Operationalizing resilience for Srinagar Smart City

Omar Bashir[1]

[1]RICS School of Built Environment, Amity University, Noida, India.
obashir@ricssbe.edu.in

ABSTRACT

Smart City Mission was launched by the Government of India in 2015, aims to develop 100 smart cities across India. The primary objective of the program is to transform existing cities into smart cities by incorporating urban renewal and redevelopment, both brownfield and greenfield and retrofitting thereby making the cities smart, sustainable and citizen friendly. The secondary objective of this program is to foster economic growth through these smart cities, which in turn will have a "rub-off effect" on neighboring cities and towns. India is vulnerable to several types of disasters – natural and man-made and such a large-scale program of urban renewal and redevelopment could have been useful in make a selected few cities disaster resilient. However, the Smart City Mission loses out on an opportunity to incorporate resilience in the newly developed smart cities.

The focus of this study is the city of Srinagar in North India, which is currently being developed as one of the Smart Cities in India. Srinagar is one of the most disaster-prone cities in India. The city has developed a detailed system with several layers of policies and procedures for disaster management, but that system is majorly reactive in approach and does not emphasize on resilience. Though several frameworks exist for incorporating resilience at a city level, there are none for operationalizing resilience at a city level. To overcome this research gap, a detailed study was carried out in association with experts related to disaster management and allied fields to develop a stage-wise holistic resilience maturity model. Though cities face unique disasters, due to their geographies, complexities, urbanization and culture, this Resilience Maturity Model can be adopted by any city of the world.

INTRODUCTION

Srinagar, the winter capital of the state of Jammu and Kashmir has witnessed unprecedented levels of unplanned urbanization over the past few decades. The population has increased from 2.85 lakhs in 1961 to 4.57 lakhs in 1971, 6.06 lakhs in 1981, 11.10 lakhs in 2001 to 20.84 lakhs in 2011. (Nengroo, et al., 2017). Same is the case with rest of India where the urban population has seen an increase of around 4% from 2001 to 2011 and is projected that 40% of total Indian population will be residing in urban areas by 2030, and nearly 50% by 2050. (Census of India, 2011). Globally as well, the trend of urbanization continues at a steady rate.

In general, urbanization does not pose any threat to the environment or development, however, access to several basic amenities is restricted by unplanned urbanization.

(Nengroo, et al., 2017). Further, if the urbanization is at a rapid rate it may lead several other issues like lack of suitable dwelling units, slums, overburdened transportation system, pollution, environmental degradation and an overall burden on the existing infrastructure. (Aijaz & Hoelscher, 2015). In India, due to the lack of strict regulations and planning cities have seems unorganized and unplanned growth. There is a large-scale migration across the country from rural to urban areas, as urban areas provide better employment opportunities and better quality of life. It is estimated that around 30% of the Indian population now live in urban areas as compared to around 18% in 1960 (World Bank, 2020). This constant, rapid and unregulated urbanization has led to the overburdening of existing city infrastructure. (Bashir, 2020) which is an underlying cause of low FDI (foreign direct investment) in India (Aijaz & Hoelscher, 2015).

NATIONAL SMART CITY MISSION IN INDIA

The National Smart City Mission launched by the Government of India in 2015 as an urban renewal program to make existing cities citizen-friendly and sustainable. It emphasized on development of core infrastructure; technological interventions and area-based development. The basic objective of this program is to drive economic growth in the 100 selected Smart city which other cities can emulate. (Praharaj & Han, 2019) (Gupta & Hall, 2017) (Smart Cities Mission, 2015).

SRINAGAR – INTRODUCTION

Srinagar is the capital and the largest city of the state (now Union territory) of Jammu and Kashmir, the northern state of India. It is located at the foothills of the Himalayas at an elevation of 1585 meters from sea level. The city is located on both the banks of river Jhelum, which divides the city into two parts and is connected by 9 bridges. The total area of the city is around 294 square kilometers.

The city is growing rapidly amongst all Himalayan cities (Bhat, 2008) and is currently ranked at 92nd based on the annual growth rate for a period from 2006 to 2020 (City Mayors, 2006). The population of the city stands at 1,180,570 as per 2011 census (Census of India, 2011). The density of population is around 4000 per square kilometer (10000 per square mile). The average temperature varies from 23.3 C during summers to 3.2 C in winters. The city has several water bodies and wetlands.

SRINAGAR SMART CITY

Srinagar is one of the Smart Cities being developed under the Smart City Mission of the Government of India. Srinagar Smart City project was approved in Round 3 of the Smart City challenge held in April 2017. Srinagar Smart City “aspires to leverage its Natural & Cultural heritage/ tourism, through innovative and inclusive solutions, enhance the quality of life for its citizens”.

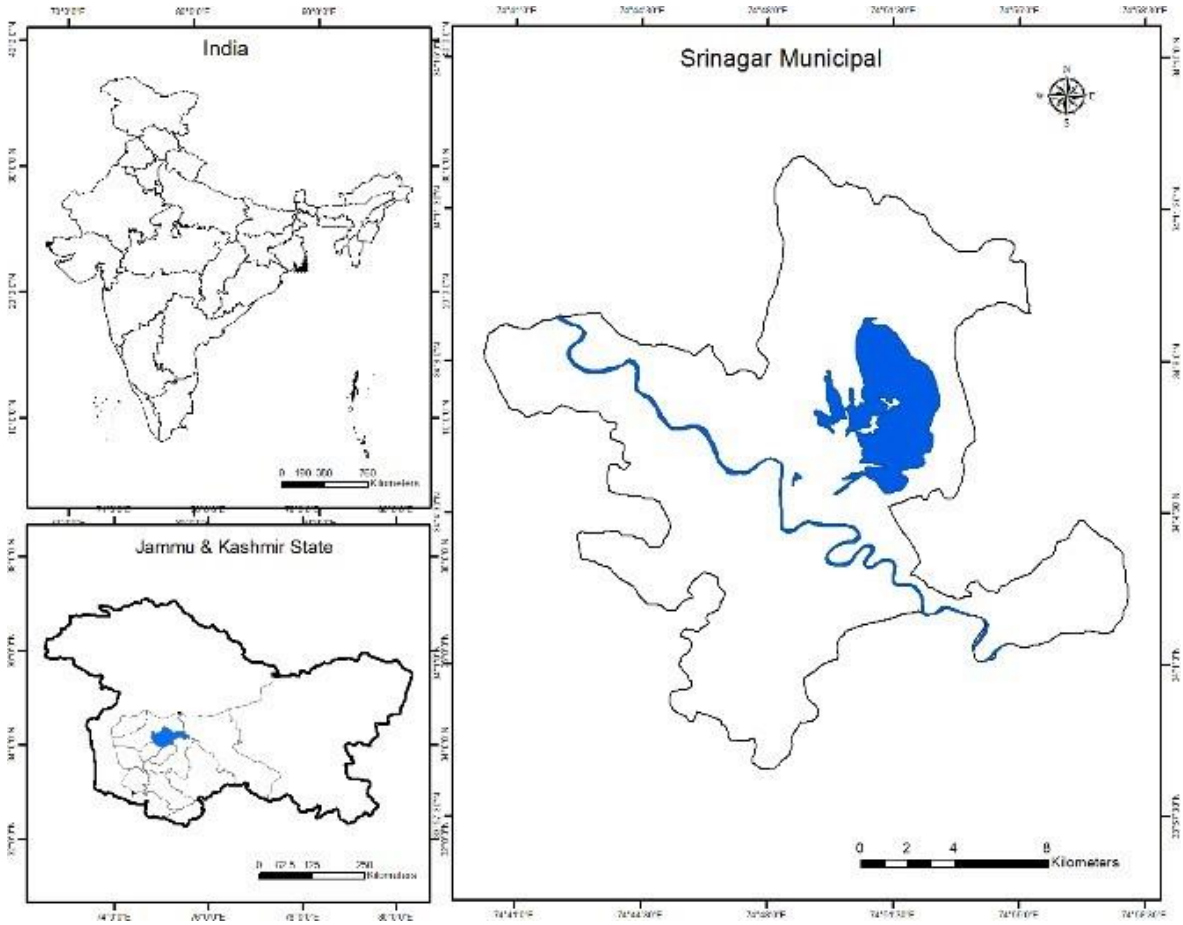

Figure 1: Location of Srinagar City (Ahmad, et al., 2017)

DISASTERS IN INDIAN CONTEXT

The vast and varied geographical expanse, geology, climatic conditions, demographic divide, socio-economic conditions and rapid urbanization makes India vulnerable to multiple disasters. These pose a great risk to the economy, population and development of the country (Bashir, 2020). More than half of the total geographical area falls under the "moderate" to "severe intensity" zone of earthquakes. Around 20% of the area is prone to drought and 12% is prone to floods. India has a long coastline of more than 7500 km which is vulnerable to tsunamis and cyclones. The mountainous region, Himalayan and sub-Himalayan ranges are prone to snowstorms, avalanches and landslides. (Metri, 2006) (NDMA, 2020).

Apart from natural disasters, India is also prone to manmade disaster like chemical, biological, radiological and nuclear proliferation. (NDMA, 2020). Further, it is also vulnerable to health epidemics, political turmoil and terrorism due to the country's varied nature. (Bashir, 2020)

LITERATURE REVIEW

URBAN AREAS AND DISASTERS

Urban areas or cities are seen from the view of a rural-urban continuum in disaster management research. This continuum includes villages or the rural countryside, towns or semi urbanized villages, cities and adjoining satellite cities or towns, metros and megapolis. Urban disasters are limited to the urban context. (Wamsler, 2014). A high density of population is one of the main characteristics of an urban area, this is often the main reason for increasing the disasters manifolds. (Malalgoda, et al., 2013). A disaster can be defined as an unprecedented and sudden disruption (either short or long term) which results in fatality, economic or environmental loss. (Bashir, 2020)

With cities growing larger and larger, the disasters have also been increasing in magnitude and intensity in the urban areas. Research also suggests that urban disasters are increasing in both in the terms of occurrences and human and economic losses. (Wamsler, 2014). This is true in Indian cities as well, the magnitude of disasters is increasing in terms of losses and can be attributed to the changing built environment of the ever-growing cities.

RESILIENCE AND URBAN STRESSORS

Resilience is often defined in terms of the system's ability to resist and function optimally during the period of stresses and threats (Satterthwaite, 2013) and how the system recovers as well (Baum, 2015). The ability to resist, for a city depends significantly on its built environment. A resilient built environment provides safety and protection to the city's physical and social environment (Haigh & Amaratunga, 2011). Using a holistic approach of understanding the strengths, weaknesses, threats, risks, linkages, stressors and relievers to make the city be able to better cope up with disasters. This leads to minimizing losses – loss of life, property, environment and economy and helps the city to return to the state before the disaster quickly and ensuring socio-economic wellbeing. (Hernantes, et al., 2019) (Spaans & Waterhout, 2017) (Bashir, 2020). The World Bank has developed the Resilient City's Program intending to incorporate resilience in the cities around the world. The vulnerabilities are categorized into five broad groups – Climate, Environment, Resources, Infrastructure and Resources. To overcome these vulnerabilities the cities, need to develop five broad groups – Governance, Institutions, Technical Capacities, Funding structures and Planning systems. (Global Facility for Disaster Risk Reduction, 2015). For a holistic resilience to be developed for a city, it needs to be at three levels – Individual level, household level and at the community level. (Satterthwaite, 2013)

From the urban planning view, a city can be termed as resilient if it can cope and respond to changes during a disaster without much loss in functionality (Tompkins & Hurlston-McKenzie, 2011). A resilient city needs to demonstrate resilience against four categories of stressors – Natural, Economic, Technological and Man-made. Natural stressors are usually unpredictable and uncontrollable. These include but not limited to earthquakes, landslides, floods, droughts, cyclones, tornadoes. A city typically has little or no control over these natural stressors. Natural stressors are majorly external barring famines or droughts, which may not be truly external. Other three stressors – Economic, Technological and Man-made are internal and the city has a certain extent of control over these internal stressors (Desouza & Flanery, 2013). However, the control may not be absolute and may vary from city to city depending on several factors – unplanned

development, growth of population, level of urbanization and dearth of resources. The systems of a city are under a lot of stress due to the combining effect of these factors and the four stressors. This combining effect extrapolates the magnitude and intensity of disasters in urban areas. (Bashir, 2020).

RESILIENCE AND QUALITY

The overall quality of the built environment is one of the main factors which determines the overall resilience of a city. Well-designed cities with good construction are more resilient to disasters and have a greater chance of recovering from a disaster in a short span of as opposed to a city with poorly designed and constructed built environment. The poorly designed and constructed built environment, in some cases, increases the magnitude of the disaster or may give rise to interdependent or secondary risks (Bosher, 2008). Even cities with the well-built and resilient built environment may have areas where the infrastructure is poorly designed and constructed. These areas suffer the most during the disaster (Satterthwaite, 2013). The quality of life in the urban area is dependent on the built environment of the city. It is essential to incorporate resilience in the systems of the city so that it not only copes and adapts to any disruption in a way that it remains functional at a certain level during the disaster and its built environment remains intact (Malalgoda, et al., 2016). Critical Infrastructure that is deemed necessary for the built environment of the city must remain functional at an optimal level during the disaster. Therefore, it is necessary to "design, develop and manage resilience" the critical infrastructure in the built environment of the city (Haigh & Amaratunga, 2011). Additionally, given the unique nature of the cities in terms of the built environment, it is essential to consider city-specific needs while designing resilient solutions for the city (Satterthwaite, 2013) which may include re-engineering the infrastructure to make it more resilient so that it can cope any disaster (Malalgoda, et al., 2016)

DISASTER RISK REDUCTION IN INDIAN SMART CITIES

The Smart City Mission launched by the Government of India in 2015 is a program of urban renewal and redevelopment of existing cities to transform them into smart cities. It had given a chance for the cities to incorporate resilience in developing the smart cities. However, examining the Smart City Proposals (SCP) of the cities submitted for the Smart City Mission it is observed that only 30% of the cities have incorporated resilience in some form but there is a lack of implementing holistic resilience in the proposals (Bhatnagar, et al., 2018). The Indian cities are some of the most densely populated cities in the world and are facing several stressors which have put a lot of stress on the already existing infrastructures of these cities.

DISASTERS IN SRINAGAR CITY

The city, in the past few decades, has faced a spate of earthquakes, landslides and floods, terrorism and is prone to multiple disasters. The recent floods in 2014 resulted in the death of around 277 people and estimated property damage of around 5 billion rupees (Mishra, 2015). The highest flood depth was around 32 meters. (Kumar & Acharya, 2015). Srinagar falls under Zone V or "very severe intensity zone" of earthquake zoning in India. Earthquakes occur frequently and are mostly of high intensity. The earthquake of 2005

measured 7.6 on the Richter scale was one of the very severe intensity earthquakes to hit the region. Nearly 90000 people lost their lives and around 100000 injured (USAID, 2006). Given the topography of the city, it is vulnerable to landslides and mudslides. Apart from natural disasters, the city is vulnerable to man-made disasters as well. The precarious political situation has given rise to terrorism and violence due to which many people have lost their lives.

RESEARCH METHODOLOGY

The study uses a mixed research method with both qualitative and quantitative research techniques using research tools such as co-word analysis, semi-structured interviews and Delphi technique. Since developing a model for resilience building requires holistic participation of various stakeholders with different perspectives. Also, it is necessary to know about the interdependencies amongst sectors and services to have coherence in policies and plans (Desouza & Flanery, 2013).

The Risk Maturity Model presented in this study was developed in collaboration with multidisciplinary expert's form district administration, State disaster management authority, State police, state fire and emergency services and the Smart City Limited. These experts were a part of the pilot interview, Delphi technique and semi-structured interview.

Table 1: Brief profile of the experts consulted in the study

	Organization	District Administration	State Disaster Authority	Police	Fire and Emergency Services	National Disaster Relief Force	Smart City Limited
Experience (years)	0 to 5	3	x	x	x	x	1
	6 to 10	2	1	x	1	1	x
	11 to 15	1	x	3	1	x	x
	15+	x	1	x	x	x	x
Total no. of experts		3	2	3	2	1	1

MAPPING WITH RESILIENCE FRAMEWORKS

The Srinagar Smart City Proposal (SCP) was mapped against two established resilience frameworks to establish a benchmark. The Sendai Framework for Disaster Reduction (2015-30) was adopted by the United Nations in 2015 as a non-binding, voluntary agreement that allows member nations to reduce disaster risk (Bashir, 2020). It comprises of seven specific targets and four areas of priority. (UNISDR, 2015)

The Rockefeller Foundation's 100 Resilient Cities (100RC) aims to establish a hundred resilient cities around the world. Applications were invited in 2013, 2014 and 2016. The City Resilience Framework developed by the 100RC, includes four priority areas, with each priority, having three drivers (100 Resilient Cities, 2015)

The two frameworks were adopted before the SCP was prepared. The criteria of both the framework were analysed and mapped against the Smart City proposal (SCP) submitted

to the Smart City Mission Challenge by using text analysis method. Further, a pilot interview was conducted with experts from the smart city project to establish the correctness of the mapping.

Table 2: Mapping against Sendai Framework

		Srinagar Smart City Proposal
Sendai Framework (2015)	Understanding disaster risk	Yes
	Strengthening disaster risk governance	No
	Investing in disaster risk reduction for resilience	No
	Enhancing preparedness for effective response	Yes
	Effective recovery, rehabilitation and reconstruction"	Yes

Table 3: Mapping against 100 RC Framework

		Srinagar Smart City Proposal
100 Resilient Cities (2015)	Provide reliable communication and mobility"	No
	Provide and enhance natural and manmade assets	No
	Foster long term and integrated planning"	Yes
	Promote leadership and effective management	No
	Meet basic needs"	Yes
	Ensure public health services	No
	Ensure social stability, security and justice"	No
	Support livelihoods and employment	No
	Promote cohesive and engaged communities"	No
	Foster economic prosperity	No
	Ensure continuity of critical services"	Yes
	Empower a broad range of stakeholders	No

DEVELOPMENT OF A RESILIENCE MATURITY MODEL

A maturity model is a hierarchical description of progress in various stages of maturity (Wendler, 2012). The main use of a maturity model is to define the level of maturity using multi-dimensional criteria which are used to derive action areas according to priority and areas for improvement (Fleming, 2001) (Becker, et al., 2009) (Wendler, 2012)

Using different incremental maturity levels of resilience, the maturity model was modified to depict different stages of incorporating resilience in the smart city. (Bashir, 2020). Using progressive and systematic increments a Risk Maturity Model can be used to develop incremental resilience in a city. (Hernantes, et al., 2019). Resilience Maturity Model (RMM) used in this study used two parameters of judging resilience – likelihood of recovery and Recovery readiness.

The stages of the Resilience Maturity Model are depicted below:

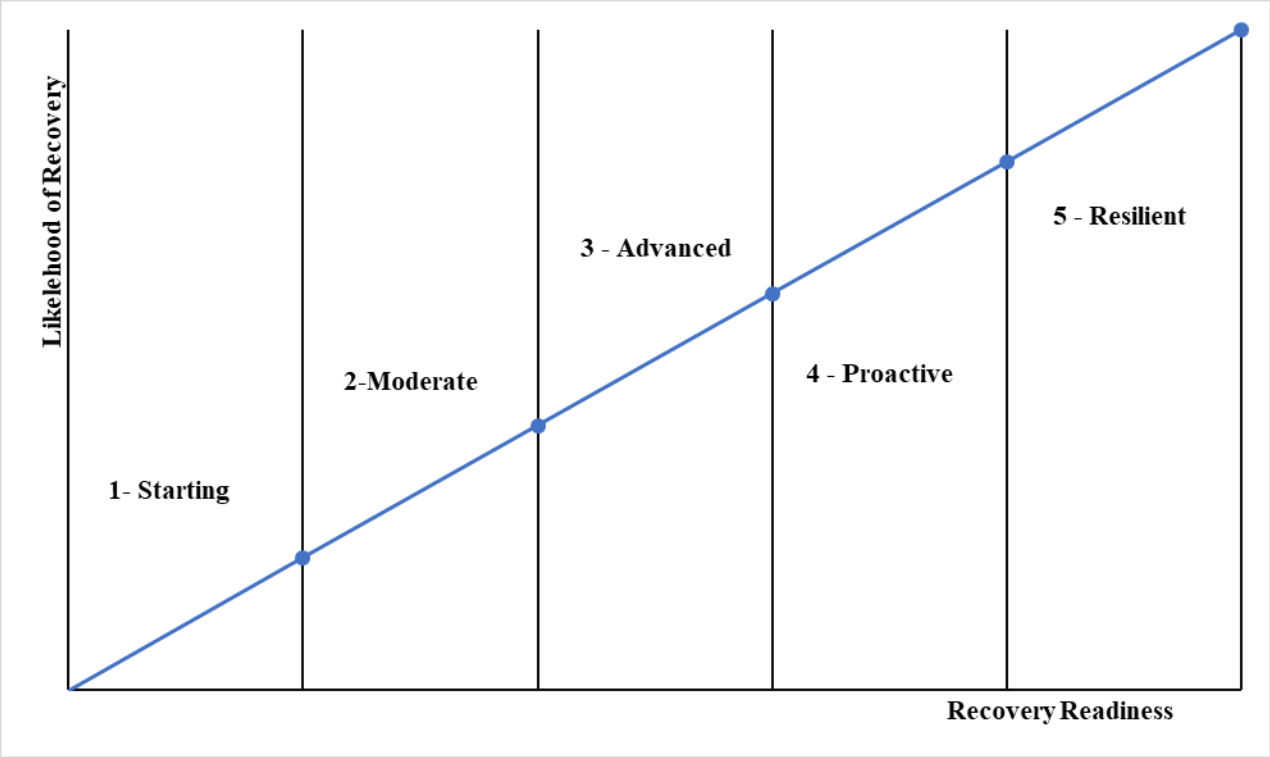

Figure 1: Five-Stage Resilience Maturity Model (RMM)

The maturity levels are defined below:

STARTING

This is the stage-I of RMM and there is no approach to incorporate resilience. There is very little or no understanding of disaster and disaster management. There is no clear policies or procedures exist for disaster management. The disaster management plan may exist in a fragmented form and there is no chance that it may be useful to deal with the disasters – unknown, unexpected or multiple disasters. There is no collaboration between the institutions and the city lacks the technical capability to deal with any disaster.

MODERATE

This is the second stage of the RMM and there are some regulations and standards which are developed to deal with disasters. Disaster Management plans exist and there is some coordination between different institutions and there is an emphasis on increasing awareness through education and training. There is a general understanding of the role of critical infrastructure during disasters.

ADVANCED

The planning systems are much advanced backed by policies, laws and regulations, standards with dedicated elements of disaster management. Greater emphasis on spreading awareness in the community and involvement of academia in the development of techniques for reducing disaster risk. The role critical infrastructure is well understood, and measures are taken to improve the reliability of the critical infrastructure during disasters. Their involvement of stakeholders is only limited to the planning stage.

PROACTIVE

This is the fourth stage of RMM, the disaster management plans are fully developed, and integrated, other policies, procedures, laws and regulations are also well developed, and the institutions of the city are actively collaborating and are proactive in approach. The community is well informed and actively participates in mock drill and training conducted by a group of volunteers. The stakeholders work together on the same platform have a full understanding of developing resilience.

RESILIENT

The city can withstand any disaster – expected, unexpected or multiple and can bounce back to its original state without much delay. The city can optimally function during the disaster due to its reliable critical infrastructure. All stakeholder work on the same platform and are engaged.

ADOPTION OF SMR AND RESILIENT CITY FRAMEWORKS

This study adopted the SMR framework (Smart Mature Resilience, 2016) for operationalizing resilience. The SMR framework is developed for European cities and was modified in collaboration with experts to be adopted for Srinagar Smart City keeping in view the unique features of the city intact. Using the Delphi technique, the dimensions of SMR framework were analyzed and using the opinion of expert it was combined with the Resilient City's Program of World Bank to develop a holistic framework for operationalizing resilience.

The World Bank has developed the Resilient City's Program intending to incorporate resilience in the cities around the world. The vulnerabilities are categorized into five broad groups – Climate, Environment, Resources, Infrastructure and Resources. To overcome these vulnerabilities the cities, need to develop five broad groups – Governance, Institutions, Technical Capacities, Funding structures and Planning systems. (Global Facility for Disaster Risk Reduction, 2015).

CONCLUSION

Cities around the world, especially in developing countries are under a lot of pressure due to unplanned and rapid urbanization. This is problematic when these cities face disasters. The cities ability to cope with disasters is limited due to rapid unplanned urbanization. Indian cities are currently undergoing redevelopment under the Smart Cities Mission and it provides an opportunity to make the cities resilient.

Srinagar city is vulnerable to multiple disasters and there is a need to incorporate resilience. There is an already existing system for Disaster Management in the city, however it is reactive in nature. There is no provision of incorporating resilience in the city. As Srinagar is being developed as a Smart City, it gives the city administration to incorporate resilience in the new developments. However, there is a need to not only incorporate resilience in the city systems but also to operationalize resilience. Though there are several frameworks available for incorporating resilience at a city level, there is a lack of any established study for operationalizing resilience. This study focusses on the development of a holistic stage-wise framework for operationalizing resilience.

Table 4: Detailed Five stage Resilience Maturity Model (RMM)

		Maturity levels				
Dimensions	Subdimensions	Starting	Moderate	Advanced	Proactive	Resilient
Leadership and Governance	Development and enhancement of laws and regulations (G1)		Develop a white paper about the governance approach at multiple levels (GM1)	Develop policies and procedures conforming to National level (GA1)	Develop policies and procedures conforming to International level (GP1)	Establish SOP's and standards for incorporating resilience (GR1)
Institution	Smart City Authority Ltd. (I1)	Develop a dedicated team for looking at resilience in the city (I1S1) Incorporate resilience in the mission and vision of the Smart City Proposals and other documentations (I1S2)	Setup a resilience department with cross-functional sub-departments (I1M1) Map the resilience plan with those other cities (I1M2) Promote equality in access to all sections of the society (I1M3)	Develop a plan to integrate cross-functional city departments like municipality, fire department, district administration (I1A1)	Map the resilience action plan with state-level agencies like State Disaster Relief Force and other institutions (I1P1)	Map the resilience action plan with national-level agencies like National Disaster Relief Force and other institutions (I1R1)

Planning Systems	Education and Training (P1)	Conduct training with city level emergency team (P1S1) Develop a group of volunteer citizen group to be deployed during a disaster (P1S2)	Conduct regular mock drills and training for emergency teams and volunteers P1M1)	Conduct mock drills and training for emergency teams and volunteers (P1A1) Audit and modify the training programs as required (P1A2) Conduct Regular educational and training programmes at schools and colleges (P1A3)	Conduct regular mock drills and training across various city authorities, emergency services and educational institutes (P1P1) Develop training with other cities (P1P2)	Develop and conduct regular training and mock drills for all sections of the society (P1R1)
	Resilience action plan development (P2)	Identify the requirements for city-level resilience (P2S1)	Formulate a plan for incorporating resilience (P2M1)	Establish indicators for the assessment of resilience plan performance (P2A1)	Assess and monitor the efficacy of the resilience plan (P2P1)	Revise and redevelop the resilience plan and monitor the performance regularly (P2R1)

Technical capacity	Reliability of infrastructures (T1)	Develop a plan to assess the reliability of critical infrastructure(T1S1)	Develop a plan to enhance the reliability of critical infrastructure (T1M1)	Develop a contingency plan for failures (T1A1)	Develop a plan for regular audit of critical infrastructures (T1P1)	Emphasize on continuous improvement of the critical infrastructure (T1R1)
	Development of partnerships with city stakeholders (T2)	Map relevant stakeholders to develop a resilience plan (T2S1) Develop a mechanism to make emergency information public ally available (T2S2)	Develop a stakeholder engagement plan defining its roles and responsibilities (T2M1) Develop an internal communication platform for sharing information with different city authorities and emergency services (T2M2)	Develop a common understanding of resilience between the different stakeholders (T2A1) Involve academia and the scientific community to improve resilience planning (T2A2)	Establish a mechanism for public consultations to receive feedback on the resilience plan and modify accordingly (T2P1)	Involve all stakeholders developing, modifying and assessing plans (T2R1)

Funding structures	Resources to build up resilience (F1)	Assess current funding opportunities for the development of resilience (F1S1) Establish a disaster relief fund for emergencies (F1S2)	Provision for a resilience action plan in the local government budget (F1M1)	Encourage insurance coverage (F1A2)	Promote R&D in building resilience (F1P1)	Incentivize resilience-building measures (F1A1)

REFERENCES

100 Resilient Cities, 2015. *City Resilience Framework.* [Online]
Available at: http://www.100resilientcities.org/resources/#section-2
[Accessed 10 February 2020].

Ahmad, T., Pandey, A. C. & Kumar, A., 2017. Evaluation of flood impacts vis-à-vis urban sprawl and changing climate in Srinagar city and its environs. *The Suresh Gyan Vihar University Journal of Climate Change and Water,* 1(2), pp. 38-46.

Aijaz, R. & Hoelscher, K., 2015. India's Smart Cities Mission: An Assessment. *ORF Issue Brief*, December, pp. 1-12.

Bashir, O., 2020. Reducing Disaster Risks in Indian Smart Cities: A Five-Stage Resilience Maturity Model (RMM) Approach. In: S. Ahmed, S. M. Abbas & H. Zia, eds. *Smart Cities—Opportunities and Challenges.* Singapore: Springer, pp. pp 411-422.

Baum, S. D., 2015. Risk and resilience for unknown, unquantifiable, systemic,and unlikely/catastrophic threats. *Environment Systems and Decisions,* 35(2), pp. 229-236.

Becker, J., Knackstedt, R. & Pöppelbuß, J. B., 2009. Developing Maturity Models for IT Management. *Information Systems Engineering,* 1(3), pp. 213-222.

Bhat, M. S., 2008. *Urban System in Himalayas: A Study of Srinagar City-Region.* 1st ed. New Delhi: Dilpreet Publishing House.

Bhatnagar, A. et al., 2018. Analysing the Role of India's Smart Cities Mission in Achieving Sustainable Development Goal 11 and the New Urban Agenda. In: W. L. Filho, J. Rogers & U. Iyer-Raniga, eds. *Sustainable Development Research in Asia-Pacific Region.* Switzerland: Springer International Publishing, pp. 275-292.

Bosher, L., 2008. The need for built in resilience. In: L. Bosher, ed. *Hazards and the Built Environment-Attaining Built-in Resilience.* London: Routledge, pp. 3-19.

Bosher, L., Dainty, A., Carrillo, P. & and Glass, J., 2007. Built-in resilience to disasters: a pre-emptive approach. *Engineering, Construction and Architectural Management,* 14(5), pp. 434-446.

Census of India, 2011. *Census of India.* [Online]
Available at: http://censusindia.gov.in/2011-prov-results/paper2/data_files/india/Rural_Urban_2011.pdf
[Accessed 03 February 2020].

City Mayors, 2006. *City Mayors.* [Online]
Available at: http://www.citymayors.com/statistics/urban_growth1.html
[Accessed 11 April 2020].

Desouza, K. C. & Flanery, T. H., 2013. Designing, planning, and managing resilient cities: A conceptual framework. *Cities,* 85(xxxx), pp. 89-99.

Desouza, K. C. & Flanery, T. H., 2013. Designing, planning, and managing resilient cities: A conceptual framework. *Cities,* Volume 35, pp. 89-99.

Field, C. & Look, R., 2018. A value-based approach to infrastructure resilience. *Environment Systems and Decisions,* 38(3), pp. 292-305.

Fleming, M., 2001. *Safety culture maturity model,* Norwich: Health and Safety Executive.

Global Facility for Disaster Risk Reduction, 2015. *Investing in Urban Resilience,* Washington: The World Bank.

Godfrey, S., 2008. *What is CMMI?.* Maryland: NASA Goddard Space Flight Centre.

Godschalk, D. R., 2003. Urban hazard mitigation: creating resilient cities. *Natural Hazards Review,* Volume 4, pp. 136-143.

Gupta, K. & Hall, R. P., 2017. *The Indian Perspective of Smart Cities.* Prague, Smart City Symposium.

Haigh, R. & Amaratunga, D., 2011. Introduction. In: R. Haigh & D. Amaratunga, eds. *Post Disaster Reconstruction of the Built Environment: Rebuilding for Resilience.* Oxford: Willey-Blackwell, pp. 1-11.

Hernantes, J. et al., 2019. Towards resilient cities: A maturity model for operationalizing resilience. *Cities,* 84(January 2019), pp. 96-103.

Kumar, R. & Acharya, P., 2015. Flood hazard and risk assessment of 2014 floods in Kashmir Valley: a space-based multisensor approach. *Natural Hazards,* 84(1), pp. 437- 464.

Linkov, I. et al., 2014. Risk and resilience lessons from Venice. *Environmental Systems Decisions,* Volume 34, p. 378–382.

Malalgoda, C., Amaratunga, D. & Haigh, R., 2013. Creating disaster resilient built environment in urban cities: the role of local governments in Sri Lanka. *International Journal of Disaster Resilience in the Built Environment,* 4(1), pp. 72-94.

Malalgoda, C., Amaratunga, D. & Haigh, R., 2016. Overcoming challenges faced by local governments in creating a resilient built environment in cities. *Disaster Prevention and Management,* 25(5), pp. 628-648.

Metri, B. A., 2006. Disaster mitigation framework for India using quality circle approach. *Disaster Prevention and Management,* 15(4), pp. pp. 621-635.

Mishra, A. K., 2015. A study on the occurrence of flood events over Jammu and Kashmir during September 2014 using satellite remote sensing. *Natural Hazards,* 78(2), p. 1463–1467.

NDMA, 2020. *National Disaster Management Authority.* [Online]
Available at: https://ndma.gov.in/en/vulnerability-profile.html
[Accessed 27 January 2020].

Nengroo, Z. A., Bhat, M. S. & Kuchay, N. A., 2017. Measuring urban sprawl of Srinagar city, Jammu and Kashmir, India. *Journal of Urban Management,* 6(2), pp. 45-55.

O'Rourke, T. D., 2007. *Critical Infrastructure, Interdependencies, and Resilience.* [Online]
Available at:
https://pdfs.semanticscholar.org/6c17/b35ec7555a9f27d5ccb6ca1d357a20b5ce0a.pdf
[Accessed 09 February 2019].

Praharaj , S. & Han, H., 2019. Building a typology of the 100 smart cities in India. *Smart and Sustainable Built Environment,* 8(5), pp. 400-414.

Pursiainen, C., 2018. Critical infrastructure resilience: A Nordic model in the making?. *International Journal of Disaster Risk Reduction,* Volume 27, pp. 632-641.

Satterthwaite, D., 2013. The political underpinnings of cities' accumulated resilience to climate change. *Environment & Urbanization ,* 25(2), pp. 381-391.

Smart Cities Mission, 2015. *Smart Cities Mission.* [Online]
Available at: http://smartcities.gov.in/content/
[Accessed 15 April 2019].

Smart Mature Resilience, 2016. *Smart Mature Resilience.* [Online]
Available at: https://smr-project.eu/home/
[Accessed 18 April 2020].

Spaans, M. & Waterhout, B., 2017. Building up resilience in cities worldwide – Rotterdam as participant in the 100 Resilient Cities Programme. *Cities,* 61(1), pp. 109-116.

Tompkins, E. & Hurlston-McKenzie, L.-A., 2011. Public-private partnerships in the provision of environmental governance: a case of disaster management. In: E. Boyd & C. Folke, eds. *Adapting Institutions: Governance, Complexity and Social-Ecological Resilience.* Cambridge GB: Cambridge University Press, pp. 171-189.

UNISDR, 2015. *Sendai Framework for Disaster Risk Reduction.* [Online]
Available at: https://www.unisdr.org/we/coordinate/sendai-framework
[Accessed 10 March 2020].

USAID, 2006. *South Asia- Earthquake Fact sheet.* [Online]
Available at: https://reliefweb.int/report/india/south-asia-earthquake-fact-sheet-25-fiscal-year-fy-2006
[Accessed 17 April 2020].

Wamsler, C., 2014. *Cities, Disaster Risk and Adaptation.* 1st ed. New York: Routledge.

Wendler, R., 2012. The maturity of maturity model research: A systematic mapping study. *Information and Software Technology,* 54(12), pp. 1317-1339.

World Bank, 2020. *Urban Population.* [Online]
Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS
[Accessed 10 April 2020].