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Will India's Smart Cities be Climate Resilient? Evidence from Pune, India

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Abstract

The response of a city towards climate change mitigation and adaptation is crucially linked to how the city operates. Broadly speaking, the level of efficiency of such 'operations' is manifested as more efficient cities being labelled as 'smart cities' in the literature, though the indicators of smart cities vary to a large extent. With regard to urbanisation challenges in India, the Government of India initiated the *Smart City Mission* in 2015 with the objective to provide the core infrastructure for a decent quality of life, clean and sustainable environment for inclusive development and application of 'Smart' solutions. Examples of smart solutions include ICT interventions for e-governance, online government services to ensure efficient and least cost core services. The aim of the paper is to evaluate the perceived urbanisation challenges to meet the climate resilient criteria for smart cities in India using the participatory theory of urban development. The researcher investigates the stakeholders' perception of the existing challenges to be climate resilient for the smart cities in Pune in India. The choice of Pune as a case study is because it has been identified as climate resilient as well as a smart city. The analysis shows that in order to contribute in long run urban sustainability, efforts to promote urban resilience to climate change need to be bundled with smart city missions. Integration of all pillars is essential if a 'Smart City' has to play an important role in achieving the stringent climate change targets such as limiting the global average temperature rise to 1.5°C. The institutional and technical challenges are ranked high in the study followed by the economic and social& cultural challenges. The research also highlights the importance of challenges such as lack of awareness of citizens, disjoint strategies between different governing bodies, lack of proper incentive schemes for end-users, the missing links between different stakeholders, absence of proper business model and foresight, absence of adequate expertise etc. The paper thus provides insights for policymakers as well as micro-consumers and service providers and developers as to how climate resiliency might be addressed as an instrument of smart city.

Keyword: Climate Resiliency, Sustainability, Smart City, Pune
JEL Classification: P25, Q01, Q54, R00

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1. Introduction

The Census of India (2011) states that about 32% of India's population lives in urban areas and this could reach 40% within 2021 and 50% within 2041. 70% of the GDP can be attributed to urban areas, while the country invests just 0.7% for urban development (Madakam & Ramaswamy, 2015). It has been predicted that India needs to create 500 new urban agglomerations in the coming 20 years to host 700 million more city dwellers by 2050 as it has been found that an average of 30 people migrates each minute from rural to urban areas of India.

Indian urban agglomeration is often confronted with multi-faceted core problems like unplanned development, informal real estate markets, inevitable population growth, lack of infrastructure, inadequate transport facilities, traffic congestion, poor power supply, incompetent health services and lack of basic services. This is the case both within the city and in the suburban and peri-urban areas. Poor natural hazard management in overpopulated areas, the prevalence of crime, and water, soil and air pollution (as exemplified by the Delhi smog; Barry, 2016) add to the concerns. Climate change and poor governance have led to urban populations living in conditions of persistent stress (Madakam and Ramaswamy, 2013).

The nation started addressing urban developmental issues from 1979 onwards with the introduction of the Integrated Development of Small and Medium Towns (IDSMT) scheme by the central government. The objective was to improve the economic and physical infrastructure of urban settlements with a population under 500,000. A total of 1854 towns were under this scheme, but outcomes of the scheme were not satisfactory because of the lack of implementation capacity,

non-availability of the investment portfolio and unencumbered land for the projects (MoHUA, GoI, 2014). In 1993, a Mega City Scheme (MCS) was introduced for five mega cities in India with a special focus on infrastructure development. These two schemes continued till 2005 after which insufficiency of investment funds led to the schemes becoming dormant (Aijaz and Hoelscher, 2015). From 2005, the Government of India initiated a comprehensive scheme – Jawaharlal Nehru National Urban Renewal Mission (JNNURM) for infrastructure development and providing improved basic services with a special focus on the transportation sector for the urban poor in sixty-five mission cities. While the mission achieved some successes, it was plagued by lack of capacity, funds and insufficient planning. In 2015, a more comprehensive, transparent, inclusive and participatory scheme was launched as *Smart City Mission* in India. The *Smart City Mission* of the Government of India (2015) promotes cities that provide core infrastructure with a decent quality of life to its citizens, a clean and sustainable environment and application of ‘Smart' solutions. Such smart solutions include ICT (Information & Communication Technology) interventions for e-governance, online government services, and improving the efficiency of core services at a relatively low cost. The main focus of this mission is on sustainable and inclusive development and to create a replicable model which will act as a lighthouse to other aspiring cities (Ministry of Urban Affairs, Government of India, 2015). Of a total of around 4000 cities and towns (Census, 2011), proposals from 90 cities were considered as winners (till June 2018) under this mission. The urban population expected to be impacted under this scheme is 25% of the total urban population of India (equivalent to 2.5% of the total urban population of the World). According to the mission guidelines, the state and central Governments are expected to invest equal amounts in the chosen cities. The total cost of this project is Rs.189,256 crores (20% for pan-city solutions and 80% for area-based development) over five years (2015-2020). The essential features of the

scheme are bottom-up planning based on citizen participation in preparing, planning and programming the city-specific developmental projects under a Public-Private-Partnership (PPP) financial model.

On the other hand, to address climate change, the Government of India adopted a *National Action Plan on Climate Change* (NAPCC) as well as a *National Mission for Green India* from 2009. These national schemes are complemented with missions like solar energy, enhanced the energy efficiency, sustainable habitats, water and sustaining the Himalayan ecosystem (Ministry of Environment and Forest, Government of India, 2010. Further, India adopted the *Paris Agreement* at the COP21 in Paris on 12 December 2015. In the agreement, all participatory countries committed to limit global temperature rise to well below 1.5 degrees Celsius. The Paris Agreement entered into force on 4 November 2016 in India.

India is the fourth largest emitter of greenhouse gases and is responsible for 5.3% of global emissions (GCP, 2018; WRI, 2015). The emissions intensity of India's GDP reduced by 12% between 2005 and 2010. In 2015, India committed to reducing the emissions intensity of its GDP by 20-25% from its 2005 levels by 2020 and by 33-35% by 2030. The role of the Paris agreement was essential to meet the UN *Sustainable Development Goals* (SDGs) of 2015 to provide affordable, scalable solutions to reduce emissions and build climate resilience.

In 2013, the Rockefeller Foundation selected four Indian cities (Pune, Bhopal, Surat and Chennai) to identify physical, social and economic challenges for becoming Resilient, of which climate resilience is a component. The cities were to be provided with resources such as climate strategies and solutions necessary to develop a roadmap to resilience. Almost 1800 concrete actions and initiatives have been identified since to create a resilient city including the climate adaptation and mitigation actions. Popular literature says it is still possible, using a wide array of technological

measures and changes in behaviour, through institutional and technological intervention to be on a *low carbon growth path* (IPCC, 2019). The participation of the public in the formulating, adopting and managing climate strategy cannot be undermined.

Given the increased rate of urbanisation and the looming threat of climate change, there is a naturally strong linkage between the strategies of *Smart City Mission* and *Climate Resiliency* of cities in any country. A careful analysis of the concepts of the *Smart City Mission* in India shows that they are essentially attached to three criteria, namely, advanced information technology and systems (March, 2016), efficacy of different production and consumption sectors with significant emphasis on energy efficiency (Khansari, 2014; Debnath *et al.*, 2014;), and effective societal governance and citizen's participation (Vanolo, 2016; Joffe and Smith, 2016; Baldascino and Mosca, 2016). Although the extent of overlap of the smart city concept and climate resilience in existing initiatives at the implementation stage is minimal, there is still some hope. Evidence shows there are existing policies aimed at addressing urban environmental problems, such as housing in risk-prone areas that can be adapted to promote climate change resilience at little or no cost (Hardoy *et al.*, 2009; Prasad *et al.*, 2008). Essentially, climate-resilient smart strategy implies a simultaneous improvement in productivity, the adaptive capacity of the economy with less greenhouse gas emission. The attention to climate resiliency is already embedded in the actions and strategies of Smart city Mission. But there is a need for simultaneous inclusion of actions together with effectual measures addressing the challenges.

In this backdrop, the aim of this paper is to evaluate the potential of Indian smart cities to be climate resilient by identifying the existing challenges to be climate resilient as perceived by the stakeholders in the cities. The specific research question, therefore, is what are the challenges perceived by the stakeholders of India’s Smart Cities to be Climate Resilient, and this question has

been addressed by stakeholders in the smart city of Pune, India. Further, the specific implications of the challenges identified with respect to climate resilience for a smart city are studied in the context of urban transportation in Pune.

This study has been organised into five sections. Section 2 briefly discusses the methodology deployed to study the stakeholders' opinion on the resiliency of smart city discourse. It also includes the description of the area of study, the structure of the questionnaire, data collection and analytical approach. Section 3 describes the findings of the study. This section identifies the perception of the stakeholders about the challenges and their corresponding basis for the city of Pune. The climate resilient actions under the smart city mission particularly for the transportation sector, strategies and their corresponding challenges have been discussed next in section 4. The last section summarizes and concludes.

2. Stakeholders' opinion on the climate resiliency of Smart city: tools and methods

This is empirical research based on a case study from Pune. The study has captured the perception about the challenges to be climate resilient for a smart city like Pune of different stakeholders like a consultant of the projects, end-users etc. A detailed theoretical and empirical background of the study is depicted in the following sections.

2.1. Theoretical background: *Participatory Theory* for urban development

The *sustainable development goal* (Goal 11) target that 'by 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, through an effective enhancement in inclusive and sustainable urbanization and creating capacity for integrated and sustainable participatory urban planning and management specially in developing countries. This is in line with the Sendai Framework for

Disaster Risk Reduction 2015-2030 which prescribes holistic disaster risk management for all. The basis of this study is the *Participatory Approach* for urban development, in line with SDG 11. The voluminous literature on this suggests that the approach has evolved from collecting accurate and detailed data from the field to developing people-centric urban development strategies ensuring good governance (Certoma *et al.*, 2015**)**. The literature argues that this approach could ensure equitable access and control over resources and decision-making process by the local people on one hand while being used by policymakers to justify their development strategies on the other (Jillella *et al.*, 2015). Integration of local people into development strategy includes enabling local people to identify the constraints and develop an action plan accordingly for efficient resource allocation. Within these participatory action methodologies, the information is owned by the community and becomes a means through which local people can identify their needs and priorities, analyse what resources are available locally and externally and consider how various local groups and in some instances, the entire community, might access and manage those resources (Malekpour *et al.*, 2015, Israel *et al.*, 2019). One of the tools used for active community participation in urban areas is the collective planning of new settlement designs to meet the needs of residents. Once a plan of the existing settlement has been made, residents' can discuss how to change and or improve services. Though this kind of community-based development is not a simple process and reservations have been expressed with respect to the tools, techniques and nature of participation (Dodman and Mitlin, 2013; Eversole, 2010; Opare, 2007), this kind of approach could strengthen knowledge and capacity of the community, their ability to negotiate with policymakers, their capability to devise and initiate strategies and and their ability to respond and resolve constraints and conflicts within the community (Potts , 2010; Platteau and Abraham, 2002; Conning and Kevane , 2002; Fredericksen and London, 2000).

2.2. Area of study- Pune city

The city is located in the state of Maharashtra, approximately 200 kilometres east of Mumbai. Pune is the 8th largest metropolitan city of India and one of the most fast growing cities in India. From being known as a military cantonment, Pune has evolved into a dynamic city of academic, cultural and economic importance, and to a business centre with the burgeoning software industry. With the rapid urbanization, the city is facing lots of problems of social as well as physical infrastructure. The city of Pune has a population of 2.8 million of which close to one million live in slum settlements distributed throughout the city (Bapat and Agarwal, 2003). The average decadal growth rate of population is 36.54% from 1951 to 2011. By 2030 Pune is expected to grow into a megacity with approximately 10 million urban dwellers (Sankhe *et al.*, 2010). The rapid growth of the city is mainly attributed to the industrialization of Pune Municipality Corporation (PMC) after 1960 and the expansion of the information technology (IT) industry in the last decade. The rapid urbanization of Pune also resulted from growth in the educational hub and the growth of subsidiary manufacturing sectors. This has contributed to massive migration from rural areas to the city (Bhailume, 2012). The demographic facts are summarised in table 1.

Table 1. Demographic feature of Pune City

Area (in Square km)	729 sq km
Population	3402458
Population growth rate (compared to 2001 level)	30.37%
Population density (per Square kilometre)	10,000
Sex Ratio (females per 1000 males)	915
Literacy rate	86.15
Infant Mortality rate (per 1000)	24
Per capita Income	1.27 lakh per year
Work Participation Ratio	34.08%

Source: Census, 2011; Thorton 2012-13; PMC, 2017

Pune ranks 145 for Quality of Living Ranking (2015) among 440 cities in the world. The city ranked higher than Mumbai (ranked 152) and New Delhi (ranked 154) (PTI, 2015) for quality of living. To meet the growing demands of its urban dwellers and to manage the appropriate physical infrastructure of the city, Pune city administrators are implementing several measures to redesign the urban agglomeration. Based on the need for urban development and the initiatives to solve the urban sustainability problems, in 2015, the Indian government chose Pune to be part of the "100 Smart Cities" initiative. According to this initiative, the Indian central government will invest INR 100 crore ($15.3 million) per year per city for 5 years to help cities develop smart infrastructures, such as electricity, housing, parking, sanitation, and transportation (TNN, 2015). Despite developmental strategies, Pune is under constant threat with respect to water security, flooding from excessive rainfall, poor air quality, earthquake, lack of affordable housing and disease outbreak due to climate change.

In 2017, the Rockefeller Foundation chose Pune as part of its "100 Resilient Cities" (100RC) initiative to build resilience along with three other cities in India — Surat, Chennai and Jaipur. The 100RC programme lists urbanisation, lack of adequate planning, globalisation and climate change as the common problems these cities face. Cities in Asia-Pacific are rushing to meet minimum standards in their infrastructure projects. In doing so, they aren't considering resilience, which leaves them undefended against shocks and stresses in the future and their newest, poorest citizens pay a disproportionately high price,' notes the 100RC research.

The PMC is undertaking a number of initiatives for sustainable development of the city, ranging from waste management to solar micro-grids and slum settlement to planting trees (PMC, 2018). The PMC has initiated an IT-empowered census for trees, which keeps track of the number of trees in the city. PMC initiated the reallocation of 3800 households from 29 slum areas of the city in

cooperation with the NGOs (Non-Governmental Organisation). Further, the PMC has adopted a number of adaptive measures to improve waste management. In 2014, Pune aimed to become a zero landfill city by using biogas plants to decompose organic waste and convert it into biogas within one year, but the work is still in progress. These plants are processing 5 tons of waste in a day and generate 375 units of electricity, which is enough for 250 streetlights ('Lessons from two cities', 2014).

2.3. Methodology

The present study is based on the secondary and primary data collected on the city Pune. The results of the data analysis are explained in three stages- first the identification of challenges, secondly, the ranking of the challenges and at last the experience of the challenges with a special focus on a specific sector such as transportation sector.

The experts were from different sectors either directly working or indirectly related to the smart city and climate resilient actions such as academics, research, policymakers, NGOs, consultants, contractors, advisors etc. PMC and Pune Smart City Development Corporation Limited (PSCDCL) are the two key players in the city for forming the climate-smart resilience actions. The stakeholders and different key personnel from these two institutions were interviewed thoroughly. Based on the pre-study qualitative interaction with these experts and other stakeholders the study formed the components and subcomponents of the challenges to be climate resilient for the smart city in India (discussed in section 3.1). A questionnaire has been developed based on findings of a qualitative pre-study, where experts and laypersons were interviewed about the challenges for a smart city to be climate resilient. The details of the questionnaire are elaborated in the following section. The finding from the data collected through the structured questionnaire mainly to evaluate the ranking of the challenges and the priority challenges. In addition to that, the identified

challenges are elaborated with the qualitative and quantitative secondary data collected from the PMC and PSCDL in the context of the transportation sector of the Pune city (in section 4). The choice of the transportation sector arises from the findings of the responses from the questionnaires, as discussed in section 3.

2.3.1 Questionnaire

For this study, a questionnaire has been developed based on findings of a qualitative pre-study (in 2018), where experts and laypersons were interviewed about the challenges for a smart city to be climate resilient. Before running the survey, the questionnaire was checked for comprehensibility, length of interview and wording. It was an online survey using a renowned survey portal. The questionnaire took 10-12 minutes to complete on an average with 22 questions. The questionnaire could be made available on request to the reader.

At the beginning of the questionnaire, respondents' belongingness to the city (of Pune including Pimpri-Chinchwad) has been validated, which helps in generating an informed response needed for the objective of the case study. Pune is the main old city and the Pimpri-Chinchwad are extensions of the city. The next part of the questionnaire deals with the role of the respondent in the climate smart city action plan. Respondents have identified their most suitable role in the action plan as per their percipience. Specific roles that they could choose are from- policy maker, consultant, contractor, researchers, a responsible consumer, concerned citizen or facilitator (Appendix 1). The next set of questions are on the level of knowledge about the *Smart City Mission* of Government of India and the *Climate Resilient Cities* in India. The last question in this section captures the perception of the respondents about the importance of incorporating climate-friendly actions into the mission.

The next part of the questionnaire assesse demographic characteristics (age, gender, education, family income status). The fourth part of the questionnaire deals with the perception of the challenges. This part has three subdivision. The first part of the challenges is on social & cultural challenges. Social & cultural challenges include cultural-behavioural barrier towards a new policy, action, and strategy, information fatigue for an elderly person or less-educated individuals, response fatigue from the same, knowledge deficit, consumption convenience over consumption savings, lack of autonomy in decision making, socio-political interference, Veblen effect and the Bandwagon effect. The second part of the section is on the perception of the economic challenges. Economic challenges include inappropriate pricing of the services, lack of indigenous associated industries, an inappropriate business model for private entities, investment & price gap, incentives, transaction cost, tax evasion and uneven distribution of funding. The next part is on institutional and technical challenges which includes inter-operability, resource-skilled persons, spillover effect, efficiency-rebound effect, cost of upgrading technologies, technical gap between expectations and current solutions, conflicting interest of different stakeholders, lack of good governance, political interference, complexity in policy and action plans, conflict between security and interoperability, lack of demand-side management initiatives, lack of investment opportunities and ‘non-essential luxurious approaches'. The last part of the questionnaire enquires about the respondents' understanding in identifying the most critical sector amongst households, industry, transport, and manufacturing, which operates in a climate resilient manner. The questionnaire also includes an open comment box, in case the respondent would like to add anything else on the issue. The findings related to the perceptions of these stakeholders from administering the questionnaire are discussed in section 3 and the ground level challenges faced by the city of Pune for smart

resilient climate actions in the transportation sector are discussed in section 4. Before that, the sample characteristics are summarised in the following section.

2.4. Data collection and sample characteristics

A sample survey was conducted in the city Pune in the first quarter of the year 2019, to capture the potential challenges to be climate resilient for a median Indian city. Almost 100 respondents voluntarily participated in the survey. Survey data was collected through an online portal from different stakeholders of the city development projects who are working with or beneficiary of the development projects with a snowball sampling process. To avoid sampling biases, a rigorous data cleaning process has been done. All responses were filtered according to the completeness, speeding (all responses that were faster than 33.33% of the median time were excluded) and consistent responses. All respondents, who gave single inconsistent answers on predefined item pairs, which had the same content in a different node (positive or negative) were excluded. From the total data set (N=107), 50% of the respondents were removed due to bad data quality. The validated 50 data points are used for further study. The demographic characteristics of the validated sample are shown in the following table.

Table 2. Demographic characteristics of the sample

Demographic Characteristics		Percentage	Demographic Characteristics		Percentage
Area of Living	Pune-Pimpri-Chinchwad city area	100%	Educational Level	Below Graduation	0%
Gender	Female	40%		Bachelors/ Under Graduation	20%
	Male	60%		Masters/ Post Graduation	60%
	Others	0%		Above Post Graduation	20%
Age	below 18 Years	0%	Monthly Family Expenditure	Less than 5000 INR	0%
	18-25 Years	4%		5001-10,000 INR	4%
	26-32 Years	44%		10,001- 20,000 INR	17%
	33-45 Years	28%		20,001- 30,000 INR	17%
	46-59 Years	24%		30,001-40,000 INR	21%
	60 Years and above	0%		40,001 INR and above	42%

Data Source: Sample data

All sample respondents are from the city area of Pune, Pimpri and Chinchwad. 60% of the respondents are male and 40 % are female. All the respondents are of the working class aged between 18-59 years. 60% of these working-class respondents are well educated with at least a post-graduation degree. 20% are highly educated and 20% are graduates. This well-educated working class is the strength of the study. Respondents are also from well to do families with average monthly expenditure more than 40000 INR. More than 50% of the respondents are from the urban middle class from 10000 to 40000 INR.

All perception items were evaluated on a 5 point Likert scale. Likert scales are commonly used to measure perception, providing a range of responses to a given question or statement. This scale was based on five possible options with 5 = 'strongly agree' and at the other extreme 1 = 'strongly disagree'. Likert scales fall within the ordinal level of measurement. Cohen *et al.,2006* contended that it is illegitimate to infer that the intensity of feeling between strongly disagree and disagree is equivalent to the intensity of feeling between other consecutive categories on the Likert scale. The legitimacy of assuming an interval scale for Likert type categories is an important issue because the appropriate descriptive and inferential statistics differ for ordinal and interval variables and if the wrong statistical technique is used, the researcher increases the chance of coming to a biased conclusion about the significance of the research. Methodological and statistical texts are clear that for ordinal data one should employ the geometric mean, median or mode as the measure of central tendency because the arithmetical manipulations required to calculate the mean (and standard deviation) are inappropriate for ordinal data, where the numbers generally represent verbal statements. In addition, ordinal data may be described using frequencies or percentages of response in each category.

3. The Results- Challenges identified by the stakeholders

Scholars have long argued that to create climate resiliency in cities in developing countries like in India is complex with the dual challenges of managing resources and creating infrastructure (Shaw *et al*., 2009). Rapid urbanization creates significant pressure on the environment and basic required social services (Cohen, 2006). Although the Indian city authorities are investing significant resources and developing strategies for addressing the key challenges in the city, the city is still facing several challenges to convert the strategies into actions. It is crucial to diagnose the critical challenges facing the city that require urgent attention on the part of urban planners. At the first stage, the identification of challenges from the pre-study qualitative stakeholders' interaction is discussed. Then the relative ranking of the different types of challenges and their relative importance are explained through the primary sample survey data with a structured questionnaire in the following section.

3.1.Category of challenges

Based on the qualitative pre-study conducted in 2018 in Pune, primarily three types of challenges, were identified, namely, economic, social & cultural, and institutional & technical challenges.

Scholars from different field identified that the most important factor of challenges is economic factors (Keivani, 2010; Kearns and Paddison, 2000). For the individual consumer, the prime concern is that the initial purchasing cost, as well as the operating costs (including market price, installation cost and maintenance cost) of new services or technologies, are high enough (for instance, the resilient smart LED lamps are 10 times more expensive as compared to the common incandescent bulb). The existing incentives are not enough to motivate the usage of new resilient services like solar roof-top energy sources for individual households. Even if a proper incentive is available, the consumer prefers consumption convenience over consumption savings because of

their myopic behaviours about consumption. Households are also not really ready to pay taxes for the resilient services provided by the authority. The market economy is not also appropriate for individual firms. The market returns are uncertain and not enough to cover the initial investment required for climate resilient strategies at least for the short run. Firms are interested in developing economically feasible solutions even if it does not completely conform to the action plans, but there is an uneven distribution of money between research and implementation. Another set of challenges are coming from the macro factors like associated industries are not sufficient, inconsistent and immobile resources, lack of investment availability, inappropriate business models for the industry. As the services are new in nature, the business model under the PPP model is not well structured. There is a trade-off between investment opportunity for infrastructure development and investment for resilient actions as the return from infrastructure development could be realized in the short run; whereas the return and social benefits from the resilience actions could be only realized in future.

The most complex set of challenges arise from end-users socio-cultural attributes. Cultural & behavioural barriers to adopt new practices are significant in society. Awareness and adequate information about the smart resilient action plans and strategies are limited. There is enough response fatigue as well, especially from elderly stakeholders. The role of NGO in creating social aspect and social awareness is important for creating climate resiliency. The role of NGOs creating awareness and supporting the implementation activities are limited to selective areas (mostly in slum areas). The fact is that there is knowledge deficiency in the middle to high-income households as well. The middle to high-income households is important as they are the bulk consumer compared to the low and slum-households. Therefore, the existing level of knowledge dissemination is inappropriate. Individual are also myopic about the development program and

financial return from the action plans as they believe that the action plans are not practically implemented by the authority. Most of the end-users feel that the current strategies are 'non-essential, luxurious' smart approach. Most of the individual make their consumption decision based on either bandwagon effect or community decision. Political interference in the program implementation is highly biased and only active during the election cycle. Moreover, the plans and/ or strategies are not compatible with the changing modern lifestyle of the city.

Another important source of challenges is the availability of improved technology and skilled resource persons to maintain improved technology at a lower cost. On the other side, the availability of improved technology will create a spill-over effect on the economy. The stakeholders identified that there is a gap between the required expected technologies for climatic solutions and currently available technologies. Individual aspects are the most critical challenges identified by the stakeholders. Apart from individual stakeholders, local governments have the most crucial role in addressing these challenges. The lack of power and authority often hinder local government from implementing and sustaining urban development. The structure of governance and institutional design limits the power given to the decision makers. For example, in the city, the municipality mayor is elected for a term of 15 months only, which is not enough time to design and implement significant plans for urban development and growth. Lack of knowledge and expertise to take a new responsibility and initiatives and accommodating new needs create another stage of a hindrance. The conflicting interest between different stakeholders and decision makers from the governing body is another source of challenges. There is also a need for good governance and zero corruption environment for multi-layered complex strategies and actions. Terms and conditions for strategies, programs and action plans is complex to implement, otherwise, naturally, the implementation processes become slow. Investment conditions are not currently easy to

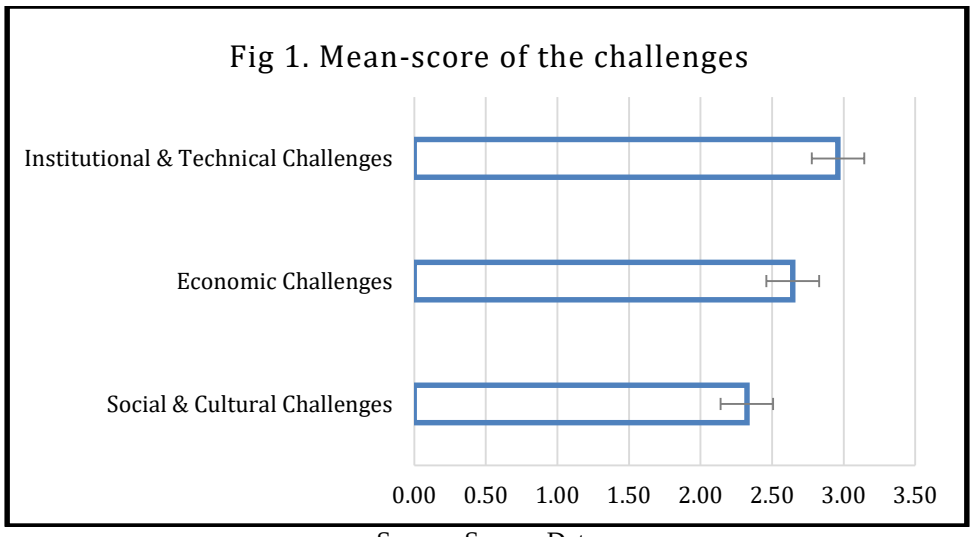
comprehend. The more crucial issue is the safety and security of private data. The conflict between security and interoperability of information may be controlled by the government with more accuracy. The local governing body is currently not generating appropriate awareness and demand management programs to create a proper market economy. We now discuss the findings from our primary study in the next section.

3.2.Ranking of Challenges

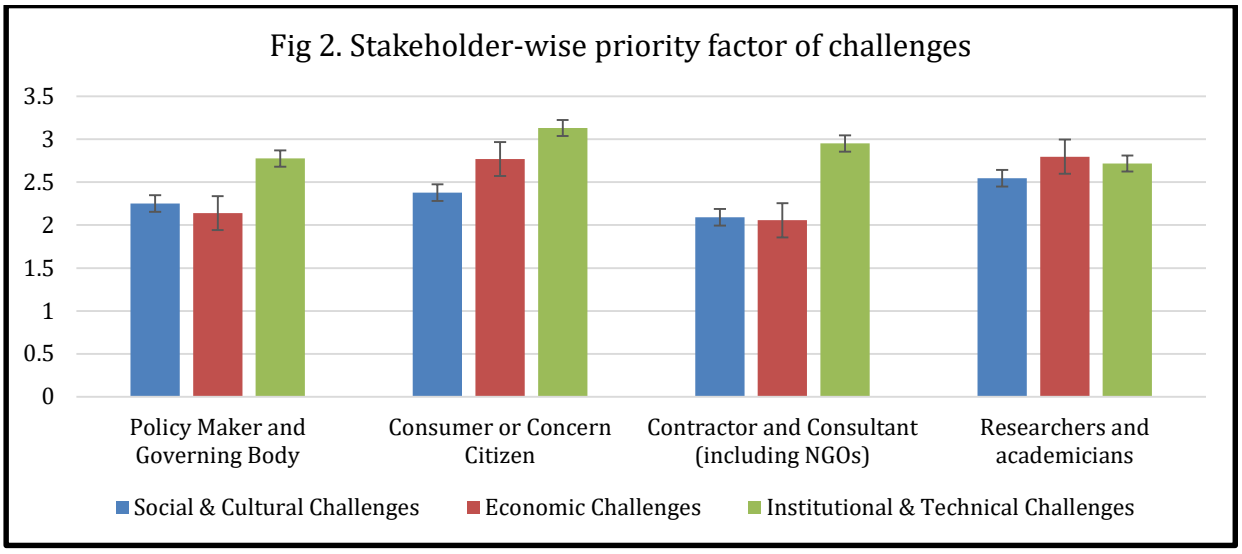
In the sample data, the representative stakeholder of the city identified that institutional challenges are the topmost hindrance of the system to be climate resilient for the city followed by the economic challenges (Fig 1). Social & cultural challenges are the least important compared to the above-mentioned category.

The analysis shows that throughout the list of challenges the modal response is in favour of the statements that the challenges are significantly affecting the smart cities to be climate resilient. Although the general consensus is the same that the different stakeholders value the challenges differently (Fig 2). The researchers and academicians, working on urban development perceived that economic challenges are the most important component among the challenges. On the other hand, policymakers and those on the governing bodies of urban development institutions perceived that economic challenges are the least important factor. Contractors and consultants of development projects also believed that economic challenges are the least important, and institutional and technical challenges are the most important component of challenges. Within each of these broad components, there are subcomponents that are also ranked relatively (Appendix 2). The first three important components of institutional & technical challenges are coming from multi-level governance, lack of demand-side management schemes and uncomprehensive plans and strategies. Similarly, the relative ranking of the sub-components for other types of challenges

is provided in the appendix 2 as well. However, this relative importance between different challenges are indicative only, as the number of respondents are small.



Source: Survey Data

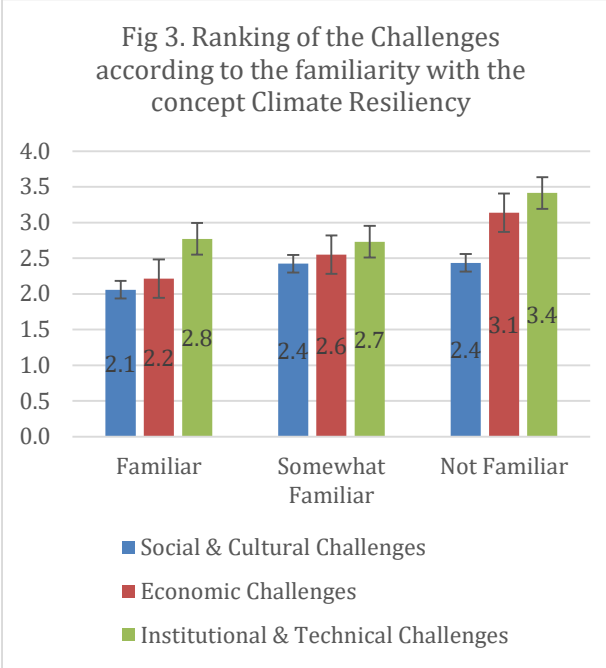


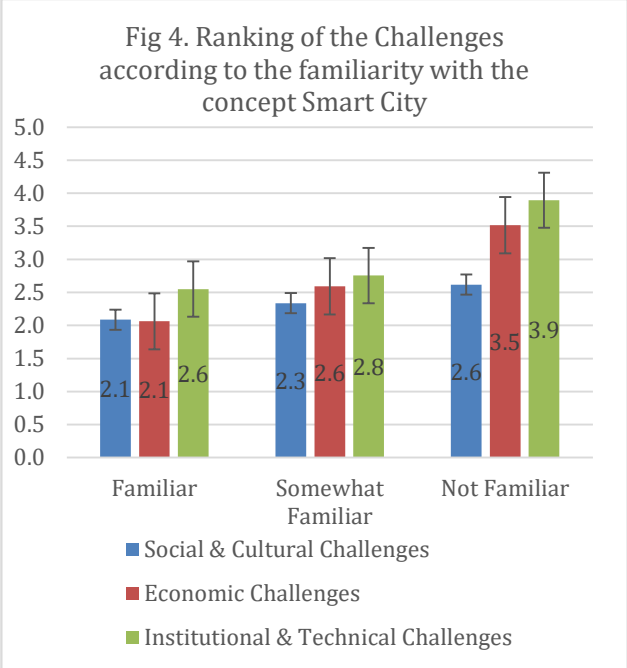
Source: Survey Data

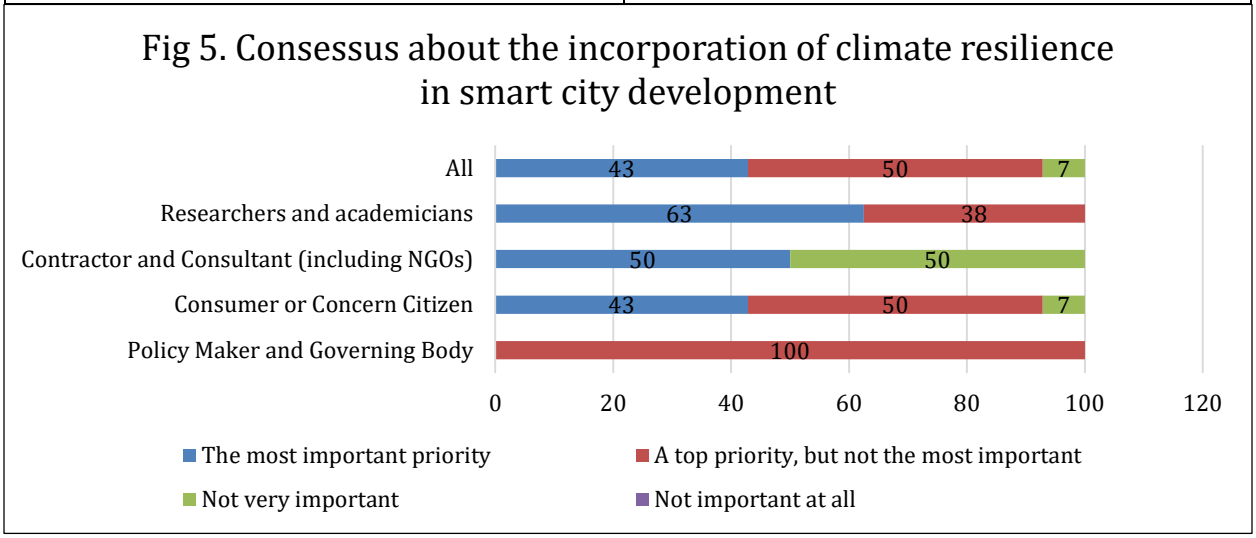
In addition, the study attempted to check whether the awareness about climate resiliency and smart cities affects people's perception about the challenges facing Pune. It appears that awareness did not affect people's perception of challenges. The ranking of the components of the challenges is identical for those who are familiar with the concepts, somewhat familiar with the concept and not familiar with the concept (Fig 3 & 4).

In general, 93% of the respondents perceived that climate resiliency is the top priority for urban development (Fig 5). 100% of the policy maker and government officials believe that the climate resiliency is the top priority but not the most important as they identified that the poverty and access to basic services like health, education are the most important sector to intervene in any Indian cities. 50% of the contractor and consultant, on the other hand, believe that climate resiliency is not an important sector to intervene. This is because primarily they don't readily realize the monetary benefits from the resiliency actions and secondly for them, infrastructure development is the most tangible and profitable venture. All the researchers and academicians working on urban development issues believe that resilient climate actions are crucial for urban development. 93% of consumers are in favour of resilient actions as they are the direct beneficiary of the actions.

The relative importance of the different types of challenges is discussed in this section. However, these are indicative only and therefore there is a need to study how these challenges interplay in the reality from the secondary source of information from PMC and PSCDCL. The study explores the function of the challenges for climate resilient actions in the smart city Pune in the next section, with a special focus on transportation sector as the transportation sector is identified as the most critical sector (appendix 3).







Source: Survey Data

4. Experience of challenges in smart-resilient action: Transportation sector, Pune

The respondents (45% of the respondent) from the primary sample survey identified that the transportation sector as the most critical and crucial sector for climate resiliency (Appendix 3). It is critical because it accounts for significant environmental and climatic hazards in the city. It is crucial to intervene in this sector because it directly hits the citizens and the solution of transport

related issues are complex enough. In 2009–2010, due to the increase in the number of vehicles, air pollution levels determined by measuring Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM), in Pune were higher than national standards. The rapid urbanisation has led to increased vehicular traffic, increased usage of diesel generators, increased construction activities and increased road dust, all of which contribute to transport-related air pollution in Pune. In 2013, Pune's carbon footprint was approximately 4.7 million tons (DNA, 2013), with the transportation sector being a major contributor. In the Pune city, residents rely heavily on a limited transport network, with a few choices of route or safe and affordable modes. Some areas of the city are still lack of any public transport.

Inclusive multi-modal transport networks allow safe and affordable travel between all neighbourhoods and key facilities across the city. Multi-modal systems incorporate redundancy and flexibility by providing alternative options in the event of failure or surges in demand. Robust and redundant ICT services could enhance safe communication and access to information systems, including the coordination of emergency services. Specific indicators those underpin this goal include the promotion of non-motorised transport system and public transport with E-buses and improved traffic control systems. Reliable communications and mobility create daily connectivity between places, people and services. This fosters a positive environment for every day working and living, builds social cohesion, and also supports rapid mass evacuation and widespread communication during emergencies. A combination of transport links and the provision of ICT are fundamental to connectivity in contemporary cities. Transport links enable physical mobility and should be characterised by a wide coverage of the city, as well as good service quality and affordability. Good infrastructure capacity, safety and efficiency are essential for the effective

operation of transport networks. There are indirect economic positive externalities also, such as facilitating trade.

The PMC is undertaking a number of initiatives for sustainable development of the city, including a multi-modal transport system which is smart as well as resilient in nature for the city. The smart city mission identified diverse and affordable multi-modal transport systems action plans including road widening, procuring 100 electric buses, redesigning of streets, smart parking, retrofitting footpaths, introducing app based bicycles and e-rickshaw, developing non-motorised street, expanding BRT (Bus Rapid Transit) systems and creating total smart parking and traffic modelling systems for the urban transport system. The improved communication technology will also create a support system for an adaptive traffic control system, bus system items, command control centre and intelligent road management. The city Pune initiated bi-cycle use for last-mile travel by procuring more than 4000 bicycles. The preliminary descriptive responses of the stakeholders communicated that the bicycles are in use but the uptake rate is very low due to behavioural issues. The practice of using the environmental friendly bicycle instead of the auto rickshaw for last mile travel is still not as popular. Only the youth are using these services because they are familiar with its applications.

Introducing electric buses for public transport is still in the implementation stage due to technical challenges. The lack of charging stations for electric buses is the main technical issue for this initiative. Apart from that the skilled technician for operating and maintaining the electric buses are scarce in the city. The expansion of the BRT network is also in the pen & paper stage as it needs a large amount of investment, and currently, the investment priority is with the development of the metro network through-out the city. So the investment priority shifted from BRT system to

the Metro network. Also, the necessity for an expanded BRT system is now weak with a proper metro network.

In Pune, for multi-modal transport, there already exists CNG buses and a BRT system; a metro network is in progress, and yet the city is procuring E-buses. The inclusion of the new transport mode may cause disruption in the transportation system as well as in the administrative process. The concern is the limited resources including corpus amount, skilled human resources and technologies which are to be used in priority areas to meet the needs of citizens. Most of the smart resilient action plans are just replications of successful projects in large cities like Delhi, Bangalore, Ahmedabad etc. which may not be appropriate for small and/or developing cities.

5. Summary and Conclusion

The ‘Smart city’ programs are conceptualised on the basis of sustainable development, which in turn encompasses climate resiliency. Thus, both the climate resilient city and smart city are inter-connected urban development strategies. The opportunity for transformational change under these urban development strategies is high. The action plans of the mission include some of the embedded climate resilient actions. However, lack of synergy between the practice, ground level realities, research and action plans are undermining some of the embedded resilient actions in the smart city.

The present study is based on a case study from a city named Pune in Maharashtra, India, which is identified as a climate resilient and smart city. Based on the participation theory of urban development the stakeholders' perception about the challenges has been evaluated. The result shows there are broadly three types of challenges (a) social & cultural challenges (b) economic challenges and (c) institutional & technical challenges. The representative stakeholders of the city identified that institutional and technical challenges as the topmost hindrance of the system to be

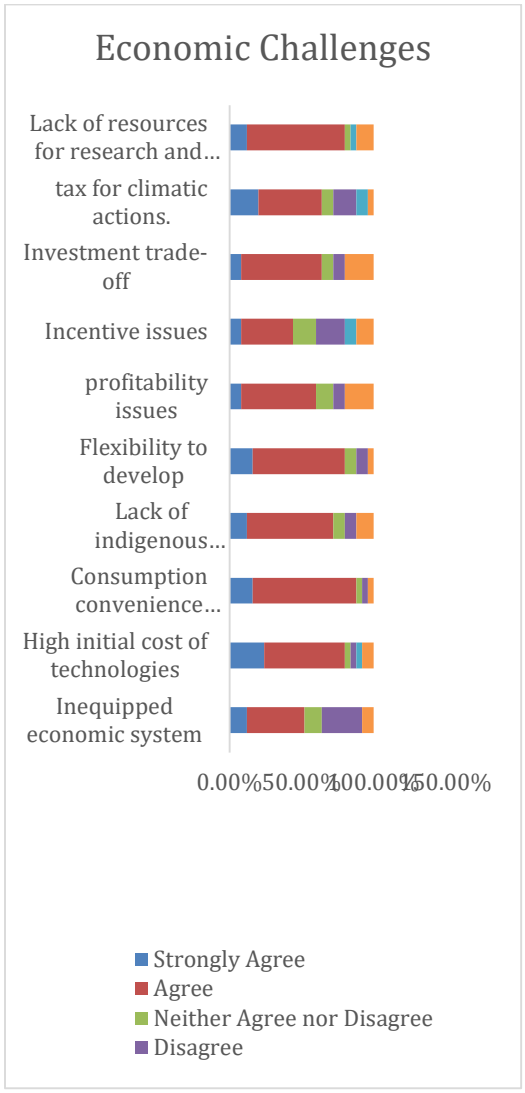
climate resilient for the city followed by the economic challenges. Accordingly, it is recommended that the government should strengthen key institutions and policy implementation through multi-level governance which will ensure the efficacy of action plans. The social and cultural challenges appear to be the least important set of challenges to be worried about. Developing an appropriate market economy for resilient action plans is the most crucial economic challenge, as derived from this study. Among all other identified challenges, few worth mentioning are the transaction cost, including installation costs, which is much higher for an average end-user. For end-users, the economic incentives to alter their non-resilient consumption pattern are not appropriately designed in most of the cases. For the manufacturing and industrial sector, the market returns are not enough to cover the investments at least for the short-run and for the long run the returns are uncertain. The dynamic tariff for resilient services should be designed such that competitive returns from the new initiatives are accounted for.

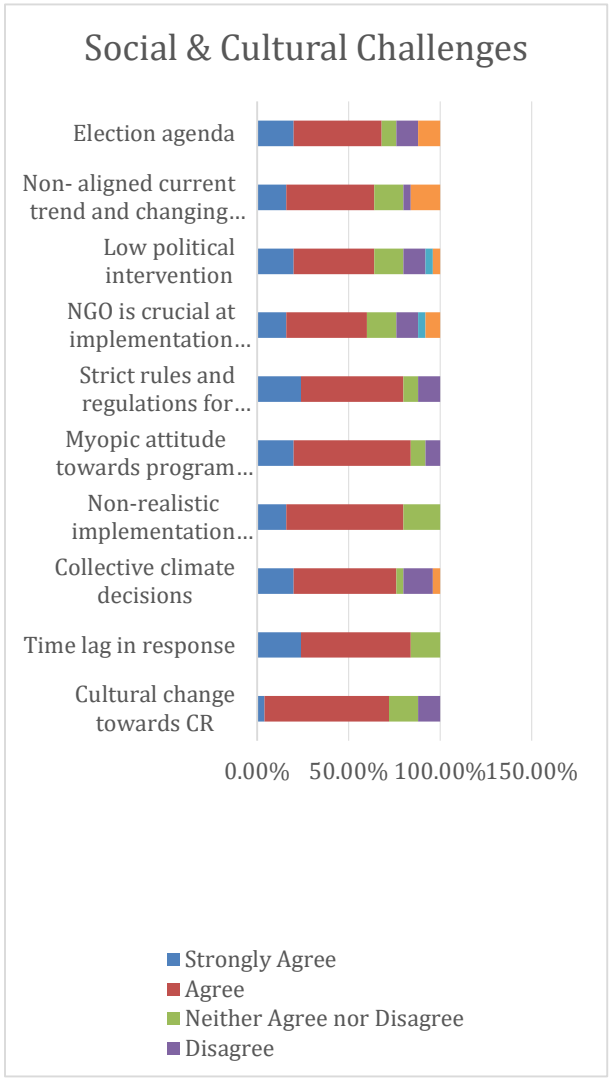
For a holistic policy like the smart city mission, experts from different fields realized that a comprehensive understanding of the mission and the resilient action plan across all stakeholders is an urgent need to arrive at a common framework for the cities. Lack of identification of the needs, proper dissemination of information and inappropriate understanding may adversely affect the fundamental objective of the mission to create resiliency in the city. In short, Indian smart cities could be climate resilient through a systematic review of the mission with revisions of the embedded action plans for climate resiliency. The identification of the challenges and their relative importance will help the planner revise and/or recreate the mission of being sustainable and to achieve a low carbon growth path. Further, this should be looked like an opportunity to improve the design and operations of resilient actions and/ or strategies and integrate them into the smart city mission within a broad urban development policy context.

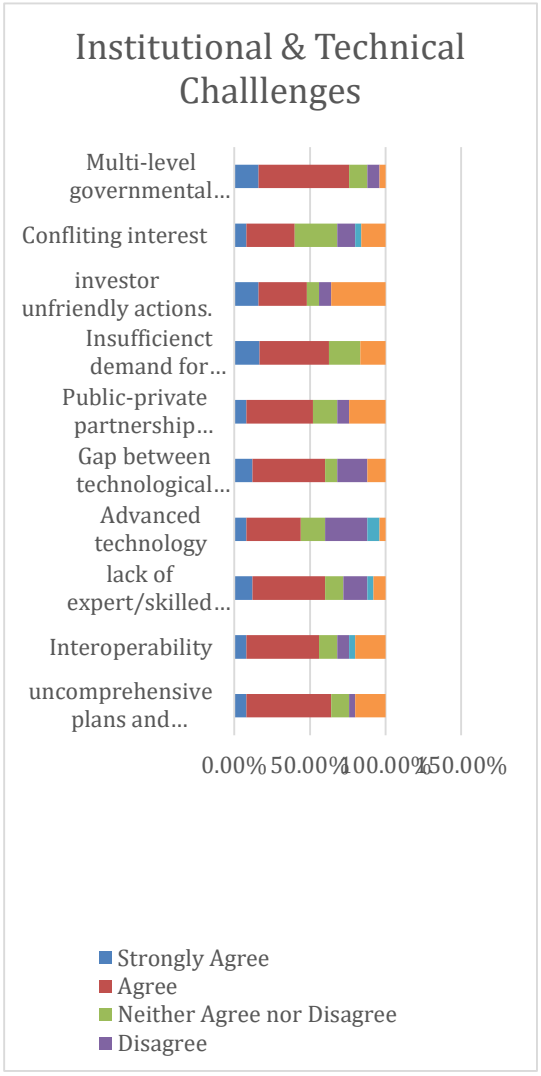
Appendix 1: Stakeholders distribution in the survey

Stakeholder Category	**Stake in Climate Resiliency Process**	**Stake in Smart City Process**	**Representation (in %)**
Policy Maker and Governing Body	Policymaking, Rules and regulation making, coordinating the conflicting stakeholders like private industrial units and poor civilians	Policymaking, Rules and regulation making, coordinating the conflicting stakeholders like private industrial units and poor civilians	14
Consumer or Concern Citizen	Using the action plans, realising the pros & cons of the action plans,	Beneficiary	52
Contractor and Consultant (including NGOs)	Implementing or facilitating the action plan	Implementing or facilitating the action plan	7
Researchers and academicians	Academic modelling and policy advisory	Academic modelling and policy advisory	28

Appendix 2. Components of the Challenges

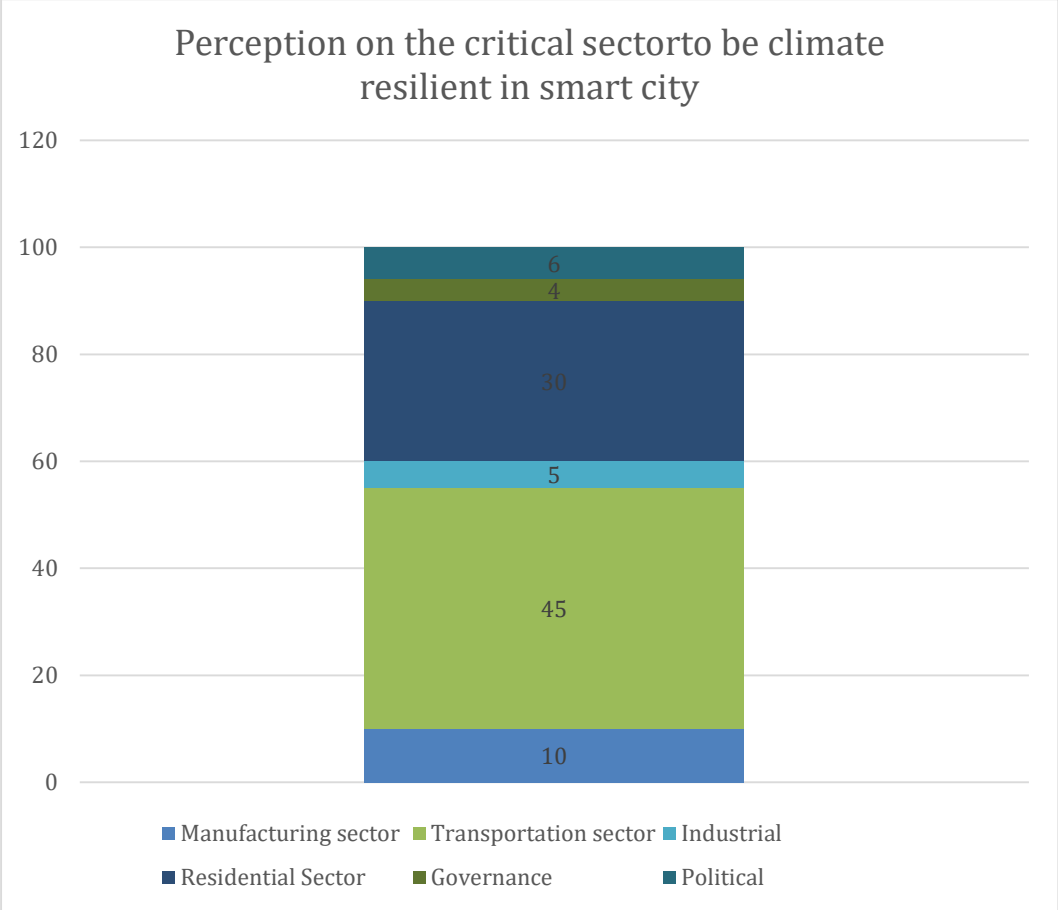






Source: Survey Data

Appendix 3.


Perception on the critical sectorto be climate resilient in smart city
120
100
80
60
40
20
0
6
4
30
5
45
10
Manufacturing sector
Transportation sector
Industrial
Residential Sector
Governance
Political

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