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# Smart cities - spatial planning and disaster risk reduction of Pune city, India

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## Abstract

Cities are becoming the preferred choice of populations to reside in due to the opportunities they offer. While the concentration of populations is increasing in the cities, there is an immediate need to equip the cities for efficient functioning and providing safety and security. The unplanned urbanization of cities is adding vulnerability, especially to the spatially relevant hazards such as earthquakes and floods. Initiatives such as the Smart City Mission support cities with investments to improve the quality of life for people and enhance the efficiency of the civic systems by integrating infrastructure and technology. However, the top down approach to decision making, especially in spatial planning, leaves out the perspective of citizens. This study, hence, attempts to gather the perception of citizens on smart city initiatives and disaster risk reduction (DRR) through a questionnaire survey in the smart city of Pune, India. The objective of this study is to understand how smart city initiatives influence the key spatial planning components for DRR. The study reveals smart city initiatives proposed for the city impacts each spatial planning component. Smart city initiatives may further stress these components, increasing the exposure to disaster risks. Therefore, there is a need for holistic integration in spatial planning for DRR. This study can help in modulating the smart city initiatives for enhancing the safety of the citizens.

**Keywords:** Smart cities, spatial planning, disaster risk reduction, urban risks, citizen's perception



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## INTRODUCTION

Cities are urban complex systems serving the needs of their citizens. They are diverse, vibrant, resourceful, and efficient. Cities are magnets attracting people with different aspirations. They are experiencing a major shift of populations from rural to urban areas, with 60% of the population now residing in urban areas<sup>[1]</sup>. The main reason for this trend is the abundance of employment opportunities and resources available in the cities. By 2050, the population living in cities is expected to be two-thirds of the world's population<sup>[2]</sup>. The functioning of the city is attributed to its administrative, legal, historical, social, economic, and cultural mechanisms<sup>[3]</sup>. Ultimately, cities have to meet the needs of people with dignity, safety, and security. Cities have evolved in their form and composition with the ever-changing needs and experiences of their users. The vision for the development of cities has become more crucial and challenging than before. Spatial planning of cities involves the process of social, economic, and environmental mechanisms to influence the distribution and coordination of population and activities in spaces<sup>[4]</sup>. It establishes a framework for landuse management, density management, the location of future areas for various functions, and the location and type of large investment projects, along with enhancement and protection of nature and the environment<sup>[5]</sup>. Spatial planning seeks to modify the functions, management, and arrangements of cities and regions, and it plays a distinguished role in alleviating disaster risk reduction (DRR)<sup>[6]</sup>. It is not a sporadic activity but a dynamic process administered by local governments. Spatial planning charts out a course of actions for reducing the vulnerability of populations in the given circumstances and in optimal ways<sup>[7]</sup>. The purpose of spatial planning is to organize the spaces for the efficient and safe functioning of the city with the help of policies and practices. Spatial planning of the cities is vital in maintaining the safety of the cities<sup>[8]</sup>. Cities manifest challenges to human settlement, and their being does not guarantee sustainable development<sup>[9]</sup>. Sustainable Development Goal (SDG) 11 recommends “making cities and human settlements inclusive, safe, resilient and sustainable”.

DRR of cities is important for enhancing the quality of life of the citizens. Furthermore, the performance of the governance mechanisms and civic services become more efficient in better planned cities. Spatial planning manipulates the development pattern and DRR with its two key instruments: Development Plan and Development Control Rules. The local administration needs to seek the integration of spatial planning and DRR processes to integrate the safety of human society with risks posed by disasters<sup>[10]</sup>. The urban fabric is a complex socio-technical system that encompasses different scales - buildings, building stocks, neighborhoods, cities, and regions - each with different time constants, actors, and institutional regimes<sup>[11]</sup>. Cities are becoming more vulnerable to disaster risks merely due to their physical environments, population density, and built footprint<sup>[12]</sup>. It is challenging for cities to maintain a balance between the high growth and development and DRR, especially considering the probability and exposure to hazards and climate change impacts. Every city is exposed to different types of disasters; mitigation measures differ as per the local conditions. There is no single formula for risk reduction which a city can adopt<sup>[13]</sup>. Moreover, DRR is an agenda of local governments and communities. Maintaining the landuse, enforcing building regulations, and providing critical infrastructure and services are responsibilities of the local government<sup>[14]</sup>. There is a need for cities to get smarter with innovative solutions to enhance livability and self-reliance<sup>[15]</sup>. DRR in cities is an outcome of conscious spatial planning<sup>[16]</sup>.

Different concepts of city development have been experimented with over centuries, and new ones are evolving in a continuous process<sup>[17]</sup>. “Smart Cities” is one such concept aiming to better the quality of life for their citizens. The concept of the smart city was to develop settlements for people to live, work, earn, have easy access to educational and health facilities, and exchange ideas, aiming to provide a better quality of life<sup>[18]</sup>. A formal definition stated by Mohanty (2020) is that “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”<sup>[19]</sup>. The planning of the infrastructure of the city needs to be compatible with the advanced ICT<sup>[20]</sup>. As the smart city drive was picking up globally, India launched its Smart City Mission in 2015. The Union Ministry of Urban Development Government of India, has the responsibility of implementing the National Smart Cities Mission, which is an urban renewal and retrofitting program aimed at developing 100 smart cities across the country. The initiatives undertaken by Smart Cities Mission have the potential to influence spatial planning, which directly or indirectly influences disaster risk. The objective of this study is, therefore, to understand how the smart city initiatives of India influence the spatial planning components. Do the initiatives contribute to DRR?

### **Smart city mission, India**

The urban population of the country is increasing, with approximately 40% of the population residing in urban areas<sup>[21]</sup>. The urban areas of the country need to strengthen themselves to provide comprehensive development of physical, institutional, social, and economic infrastructure to absorb the population growth. All of this aims to improve the quality of life of the citizens and attract people and investments to the city. Thus, “Smart Cities” is an approach adopted by the Ministry of Urban Development Government of India, for the development of the urban areas. It is a comprehensive program where the Union Ministry of Urban Development plays the primary role, and the states and Urban Local Bodies (ULB) play a key supportive role in the development of smart cities. It also requires the participation of the residents in making key decisions about the development issues of the city. [Figure 1](#) lists the core infrastructure elements included in the Smart City Mission. The objective of the Smart City Mission is to promote “cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of “Smart” Solutions”<sup>[22]</sup>.

As per the Mission, the focus is on sustainable and inclusive development, and the idea is to look at compact areas and create a replicable model that will act as a lighthouse to other aspiring cities. The Smart City Mission promotes area-based development by retrofitting or redeveloping the existing areas in the cities, including the slums, through better planning of spaces. It also encourages the greenfield developments to accommodate the increasing population density. Integrating the technological solutions to collate data and information for improving the delivery of civic services would be the top agenda for the smart solutions, with governance mechanisms strengthened<sup>[23]</sup>. The investments in the ICT system promoted by the smart mission can help in many ways for DRR, from early warning to response and recovery<sup>[24]</sup>.

### **Smart city initiative - Pune, Maharashtra, India**

Pune is a diverse and vibrant city, ranking 8th in the country, located in the state of Maharashtra, India. It is famous for its education, automobile industry, and IT industry and is rated as the most livable city. Pune has ranked second in the top 20 list of 100 smart cities selected by the Ministry of Urban Development Government of India, after Bhubaneswar. The Smart City Initiative of Pune focuses on two approaches: first, retrofitting area-based development, and second, providing pan city solutions. [Figure 2](#) shows the list of 51 projects selected by the Pune Smart Initiative for the area-based development and pan city solutions. The initiative was launched in Pune in 2016, with the highlight being the “citizen engagement programs”. The initiative was welcomed by citizens with huge excitement. The vision and goal for smart city development in Pune are to leverage its rich culture and natural heritage, strong human capital, and robust business environment, aspiring to become one of the most livable cities in India by solving its core infrastructure issues in a future-proof way<sup>[25]</sup>.

- The core infrastructure elements in a Smart City would include:
- adequate water supply,
  - assured electricity supply,
  - sanitation, including solid waste management,
  - efficient urban mobility and public transport,
  - affordable housing, especially for the poor,
  - robust it connectivity and digitalization,
  - good governance, especially e-governance and citizen participation,
  - sustainable environment,
  - safety and security of citizens, particularly women, children and the elderly,
  - health and education

Figure 1. shows core infrastructure elements in a Smart City. (source-reimaging pune: Mission Smart City, 2016).

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	Transport
2 100 Electric buses	19 River water cleaning	36 Bus System ITMS	Urban Planning
3 Redesign of streets	20 Solid waste management	37 Command Control Center	Water
4 Smart parking	21 Sanitation	38 Total Smart Parking	ICT
5 Footpaths (additional and retrofit)	22 Electricity distribution – Smart grid & metering	39 Intelligent Road Management	Marquee
6 Placemaking	23 Solar energy supply	40 Traffic modeling system	Others
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	

Figure 2. List of Smart City Initiatives in Pune. (source-reimaging pune: Mission Smart City, 2016).

### Citizen engagement

The entire administrative machinery, along with media, NGOs, private companies, and educational institutes, participated in outreach mechanisms. Fifty percent of the total households in Pune, which is four lakh households, were reached out to get inputs on the vision and goals, covering all 15 wards across the city in a door-to-door campaign by 150,000 smart volunteers. The 35 lakhs and more inputs were received on social media platforms. The inputs given by the citizens for the city were - “Clean, Beautiful and Green City” and major issues highlighted by citizens were - transport, water, and other core infrastructural issues. Banking upon the citizen engagement programs, different projects were formulated for the area-based development and pan city, with the focus on making the city livable and enhancing the infrastructure.

### *About Pune*

Pune city evolves in an organic pattern; it is not a planned city. The decision on the development pattern of the city is made by Pune Municipal Corporation in a consultative process with stakeholders. Over the years, there has been an increase in city limits, with fringe villages getting incorporated in the city limits. The recent introduction of Uniform Development Control Rules 2019 (UDPCR, 2019) has amplified the floor space index (FSI), resulting in an increase in the height and density of buildings<sup>[26]</sup>. The road pattern and critical services of the city evolve as per the need generated due to the development of new residential areas. The high demand for residential units makes the real estate market lucrative, pressurizing all the civic services available in the city.

Pune city is situated on the confluence of the rivers Mula and Mutha. It is the second largest city in the state of Maharashtra, with a population of 3.99 million spread over an area of 331.26 sq km located at the elevation of 560 m above MSL in the Sahyadri mountain range. It lies in the Moderate Damage Risk Zone III of an earthquake adjacent to the active seismic zone of Koyna. Though there is no history of earthquakes, except for severe tremors felt during the Latur earthquake on 30 September 1993, the city is highly vulnerable to earthquakes<sup>[27]</sup>. [Figure 3](#) shows the map of physical features of Pune.

The city experiences low to moderate flooding every year due to instances of high precipitation or release of water from the four upstream dams. The Panshet dam burst (12 July 1961) and the cloud burst on 25 September 2019 are major flooding events in the history of the city. Each year during the monsoon, there are events of riverine flooding and flash flooding in the city, disrupting its normal functioning.

The smart city initiative has boosted the development pattern of the city. All the initiatives proposed in the Smart City mission of Pune have a strong linkage to the spatial planning of the city. The development pattern of the city shall be further elevated with the introduction of the Metro for mass transportation and Transit Oriented Development (TOD) (an area within a radius of 5 kms of metro stations with dense and compact development, enjoying an FSI of five for residential and commercial landuse).

## **METHODOLOGY**

### **Selection of spatial planning components**

Urban planning in India comprises six key components: population density, landuse, open spaces, roads, physical infrastructure, and critical infrastructure, modulated through two key instruments: development plan and building codes. Hence, these spatial planning components were selected in this study as they play an important role in DRR<sup>[28]</sup>. These components form the basis of spatial planning and are impacted directly and indirectly by any developmental decision taken by the local government<sup>[29]</sup>. [Table 1](#) shows the spatial planning components, subcomponents, and description of the perceptions gathered in the survey from participants on smart city initiatives from a disaster risk perspective.

### **Method**

Pune city is selected for this study as a case. This method helped us to conduct a comprehensive study of the city, smart city initiatives, and its implications from a disaster perspective. The study focuses on understanding the perceptions of citizens of Pune on DRR for spatially relevant hazards, earthquakes, and floods. We selected a questionnaire survey method<sup>[30]</sup>. An articulated questionnaire was distributed in 15 wards of the city through the volunteers of a non-profit organization. The questionnaires were circulated to almost 2,000 citizens, and with gender equality, we received back almost 1,350 questionnaires, out of which 800 (400 men and 400 women) were used in the study for analysis as they had answers and comments. Most of these participants were also part of the city engagement program conducted by the smart city initiative (as per the question answered). The rest were incomplete or vaguely answered.

**Table 1. Shows the spatial planning components and description**

Spatial planning components	Subcomponents	Description of risk perceptions gathered on smart city initiatives from participants
Density	Residential	Population increase due to SM initiatives
	Floating	Population increase due to SM initiatives
	Migrant	Population increase due to SM initiatives
	Cultural stability	Impact on cultural stability
Landuse	Residential	Residential landuse increase
	Commercial	Commercial landuse increase
	Mix use	Mixuse landuse increase
Roads	Width of roads	Carriage way of roads reduced
	Pedestrian pathways	Beautification of pedestrian pathways
	Traffic density	Traffic Jams, Travel time increased
	Surface drainage	Water logging, choking of drains
	Safety issues	Cases of accidents increase
Open Spaces	Public gardens	Less availability, accessibility
	Public playgrounds	Less availability, accessibility
	Undeveloped land	Availability of open land parcels
Physical Infrastructure	Density of buildings	High footprint, close to each other
	Floor space index	FSI increased
	Building margins	Natural light and Ventilation compromised
	Building height	Safety mechanisms for high buildings
Critical Infrastructure	Hospitals	availability quantitatively, qualitatively
	Police stations	availability quantitatively, qualitatively
	Fire stations	availability quantitatively, qualitatively
Critical Services	Water supply	available 24 × 7, 135 liters per person/day
	Sewage management	availability quantitatively, qualitatively
	Waste management	availability quantitatively, qualitatively

The participants of the survey were qualified adults of different age groups and educational and economic backgrounds. The survey was conducted in September 2022, six years after the launch of the smart city initiative. During this time, the citizens experienced two extremely heavy precipitation events in 2019 and 2021. The questionnaire comprised of open-ended questions in the local language, focusing on each spatial planning subcomponent. The questions framed were as follows: “Do you think the population will increase due to the initiatives like local area development and metro”, “Does the storm water enter your building during heavy rains?” and “Can the fire engine easily reach your building in case of emergency? If not, comment why?” The participants had to mark their answers as “Yes, No, or Not Sure” and provide their understanding of each answer in the comment column from a disaster scenario perspective. Additionally, the participants had to rate the disaster risk on a Likert scale based on their perception of whether the spatial planning component will increase the disaster risk due to the smart city initiative. This method of “survey” is selected as it aligns itself with the citizen engagement program of smart city initiatives. This method allowed us to reach a good number of people and helped in gathering individual perceptions, which were not influenced by others. Secondly, the questionnaire was in the local language, “Marathi”, so participants could understand better and share their opinions openly in the comment section. Newer initiatives, such as smart cities, are valuable for the development of the city. This study examines it from a different perspective, offering a fresh insight for further studies. However, there are limitations to this study.

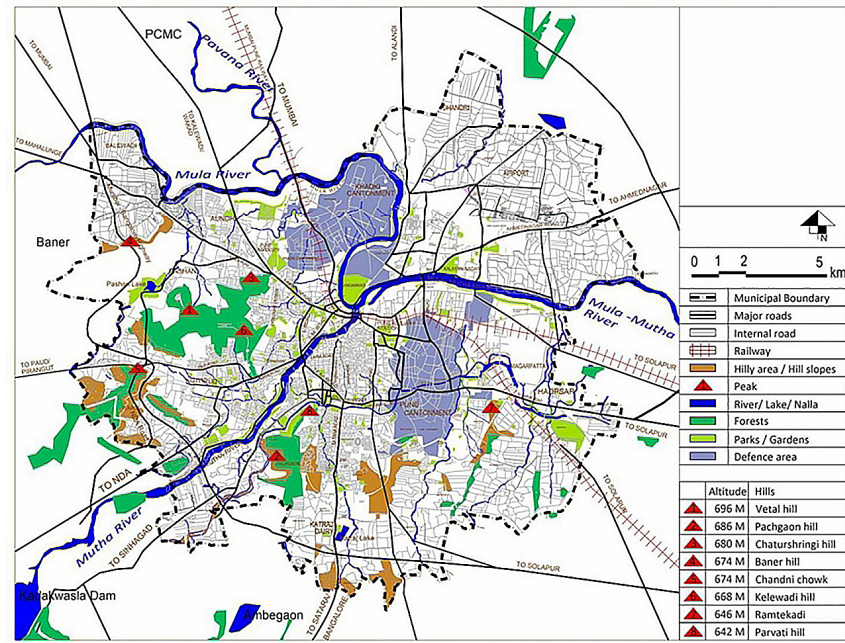


Figure 3. Map of physical features of Pune. (source: DM Plan 2016, PMC).

The answers and comments given by participants are their individual perceptions based on their understanding. In some instances, we had to adopt different methods, such as interviews and field visits, to validate the received data.

## RESULTS

Table 2 shows the responses of participants on the smart city initiatives.

### Density of population

Smart city initiatives shall be instrumental in attracting a larger population for better opportunities. The density and composition of the population are cardinal in disaster scenarios. According to 80% of the participants, the population density will increase as an indirect impact of smart city initiatives, while 15% participants feel that the population growth is not attributed to smart city initiatives. Additionally, 5% participants are unsure about the relation, implying high-risk exposure due to population concentration. The floating population in the city will increase, according to 80% participants, primarily due to better transport facilities. This increase in the floating population can result in high exposure to disaster risks, while 10% participants disagree with this view, and another 10% participants are unsure. Over the decades, Pune city has been witnessing an increase in the migrant population, with almost 65% of the participants believing that migrant population density will be influenced, leading to more migration in the future. Furthermore, 20% participants disagree with this perspective, while 15% participants are unsure of their opinion on the migrant population. Pune city has effectively integrated migrant populations, resulting in a medium level of risk during disasters. Only 30% participants feel that the increase in population density might influence the cultural stability of the city, 50% participants believe there is no threat to cultural stability, and 20% are not sure. Cultural differences can be hindrances in disaster scenarios; however, in a homogenous and stable society, cultural differences pose a low-risk factor. Despite this, the overall risk factor for this component has been rated high.

**Table 2. Shows participant's responses**

Spatial planning Components	Participant responses			Aggregated Risk
	Yes	No	Not sure	
<b>Density</b>				
Residential	80	15	5	High
Floating	80	10	10	High
Migrant	65	20	15	Medium
Cultural stability	30	50	20	Low
Overall risk				High
<b>Landuse</b>				
Residential	75	25	0	High
Commercial	75	20	5	High
Mix use	80	15	5	High
Overall risk				High
<b>Roads</b>				
Width of roads	50	40	10	Medium
Pedestrian pathways	50	25	25	Medium
Traffic density	90	7	3	High
Surface drainage	70	20	10	High
Safety issues	50	20	30	High
Overall risk				High
<b>Open spaces</b>				
Public gardens	60	20	20	Medium
Public playgrounds	80	15	5	High
Undeveloped land	30	60	10	Low
Overall risk				Medium
<b>Physical infrastructure</b>				
Density of buildings	75	20	5	High
Floor space index	55	30	15	Medium
Building margins	60	20	20	High
Building height	75	20	5	High
Overall risk				High
<b>Critical infrastructure</b>				
Hospitals	70	15	15	Medium
Police stations	50	25	25	Medium
Fire stations	50	25	25	Medium
Overall risk				Medium
<b>Critical services</b>				
Water supply	65	15	20	Medium
Sewage management	75	20	5	High
Waste management	85	10	5	High
Overall risk				High

## Landuse

The city is growing in its spatial boundaries and population. The development plan over the years has shown an increase in residential and allied landuse. According to the survey participants, 75% opined that residential landuse will increase to accommodate the growing population, especially attracted due to smarter developments in the city, while 25% feel that smart city initiatives may not contribute to the landuse pattern. Almost 75% participants also feel that the commercial landuse will increase in the city in response



to the growing residential use, while 20% participants disagree, and 5% participants are unsure. Additionally, almost 80% of the participants feel that mixed landuse will increase as proposed by smart city initiatives, 15% participants disagree, and 5% participants are skeptical about the impact of smart city initiatives on mixed landuse. The real estate market in the city is experiencing exponential growth with high property rates for residential and commercial landuse. This forces the poor communities to occupy hazardous and illegal locations, such as low-lying areas, steep hill slopes, and river banks, as they have no affordable and safe options in the city. The participants have rated this component high for disaster risks.

### **Roads**

The smart city initiative intends to beautify the city by extending the pedestrian pathways and furnishing it with street accessories, resulting in a reduction of carriageways of roads and roadside parking. Pune city is famous for the number of private vehicles on the road. Fifty percent of participants feel the carriage width of the roads has reduced the traffic carrying capacity of the roads, while 40% feel beautification has added value, so it is justified, and 10% participants are unsure about the reduction of carriageways. The traffic jams and travel time on roads make the participants dubious, and they have rated the risk as medium for this indicator. Nearly 50% participants feel positive about the beautification of the walkways, while 25% participants are skeptical about the vendor encroachments, and another 25% are not sure if it actually helps pedestrians. Most of the surveyed participants, 90%, feel traffic density on roads will increase, while only 7% participants disagree, and 3% are skeptical. The risk due to traffic density is rated high by the participants, especially considering their experiences of traffic jams, longer travel times, and road accidents. Nearly 70% of participants agree that surface drainage systems are inadequate, causing water logging in the monsoon months, while 20% blame the issue on heavy precipitation, and 10% participants are unsure about the risk it creates. The citizens are aware of the past two heavy precipitation events that flooded the city, resulting in disruptions to normal functioning and loss of life. Water logging is a common phenomenon during the monsoons, which prompts citizens to demand appropriate surface drainage systems. The disaster risk from urban flooding is high. Almost 50% of participants feel that road safety will be compromised due to the beautification of roads resulting in blind spots and accidents, while 20% participants disagree, and 30% participants have an ambiguous response to this indicator. According to some participants, the smart city initiatives, along with other road development works, have focused on beautifying roads instead of safety on roads. As a result, the overall risk factor of this component is high.

### **Open spaces**

The rapid built development and increasing land prices in the city have stressed the open spaces. Citizens acknowledge the scarcity of the open spaces in the form of public gardens and playgrounds available and accessible to all. Hence, 60% participants feel there are no adequate public gardens, 20% participants disagree, and 20% participants are not sure about the importance of public gardens. The inadequacy of open spaces can worsen the impact of disasters. The green cover and biodiversity contributed by the open spaces are important for the sustenance of the city; the lack of open spaces would make the city more vulnerable to hazards, marking it as medium on the risk scale. Open spaces in the form of playgrounds are non-negotiable resources for the city; however, these resources are currently only available to a few organizations and individuals in their personal domains. Almost 80% participants feel there are negligible public playgrounds for the children, while 15% participants feel there are paid sports facilities available, and 5% are not sure about the availability of public playgrounds, rating it high risk. The stress on land is high, with very few open land parcels remaining; hence, 30% participants feel there are limited undeveloped public open spaces for future use, 60% participants feel undeveloped space in public and private sectors could be converted to public use, while 10% participants are not sure. The lack of open spaces can be an encumbrance in disaster response and recovery. However, the survey participants rated the risk for this indicator as medium.

### Physical infrastructure

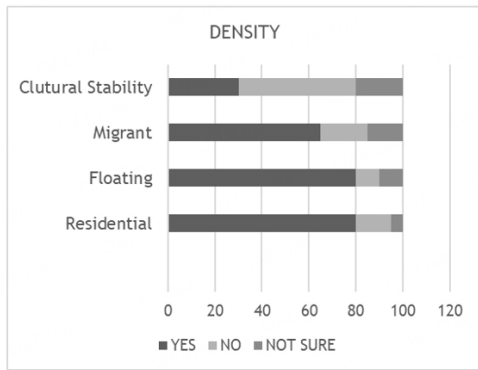
The population increase has led to growth of physical infrastructure and the built environment. The demand for housing and aligned facilities is high, creating dense built footprint; hence, 75% of survey participants feel the increasing density of buildings will add to the threat of disasters, while 20% disagree, and 5% participants are unsure of the growing risk. In earthquakes and floods, the probability of damage for such a dense built footprint is high. This was also evident from the past two urban flooding experiences caused by heavy precipitation, which rated the risk as high. The dense built area makes 55% of participants feel that additional FSI will impact the disaster safety of the occupants negatively, while 30% participants feel there is a need for extra FSI, and 15% are unsure if disaster safety is compromised, rating the risk as medium. Furthermore, 60% of the participants feel the side margins, as per building regulations to accommodate the compact planning, will have negative impacts on the built environment and building safety. Meanwhile, 20% disagree with this view, and 20% participants are unsure about the importance of side margins. The squeezing of side margins can be an impediment in disaster scenarios, marking a high risk to occupants. The increased height of the buildings will require energy intensive evacuation mechanisms; 75% participants feel that it is a high risk from a disaster perspective, while 20% feel increasing building height is required for a growing population, and 5% are not sure. The overall rating on the risk scale is high.

### Critical infrastructure and services

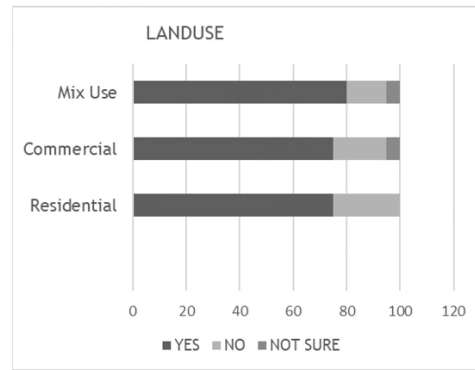
Critical infrastructure is important for DRR and early recovery. Hospitals with appropriate healthcare facilities for emergency scenarios are assets; 70% of participants feel healthcare systems are quantitatively adequate, while 15% participants disagree, and 15% participants feel there is a dire need to enhance the healthcare system for DRR, rating the risk as medium. Similarly, 50% of participants experience that the police stations are inadequate in comparison to population, while 25% participants disagree, and 25% participants are not sure about police stations quantitatively, rating the risk as medium. The critical facilities, such as fire stations, are of prime importance in disaster scenarios; 50% participants feel they are inadequate, 25% participants feel they are quantitatively adequate, and 25% feel they are not equipped appropriately to face disaster scenarios based on their past experiences. The easy movement and accessibility of a fire engine in dense areas make the risk high. However, the overall risk from critical infrastructure is rated as medium.

Pune, though it enjoys good water supply from four upstream dams, has lacunas in its water distribution system, according to 65% participants. Meanwhile, 15% disagree, and 20% participants feel there is a need to enhance the water management system, rating the risk as medium. Furthermore, 75% of the participants are incredulous about the sewage management and treatment, 20% participants feel the sewage system is fair, and 5% participants feel sewage system failure in disaster scenarios will add risk, especially during heavy precipitation, marking the risk as high. According to 85% of the participants, the waste management system in the city is inadequate, while 10% participants feel it is appropriate, and 5% population is skeptical about it, rating it as high on the risk scale. The critical services are crucial for the sustenance of urban life. Failure of these systems can hamper the recovery process in post-disaster scenarios. The overall risk for critical services is rated high. The enhancement of these systems needs to be aligned for their performance in emergency scenarios.

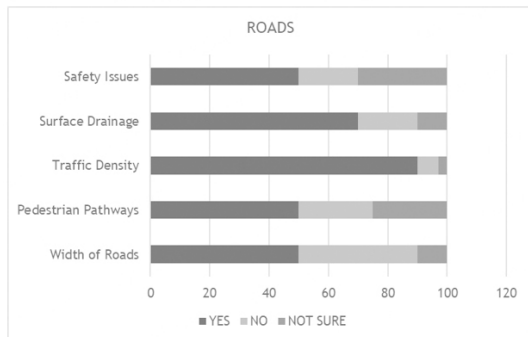
The results show most of the participants feel that the developmental decisions and planning along with smart city initiatives may be appropriate in normal conditions but may not be efficient in disaster events. This will expose populations to more risk and slow down the response and recovery process, as expressed in [Figure 4](#).



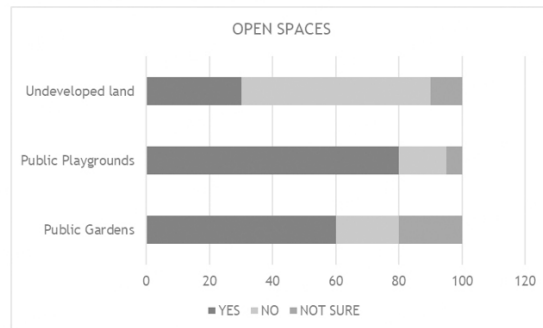
(A) Risk perception for Density



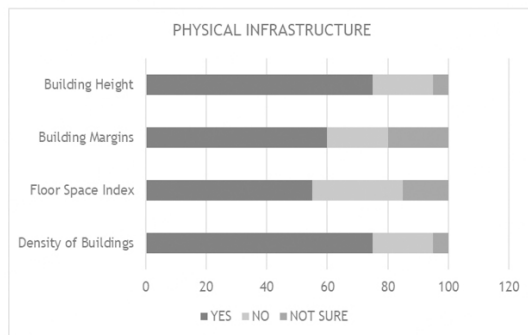
(B) Risk perception for landuse



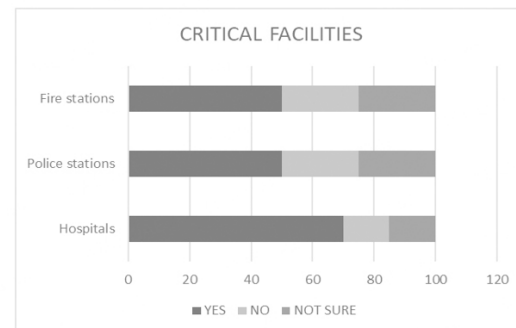
(C) Risk perception for roads



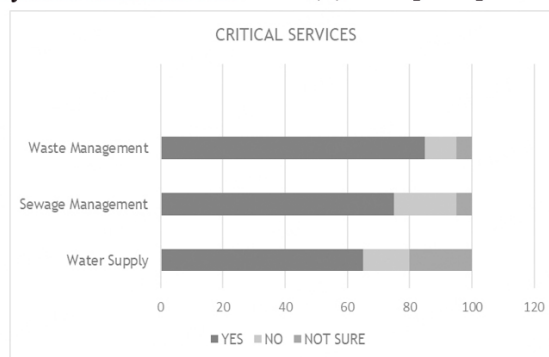
(D) Risk perception for open spaces



(E) Risk perception for physical infrastructure



(F) Risk perception for critical facilities



(G) Risk perception for critical services

**Figure 4.** The risk perception of participants for spatial planning components. Risk perception of density (A), landuse (B), roads (C), open spaces (D), physical infrastructure (E), critical facilities (F), critical services (G).

## DISCUSSION

The population will naturally increase, with migrant populations who choose the city for permanent residence and floating populations from fringe areas around the city. People choosing the city from different parts of the country will bring in their own cultural identity. Pune city has been a cosmopolitan city with a mix of cultures. Yet, according to the participants, the homogeneity of Pune city will not be affected by the cultural differences of the populations. However, the concentration and composition of the population may add to the vulnerability of disasters<sup>[31]</sup>. Population growth in cities is a natural phenomenon, but the exponential growth promoted by various developmental initiatives increases the risk exposure, especially when dedicated efforts for risk reduction are not prominent in the spatial planning of the city. These initiatives fail to contribute to DRR, marking the disaster risk as high.

The increased population has led to an increased demand for housing and commercial activities, which has been evident for the past three decades. Smart city initiatives in Pune encourage compact development in housing and promote mix use development, where people can access the “place of work or entertainment, walking”. It will influence the landuse pattern prescribed in the development plan of the city, especially with the decision of “TOD”. To accommodate the increasing densities, the landuse patterns are continuously modified with the focus on residential and mix landuse, increasing the risk exposure. The imbalance of densities of population and built structures created in the spatial planning of the city due to initiatives, such as “TOD”, on the contrary, increases the risk probabilities in emergency scenarios, contributing negatively to DRR. A recent study conducted by researchers in Taiwan showing the relationship between landuse changes for built footprint and disaster risk summarizes the need for an informed decision system<sup>[32]</sup>. Spatial planning needs to acknowledge disaster risks and be sensitive to perform in worst-case scenarios to avoid loss of life and assets.

One of the focus areas of smart city initiatives in Pune is to promote walkability. The pedestrian walkways are increased in width and are beautified, resulting in reducing the carriage width of roads and roadside parking. Citizens have welcomed the beautification of walkways but are not satisfied with the narrower carriage width of roads, which results in occasional traffic jams. Transport systems were the top issue highlighted by the citizens in the citizen engagement survey conducted by a smart city team. To resolve the issue, the Metro, as a mass transport system, is introduced (under construction). Despite efforts being made for strengthening the mass transport system and public transport, participants feel the traffic density on roads will increase due to feeder transport facilities, the use of private vehicles, and the hindrances caused by the metro infrastructure. Surface drainage systems are one focus area of smart city initiatives in Pune. However, the lack of surface drainage systems, both quantitatively and qualitatively, creates water logging problems in the city during monsoons, which is left unaddressed while beautifying the pedestrian walkways. This increases the risk of flash floods in every monsoon, disrupting the normal functioning of the city, which was evident in the past two heavy precipitation events. The density of traffic, uncoordinated traffic signal systems, encroached walkways, beautification of road dividers, and the number of road accidents in the city make the participants feel their safety is being compromised on the roads. The citizen engagement program has highlighted this issue. In disaster scenarios, roads are the lifelines. The roads of Pune city were already overstressed; the ever-increasing number of private vehicles and reduced carriageways have added to risk on roads. Moreover, roads are the only open land parcels in some dense parts of the city in disaster scenarios.

The changes in the development plan of Pune over the years have converted the open parcels of land into residential areas, with very little effort on proportionately increasing the open spaces for gardens and playgrounds for citizens. Moreover, open spaces are important resources in disaster recovery<sup>[33]</sup>. Though for

major residential projects, the open spaces are mandatory, they are private and fragmented. The other open spaces in the city are mostly private and not accessible to the public. There is an increasing trend to convert the hill slopes into manicured gardens as “open spaces”, limiting the accessibility to the public. Pune city is starving for open playgrounds for children, which may lead to negative social issues. Due to the inadequacy of playgrounds and public parks for children, some participants have rated the risk as high. Smart city initiatives had the agenda of making the city “Clean and Green”, which further did not culminate in increasing the open spaces in a development plan, obviously due to lack of space. Moreover, open spaces, such as roads, are important resources for the citizens. The inadequacy of safe open spaces can weaken the evacuation operations in disaster scenarios, as evident from earlier experiences. However, private open spaces could be used in emergency situations; hence, the overall risk from a disaster perspective is medium.

The density of buildings will increase due to the increase in population. Commercial activities will boom with overall development in the city. Pune city administration is permitting higher FSI, further increasing the density of buildings and higher built footprint. The physical infrastructure, which is residential and commercial buildings referred to in these studies, does not necessarily comply with the requirement of mandatory safety systems quantitatively and qualitatively. The revisions in the building regulations that allow lesser side margins and permit extra heights compromise the natural light and ventilation in the buildings and stress the evacuation and safety mechanisms. The additional FSI will result in more built stock and requirements of safety systems. With 40% of the population staying in shanty settlements or slums, the risk due to physical infrastructure is high. The concentration of people and buildings without additional safety systems and non-availability of encroachment-free accessible roads will increase the risks of citizens in emergency scenarios. The built areas are assets that need to be protected from the impacts of natural hazards to reduce vulnerability<sup>[34]</sup>. The compact and dense development promoted by the smart city initiatives shall add to the risks due to many reasons, such as evacuation failures, dependence of energy intensive mechanisms in buildings, inaccessibility of critical facilities, and lack of green spaces, making the development pattern unsustainable. The spatial planning gets stressed due to such developmental excitation. The city administration needs to look beyond mere needs of citizens, recognizing the implications of the decisions in worst-case scenarios. Spatial planning decisions should be informed decisions with necessary mitigation measures to contribute to DRR.

Planning of critical infrastructural facilities is key to DRR and early recovery<sup>[35]</sup>. Participants with their experience are skeptical about quality and affordability of the healthcare facilities. The smart city initiatives in Pune propose strengthening of healthcare facilities, especially in the local area development, which will be replicated pan city. The other critical infrastructure facilities, such as police stations and fire stations, are quantitatively and qualitatively lesser than desired urban development norms in terms of infrastructure and resources; however, there are no concrete measures in the smart city initiatives to address this aspect. The city enjoys good quantity and quality of water, though the distribution system has its own challenges. The citizen engagement program had highlighted this issue of water management. The incapability of the sewage treatment plants in the city to treat the sewage completely is perturbing. The untreated sewage discharged in rivers is a concern. Smart city initiatives propose the enhancement of capacities of sewage treatment plants under various government schemes. The pace of growth of Pune city is not aligned with the infrastructural facilities and services; with smart city initiatives, it shall aggravate further, making it critical in emergency scenarios. The organic pattern of development needs enhancement in spatial planning for critical facilities and services, especially from a DRR perspective. The disaster risk is high due to insufficiency of critical infrastructure and services.

The aim of smart city initiatives to provide more facilities and improve the quality of life of citizens is appreciable, but the repercussions it can have on different aspects of urban infrastructure need consideration, especially for the impacts of natural hazards. The disaster prevention and mitigation measures are not the direct agenda of the smart city initiative; however, safety should be the priority for any initiative and should not be an afterthought. Natural hazards have the potential to rip off all the developmental initiatives if their impacts are not contemplated and consolidated in spatial planning decisions. Smart cities should smartly navigate through the complexities and intricacies of the urban agenda and infrastructure challenges. Furthermore, DRR requires a conscious and persistent effort, not a forced activity.

## CONCLUSION

Smart city initiatives have built aspirational values in citizens to satisfy their basic civic needs and improve their quality of life. Hence, more people will choose to live in Pune, increasing the population density. The rise in population will further drive the demand for residential and commercial spaces, stimulating the changes in landuse patterns. The stress on transport facilities will require larger roads to accommodate private and public vehicles. There will be a greater need for open spaces to suffice the growing population. The demand for physical and critical infrastructure facilities and services shall exhaust the resources and carrying capacity of the city, as evident from past experiences. The study reveals that smart city initiatives proposed for Pune city influence each spatial component, resulting in increasing exposure to disaster risks due to two main reasons: not addressing the issue or partially addressing the issue and not considering the repercussions of the initiatives on disaster risks. The study further divulges the poor contribution to risk reduction measures; on the contrary, the disaster risk exposure may increase due to the increase in population density, changing landuse, road conditions, inadequacy of open spaces, obnoxiously growing built infrastructure, and quantitative and qualitative inadequacy of critical infrastructure facilities. It is observed that there is a wide gap between the aspirations of the citizens and the choices of the initiatives made by the administration.

Smart city initiatives, if integrated into spatial planning holistically, could help in managing the performance of civic facilities and services by its ICT components. It can be instrumental in DRR with its ICT approach and real-time data for making informed decisions for DRR, such as urban flood management. Smart city initiatives should refrain from being an “add-on feature” and another “top down” governance mechanism.

## DECLARATIONS

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### Authors' contributions

Made substantial contributions to the conception and design of the study and performed data analysis and interpretation: Kodag S

Performed data acquisition and provided administrative, technical, and material support: Kodag A

### Availability of data and materials

Not Applicable.

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None.

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Both authors declared that there are no conflicts of interest.

### Ethical approval and consent to participate

Not Applicable.

### Consent for publication

Not Applicable.

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