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Identification of Flood Vulnerability Zones for Managing Disaster in Srinagar City, India

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Abstract: Srinagar municipal area, in Jammu and Kashmir, Union Territory of India, is highly prone to floods, due to its physiographicstructure and human interventions, both structural and non-structural. Srinagar city, experienced worst flood, during first week of September 2014, due to unprecedented and incessant rains. A total of 42% area of Srinagar city, comprising of 91% population, out of 1.18 million population, was affected by the September 2014 flood. Present study, attempts to identifyphysical and human intervention flood vulnerabilities in Srinagar city in order to integrate disaster risk reduction strategies for managing flood disasters. Identification of flood vulnerabilities has been attempted with support from,both secondary and primary sources of data and information.Physical (elevation of spatial units), demographic and socio-economic indicators were selected for identifying vulnerabilities at ward level unit. Socio-economic indicators, selected include,density of population, distribution of child and old age populationand house structures,in terms of building material used for construction. Based on these four selected indicators, award wise, composite index of flood vulnerability zones have been prepared. Different weights were allotted to the indicators in view of their sensitivity for flood vulnerability.Vulnerability index separately for all four indicators and a composite vulnerability index were identified.Based on statistical model, high,medium and low flood vulnerable zones were identified.The composite flood vulnerability index depicts, 35 % of area, 51% of population and 44% of wards are susceptible to high flood vulnerability, while 26% of area, 27% of population and 31% of wards were identified as medium vulnerability index zones. Thus a significant proportion of area, population and wards are vulnerable to floods in Srinagar Municipal area. The results portray, need for incorporating Disaster-Risk- Reduction,protection and preparedness measures, that are in sync with the Sendai Framework of Action,highlighting Community participation and preparedness for managing disasters.

Key Words: Flood vulnerability, Sendai Framework, Disaster Risk-Reduction Management, Community participation and preparedness, Structural and Non-Structural Vulneraries.

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I. INTRODUCTION

Vulnerability can be conceptualized in many different ways.Intergovernmental Panel on Climate Change(IPCC),defines vulnerability, as a degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. [1]Vulnerability usually refers, the inverse of the resilience, where resilience describes the capacity of ecosystems to react against the stress. Thus, vulnerability represents the territorial system tendency to suffer damage during an extreme event. Vulnerability is also considered as the extent of harm, which can be expected under certain conditions of physical, cultural, social and economic exposure, susceptibility and resilience.[2]

Disasters due to, natural hazards are increasingly globally. The frequency and severity of weather and climaterelated hazards have increased, exposing more people and a greater value of assets to disasters. Climate-related disasters are becoming more frequent and negatively impacting development progress across the world. Disaster is"The result of a vast ecological breakdown in the relationship between man and his environment, (a serious and sudden) disruption on such a scale, that the stricken community needs extraordinary efforts to cope with it".[3, 4]

People are already experiencing the impacts of climate change, for example, sea level rise and greater variability in the seasonality of rainfall, and extreme weather events, particularly extremes of heat, rainfall and coastal storm surges are common features nowadays.[5]At the same time, economic damage from climate-related extreme events and disasters has increased dramatically in the last 50 years, with developing country economies being particularly badly hit. {6}There has been significant rise in economic losses from disasters for the Asia and Pacific region.[7]Actions towards Disaster Research Management (DRM) must be compatible with a changing climate. This requires each country to have a plan to avoid the losses and damages associated with extreme

weather and to make community based disaster resilience central to economic and social policies.[8, 9] While it is clear that climate- and disaster-related shocks and stresses undermine economic growth and development, there are many actions that governments and other agencies can take to reduce the risks to lives, livelihoods and economies.[10, 11]Poor people suffer the most from disasters, as they lack the capacity and resources to effectively cope. Risk management in policies and programmes to reduce disaster risk reduction, is vital for helping to ensure that, the most vulnerable people can access the benefits of development.

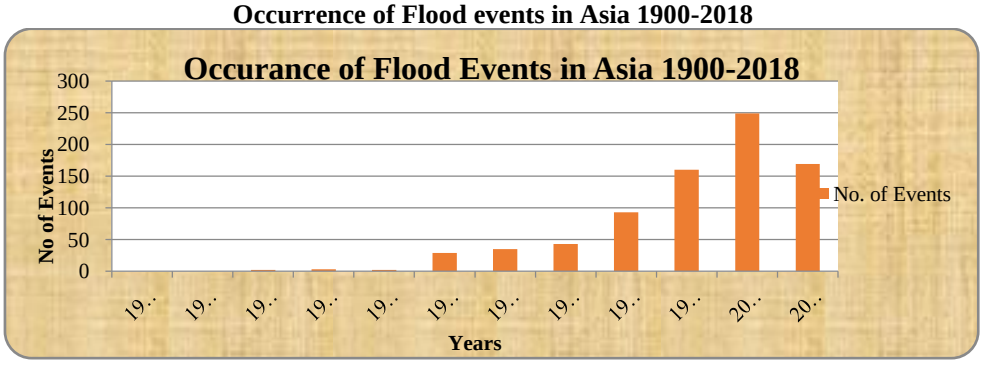
Floods being the most common natural disaster, people have, out of experience, devised many ways of coping with them. On account of frequent occurrence of floods, since times immemorial, people have learnt to live with them. They have generally set up settlements away from frequently flooded areas, which have been used for other activities such as agriculture, grazing of cattle etc. The crops that can sustain submergence are grown in the flood prone areas, during rainy season. However, encroachments into the flood plains over the years have aggravated the flood problem and a need to take effective and sustained flood management (FM) measures has been felt. FM measures include physical, structural and non-structural. If these FM, are in place a considerable protection towards DRM can be ensured for the protection from human fatalities, loss of building and other construction and infrastructure structures, agricultural crops, loss of animal and livestock.

The assumption that, it is more expensive to invest in disaster-resilient development, such as drought-resistant crops, flood proofed roads and disaster resilient shelters has not been corroborated with evidences. In fact a cost-benefit analysis for the housing sector shows, building homes, that can withstand floods is far lower than the cost of repairing homes, that cannot stand when a flood does hit it. Results have shown that costs of building flood resilient structures, houses and cultivating flood resilient agricultural crops can be minimized with use of modern technology. Challenge in flood damage research requires better understanding of the flood vulnerabilities, social dynamics of flood risk perception, preparednessand flood risk management.

Flood vulnerability assessment, is a multidimensional approach encompassing a large number of indicators which includes environmental setting,meteorological events supported by human interventions- both structural and non-structural. Vulnerability is dependent on the economic wellbeing, awareness of the people living in a society, preparedness and recovery conditions of the community. The poorest are disproportionately vulnerable and they have less capacity to cope with disasters. Lack of participatory flood vulnerability assessment has been identified as one of the major limitation in designing and implementing appropriate adaptation strategies to reduce flood risk. [12]

A vast literature on disaster vulnerability,points out, physical unsustainability, strengthened by human activities as major cause of strengthening vulnerabilities especially unprotected conditions.[13,14,15] These unprotected conditions makes acommunity weak to live with natural disasters and hazards. Therefore, addressing these vulnerabilities is the key, towards creating conducive solutions for achieving disaster-risk-reduction strategies. The number of flood disasters reported, has been on the increase since the last seven decades in Asia. This increasing flood events is closely associated with non-existent approaches towards attending vulnerability of flood associated disasters. According to the International Disaster data base report,occurrences of flood events in Asia has increased significantly during 1900-2018 period.Asian countrieslike India, China, Bangladesh, Indonesia, Pakistan, Myanmar, Iran andAfghanistan are more vulnerable to flood disaster(Refer Fig.No.1)

Fig No.1
Occurrence of Flood events in Asia 1900-2018



Source: International Disaster Database, prepared by Centre for Research on Epidemiology Of Disaster (CRED), 2019

II. OBJECTIVES OF THE STUDY

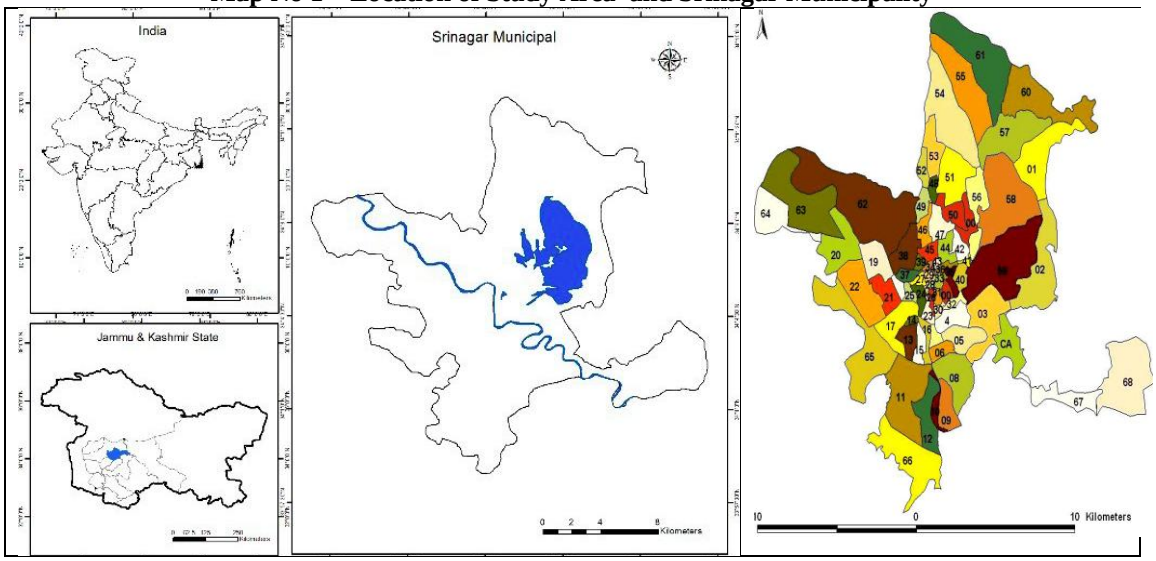
The Present study, attempts to

- Identify, flood vulnerability zones,in Srinagar Municipality, in terms of physical landscape, meteorological influences, human interventions both structural and non-structural and demographic andsocial vulnerabilities.

III. STUDY AREA

The area selected for the study is, Srinagar Municipality, with an area of 278.60 Square Kilometres. Srinagar municipal area recorded population of 1,186,867(Census 2011). The areais divided into34 administrative wards and 68 Electoral Wards.[16] Srinagar Municipality was affected by severe flood during 1-10th September, 2014. River Jhelum flows in the centre of Srinagar municipality. (Refer Map No 1, Location of Study area with Ward location numbers in Jammu & Kashmir, Union Territory in India)

Map No 1 – Location of Study Area and Srinagar Municipality



Source: Census of India and Srinagar Municipality

IV. DATA SETS AND METHODOLOGY

Flood vulnerability is a function of, location, exposure to hazards, and the physical performance of a structure.Socio-economic vulnerability refers to the prevailing socio-economic conditions.[17.18]. Foridentification of flood vulnerability among the Wards (unit), in Srinagar municipality, indicators selected were, related to physical vulnerability like; terrain elevation and altitude above sea level, in relation of river Jhelum water bed. Other indicators selected were, density of population, proportion of child and old population and house structure in terms of house building material used for construction.The contribution of the selected indicators towards,flood vulnerability varies significantly, based on their sensitivity to flooding mechanism. The weightages to the indicators for developing vulnerability index was implemented in multiple steps. Heterogeneity of indicators, contributing to flood hazard, were developed by using statistical model and all the four variables were standardised. A knowledge-based weighting scheme was applied to each of four variables.Indicators that represent a high level of dispersion were given more weight; a variable depicting a uniform situation across the study area and is not likely to distinguish between vulnerable and non-vulnerable zones were given lower weights. The variable 'terrain elevation' was attached to high importance, because the low lying areas of the study areas are frequently inundated by flood water. The highest value of (40%) was given to terrain elevation, because under normal conditions (without structural measures), it determines the flood impact. The rest of the 3 indicators were given value of (20%) each.Ranks were given according to the intensity of the indicator values. High vulnerability for floods intensity category for all selected indicators was given, rank of 1, followed by 2 and 3rank, for medium vulnerability and low vulnerability simultaneously. A composite index for all 68 wards of Srinagar city was worked to identify flood vulnerability zones selecting all 4 indicators. (Refer Table No 1)

Table No 1
Indicators Selected, Weights and Category Ranks

Indicator	Weight Value in Percent	Category Size	Rank
Average altitude/ elevation of Ward (Metres above sea level)	40	< 1500 1501- 1525 Above 1525	1 2
Density of Population (persons/ Sq. Kms) Census -2011	20	>7000 7001-14000 >14001	1 2 3
Houses material used for construction	20	Permanent Semi-permanent temporary	3 2 1
Percent Population, Children and Aged (Less than 15 and more than 60 years)	20	< 10 percent 10-15 percent <15percent	3 2 1

Source: Research Methodology Used for Composite Index

V. DATA SOURCES AND PRIMARY SAMPLE SURVEY.

The data related to average terrain elevation and altitude above sea level was collected from the previous study.[19] The data on ward wise, density of population was collected from Census of India-2011. Data on houses material used for construction and proportion of child and old age groups of population, was collected from office of Srinagar Municipality,Election Commission and Public Distribution System of Rations. In addition, a primary household survey appropriately selected, sample wards of Srinagar municipality was also conducted for data supplementation and triangulation, to represent all types of wards. Five hundred households, from 10 areas/ localities of Srinagar city, were selected in September -November 2019 for primary field survey. These 10 areas/ localities, were randomly selected, from the strata of severely, moderately, mildly affected flood areas in September 2014 floods. Households, were randomly selected from different grids (areas) of selected wards to represent Srinagar municipality wards. (Refer Table No 2 for selection of wards and households for primary field survey)

The field study methods, utilized, include, field observation, focused group discussion and triangulation methods, utilised for the validation of the information, provided by households. Structured questionnaires, were prepared having, both quantitative and qualitative components, with both open-ended and multiple choice questions –answers. Research investigators, selected for the survey, were imparted special training for adherence to ethical issues, while conducting the field survey. The research team initiated the data collection process and field observation, in compliance with the ethical code of conduct, as specified by the Indian Council of Social Science (ICSSR). Informed consent from the respondents was sought, prior to data collection, to ensure that the rights of the individuals and groups, participating in the survey were neither violated nor trespassed upon.

Table No 2
Srinagar Municipality- Areas selected for Sample Primary Field Survey and their sample size

Flood Affected Wards, during September 2014 flood	Areas/ Localities selected for field survey	Number of Households selected for Survey
Severely	Rajbagh, Lal Chowk, Gogji Bagh, Barbarshah, Hazratbal	300 (60 from each area/ locality)
Moderately	Rawalpora, Bemuna, Hasanabad	90 (30 from each area/ locality)
Mildly	Khanmou	50
Safe	Nishat	60
ALL Areas	**10 Areas/ Localities**	**500**

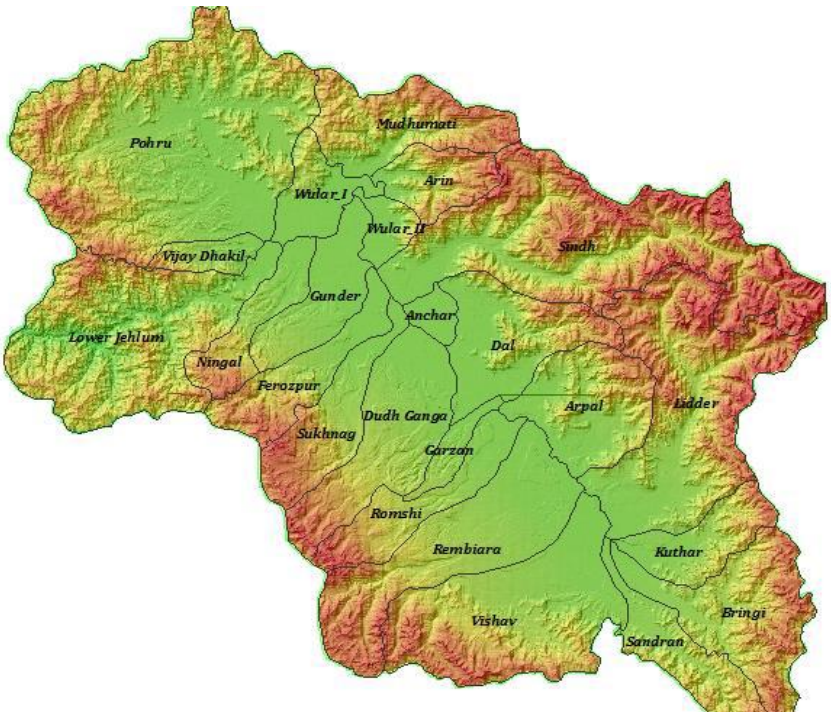
Source: Research Methodology for selecting households

VI. PHYSIOGRAPHIC AND METEOROLOGICAL VULNERABILITY

Kashmir Valley, in Jammu and Kashmir, Union Territory of India, is highly prone to floods, due to its physiographic and geologic structure. Kashmir Valley is a deep, asymmetric basin, delineated from the adjoining mountain systems, on the basis of drainage network and its catchment basin . The valley of Kashmir includes, all land lying, within the water divides, formed by the Pir-panjal mountain ranges in the south, and greater Himalayas in the north. These mountain ranges encircle great synclinal trough, occupied by Jhelum river in Kashmir Valley.[20] Average height of Kashmir Valley is about 1850 meters, above sea level, but the surrounding mountains, are generally snow clad and they rise up to 3000 to 4000 meters, above sea level (Census of India, 1988) (Refer Map No.2). River Jhelum, has shaped up the ecology, economy and the life style of the inhabitants of the Kashmir valley and Srinagar city. The whole length of the Jhelum from its source (Verinag spring in south-east of Kashmir Valley to Baramulla (North-west) is 150 Kilometres. The fall of the river is just 18 metres in 113 Kilometres. All along its course, the river is characterized, by the sluggish flow of main Jhelum river and the highly torturous course of its 24 tributaries, draining from the slopes of Pir-Panjal and Himalayan ranges. (Refer Map No 2).The Valley experiences both western and monsoons disturbances, during August - October months. This creates conditions of incessant rainfall and abnormal discharge of water from all tributaries.

Like all sedimentary basins, Kashmir valley has a combination of depositional and erosional features. Low lying waterlogged areas and Jhelum river channel are subject to, receiving layer after layer of fine silt and coarse gravel, that increases, water level of Jhelum river during monsoon period. During August-September months every year, usually incessant rainfall for 15-20 days occurs, during withdrawal of monsoon period from this region. This enhances the flood conditions in the low-lying areas of Kashmir Valley, especially its capital, Srinagar city. Srinagar city has embankment walls around the city, supported by construction of bunds on both sides of its river channel. However these embankment walls are old constructions and they breaches sometimes, owing to higher water discharge from its upper reaches, due to incessant rainfall.

Map No.2-
Kashmir Valley Physiography and
Jhelum Basin Drainage Network



Source: Atlas of Jammu & Kashmir, Census of India -1981

The valley of Kashmir has a long history of floods due to excessive water discharge from the tributaries of Jhelum river during strong western disturbances (November to April) and monsoon period (July- September). According to Sir Walter Lawrence "Many disastrous floods are noticed in vernacular history of Kashmir valley (Refer Table No 3)."[21]

Table No 3
Major Recorded Historical Flood Events in Kashmir Valley

Year	Major Floods	Source
879	Channel of Jhelum was blocked and large part of valley was submerged, this terrible inundation followed the slipping of the Khadanyar mountain in Baramulla	Sir Walter Lawrence
1841	Lawrence notes that it, "caused much damage to life and property."	Sir Walter Lawrence
1893	52 hours of continuous rainfall, beginning 18 July, caused "a great calamity".	Sir Walter Lawrence
1903	The floods, of that day were classified as the "greatest flood ever known", which came down the Valley and inundating Srinagar on 23 July 1903, converting the city into "a whole lake".	Sir Walter Lawrence
1929	Most affected areas where the parts now known as Pakistan Occupied Kashmir	Sir Walter Lawrence
1957	The floods almost submerged valley plains. The then Prime Minister of Jammu and Kashmir, Bakshi Ghulam Mohammad was quoted as saying that, "the floods recorded in Jammu and Kashmir were the highest ever recorded in the state, and that the damage caused by them was colossal."	Newspaper Reports
1959	Glacial flood due to four days of incessant rains	Newspaper Reports
1992	According to newspaper reports from September 1992, over 200 people lost their lives and the floods left over 60,000 people marooned in several north western border districts	Newspaper Reports
1996	Inundated villages around river Jhelum and huge loss of property.	Newspaper Reports

Source: Sir Walter Roper Lawrence , The Valley of Kashmir (1895) and newspaper reports.

Srinagar city experienced, the worst floods in the past 60 years, during first week of September 2014, due to unprecedented and incessant rains, which was considered as one of the extreme weather events. "The synchronization of movement of westerly winds in the extreme north, with the passage of monsoon disturbances in the lower latitudes, caused heavy to very heavy rainfall along the foothills of the Himalaya, and adjoining areas of Jammu & Kashmir"[22]. Continuous rainfall from Ist September – 6th September 2014, with a record of 30 hour of continuously incessant rainfall from 3rd September 2014, broke the record of many decades. Majority of rainfall stations, in Kashmir valley, recorded deviation of more than +6000 percent rainfall for the 4 days (3-6th September 2014), as compared the norm of rainfall, for the same days recorded from 1970-2000.Inadequate capacity of the Jhelum river and its tributary rivers to contain within their banks, the high flows brought down from the upper catchment areas following heavy rainfall, lead to flooding of villages. The existing embankment/bunds on river Jhelum in Srinagar city could not contained Jhelum river and as a result of this, nearly 90 breaches were found at several places in and around Srinagar city.[23] These breaches flooded nearly 3/4th of city Srinagar city and its lower level inhabitations. (Refer ISRO Photographs of Srinagar city taken before and during September 2014 flood)

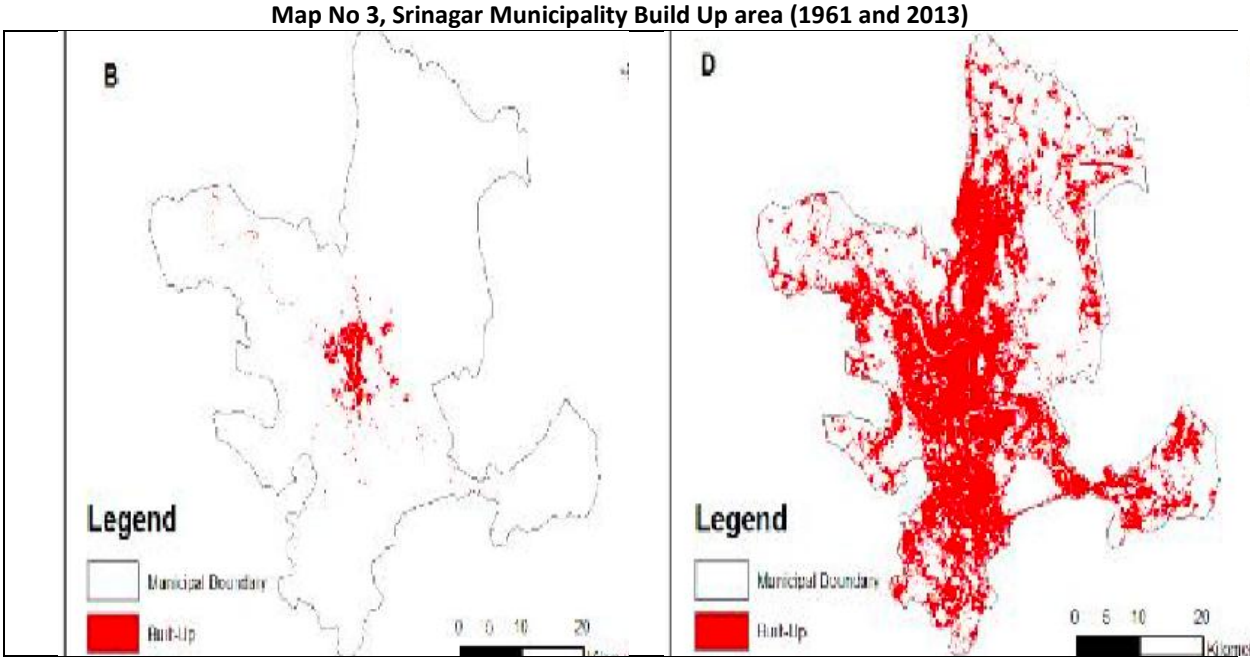
Major structural vulnerabilities contributing towards flooding in Srinagar city were, inadequate carrying capacity, due to design and poor maintenance of embankments/bunds, flood walls and flood levees and flood channels.Other structural vulnerabilities are improper channel improvement like; desilting/dredging of rivers, dams, reservoirs and other water storages and structurally inappropriate alignment, location, design and provision of waterway i.e. vents, culverts, bridges and causeways located on national highways, state highways, district and other roads.

Non-Structural vulnerabilities includes unabated urban expansion and change of land use and land cover on both sides of the river Jhelum in Srinagar city. Based on satellite data and existing toposheets, a comparative statistics of the Srinagar city build-up area during 1961 and 2013 has been developed. It clearly reflects a drastic change in land use and land cover from 1961-2013 period. Srinagar city build-up area, has increased from 2.45 % in 1961to 39.08% in 2013. The overall percent increase in build-up area was 36.63% during this period. (Refer Map No 3, Srinagar City Build-up areas during 1961 and 2013)

Remote Sense Photographs of Srinagar City (Before and During September 2014 Flood)

Source : https://mykashmirvalley.files.wordpress.com/2015/07/4551189_orig.png ,accessed on 16th April 2020.

Map No 3, Srinagar Municipality Build Up area (1961 and 2013)



Consequently area under agricultural, plantation and horticulture activities have decreased continuously. Several water bodies have even disappeared. Even areas around flood channels were converted into build-up areas. All these activities have, hindered free flow of Jhelum river in Srinagar city.

The flood vulnerability scenario in the Jhelum basin has worsened, during the last few decades as most of the wetlands that used to act as sponge during flooding, have been urbanized and converted into concrete landscape in the entire Kashmir valley. Most of wetlands and water bodies are fighting a losing battle for their survival. The functionality of wetlands, having strong linkages with the hydrological cycle, has got adversely affected due to their encroachment and seasonal changes in the precipitation and runoff attributed to the climate change. In and around Srinagar only, 20 wetlands were lost to urban development colonies during the last five decades, particularly in the South of the Srinagar city. The impervious concrete surfaces in the city have increased from 34% in 1990 to more than 65% in 2010. It has, severally affecting the hydrological processes particularly infiltration. Shrinking of most of the wetlands in Kashmir valley, deforestation, urbanization of floodplains and siltation of water courses has degraded the ability of environment to absorb the excess rainwater

and thus, increased the vulnerability of the Jhelum basin to flooding, which is manifested in the frequent flash floods and water logging observed in the floodplains of Jhelum including the Central Business District (Lal Chowk) after just a few centimetres of rainfall. Most of the housing colonies built in the floodplains of Jhelum and along the Jhelum river course stand, regularized by the successive governments and thus, encouraging the conversion of the remaining wetlands in the vicinity of the Srinagar and elsewhere to built-up enclosures. .[23]

Thus a combination of physiographic, geologic structure, meteorological, structural and non-structural vulnerabilities were responsible for the September 2014 flood in Kashmir Valley. Most populated areas and high density areas were submerged in Srinagar city. Ninety six percent population of 1.18 million population of Srinagar Municipal area, was affected by the September 2014 floods. Out of 278 square kilometres area of Srinagar Municipality, 118 square kilometres of areas constituting 42% of the Srinagar city areas, was completely inundated/ submerged for 10 days.[23]

VII. RESULTS AND DISCUSSION

The statistical model used for identifying flood vulnerable index, for selected indicators and for composite flood vulnerability index were derived. (Refer Table No 4 and Figure No 1-3)

Terrain elevation vulnerability,depicts 62% of wards, 45% of the area and 58% of population in Srinagar Municipality were susceptible to high flood vulnerability. House material used for construction, also depicts 52% of population, 42% of area and 50% of wards are highly vulnerable to floods. Density of population indicator , depicts 51% of population and 50% of wards have high flood vulnerability index. Proportion of high child and old population, also indicates that 52% of population, 42% of area and 44% of Wards have high flood vulnerability.

The composite flood vulnerability index depicts, 35 % of area, 51% of population and 44% of wards are susceptible to high flood vulnerability, while, 26% of area, 27% of population and 31% of wards have medium vulnerability index. Thus a significant proportion of area, population and wards are having high and medium vulnerable index to floods in Srinagar Municipal area. (Refer Map No 4, Table No 4 and Figure 1-3).

This indicates that measures related to structural and non-structural components, like drudging and de-silting of river Jhelum channel, removal of encroachments for free flow of water of river Jhelum, development of alternate flood channel and maintenance and construction of retrofired embankments, flood walls and bunds around Srinagar city area, must be done regularly to avoid breach in embankments/ bunds during rainy seasons and save Srinagar city from flooding in future.

The results depict that state machinery and community, must create conducive atmosphere of implementing rules and regulations especially, zero tolerance towards illegal encroachments in the river channels. There is need to create structural and non-structural measures towards disaster risk reduction by adopting, protective and preparedness measures. Steps like de-silting, drugging, maintenance of bund walls, clearance of river channels must be taken annually by government agencies.[24] Flood vulnerable house structures, must be identified in old Srinagar city, for maintenance with retrofired structures or even re-developed structures. However, awareness generation measures, like early warning system, safety audits, implementation of building codes and development of emergency resettlement centres must be ensured. Community needs to be sufficiently informed about rules and regulations of not encroaching river channels and flood channels.

Training and capacity building of NGOs/CBOs, is most effective tool of reducing disaster vulnerabilities. It should be endeavour of government's, Non-Government Organisations (NGOs) and Community Based Organization (CBOs), to create a trained cadre of officers/officials/ staff of different departments, who are directly involved in disaster management. In this direction the role of various institutions, need to be highlighted, since disaster management involves multi-stakeholders and as such, needs to be dealt with accordingly.

Figure No 1

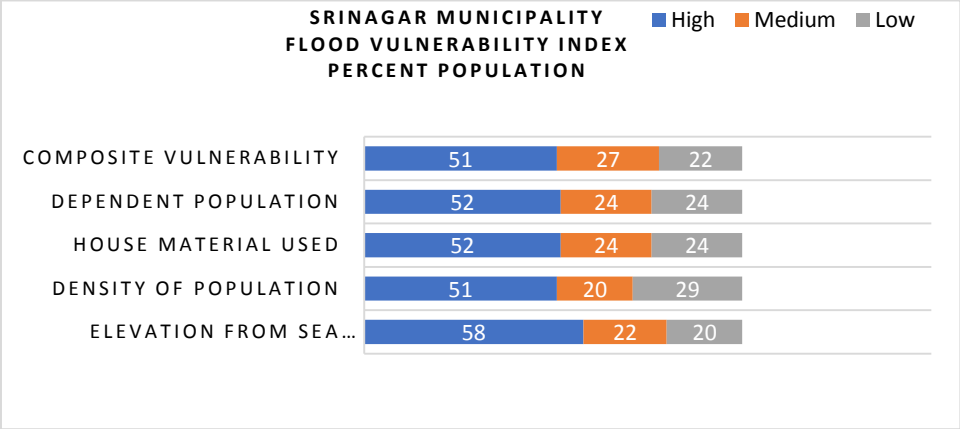


Figure No 2

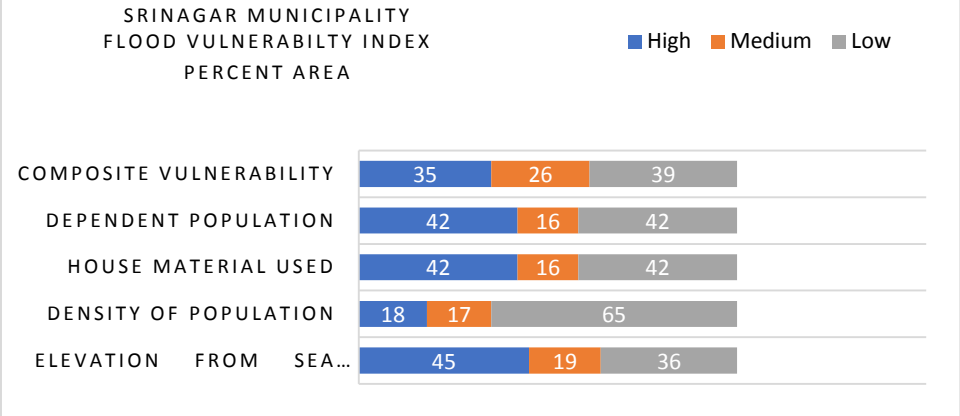
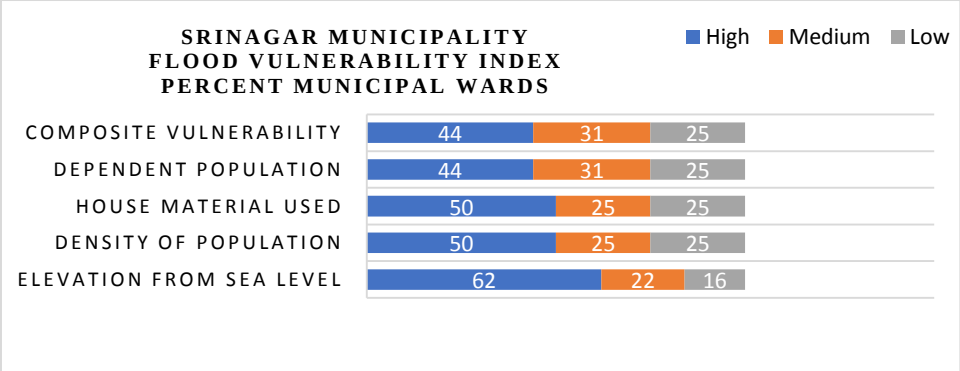


Figure No 3



Map No 4

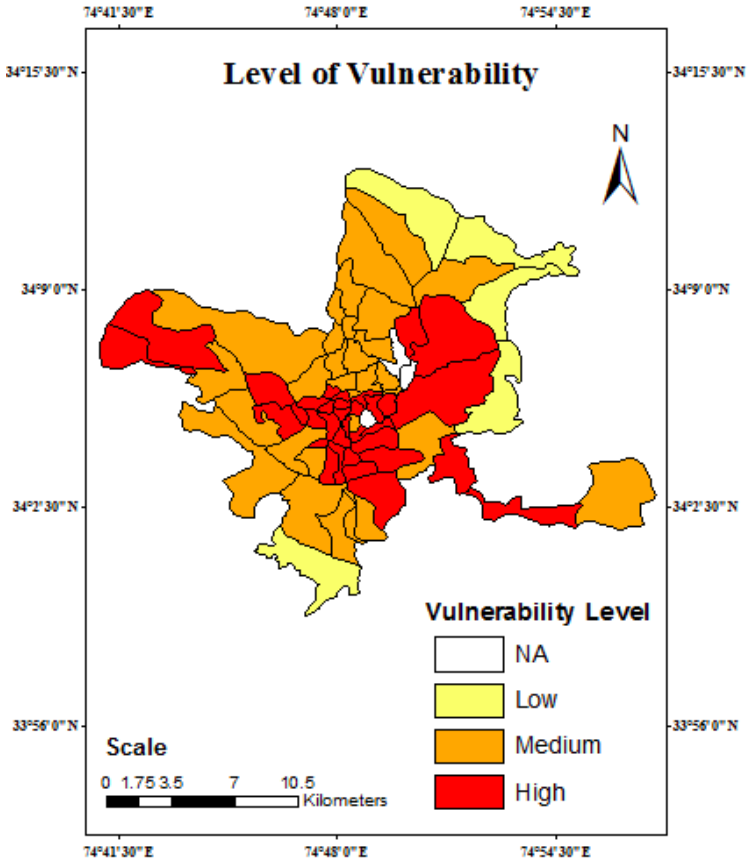


Table No 4
Flood Vulnerable Zones based on Selected Indicators

Elevation / Altitude above sea level
High Vulnerable Wards Dal Gate, Lal Chowk, Raj bagh ,Wazir Bagh,Saria-Bala, Mehzoor Nagar, Natipora, Sheikh Dawood Colony, Batmalnoo, Aloocha Bagh, NundReshi colony , Qamarwari, Parimpora, Zainakot, Bemina A, Bemina B,, Shahid Ganj, Karan Nagar, Chattabal, Syed Ali Akbar , Nawab Bazar, Islamyarbal, Alikadal, Ganpatyar, Malik Angan, Barbarshah, Khan Qah Mohalla, S.R. Ganj, Aqil-Mir-khanyar, Khawaja-Bazar, Safakadal, Eid-Gah, Tarabal, Jogilankar, Zindshah-sahib, Jamia-Masjid, Hazratbal, Bud-Dal, Locut-Dal, Palapora, Maloora, Lawaipora, Padrethan **Medium Vulnerable Wards** Channapora, Bhagat-I- Barzala, Rawal Pora Magarmal Bagh,, NundReshi colony , Hasanabad, Mukhdoom sahib, Kawdara, Zadibal, Madin-sahib, Now-shera, Zoonimar, Lal-Bazar, Soura, Khumani Chowk **Low Vulnerable Wards** Harwan, Nishat, Umar colony, Buchpora, Ahmad-Nagar, Zakura, Tail-bal, Dara, Alasteg, Humahama, Khanmoh
Density of Population (Population / Sq Kms)- 2011
High Vulnerable Wards Lal Chowk, Wazir Bagh, Saria-Bala, Mehzoor Nagar,, Channapora, Batmalnoo, Aloocha Bagh, Qamarwari, Parimpora, Shahid Ganj, Karan Nagar, Chattabal, Syed Ali Akbar , Nawab Bazar, Islamyarbal, Alikadal, Ganpatyar, Malik Angan, Barbarshah, Khan Qa Mohalla, S.R. Ganj, Aqil-Mir-khanyar, Khawaja-Bazar, Safakadal, Eid-Gah, Tarabal, Jogilankar, Zindshah-sahib, Hasanabad, Jamia-Masjid, Mukhdoom sahib, Kawdara, Soura **Medium Vulnerable Wards** Dal Gate, Raj bagh , Natipora, Bhagat-I- Barzala, Sheikh Dawood, Colony, Magarmal Bagh, Zainakot, Bemina A, Bemina B, Zadibal, Madin-sahib, Now-shera, Zoonimar, Lal-Bazar, Hazratbal, Tail-bal

Low Vulnerable Wards Harwan, Nishat, Raj bagh , Natipora, Sheikh Dawood Colony, Magarmal Bagh, Lal-Bazar, Umar colony, Soura, Buchpora, Ahmad-Nagar, Zakura, Dara, Alasteg, Humahama Khanmoh
Houses material used for construction **High Vulnerable Wards** Saria-Bala, Qamarwari, Parimpora, Bemina A, Shahid Ganj, Chattabal, Syed Ali Akbar , Nawab Bazar, Islamyarbal, Alikadal, Ganpatyar, Malik Angan, Barbarshah, Khan Qa Mohalla, S.R. Ganj, Aqil-Mir-khanyar, Khawaja-Bazar, Safakadal, Eid-Gah, Tarabal, Jogilankar, Zindshah-sahib, Hasanabad, Jamia-Masjid, Mukhdoom sahib, Kawdara, Hazratbal, Tail-bal, Bud-Dal, Locut-Dal, Palapora, Maloora, Lawaipora, Padrethan **Medium Vulnerable Wards** Dal Gate, Lal Chowk, Wazir Bagh, Mehzoor Nagar, Channapora, Bhagat-I- Barzala, Rawal Pora, Batmalnoo, Aloocha Bagh, NundReshi colony , Zainakot, Bemina B, Karan Nagar, Zadibal, Madin-sahib, Now-shera, Zoonimar **Low Vulnerable Wards** Harwan, Nishat, Raj bagh , Natipora, Sheikh Dawood Colony, Magarmal Bagh, Lal-Bazar, Umar colony, Soura, Buchpora, Ahmad-Nagar, Zakura, Dara, Alasteg, Humahama Khanmoh
Population percent Aged (less than 15 and more than 60 years **High Vulnerable Wards** Saria-Bala, Qamarwari, Parimpora, Bemina A, Shahid Ganj, Chattabal, Syed Ali Akbar , Nawab Bazar, Islamyarbal, Alikadal, Ganpatyar, Malik Angan, Barbarshah, Khan Qa Mohalla, S.R. Ganj, Aqil-Mir-khanyar, Khawaja-Bazar, Safakadal, Eid-Gah, Tarabal, Zindshah-sahib, Jamia-Masjid, Hazratbal, Tail-bal, Bud-Dal, Locut-Dal, Palapora, Maloora, Lawaipora, Padrethan **Medium Vulnerable Wards** Dal Gate, Natipora, Channapora, Bhagat-I- Barzala, Rawal Pora, Sheikh Dawood Colony, Aloocha Bagh, Magarmal Bagh, NundReshi colony , Zainakot, Bemina B, Karan Nagar, Jogilankar, Hasanabad, Mukhdoom sahib, Kawdara, Zadibal, Madin-sahib, Now-shera Zoonimar, Khumani Chowk **Low Vulnerable Wards** Harwan, Nishat, Raj bagh , Wazir Bagh, Mehzoor Nagar, Batmalnoo, Lal-Bazar, Umar colony, Soura, Buchpora, Ahmad-Nagar, Zakura, Dara, Alasteg, Humahama, Khanmoh
Composite Vulnerability **High Vulnerable Wards** Raj bagh , Saria-Bala, Wazir Bagh, Mehzoor Nagar, Natipora, Batmalno, Aloocha Bagh, Qamarwari, Parimpora, Bemina A, Shahid Ganj, Karan Nagar, Chattabal, Syed Ali Akbar, Nawab Bazar, Islamyarbal, Alikadal, Ganpatyar, Malik Angan, Barbarshah, Khan Qa Mohalla, S.R. Ganj, Aqil-Mir-khanyar, Khawaja-Bazar, Eid-Gah, Tarabal, Jogilankar, Zindshah-sahib, Jamia-Masjid, Hazratbal, Bud-Dal, Locut-Dal, Palapora, Maloora, Lawaipora, Padretha **Medium Vulnerable Wards** Dal Gate, Lal Chowk, Channapora, Bhagat-I- Barzala, Rawalpora, Sheikh Dawood Colony, Magarmal Bagh, NundReshi colony , Zainakot, Bemina B, Hasanabad, Mukhdoom sahib, Kawdara, Zadibal, Madin-sahib, Now-shera, Zoonimar, Lal-Bazar, Khumani Chowk **Low Vulnerable Wards** Harwan, Nishat, Umar colony, Soura , Buchpora Ahmad-Nagar, Zakura, Tail-bal, Dara, Alasteg, Humahama, Khanmoh

Source; Outcome of Statistical Model Analysis of the data sets (2019) prepared by the Author of Paper.

VIII. CONCLUSION

The findings from the study indicate that Srinagar city is highly flood vulnerable city due to combination of physiographic, geologic structure, meteorological, structural and non-structural vulnerabilities. The composite flood vulnerability index depicts, 35 % of area, 51% of population and 44% of wards are susceptible to high flood vulnerability, while, 26% of area, 27% of population and 31% of wards have medium vulnerability index.

In the light of study findings State machinery must be created, for incorporating Disaster-Risk- Reduction protection and preparedness measures, that are in sync with the Sendai Framework of Action.

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