Smart city initiatives and disaster resilience of cities through spatial planning in Pune city, India

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Abstract
Cities are attracting populations at alarming rate. Cities provide the need of populations in every way from livelihoods to livability. In doing so it is exhausting its resources resulting in increasing threats of risk. An initiative like Smart City Mission is aiming to enhance the capacities of the cities to increase livability and quality of life for its population and decrease threats of risk. This study examines the impact of smart city initiatives on resilience to earthquakes and floods through a spatial planning perspective for the city of Pune in State of Maharashtra through series of structured interviews with key stakeholders.

The findings suggest that smart city initiative is still in its primary stage and requires assimilation with the development strategy to contribute to the resilience of the city. The study further proposes the need to integrate the smart city initiative with all the current and future developmental projects.

Keywords: Smart Cities, Urban Resilience, Disaster Risk Reduction, Spatial Planning, Urban Risks.

Introduction

Cities are complex urban mechanisms attracting population and resources to keep them sustaining and growing. People choose cities for multiple functions and aspirations. Cities provide hope and opportunities to survive and sustain. The role cities play as 'providers', encumbers them with responsibilities to perform. In its journey of growing and performing, it keeps on attracting risks directly or indirectly through natural or manmade consequences. Cities promising a good life to its citizens could turn into spaces with disastrous experiences. Planning cities have become more challenging in current situation with multiple forces acting on it.

With growing populations in the cities, there is need to experiment with newer ideas to better the cities. One such idea which is accepted globally is 'Smart Cities'. With 60% of populations choosing to live in cities, the cities need to offer them there basic needs[28]. To cater to the needs of populations, cities need to upgrade themselves in various aspects. Spatial Planning is one such aspect which influences the risk and resilience of the populations[3]. Spatial planning becomes an important mechanism for balancing the densities and the built structures and effective functioning of the urban systems involving the social, economic and environmental mechanisms[26].

According to March[17], spatial planning tries to modulate the management and functions, arrangements of urban regions and plays a decisive role in reducing disaster risks. It plays key role in reducing the vulnerability of populations by its decisions and actions[4]. The key function of spatial planning is to demonstrate a framework for density and land use management, newer locations for various functions for present and future and identifying future investment projects, simultaneously safeguarding nature and environment[7]. Spatial planning is a dynamic process involving different actors and local governments. The functioning of urban systems is efficacious when the cities are planned well and its administrative mechanisms and civic services perform efficiently[14]. Spatial planning drives the development pattern with its two key tools, development plan and development control rules[18]. The local governments should integrate the spatial planning and disaster risk reduction for building the resilience of the cities[4]. Spatial planning plays an important role in elevating the resilience of the populations by reducing the risks and maintaining safety[9].

Disaster resilience is important for enhancing the quality of life of the citizens by reducing disaster risks. Resilience is the attribute of the city to ingest the shocks of hazards and to adapt to situation[2]. Cities are increasing their vulnerabilities due to their built environments and concentration of densities[8]. To reduce the vulnerabilities brought in by urbanization, local governments should attempt effective landuse management, enforcement of building regulations and provision of critical facilities[10]. Moreover, there is no single prescription to reducing disaster risks which the local governments can embrace[5]. To build a resilient system, the local government needs to acknowledge the hazard impacts with its inherent character and simultaneously must be able to adapt and renew with its consequential impact[16].

Disaster resilience of cities is thus, an outcome of conscious spatial planning[23]. This also generates need for looking at innovative solutions for cities which can help in enhancing livability and building resilience[11]. 'Making cities and settlements for humans inclusive, safe, sustainable and resilient'[28] is recommended by Sustainable Development Goal 11. Global initiative like 'Smart City Mission' was

conceptualized to provide better life and living conditions by providing better civic services and facilities to people integrating technology[20].

The smart city mission thus influences every aspect of the city including the spatial planning. The objective of this study therefore, is to understand how the Smart City Mission initiatives impact the spatial planning and how they influence the disaster resilience of the city especially in the emergency scenarios of earthquake and floods. The study is carried out in city of Pune, in State of Maharashtra, India.

Smart Cities: Globally the concept of smart cities aspires to integrate technology to make the civic systems efficient, though it is unclear about its framework of roles and responsibilities[13]. A formal definition stated ‘’A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operations and services and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects”[19]. The primary focus of smart cities mission is to improve governance by integrating Information and Technology (IT) solutions and to enhance the efficiency of civic services[1].

With this global arrangement of smart cities concept, India in 2015 picked up the concept to launch its ‘Smart City Mission’. The aim of the mission was to make cities efficient with an urban renewal and retrofitting program in 100 cities across the country. The responsibility of implementation of the mission is with Union Ministry of Urban Development, Government of India with support from State governments and urban local bodies.

The concept of smart cities adopted for Indian cities is to be looked at wider perspective than just adopting technology. The Ministry of Urban Development, Government of India proposes an extensive development program indulging various aspects of development of city including spatial planning of the city. The Union Ministry of Urban Development plays the primary role and the States and Urban Local Bodies (ULB) are in supportive role in the development program of smart cities. 40% of the country’s population will choose to live in urban areas in search of better opportunities and accessibility to civic facilities[29]. Comprehensive development of urban areas has thus become the need of the hour to develop the physical, social, economic and the institutional infrastructure to suffice the needs of populations[22].

The smart city mission calls for participation of citizens to contribute to the vision of the city. ‘Area-based development’ by retrofitting or redeveloping of the existing areas is the key theme adopted by the smart city mission of India, which includes development of slums and better planning of available spaces[24]. Providing ‘quality of life’ to citizens by improving the core infrastructure and facilities which are part and parcel of spatial planning of the city and creating newer opportunities to the cross section of the society is the prime focus of smart city initiatives in India.

Table 1
The list of 51 projects for Pune

51 projects selected as part of the Smart city proposal

ABB				Pan City	
#	Smart feature	#	Smart feature	#	Smart feature
1	Road and road widening	18	Smart metering (water)	35	Adaptive Traffic Control System
2	100 Electric buses	19	River water cleaning	36	Bus System ITMS
3	Redesign of streets	20	Solid waste management	37	Command Control Center
4	Smart parking	21	Sanitation	38	Total Smart Parking
5	Footpaths (additional and retrofit)	22	Electricity distribution – Smart grid & metering	39	Intelligent Road Management
6	Placemaking	23	Solar energy supply	40	Traffic modelling system
7	Bicycles	24	Street lighting	41	e-Chalaan
8	Bus stops (revamp 54 stations)	25	Security	42	Connectivity costs
9	Junction redesign for 14 junctions	26	Riverfront development	43	Pilot DMA for 24X7 Water
10	Non-motorised street	27	Open spaces	44	Bulk Meters
11	BRT	28	Fire stations – 2	45	Helium leak identification
12	Express airport services	29	Low income skill development and healthcare	46	Smart Commercial Meters
13	e-rickshaws	30	Build affordable housing	47	Smart Domestic Meters
14	Waste water recycling	31	e-gov	48	Customer Mapping and Survey
15	Storm water use	32	IT connectivity	49	Naidu STP Energy Generation
16	Adequate water supply	33	Transit hub	50	Mobile app and website
17	Rainwater harvesting	34	Start up zone	51	Consultancy Services
				52	Consumer Awareness

Transport
Urban Planning
Water
ICT
Marquee
Others

Source: Reimaging Pune: Mission Smart City, 2016

Pune city was awarded second rank in the country in the list of 100 smart cities of India. The smart city initiative of Pune chose two approaches for the betterment of the city, first a retrofitting approach of a selected area wherein the basic services and amenities of the selected area would be improved physically and aesthetically and second ask for city solutions for betterment of basic facilities like water supply and transport facilities. The list of selected 51 projects under smart city initiatives for Pune is shown in table 1. The initiative was welcomed by citizens with curiosity and enthusiasm.

The city engagement program was the highlight of the initiative with 35 lakh and more inputs received on social media platforms. The citizen inputs highlighted the core infrastructural issues of transport and water on priority and aspired for green and clean city. Pune smart city goals were conceptualized by local government based on citizen inputs aiming at solving issues of core infrastructure and making it most livable city of the country[21]. Fig. 1 shows the smart city goals for Pune.

Material and Methods

Study area: Pune city in its municipal limits is selected as study area. It has a population of 3.99 million and area of 331.26 sq. km. The city is situated in Sahyadri mountain ranges at an elevation of 560m above MSL on the confluence of rivers Mula and Mutha. The physical features of the city are shown in fig. 2. The disaster scenario of the city as per the Disaster Management Plan of 2016 confirms the earthquake zone III of India which is moderate damage zone (6). The city has not experienced earthquake except for the tremors felt on 30 September 1993 during Latur earthquake. Moderate flooding due to high precipitation and release of water in river from upstream dams is evident in the monsoon months of June to October every year disrupting the normalcy of the city.

Pune city evolves in organic pattern and it is not a planned city. In the last two decades, there have been rapid changes in land use pattern with residential and commercial landuse increasing over others. The city limits are expanding with villages on the fringe getting added to the municipal limits. The recent revision of building byelaws as 'Uniform Development Control Rules 2019' has amplified the floor space index (FSI) resulting in increase in the height and density of buildings[27].

Over time, the road pattern and critical services of the city are evolved as per the need generated due to development of new residential areas, more than a planned approach. The high demand in real estate market for residential units makes the real estate investment lucrative while the civic services and amenities get stressed. The critical infrastructure and facilities develop at low pace, stressing the civic system further. The unavailability of land parcels for critical infrastructure and open spaces, stresses the existing infrastructure further.

Fig. 1: Smart City goals for Pune

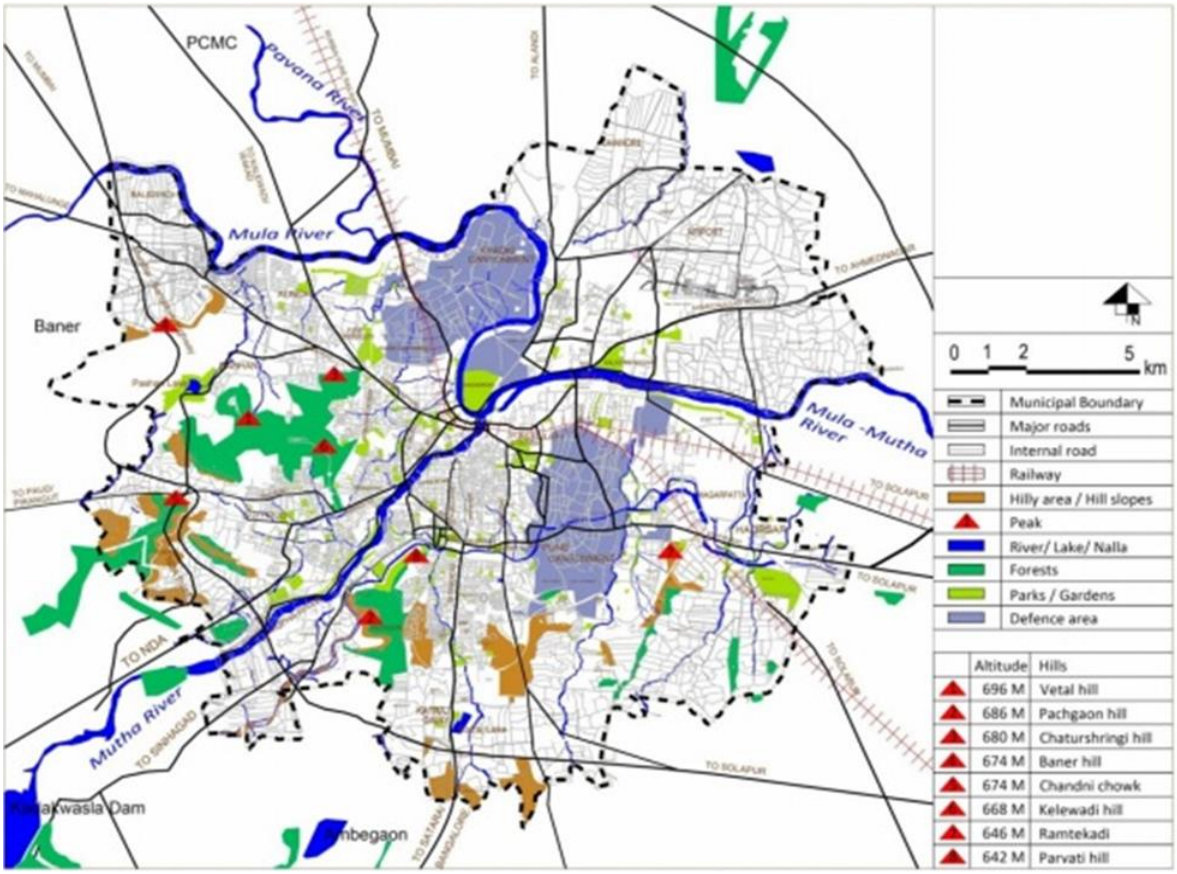


Fig. 2: Map of Pune city
(Source: Disaster Management Plan of Pune 2016)

The initiatives proposed by Smart City Mission of Pune has direct and indirect impact on the spatial planning especially the facilities and services provided by city administration. The launch of Metro for mass transportation with its infrastructure and Transit Orient Development (TOD), an area within 5 kms of metro station, residential or commercial with floor space index of 5, will boost building density in the city. Smart City Mission promotes compact and dense development with better civic facilities[21].

Selection of Indicators: The components which define the spatial planning are density, landuse, open spaces, roads, physical infrastructure and critical infrastructure and services[15]. These components are condemnatory to disaster risk reduction. The components were further split into subcomponents to formulate questions to the interviewees. Table 2 shows the spatial planning components and sub components. Each of these components gets modulated by the smart city initiative.

Method: The study adopts a semi structured interview method with 22 key stakeholders[13]. Table 3 shows the stakeholder and their designations. Each of the selected participants has contributed to the smart city initiative and in disaster management of the city. A questionnaire was formulated after studying the smart city proposal for Pune and the 51 smart city initiatives proposed for Pune city for the local area development and for the overall city. The interviews were conducted in person for 1.5 to 2 hours. The smart city proposal report of Pune was sent to all the participants for their study before the interviews were conducted. A write up was prepared to explain the smart city proposal, challenges of spatial planning and disaster risks of the city.

The interviews started with discussion on spatial planning and disaster scenario of the city with focus on earthquakes and floods. Each indicator was discussed for its impact and its performance in emergency scenario of earthquake and floods. Each participant was given enough time to reflect and respond to the questions. After the discussion on each indicator, the participant had to rate the risk on Likert scale for each subcomponent. The inputs received from the participants were analyzed to understand the risk scenario and the impacts of smart city initiatives on resilience, positive or negative.

The representations were gained from Smart City Office, practicing urban planners and architects, State disaster management authority, disaster management cell of Pune Municipal Corporation, civil society organisations, healthcare system, fire department and citizens residing in the city. All the 22 stakeholders participated in the study willingly, though some participants had hesitance discussing governance issues.

Table 2
Spatial Planning components and Sub components

Spatial Planning Components	Subcomponents
Density	Density of population
	Migrating Population
	Cultural Stability
Landuse	Residential
	Commercial
	Mix Land use
Roads	Width of roads
	Pedestrian Walkways
	Traffic Density
	Surface Drainage
	Safety Issues on roads
Open Spaces	Public Gardens
	Public Playgrounds
Physical Infrastructure	Density of buildings
	Floor Space index
Critical Infrastructure	Hospitals
	Police Stations
	Fire Stations
Critical Services	Water Supply
	Sewage Management
	Waste Management

Table 3
Stakeholders selected

Organization	No. of Partici.	Designation and Description
Smart City Office	2	Special Purpose Vehicle created by Smart City Mission for the coordination and implementation of Initiatives
Practicing Architects	2	Practicing in the city for past 3 decades
Urban Planners	2	Advocating the Municipal Corporation
Disaster Management	3	Disaster Management cell of Municipal Corporation and State Disaster Management Office
Civil Society Organizations	3	Working in disaster management of the city in all phases of disasters
Health Care System	2	Doctor with Municipal healthcare system and private doctor practicing in the city
Fire Department	2	Municipal Corporation
Citizens	6	2 residing in the area currently implementing the local area development plan
		4 staying in other parts of Pune
Total	22	

Results and Discussion

Density: 17 participants expressed that the population density will increase in the city as result of smart city initiatives attracting floating and migrating populations which will result in high risk in disaster scenarios. 3 participants feel the risk due to increase in population density as medium, while only 2 participants opined that the increase in population density may not affect the risk scenario. Migrating and floating population in the city will add to the risk exposure, 9 participants have rated it high on risk scale while 7 participants rated it medium and 6 participants rated it low on risk scale. Cultural stability does not pose high risk in the city, according to participants, hence 11 participants have rated it medium and other 11 participants have rated it low on risk scale, making the overall risk low for this indicator.

The smart city initiative aiming to enhance the quality of life of citizens will attract populations for various reasons. The concentration of population densities will increase in the city increasing the exposure to risk. The floating population will increase in the city with the smart city initiatives like mass transport system. Migrating populations will settle in the city for better livelihood opportunities. These populations will bring with them their cultural identities. Their belongingness to the city may not be the same as the resident population. The interview participants do not feel that there will be any significant impact on the cultural stability of the city and will bear positive impact on resilience due to this indicator. The overall impact of this indicator on resilience is positive.

Landuse: 14 participants feel that there will be increase in residential landuse and the concentration of built densities will increase the exposure to disaster risk, rating it high on risk scale while 4 participants feel that the risk would be insignificant rating it medium, while another 4 participants rate the risk low for this component. The commercial landuse will increase in the city, 13 participants have rated this increase as high on risk scale while 6 participants have rated it medium and another 3 participants have rated it low. The mix landuse promoted by smart city initiatives makes 4 participants think of high risk in disaster scenario while 10 participants feel that it may not affect in the disaster scenario rating it medium and another 8 participants rate it low on the risk scale.

All the participants agree on the increase of residential landuse in the city as a result of increase in population density. There will be comparative increase in commercial landuse. Smart city initiative promotes mix development of residential and commercial landuse which may increase the exposure to disaster risk. Participants from different sector have different opinion about landuse.

The smart city initiative has not influenced the development plans of the city to increase the landuse for other critical activities proportionately. The overall impact of this indicator on resilience is negative.

Roads: 17 participants think the width of the roads is not appropriate for the density of traffic. The smart city initiative promotes the extension and beautification of adjacent sidewalks further reducing the carriage width of the roads rating it high on risk scale while 4 participants have rated it medium and another 4 rated it low on risk scale. The retrofitting of pedestrian walkways is welcomed by the participants with 8 participants rating it high and medium each while another 6 rated it low on risk scale. 17 participants think the traffic density on roads will not reduce inspite of the measures taken on public transport system, rating it high on risk scale while 4 participants have rated it medium and only 1 participant has rated it low on risk scale.

12 participants feel that the surface drainage system is not integrated in design while retrofitting the pedestrian walkways, rating it high on risk scale while 8 participants have rated it medium and 2 feel that it may not increase the risk, hence rated it low on risk scale. 11 participants think that safety issues on roads are compromised rating it high on risk scale while 6 have rated it medium and 5 rated it low on risk scale. The smart city initiative has adopted retrofitting of pedestrian walkways by increasing the width of walkways for beautifying the walkways resulting in decreasing the carriage width of roads which has given rise to traffic jams, especially at the road turnings. Though citizens have welcomed the beautification of walkways, traffic movement becomes slow.

The widening of walkways is experiencing encroachments from street vendors losing its purpose of providing good walking experience to citizens. The premise on which transport planning was based, introduction of metro and enhancing the existing public transport to reduce traffic density on roads, is yet to succeed. The city witnesses flash flooding every monsoon due to inadequate surface drainage system. While beautifying the walkways, the integration of storm water drains which is integral part of road and walkways, is not augmented. The combined effect of traffic density, encroachments, traffic jams, water logging is resulting in compromising the safety of citizens on roads. In disaster scenarios, the situation could worsen, aggregating negative impact on disaster resilience.

Open Spaces: 9 participants opine the quantum of public open spaces in form of accessible public gardens and parks which are less in the city, rating it high on risk scale while another 9 participants express the availability of public gardens as good in quantum, rating it medium on risk scale and remaining 4 participants rate low on risk scale, giving an overall positive impact.

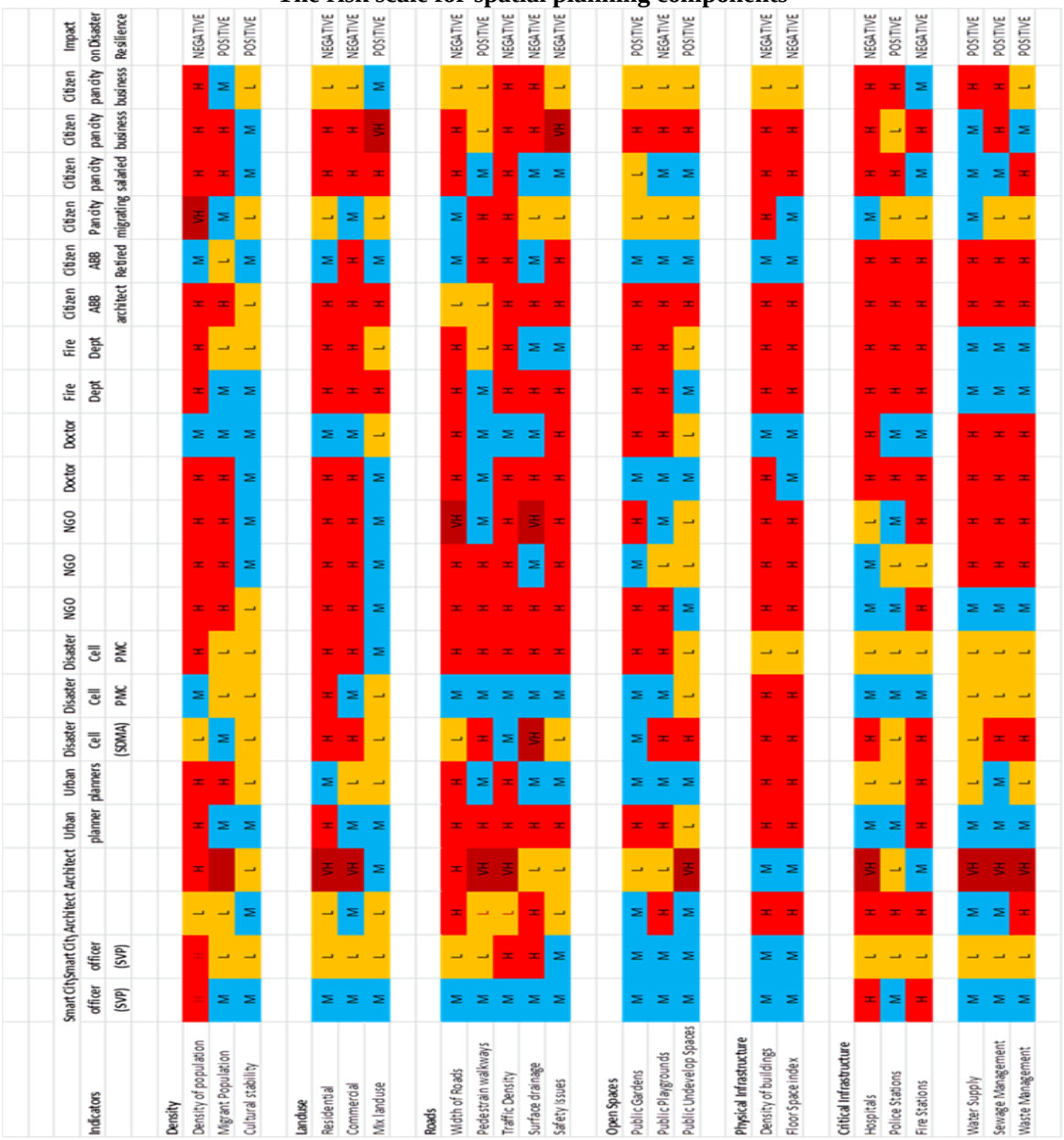
This scenarios, slightly changes with the indicator of public playgrounds for children, wherein the non-availability of enough quantum of public playgrounds has reverberated 10 participants to rate it high risk scale, another 8 as medium on risk scale and remaining 4 feel that the risk is low. The spatial planning of the city is starving for open parcels of

land in form of public gardens, parks and playgrounds. The distribution of open spaces in form of public gardens, parks and playground differs across the wards of the city as evident in the development plan. Lack of playgrounds for children will have serious social repercussions on the development of children and adolescents as expressed by participants from civil society organisations. The open spaces in the form of private ownership of institutions and housing societies are in good quantum in the city which is an important resource in the post disaster scenarios. The overall disaster risk scale for this component has positive impact on resilience.

Physical Infrastructure: 15 participants think that density of buildings will increase as result of increase in population rating it high on risk scale while 5 participants express the risk due to increase in density of buildings as medium and remaining 2 participants rate it low. Similarly, the increase in the floor space index (FSI) for the buildings resulting in more floor space to the city, will impact the built environment of the city. 13 participants express that the risk due to additional FSI will increase the exposure to disaster risk rating it high on risk scale. 7 participants opine that the risk would be medium and 2 participants feel that there is no risk exposure due to additional FSI rating it low on risk scale.

Smart City Mission promotes compact development; the local Governments have adopted the policy to increase the built footprint of the buildings by revising the building regulations. The increased built density will stress the land resources, the demand for critical services and safety mechanisms.

Table 4
The risk scale for spatial planning components



The additional floor space allowed for the buildings will result in increasing the height of the buildings, demanding more sophisticated evacuation strategies and fire-fighting systems, which are not evident in the building regulations. Hence, the overall impact on resilience to this indicator is negative.

Critical Infrastructure: 13 participants express that the health care infrastructure is inadequate rating it high on risk scale while 5 participants think the impact on risk due to healthcare infrastructure is medium and 4 participants rate the risk low. Police stations as part of critical infrastructure are rated high on risk scale by 8 participants, 6 participants think that the risk is medium while 8 participants opine that the risk due to this component is low. Fire stations share equal responsibility in critical infrastructure, 13 participants said the inadequate infrastructure will add to threats of risks rating it high on risk scale. 5 participants feel the risk due to inadequacy fire- fighting infrastructure as medium, while 4 participants have rated it low on risk scale.

Critical services like water supply system perform fairly well on the risk scale due to availability of water, hence only 9 participants have rated it high on risk scale, while 9 participants have rated it medium and another 4 participants rated it low. Similarly, sewage system in the city can pose high risk according to 10 participants, medium risk as per 8 participants and another 4 participants have rated the risk low. Critical service of waste management system is inadequate for the city as per 10 participants rating it high on the risk scale, while 6 participants think that the risk is medium and the remaining 6 participants have rated it low on risk scale.

The population growth is evident, especially with the smart city initiatives; the city will witness increase in floating and migrating population. The critical infrastructure of hospitals, police stations and fire stations, needs to get enhanced quantitatively and qualitatively at the pace of the increasing population, which is not evident in the smart city proposal or the vision plan of the city. It could have serious impacts in emergency scenarios. The overall impact of this component of critical facilities on resilience is negative

The critical services like water supply system are good for the city though with growing city limits, distribution has challenges. The administrative efforts for sufficing these services and the time to time investments in these services have resulted in positive impact on city. Smart city initiative proposes to strengthen the core infrastructure further by incorporating technology and by generating funds. The overall impact of this component of critical services has positive impact on resilience.

Conclusion

The participants of this study contributed their knowledge and understanding of smart city initiative, expressing their challenges and fears. The study reveals the smart city initiative impacts in every aspect of spatial planning directly or indirectly modulating the resilience to disasters. The spatial planning of the city cannot be independent of the choices and decisions made by the smart city initiative. The study further reveals that all the decisions made do not necessarily have positive impact on disaster resilience of the city. Direct or indirect impacts of the initiatives on the components like roads and physical infrastructure have potential to elevate the disaster risks in emergency situations.

The concentration of population and built structures will increase the exposure to disaster risks as the initiative does not aid any proactive mechanisms of balancing densities. Smart city initiatives currently as adopted seem to be at a very primary stage of its progression and need holistic assimilation with the spatial planning to achieve disaster resilience.

Way Forward

The study is conducted from spatial planning perspective and there are other influencing factors which impact the choices and decisions made by smart city initiatives for the city. However, safety of citizens is of prime concern. Hence the smart city initiative needs to be integrated in the development plan of the city and the decisions made should be an outcome of holistic planning of the city, rather than an independent and sporadic activity.

Disaster resilience is not an add-on feature of spatial planning, on the contrary the objective of spatial planning is to reduce the threats of disaster risks by reducing exposure to risk and mitigate the impacts of disasters. Disaster risk reduction needs to be integral part of decision making of any developmental initiative like smart city initiative; else the smart city initiative will be only a fragile and cosmetic initiative.

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