems. The actors have been scored on a resilience score from 1-27 with 1 being least resilient and 27 being the highest. These scores have been calculated on the basis of three parameters namely, responsiveness, resourcefulness and capacity to learn. The adaptive capacity of the urban systems has been assessed on the basis of five parameters economic capacity, technological/infrastructural capacity, governance, societal capacity and ecosystem services.

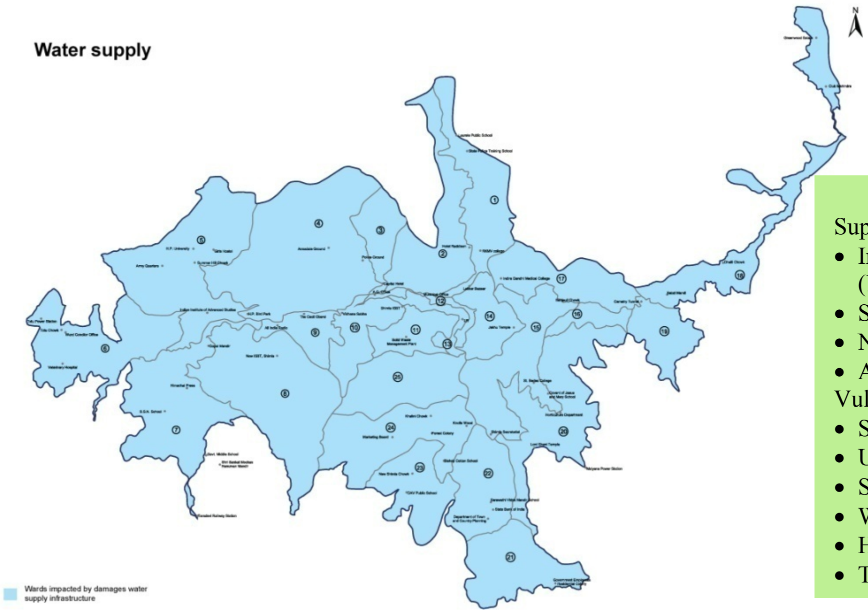
For each fragile urban system the vulnerable areas have been mapped for the city. Further, the vulnerability of each ward of the city has been identified in order to find the vulnerable hotspots of the city.

[9] IPCC, http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter2.pdf, Accessed on December 3, 2012

5.1 Water supply

Secondary Impacts: The damaged water supply infrastructure due to increased precipitation can hamper the functioning of sewerage management. This would degrade the quality of sanitation in the city, creating health issues. It would cause shortage of potable water supply leading to usage of water from open sources of questionable quality which impacts the health adversely. Damaged water supply system infrastructure would impact the road systems would in turn cause traffic congestion. Landslides due to downstream impacts of water may affect infrastructure thereby leading to a decrease in tourism and hence impacting the economy. Freezing of water in the pipelines would cause disruption of water supply and will therefore have an adverse impact on the tourism and economy. Wear and tear of existing water supply infrastructure due to additional stress on urban services would pose financial stress on Municipal Corporation.

Vulnerable areas: The vulnerable wards in terms of the water supply system for the city have been highlighted in the following figures.

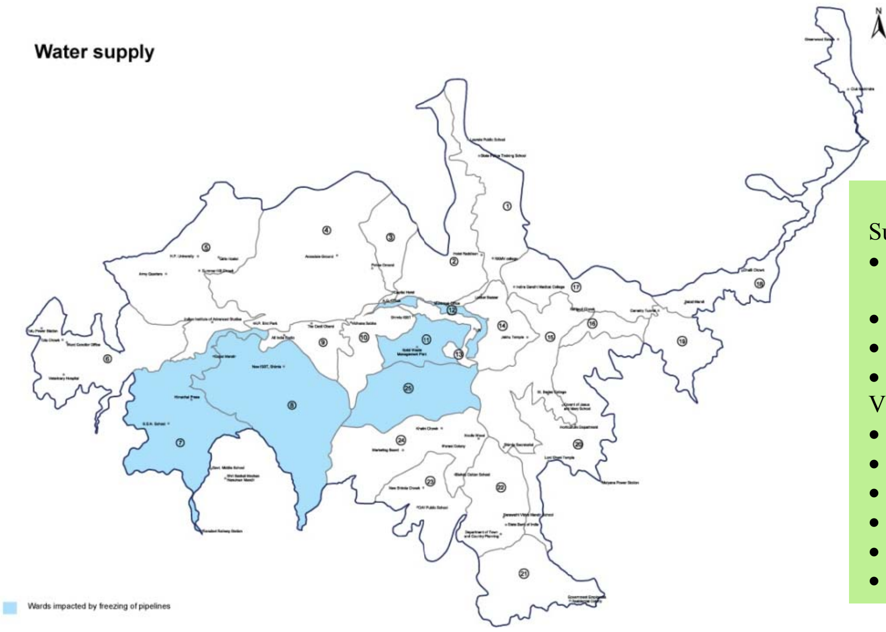


Actors involved

Supporting actors:
- Irrigation and Public Health (I&PH) department
- SMC
- NGOs
- Additional SMC staff

Vulnerable actors:
- Street vendors
- Urban residents
- Slum residents
- Women
- Hoteliers
- Tourists

Figure 8: Wards impacted by disrupted water supply infrastructure and increased demand for water supply



Actors involved

Supporting actors:

- Irrigation and Public Health (I&PH) department
- SMC
- NGOs
- Additional SMC staff

Vulnerable actors:

- Street vendors
- Urban residents
- Slum residents
- Women
- Hoteliers
- Tourists

Figure 9: Wards impacted by freezing of water in pipelines

Adaptive capacity:

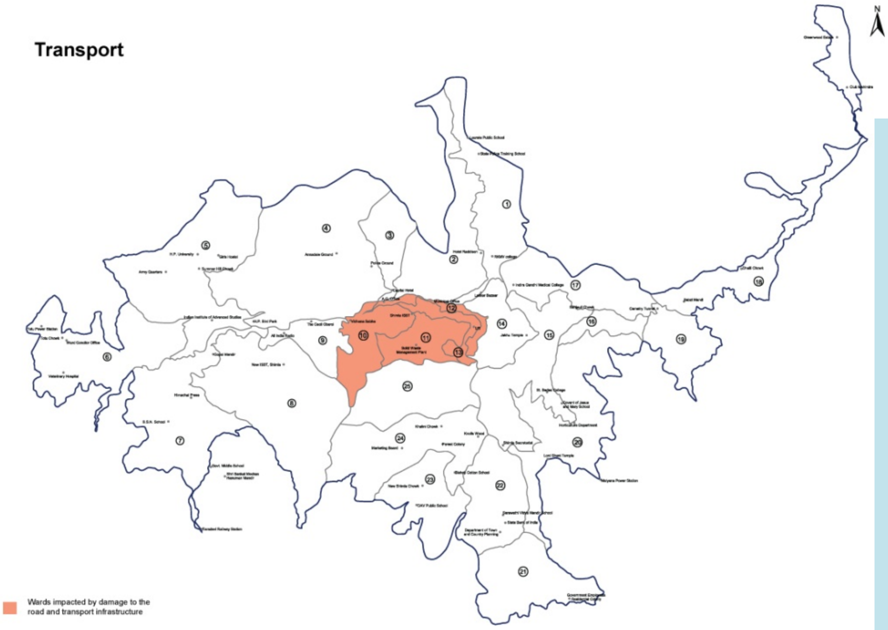
	Low	Medium	High
Economic			
Technological/ Infrastructural			
Governance			
Societal			
Ecosystem services			

The water supply system has been found to have a high economic, infrastructural, ecosystem services and governance capacity. However, the societal adaptive capacity of the system is medium.

5.2 Transport

Secondary Impacts: Impact on road systems due to increased precipitation would in turn cause traffic congestion and increase the chances of road accidents and can cause loss of life and livelihood. Increased travel time caused due to traffic congestion leads to loss of productive hours and thereby impacts the economy. Increased precipitation can cut off the city from rest of the area leading to shortage of food supply. This can lead to malnutrition of the citizens specially the poor.

Vulnerable areas: The vulnerable wards in terms of the transport system for the city have been highlighted in the following figures.



Actors involved

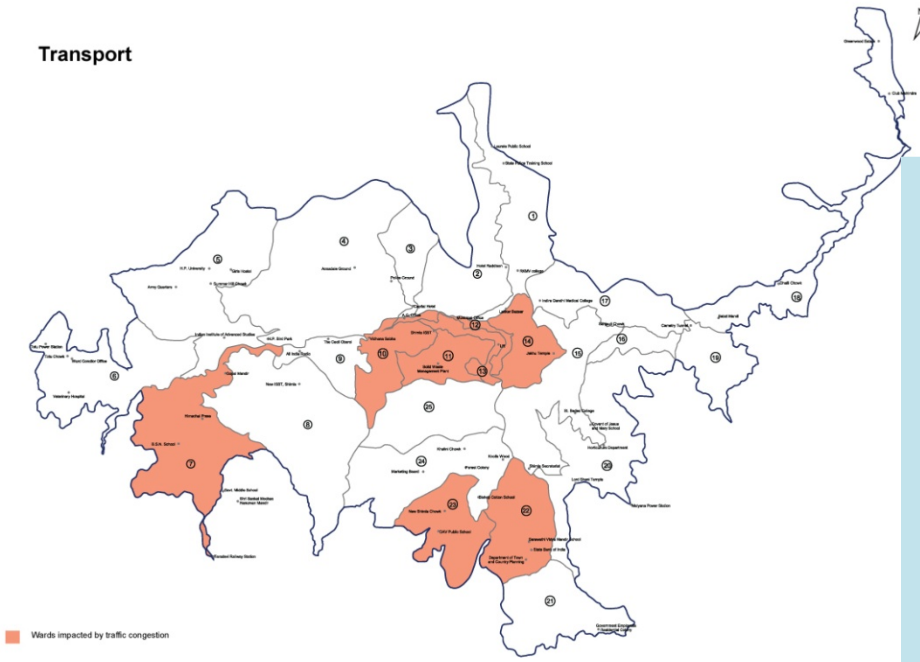
Supporting actors:

- SMC
- Traffic police
- State Pollution Control Board (SPCB)
- Himachal Road Transport Corporation (HRTC)
- Himachal Pradesh Public Works Department (HPPWD)

Vulnerable actors:

- Urban residents
- Tourists
- Slum residents
- Street vendors
- Institutions
- Students
- Commercial organisations

Figure 10: Wards affected by disrupted road infrastructure



Actors involved

Supporting actors:

- SMC
- Traffic police
- State Pollution Control Board (SPCB)
- Himachal Road Transport Corporation (HRTC)
- Himachal Pradesh Public Works Department (HPPWD)

Vulnerable actors:

- Urban residents
- Tourists
- Slum residents
- Street vendors
- Institutions
- Students
- Commercial organisations

Figure 11: Wards affected by increased traffic congestion

Adaptive capacity:

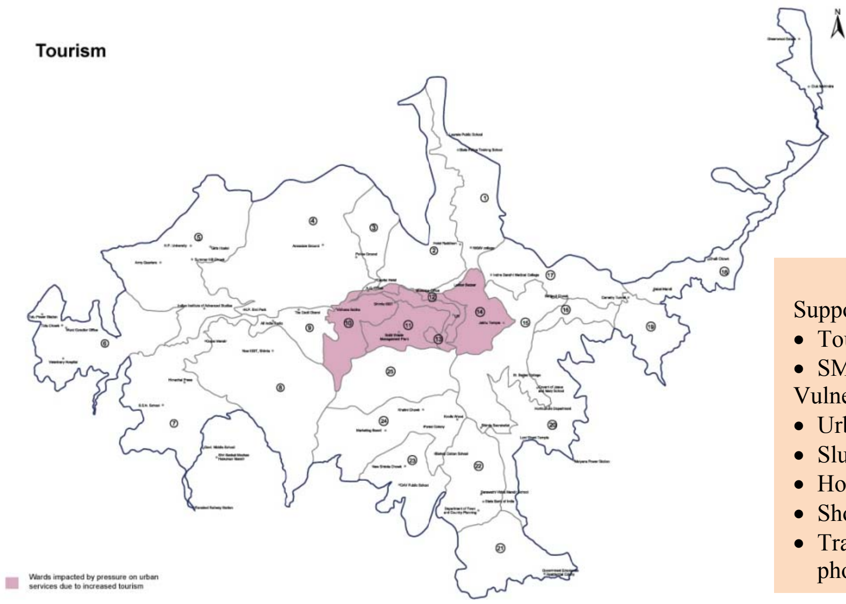
	Low	Medium	High
Economic	(highlighted)		
Technological/ Infrastructural			(highlighted)
Governance		(highlighted)	
Societal	(highlighted)		
Ecosystem services			

Transport in the city has been found to have a low economic and societal capacity. However, the technological/ infrastructural capacity is said to be high. Further, the adaptive capacity in terms of the governance is medium.

5.3 Tourism

Secondary impacts: Increase in temperature in surrounding areas is leading to increased tourism, causing stress on urban services. This would further increase the demand for parking spaces and congestion on roads. It would cause financial burden on the municipal corporation.

Vulnerable areas: The vulnerable wards in terms of the tourism for the city have been highlighted in the following figure.



Actors involved

Supporting actors:
- Tourism Department
- SMC

Vulnerable actors:
- Urban residents
- Slum residents
- Hoteliers
- Shop keepers
- Travel agencies, guides, photographers, coolies

Figure 12: Wards facing additional stress on systems due increase in tourism

Adaptive capacity:

	Low	Medium	High
Economic			
Technological/ Infrastructural			
Governance			
Societal			
Ecosystem services			

The water supply system has been found to have a high economic, infrastructural/technological capacity, governance, and ecosystem services capacity. However, the societal is medium.

5.4 Vulnerability Hotspots

Many areas in the city are impacted by more than one fragile urban system. These areas relatively need more attention as they pose threat from multiple fragile urban systems. Such areas are called the vulnerability hotspots. The following figure identifies the vulnerability hotspots for Shimla city in terms of their degrees of vulnerability.

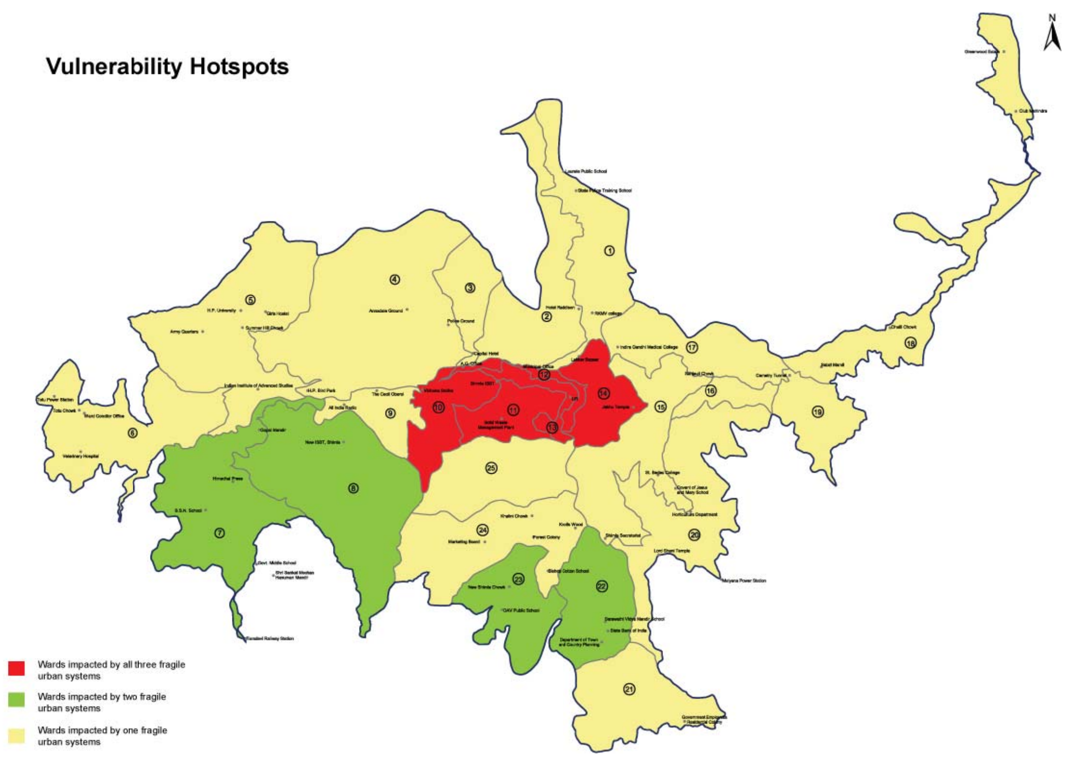


Figure 13: Vulnerability hotspots

It is interesting to note here that the highly vulnerable areas are the ones where the tourist influx is the maximum in the city (Mall road area). This floating population can be one of the reasons for the stressed resources in this area.

6. Resilience interventions

In the previous section the vulnerable areas affected by the four critical urban systems, and the vulnerable population groups have been identified. In order to minimize the impacts of changing climate on these systems the key relevant resilience interventions have been identified.

In this section the identified climate resilience actions have been evaluated in terms of their resilience (redundancy, flexibility/robustness, responsiveness/re-organisation, capacity to learn), feasibility (technical, political, cost), and benefits of the action (short term/medium term/long term). On the basis of these criteria their applicability for the city has been identified.

In total 30 resilience interventions have been identified for the three vulnerable sectors – water supply, transportation, and tourism.

Following table assesses the identified resilience interventions on the basis of the resilience indicators:

Table 2: Resilience Interventions assessed on the basis of resilience indicators

Urban Systems	Potential Climate Resilience Interventions	Redundancy	Flexibility/ Robustness	Responsiveness/ re-organisation	Capacity to learn
Water Supply	Rain water harvesting strategy for the city	√	√	√	√
	Reviving traditional water sources	√	√	√	√
	Extensive early warning systems for increased precipitation	√	-	√	√
	Use of composite pipes instead of conventional galvanised iron pipes	-	√	√	-
	Extensive patrolling of area to take immediate action on water freezing	-	-	√	-
	Multiplicity of command needs to be unified. E.g. IPH, MC AND Electricity department *(To be outsourced in PPP mode*)	-	√	√	√
	Ferro cement water storage tanks for households/ clusters	-	√	√	-
	Channelization of existing nallahs and natural drainage system	-	√	√	-
	Proper maintenance of sewerage line- Connectivity of the missing links	-	√	√	-
	Septage and STP's Sludge management	-	√	√	-
	Construction of more public toilets and subsidising user charges	-	√	-	-
	Decentralized wastewater treatment options	√	√	√	√
	Encourage recycling and conservation of water	√	√	√	√

Urban Systems	Potential Climate Resilience Interventions	Redundancy	Flexibility/ Robustness	Responsiveness/ re-organisation	Capacity to learn
Transport	Implementation of the city mobility plan	√	√	√	√
	Mass transport systems to be developed – buses, trains, rope rail, escalators	√	√	√	√
	Integration of existing bus service with regional bus service and HRTC taxi service	-	√	√	√
	Augmentation of existing public transport - bus service	√	√	√	-
	Preparation and implementation of by-laws for road usage/ regulation	-	√	√	√
	Parking provisions in new construction/ new Parking provisions/ Byelaws on Hotel's parking provisions	√	√	√	√
	Snow clearance/ cutters on road	-	√	√	-
	Development of anti-skid pathways	-	-	√	-
	Urban planning to keep important buildings which attract traffic in outskirts	-	√	√	√
Tourism	Development of legal provisions and their strict implementation	-	-	√	√
	Construction of more lifts and escalators (Old ISBT to DC office)	√	√	√	√
	Green tax for cars from outside Himachal Pradesh	-	-	√	√
	Construction of trams, mini deluxe buses (Dhalli to regal building, Secretariat to lift, Advanced studies institute to CTO)	√	√	√	√

Urban Systems	Potential Climate Resilience Interventions	Redundancy	Flexibility/ Robustness	Responsiveness/ re-organisation	Capacity to learn
	Construction of sky buses (on the circular road linked to mall road through flyover)	√	√	√	√
	Construction of multi storied parking	√	√	√	√
	Preparation and implementation of bye laws on tourism to address water shortage, traffic congestion	√	√	√	√
	Urban forestry Initiatives to be undertaken	-	-	√	-

These interventions have further been assessed on the basis of feasibility indicators and long/medium and short term impact. A combination of these assessments helps in determining the applicability of the interventions as high/medium/low. 23 Interventions have been categorized as highly applicable measures for the city of Shimla.

Table 3: Applicability of the resilience interventions

Urban Systems	Potential Climate Resilience Interventions	Feasibility			Impact	Applicability
		Technically	Politically	Cost	(short/medium/ long term)	(low/ medium/ high)
Water Supply	Rain water harvesting strategy for the city	High	High	High	Short	High
	Reviving traditional water sources	High	High	High	Long	High
	Extensive early warning systems for increased precipitation	High	High	High	Short	High
	Use of composite pipes instead of conventional galvanised iron pipes	High	High	High	Med-long	High
	Extensive patrolling of area to take immediate action on water freezing	High	High	High	Short	High

Urban Systems	Potential Climate Resilience Interventions	Feasibility			Impact (short/medium/ long term)	Applicability (low/ medium/ high)
		Technically	Politically	Cost		
	Multiplicity of command needs to be unified. E.g. IPH, MC and Electricity department	High	Medium	High	Long	High
	Ferro cement water storage tanks for households/ clusters	High	High	High	Short	High
	Channelization of existing nallahs and natural drainage system	High	High	Med-low	Long	High
	Proper maintenance of sewerage line- Connectivity of the missing links	High	High	Medium	Long	High
	Septage and STP's Sludge management	Medium	High	Medium	Long	High
	Construction of more public toilets and subsidising user charges	High	High	Medium	Short	High
	Decentralized wastewater treatment options	High	High	Medium	Long	High
	Encourage recycling and conservation of water	High	High	High	Med-long	High
Transport	Implementation of the city mobility plan	High	High	Low	Long	High
	Mass transport systems to be developed – buses, trains, rope rail, escalators	High	High	Medium	Medium	High
	Integration of existing bus service with regional bus service and HRTC taxi service	High	High	High	Short	High
	Augmentation of existing public transport - bus service	High	High	Medium	Short	Medium
	Preparation and implementation of by-laws for road usage/ regulation	High	Medium	High	Medium	High

Urban Systems	Potential Climate Resilience Interventions	Feasibility			Impact (short/medium/ long term)	Applicability (low/ medium/ high)
		Technically	Politically	Cost		
	Parking provisions in new construction/ new Parking provisions/ Byelaws on Hotel's parking provisions	High	High	Low	Long	High
	Snow clearance/ cutters on road	High	High	High	Short	High
	Development of anti-skid pathways	High	High	Low	Medium	Medium
	Urban planning to keep important buildings which attract traffic in outskirts	High	Medium	Low	Medium	Medium
Tourism	Development of legal provisions and their strict implementation	High	Medium	High	Long	High
	Construction of more lifts and escalators (Old ISBT to DC office)	High	High	Medium	Long	High
	Green tax for cars from outside Himachal Pradesh	High	High	High	Long	High
	Construction of trams, mini deluxe buses (Dhalli to regal building, Secretariat to lift, Advanced studies institute to CTO)	High	Medium	Low	Long	Medium
	Construction of sky buses (on the circular road linked to mall road through flyover)	High	Medium	Low	Long	Medium
	Construction of multi storied parking	High	Medium	Low	Long	Medium
	Preparation and implementation of bye laws on tourism to address water shortage, traffic congestion	High	Low	High	Long	High
	Urban forestry Initiatives to be undertaken	High	Medium	Low	Long	Medium

7. Conclusion

The City Resilience Strategy for Shimla Municipal Corporation, developed using the ICLEI ACCCRN Process, has helped to identify 2 major impacts of climate change –increase in precipitation and increase in temperature, that will be faced in future by the city of Shimla. The primary urban services which will most severely face these climate impacts are water supply services, transport and tourism as identified by the core team of the Shimla Municipal Corporation through the ICLEI ACCCRN Process. Notably, for these fragile urban systems, most of the concerns are due to increased precipitation, rather than for increased temperatures.

The process then went on to identify the different risks to these fragile urban systems due to the climate impacts and helped the core team to identify the most vulnerable areas likely to face these risks and the most vulnerable actors, as well as the adaptive capacity of the fragile systems. On the basis of these vulnerable urban systems, areas, and actors, resilience actions have been identified by the core team to counter the climate impacts on these systems.

The resilience strategies identified have been assessed in terms of their technical, political and financial feasibility and their impact potential. Apart from the structural strategies to counter the climate impacts of these fragile urban systems, the process also recognized the importance of developing and implementing plans for these urban services keeping in mind the possible future impacts. Another important aspect that evolved from the discussions of the core team members was the need for better coordination among different government agencies. Since some of the urban services are under the control of different government agencies (for instance, water supply is handled both by the Irrigation and Public Health Department and the Municipal Corporation), it is necessary for the different government bodies to coordinate their activities so as not to work at cross purposes. Stricter implementation of regulatory provisions for conservation of water, traffic control and tourism management could also help the municipal corporation to reduce the impacts of sudden disruption to services because of climate impacts.

A large number of government schemes are ongoing in the city of Shimla for developmental purposes, such as the JNNURM Scheme, Parking Project, City Sanitation Plan, and so on. The JNNURM scheme provides a huge amount of funds for the improvement of transport, drinking water supply system, sewerage system and promotion of tourism in the city. It is upto the city government to utilise the funds under these schemes to their best possible benefit, keeping in mind possible future impacts of climate change on their urban services.

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