

### **Assessment of Disaster Risk and Mitigation Strategies for Srinagar City**

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#### **Abstract**

*Disaster is an event/combination of the events that come sudden/slow and uninvited, which incurs widespread human, material, economic or environmental losses and impacts, exceeds ability of the affected community or society to cope using its own resources. Disasters are always painful as they take toll of life and property where they occur. Disasters are the continuous process and have been happening from the birth of earth be it in any form. With the passage of time, the intensity and the frequency of the disasters have increased as a result of the wrath of the mankind and the negative interaction of man with the nature. The state of Jammu and Kashmir in general and Kashmir valley in particular is more prone to disasters from the times immemorial owing to its fragility and the devastation by mankind. The summer capital of Jammu and Kashmir i.e. Srinagar is among the most disaster vulnerable cities owing to unwise play of the man with the nature and unplanned interaction with the natural landscape. The disasters have resulted from not only the natural catastrophes but also by the other means like epidemics, plague, cholera and famines in the 19th and early 20th century which has taken a heavy toll of human as well as animal population in addition to damage to houses, public infrastructure and crops.*

**Key Words:** Disaster, Interaction, Fragility, Unplanned, Uninvited, Losses

#### **Introduction**

Disaster is an interaction between people and nature governed by the co-existent state of adjustment in the human use and state of natural event system (White G.F 1993). It is the most rapid, instantaneous and long-range conflict of the natural environment with the socioeconomic system and the human society (Mercer, 2009; Cutter et al., 2013). A disaster, either natural (earthquake, fire, etc.) or caused by humans (war conflict, nuclear accident), shapes human and natural environment and disrupts and affects operation of the region at an economic and social level depending, of course, on its degree and extent (Becker et al., 2013; Yellman and Murray, 2013).

A catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of property, or damage to, or degradation of environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area (Disaster Management Act, 2005). As per Miletti (1999), disaster is sum total of interaction of three main systems I) Physical environment, II) Demographic environment and socioeconomic environment and III) Structural environment (Residences, buildings and infrastructure). It is generally been observed that disaster is the correlation between these three systems from which their complex texture is gained.

Disasters are more destructive in the developing world and whenever come not only incur property losses but also take toll of life. The more destructive nature of the disasters in the developing world is the result of economic condition of developing world. Besides this developed countries have adopted modern techniques and are following proper plans to overcome the wrath of these disasters. In developed nations disasters are mitigated in such a manner so as to have minimum impact on the life of people. Hazards pose threats to people and assume serious proportions in under developed countries with dense population. During second half of 20th century, more than 200 worst natural disasters occurred in different parts of the world and claimed lives of around 1.4 million people. Losses due to natural disasters are 20 times greater (as percentage of GDP) in developing countries than in industrialized one. Asia tops the list of casualties due to natural disasters (Ministry of Home affairs Govt. of India, May 2011).

### Database and Methodology

The study includes collection of data from different sources whether primary or secondary. The primary data collection comprises of surveys and observations carried out in the study area. Secondary data has been collected from different sources like govt. offices, NGOs, books and papers of the different journals published over the period of time by different organizations and authors. The main thrust of data collection is to rely on the secondary data sources as there is minimum need to go for primary survey for data collection. The data collected has been compiled and analyzed by various statistical & cartographic techniques, softwares and then put in the form of tables, figures, tables, diagrams and maps. In addition to that Geo-Spatial tools like Arc GIS have been used in the current study.

### Study Area

Srinagar, the largest among all Himalayan urban centers is located in the heart of Kashmir valley. Srinagar lies between  $33^{\circ}53'49''$  -  $34^{\circ}17'14''$  N latitudes and  $74^{\circ}36'16''$  -  $75^{\circ}01'26''$  E longitudes is located on the banks of river Jhelum on the both sides at an altitude of 5200 feet above mean sea level. Srinagar city has grown on the banks of river Jhelum over the stretch of 29 kilometers and the boundaries are surrounded by natural frontiers like mountains (sub-mountain branches of the Pir Panjal range) whose height varies from 1800 to 4300 meters above mean sea level. Srinagar city being in heart of the mountains is having undulating topography and on southwest side of the city and the southern side is bounded by karewas, The area suitable for development in north is limited to the north-west and south while the eastern extension is limited to the present municipal limits, as the physical extension of the settlements in this area is hindered by Zabarwan hills. Presence of Perennial River has helped in shaping valley in the oval shape at the same time added significance to the Srinagar city as nodal point or main attraction for urban growth. Srinagar is Primate City in the region because its population is disproportionately larger than other towns of valley. Since historic times, it has been seat of government as well as the Centre of religious and cultural activities for about 1400 years (H. Farooq, 2013). Owing to fragile environment and unplanned development Srinagar has been hotspot of disasters from times immemorial.

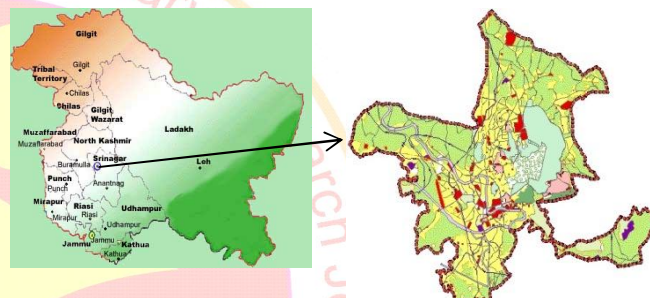


Figure 1: Location of Srinagar City

### Results and Discussion

Srinagar City lying in heart of Himalayas is one of the most disaster prone cities in world. Lying in the Zone V of Indian earthquake zonation map, making it highly vulnerable to severe and frequent earthquakes. Srinagar city being capital city is no exception to the floods of the Kashmir, being located on the banks of river Jhelum and having many other water bodies whenever floods strike Kashmir valley the Srinagar city has drowned always either partially or have had adverse impacts on the urban Srinagar. Lying in the fragile ecosystem has been susceptible to many disasters only reason being the faulty and unwise interaction of man with environment. With the passage of time vulnerability to man-made disasters has increased owing to many reasons and man nature conflict which has been there in the name of development. The vulnerability analysis of Srinagar is given as follows

### Spatio-Temporal Changes in Srinagar City

Srinagar City has grown enormously in last twenty years. The area of the city has increased from 12.80 Km<sup>2</sup> in 1901 to 461 Km<sup>2</sup> in 2011. Though area of the city has increased at a slow pace initially, but after 1971, there was a

drastic change in spatial extent of the city. The abrupt change in last 30 years in city can be ascribed to large scale migration, encroachment of marshy and wastelands etc.

Year	Area (in Km <sup>2</sup> )	Decadal variation ( in percentage)	Year	Area (in Km <sup>2</sup> )	Decadal variation ( in percentage)
1	12.8	-	1961	41.42	16.29
1	12.85	0.5	1971	82.88	41.44
1	14.48	1.63	1981	208.09	125.39
1	17.6	3.12	1991*	243.09	16.82
1	17.6	0	2001	278.1	14.4
1	29.52	11.29	2011	461.8	50.92

Source: Town Directory, Series-8, Part-X-A, Jammu and Kashmir, 1981 and Srinagar Municipal Corporation.

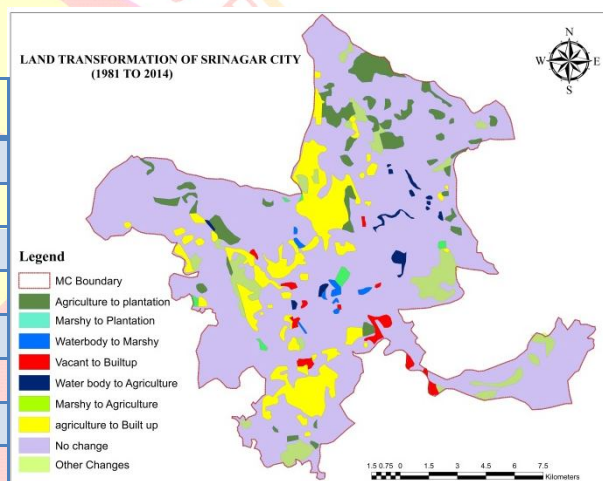
\*Population of 1991 was obtained through interpolation as census was not conducted in J&K.

### Land transformation

Land transformation in Srinagar city is very alarming as this phenomenon has transformed water bodies of the city into housing colonies. This phenomenon has added to fragility of city to different types of disasters and loss of property and life.

#### Land transformation 1981 to 2014

Landuse	1981 (area in hectares)	2014 (area in hectares)
Built up	5969	19106
Defense	1440	2190
Forest	917	724
Marshy	4404	1660
Parks	396	1272
Vacant land	1826	975
Water bodies	5685	4850
Agricultural land	40078	29498



Source: Computed value

Land transformation in Srinagar has been a big issue as Srinagar lies in one of the most active zones of India, keeping in view seismic activities and flooding being the reason of encroachment in waterbodies. Land transformation is the reason which increases vulnerability of Srinagar city to disasters. The land transformation is taking place without proper procedure and consideration local bodies playing pivotal role in accelerating the intensity of disasters.

### Natural hazard vulnerability

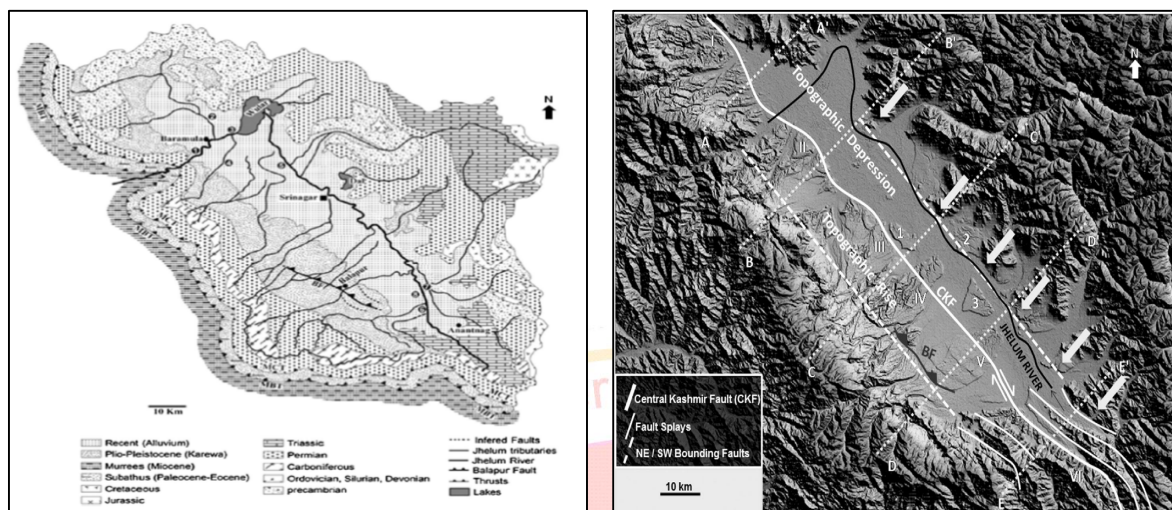
#### Earthquake vulnerability

Vulnerability of buildings to earthquakes is dependent on a variety of form and functional parameters. Residential building vulnerability is up to five times larger than either commercial or industrial building vulnerabilities. The Global Earthquake Model initiative identified different factors like building height, age, design and construction as main indicators for building stability, (Panahi et al. 2013) defined the construction materials of structures, year of construction and their quality as major affecting factors in structural



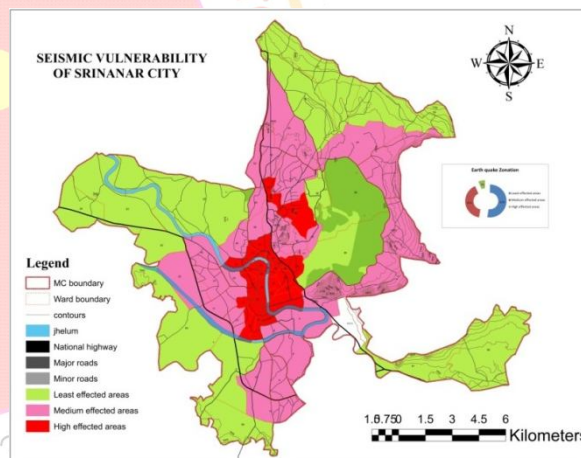
vulnerability. Srinagar lies in one of the most active seismic regions of country where by the fault lines pass by and are in the adjacent to the city.

The figure below clearly shows the fault lines which are very close city are making valley one of the most earthquake prone regions of the country. Central fault line of Kashmir is running just adjacent to Srinagar city within the distance of few kilometers making it vulnerable to wrath of disasters of seismic origin.



Source: Alam et.al,

Vulnerability to earthquakes can be analyzed by the figure below in which the vulnerability of Srinagar is carried out based on age and condition of buildings in Srinagar city as a whole. The old age buildings in core areas are in deteriorated condition hence more prone to the wrath of earthquakes. Besides ages and condition of buildings in core, the density is very high and many houses having height of 4 floors are left in mercy of nature which poses as great threat in case of catastrophe. The medium vulnerable parts comprise of the areas where the buildings are having age not more than 20 to 30 years and population density is low as compared to core areas like Nishat, Pantha Chowk. The least vulnerable portion is outer portion of Srinagar where building height, age and material used is appropriate and above all least density of population in these areas.

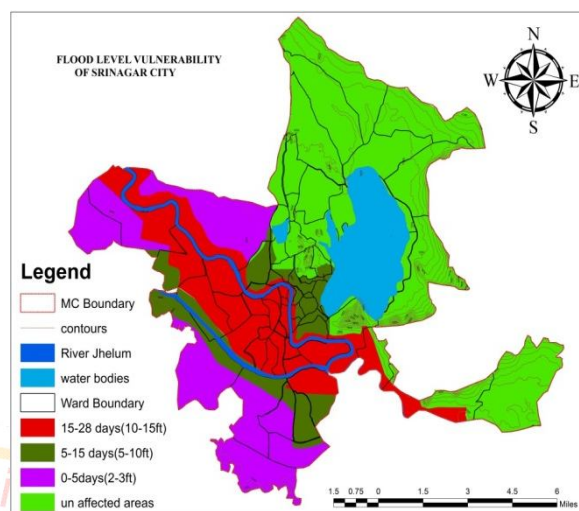


### Flood vulnerability

Srinagar located along the banks of river Jhelum on the both sides has unbroken lines of houses constructed on both the embankments. These embankments were once used as a shield from floods, with the passage of time have been encroached and wherever they exist, with the siltation of the river are of low to minimal value from the flood protection view. The drainage system has been disrupted to such an extent that the major streams or nallahs flowing through the heart of the city are either less than of the actual size or are only in the papers to exist. During the heavy rains, the city gets flooded and creates problem to the city dwellers.

Flood level and vulnerability has been carried out on the basis of low lying areas and the time during which the water remains stagnant in Srinagar and nearness to the water bodies.

- In the first category (most vulnerable) the flood level rises up to 15 feet and remains for more than 15 days, the most vulnerable keeping in view age and condition of buildings into consideration and at the same time is adjacent to Jhelum river as the areas are mainly encroached claimed from Jhelum river and settlements which came in Jhelum flood plain.
- The second category is that portion in which the flood level rises from 5 to 10 feet and remains there for up to 15 days. This comprises of areas near the banks of Jhelum and occupies 11 percent of total geographical area and 19 percent of total population.
- The third category of least affected area comprise of 16 percent of total geographical area in this portion the water level rises 3 feet and remains for the duration of 5 days. This area accounts of 12 percent of total population of Srinagar city and spanning over southern and northwestern parts of Srinagar city. The unaffected portions are old parts of city and the outer parts which are having high altitude and above all distance from water bodies this area is approximately 50 percent of the geographical area of Srinagar city.



#### Land slide/ avalanche vulnerability

Landslides and the avalanches are the outcome of the merciless cutting of trees and slope stabilization by man and construction of roads to the Pari Mahal and the other tourist stations. The quarrying of the stones in the Pantha Chowk is an open invitation as this side is on the lee ward side so devoid of the vegetative cover making more vulnerable to the avalanches and the landslides.

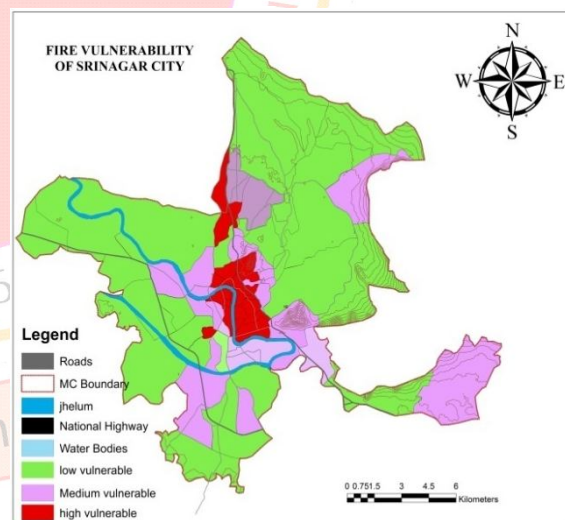
#### Anthropogenic vulnerability

##### Fire vulnerability

The fire vulnerable areas of Srinagar have been delineated on the basis of building material and accessibility at the same time incidence of fires in the city over the period of time. The main reason for the fire breakouts in Srinagar are building material, as the oldest buildings in Srinagar are mainly built of wooden material and they are high vulnerable to fires.

The high fire vulnerable areas comprise 7 percent of the total geographical area of Srinagar city. medium vulnerable comprises of 21 percent of total geographical area spans in the areas having buildings of mixed characteristics both wooden and concrete but population density and rescue operations still an issue in case of fires.

It includes some posh areas of Srinagar like Raj Bagh and the vicinity of Kashmir University. Least vulnerable areas are outer portions of city and areas which are having dominance of concrete buildings and at the same time less dense population added with the presence of agricultural land covering about 72 percent of total geographical area of Srinagar city.





### **Traffic accidents**

Srinagar being prime city in the region is major attraction for tourists worldwide. Roads in city are not wide enough to let the traffic go smoothly, streets are as narrow as 3 meters in some areas of Srinagar like Malla Bagh and core areas streets are even narrower than this. During peak hours, traffic jams is the common thing and traffic jams go even for the 3 hours which is severe problem in the city. The major accident points in the Srinagar city are Batamaloo, Pantha Chowk, Parimpora, Nishat, Nowshera, Bemina and Zakura besides other places.

### **Suggestions and Recommendations**

The strategies have been carried out on the empirical basis and with the sole aim of disaster mitigation and preparedness. The developmental considerations have been incorporated and must be followed to maintain the harmony between natural landscape and the man-made environment. The strategies must be followed in order to reduce vagaries of natural as well as man-made disasters.

### **Floods**

River front development all along Jhelum with main emphasis on bio-shields and special activities on selected portions within the city. This will not only save the water bodies but also regenerate the flood plains and greenery of the Srinagar city. The river front development will prove a check and the water will get sandwiched between the embankments and the spill will be minimal.

Rejuvenation channel to make the extra water go outside the city and the dredging of the same to increase the volume of it in Doodh Ganga. Rejuvenation of the spill channel includes the dredging and check on the structures coming within the fold of spill channel and Doodh Ganga.

Flood resilient structures within high flood vulnerable zones of Srinagar city like stilt structures and height of the plinth should be increased. Stilt housing will be the good option and will be less costly, a good step in the flood mitigation. Proper embankments with bio-shields all along Jhelum River within the Srinagar city, preferably walnut trees to be planted to protect soil from erosion. The embankments act as checks on the extra water and bio-shields like walnuts and willows will help as check on soil erosion.

Dredging of Jhelum River especially in areas near Haba Kadal, Amira Kadal, Lal Chowk, and Raj Bagh as siltation from sewerage system and particularly the erosion from karewas by the construction of railway track in valley has decreased the depth of the Jhelum River up to 2 inches.

Early warning systems and increased reliability by modern techniques and use of modern techniques in forecasting, the rainfall and water level at the three stations of the Srinagar city.

Spatial planning regulations for new construction in most vulnerable portions, total ban in for construction in the flood plains and severe punishments to the defaulters.

Evacuation plans of flooded areas and government buildings to be used as shelter houses at the time of emergency like school buildings in the safe areas of Srinagar like Nishat, Brain, Hazratbal and the other places in the central parts of the city.

Total ban on plastic bags and other effluents in water bodies mainly in the lakes which have been the main victims of the vagaries of man. Regulate and redevelopment policies in flood hit areas with Bemina and the Raj Bagh as the preferential areas.

### **Earthquakes**

Retrofitting of the existing buildings in areas like Hazratbal, Makhdoom Sahib and Dastageer Sahib, Jamia Masjid at Nowhatta. These buildings need to be retrofitted by the provisions of external iron beams and columns to withstand earthquakes. Reframing of the old structures so as to make them withstand shocks of earthquakes and tremors of earthquakes. Movement resistant frames for areas where the oldest buildings of the city are located.

Replacement of pole laden transformers with plinth laden transformers, the pole laden transformers are more reluctant to the electric shocks during shaking of earthquakes and cause damage by the collapse of transformers and electric wires. Water towers and storage tanks design to withstand earthquake and check on building materials and height of the storage tanks within residential areas so as to minimize the impact in case of collapse.

Clubbing of the old traditional Dhajji Dewari with the contemporary building technology and provisions for promotion of the same, Micro zonation of earthquake vulnerability continuous assessment in high vulnerable areas like Eid Gah, Safa Kadal.

Building byelaws, retrofitting and special assistance in traditional techniques like Dhajji Dewari which is traditional technology and has the capability to withstand the vagaries of earthquake. Training and awareness camps to the people of city, regarding the techniques for prevention from earthquakes and safety parameters.

Provisions for the installation of seismographs and use of most reliable tools to check seismic activities, which will provide timely information of seismic activities in the fault lines of Kashmir valley.

### **Landslides/Avalanches**

Concrete walls along the contours to prevent mud flows all along the Zabarwan and Nishat areas by road side so as to avoid the mud flows and the uprooting of natural vegetation.

Flexible debris resisting barrier the Fore shore road which lets water to go through but restricts solid and the soils to go further and is a best technique to prevent damage.

Plantation to check soil erosion, mud flow resulting to landslides in steep sloppy areas of Srinagar and the trees to help in percolation of water to the ground which prevents landslides.

Correction of existing drainage, choked streams and nullahs and feeder channels of Jhelum within the city. Rejuvenation of drains and streams encroached over the period of time and strict laws for protection of the water bodies whether large or small.

Restrictions on construction along contours in the areas of Zabarwan hills and the steep areas which are at the slope of more than 30° and special checks on the extraction of stones and building material from the hills in the Pantha Chowk area of Srinagar. Plantation of trees, like pine and walnuts whose cutting is offence in the state, to prevent the soils from getting exposed to erosion. Land slide mapping of city region, delineation of city into different zones; preparation steps to be taken accordingly. Mobilization of communities and government agencies, other stake holders and early warning systems

### **Low lying Areas**

Stone walls to protect buildings in areas along Jhelum River, and water bodies like Dal Lake, Nigeen Lake etc. High plinth level buildings which lie in areas of Raj Bagh, Bemina areas of Srinagar.

Stilt housing in low lying areas which will withstand the water level increases and will be able to shelter the people in the flooding of the areas. Wet proofing of buildings in marshy areas to ensure minimum loss in areas like Hassan Abad, Soura, and Jogi Lankar.

Evacuation plans for the people in case of the floods and the provision of the different facilities along the routes so that evacuation will be easily done.

Avoid new construction by declaring the areas in the vicinity of water bodies as no construction zones so that water will flow smoothly after rains avoiding urban floods after every rainfall. Schemes for Solid waste management to avoid choking of drains and severe laws for the encroachments.

### **e) Fires**

More fire stations in the core area of the city where fire stations are not adequate like Bab Demb, Seki Dafar etc. Fire hydrants in those portions where fire stations are inaccessible like Maharaj Ganj, Kani Mazar,

Zal Dagar Fire alarms in the public buildings like Jamia masjid, secretariat, and Allama Iqbal library of Kashmir University etc.

Fire resistant buildings in core areas, public sector buildings and commercial buildings in Lal Chowk, Regal Chowk Batamaloo, Karan Nagar and many other places. Release of firefighting resources and enhancement in capabilities. Fire-fighting mock drills periodically to the concerned department. Ensure safety audits regularly in the localities. Community base disaster management system for fire-fighting.

#### **f) Traffic Accidents**

Widening of roads all along the city wherever possible, construction of dividers on the fast moving roads within and outside the city. Installation of traffic light at the black spots like Pantha Chowk etc. Diversions of traffic in the heart of city through Batamaloo via Hyderpora Bye pass. Strict traffic rules and enhancement in the techniques used for traffic regulation and special arrangements for vulnerable groups.

Priority based routes within the city such as alternate routes during the peak hours to avoid traffic congestion. Encouragement to public transport and the use of public transport instead of cars and use of two wheelers which will not only reduce congestion but also accidents on the surface of roads.

#### **Conclusion**

The recommendations have been given keeping in view the short term and the long term mitigation measures in consideration. The strategies are formulated keeping in view the specifications and the viability in the Srinagar city. Moreover the strategies are in accordance with the national and the state disaster management policies and the plans. The strategies will play the pivotal role in not only the mitigation but at the same time in the response and the rehabilitation of the disasters in the city. Furthermore the recommendations are future guidelines which will ensure the harmony of man with the nature in case of the encroachments which are the basic reason for the devastation in case of the floods and the landslides which are accelerated by the anthropogenic activities over the period of time.

The proposals are formulations and suggestions which ought to be followed and kept into consideration while preparation of disaster free city. In case of the Srinagar city, proposals have been formulated after keen observations and the analysis of the trend of the disasters over the period of time. Rescue operations and shelter houses are in accordance with utmost need and in many places already facilities are to be utilized to avoid confusion. Amalgamation of traditional and the contemporary technology is the new blend for proper functioning of the disaster management plan.

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