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A March towards Smart Livable City: Understanding Spatial Disparity of Smart Public Infrastructure across Thane Municipal Corporation

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ABSTRACT: The emergence of the Smart Livable City concept which believes in the notion of inclusiveness and convergence are presently questionable because of the disparity in the level of developmental processes across the cities. Spatial disparity, which is a challenging issue for all planners, policymakers, researchers and academicians, is the core of this study. In this study, the spatial variability analysis through hot-spot analysis and location quotient is done to identify the existing gaps among the different wards of Thane Municipal Corporation. Furthermore, the ward prioritization map based on infrastructural gaps is done for understanding the spatial disparity in relation to the availability and concentration of smart amenities. The study reveals a lead-lag relationship between the different wards in terms of the spatial distribution of facilities. The western wards are far developed while the eastern wards lag far behind the average level of development. Hence, it is observed that the city is unwilling to keep up the notion of inclusiveness and convergence. This might lead to a widening of the existing gap conspicuously between high and low-income groups, and digitally literate and illiterate population within and among the wards. So, the result emphasized that the present planning efforts could not provide an equitable development of the city and a more concrete plan of development should be embarked on.

Keywords: Spatial disparity, Smart public infrastructures, Spatial concentration, Location quotient, Inclusiveness.

I. INTRODUCTION

The quality of life of the people of a particular area is perceived by its socio-economic infrastructures and urban facilities they provide [1-3]. And the disparity arises from the inequitable distribution and poor allocation of the social infrastructures which accelerates the social, economic and cultural problems of the region or area, by widening the existing gaps and hampering the regional development [4, 5]. In this digital age, when people are becoming more and more techno-centric [6], the advent of smart city concept has grasped the city into its smart digital framework. The holistic view of the smart city represents the effective amalgamation of smart development outlooks, through digital management of urban systems - social, environment and resources, along with providing a digital urban infrastructural base for intelligent urban management and services [7, 8]. Digital technological infrastructures or more commonly known as smart infrastructures are providing greater and more efficient mobility and better access to opportunities for urban citizens [9]. Digital technology and new media basically act as an enabler in "creation of new human construct, concepts, social relations and qualities of being human." [10] Where technology continues transforming the way we relate to and engage with the spaces we inhabit. Smart applications are accelerating the demand for infrastructural updates which lead to an evolution of a smart nation [11]. Besides, the application of smart digital technologies will foster in solving prodigious challenges that the city faced, like increased pressure on services and rapid urbanization [12], and will also aid in the management of the urban infrastructure [13]. As rightly pointed out by Worden, Bollough & Haywood in 2003 [14],

"*Technologies with the ability to sense changes in their circumstances and execute measures to ensure their functionality under the new circumstances offer enormous benefits in performance, efficiency, operating costs and endurance.*"

In this postmodern society, governmental and non-governmental systems are becoming reliant upon the smart digital infrastructures. The administrative works(e-governance), transportation, environment and economic sectors (banking) are using the internet and smart infrastructures to provide modernized, better and more secured facilities to their customers and users [15, 16]. These smart infrastructures are accelerating the technical interconnectedness by reshaping the urban governance process. Smart infrastructure increases awareness among individuals regarding their usage of a particular resource and reduces the consumption at times of limited demand automatically. Consequently, it is helping in improving the city's environmental sustainability and quality of life [17,18]. And in a city, the spatial variation of these smart public infrastructures is important to study to acquire a proper insight into its approach towards smart living.

Previously a wide variety of studies are being carried out under the smart city realm focusing on the urban infrastructure [19-21], green infrastructure [22, 23], e-governance [24, 25] and digital banking role [26]. But neither of the studies focused on the spatial variation of the smart public infrastructures which influences the quality of life of the citizens residing in the urban areas.

Asit's variation and distribution also affect the overall development of the city. So, the study is important to understand the agglomeration of the digital infrastructure of a particular location which can influence its digital economy and also its position in the micro-level regional development and consequently in the meso-level development as well [27]. Also from the point of view of inclusiveness (one of the three main theories behind the smart livable city)that focuses on the sense of convergence between all the sections of the community- age, gender, religion and income [27,28], this study becomes important. In fact, the Government also focuses on the necessity of the inclusiveness of the city and to bring the disadvantaged section into the mainstream development process [29,30]. But in the rapid pace of development, the inclusive nature is left behind. The urban infrastructures are expanding at a slower rate in comparison to the urban areas and are seemed to be limited to city core or within a few urban pockets [31]. Therefore, it becomes noteworthy to analyze the spatial variation of the smart public infrastructure for a proper understanding of the availability of these infrastructures to the common mass in a city and in addition the development of the city into a digital city [32]. The study too will help in understanding the degree of inclusiveness within the city. For which Thane Municipal Corporation (TMC), one of the members of the smart city mission is chosen for this study.

So, the study will provide a thorough understanding of the spatial variation of distribution, concentration and availability of the smart physical infrastructure, especially those which are of public use, across different wards of Thane Municipal Corporation to shed light upon its notion of inclusiveness and its march towards smart livable city.

II. STUDY AREA

In September 2016, in the third round of smart cities, the government selected Thane as a member of the smart city mission. In reference to socio-economic characteristics, Thane being proximate to Mumbai City, its demographic profile highlights continuous growth in the population mainly attributing to industrial, commercial, administrative and strategic development. Thane is acting as an upcoming new economic avenue with higher population inflow and providing a better lifestyle. Its overall economic structure is versatile with key contributors being secondary and tertiary sectors. Thane with its tremendous growth in the real estate sector has witnessed a vertical growth as well as peripheral development in many areas viz. Kolshet Road, Pokhran Road, Majiwada Junctions, Godhbunder Road and others [33] with people mainly preferring open spaces for a better quality of life. In fact, the wards of Naupada, Ram Maruti Road, Jambhali Naka which were the main market and retailing places have lost their importance to the "mall culture" [34,35]. The key components for its urban development of the smart city are to improve urban quality of life, increasing employment opportunities thereby enhancing income for urban poor and disadvantaged section of people. The prime objectives adopted by Thane Municipal Corporation include: improvement (retrofitting/area-based development), city renewable (redevelopment), city extension (Greenfield development) and Pan City development [36]. With this view of Thane, as an emerging smart city, the analysis of the spatial variation of the smart physical infrastructures across its geographical extent become supreme importance for understanding its journey towards the smart living city.

And since the varied geographical unit of measurement can be selected like census tract, school district, municipality and watershed, which influences the analysis of the livability of a place [37], so in the present analysis, the ward level data of the TMC are used as a geographical unit of measurement of the spatial analysis.

III. MATERIALS AND METHODS

The spatial variability of smart public infrastructures in this study was assessed through maps and spatial statistics analysis. In the present study, emphasis is laid on the smart public infrastructures which form the basic requirement in the path of improving citizen's quality of life in the smart city realm. These infrastructures incorporate smart governance centers like e-sevakendras, smart banking facilities like ATM withdrawal and deposit machines, smart mobility facilities like smart cycling and smart bus stands, smart water facilities like water vending machines, solar power street lights and building projects.The analysis was applied against different types of data, which are acquired through survey and from secondary sources as well. To reach to the accomplished objectives, the methodology has been divided into three branches:

The base map is prepared, generated and geo-referenced in Arc GIS 10.2.2 software. And demographic attributes of Thane Municipal Corporation-population (total, male and female), sex ratio, literacy rate, total workers and non-workers were collected from Census of India 2011 [38] and District Census Handbook 2011 [39], which is then attached as a spatial attribute to the wards. These demographic attributes will help to get a deeper understanding of the existing relationship between the spatial variability, spatial concentration and disparity between the wards

The smart public infrastructures and e-service centers which are selected include ATM (deposit and withdrawal machines), E-sevakendras (e-aadhar card center, pan card center, e-passport sevakendra, Maha e-sevakendras), smart cycling stops and water vending machines. The locations of these facilities are recorded with the help of GIS and are then overlaid upon the base map to portray the spatial distribution of smart public infrastructure across the wards of TMC.

The spatial variations i.e. the distribution of the infrastructures are analyzed using hot-spot analysis (Getis-Ord statistics) to identify the spatial centers of development. Here the total available infrastructures in wards are used as an input. The hot-spot analysis provides an understanding of the spatial cluster and spatial centers of the infrastructures [40,-42]. The high value of Getis- Ord statistics [43] is the hot spot area while the cold spots are denoted by low value [44]. The mathematical expression (Equation 1, 2 and 3) of the Getis-Ord statistics is as follows:

$$\mathbf{Gi} = \frac{\left\{\sum_{j=1}^{n} \mathbf{wi,j}\mathbf{xj} - \bar{X}\sum_{j=1}^{n} \mathbf{wi,j}\right\}}{\mathbf{S}\sqrt{\frac{\left\{\left[\mathbf{n}\sum_{j=1}^{n} \mathbf{w^2i,j} - \left(\sum_{j=1}^{n} \mathbf{wi,j}\right)^2\right]\right\}}{\mathbf{n-1}}}} \quad (1)$$

Where xj is the attribute value for feature j, w i,j is the spatial weight between feature I and j, n is equal to the total number of features and:

$$\dot{X} = \frac{\sum_{j=1}^{n} xj}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x^2 j}{n} - (\dot{X})^2} \quad (3)$$

The Gi statistics is a z-score so no further calculations are required.

Location Quotient (LQ) is used to measure the extent to which the facilities in different wards are in balance or not [45]. It is a method of comparing the ward's percentage share of a particular smart public facility with the percentage share by its population to the total available facility percentage and population of the entire municipal area [46, 47] (Equation 4).

$$LQ = \frac{\frac{ni}{pi}}{\frac{Ni}{P}} \quad (4)$$

Where ni is the number of smart public infrastructural facilities "i" in a given ward, p is the population of the concerned ward, Ni is the number of smart public infrastructural facilities in thane Municipal Corporation and P is the total population of Thane Municipal Corporation.

If the LQ < 1, indicates deficiency of the facility

LQ = 1, indicates self-sufficiency of the ward and

LQ > 1 indicates the total availability of the particular infrastructural facility in the concerned ward exceeds that of the city total.

And to identify the gaps in the smart public urban infrastructures, weightage has been given as per the availability of the infrastructure in different wards [46,47]. Then for all the facilities aggregate weightage score is calculated for each ward by summing up all the weightage of each facility available, and finally, the map is prepared to identify the wards not covered by the facilities and probable reasons of such spatial distribution are done by analyzing the demographic structure of the municipal corporation. The following calculation is used to identify the gap (Equation 5):

Weightage of the facility in each ward = Total facility in each ward* (Aggregate no. of all facilities/ Total no. of each facility)

IV. RESULTS

A. Spatial variability

Understanding of the spatial variability in the distribution, availability and access to infrastructural facilities helps to provide an insight into the existing spatial disparity [48]. So, the inequalities existing among the spatial units can be explained [48-52]. The spatial variation of smart public infrastructures across Thane City provides an understanding of the step towards the development of the city as a smart living city. Wide variation is observed in the availability and distribution of the smart facilities across wards (Fig 1, 2). Total 210 facilities are available comprising 15 ATM deposit machines, 169 ATM withdrawal machines, 13 e-sevakendras and 13 smart cycling stands (there are in addition two water vending machines installed at Thane Railway Station and two solar power street light in Cadbury junction but are not counted because of its limited availability and it does not have any impact of the outcome of the study).

Among the total shares of the smart public facilities, Kavesar and Wagbil (ward 2 and 9) share the highest number of facilities, which account for only 17.14% of the total facilities, lying at the western part of the city, presently these areas are undergoing urbanization process with multiple sustainable construction projects being undertaken. Followed by Patlipada&Dongripada (ward 3) and Premnagar & Daulatnagar (ward 89), also located at the western limit of the city are having shares of 4.29 % and 4.76%. With a percentage share rainging between 2 to 3 are 8 wards located on the central part of the Thane City. 1 to 2 % of the total smart infrastructural facilities are found within the 18 south-central and western wards of the TMC. While the remaining 34 wards having barely 1% available share (which accounts for one or two numbers of smart facilities) and the rest of 51 wards lack the facilities completely, this comprises the eastern wards of the city. So, the spatial variation of the facilities across Thane City reveals that the western and south-central wards have a greater share of the smart public facilities.

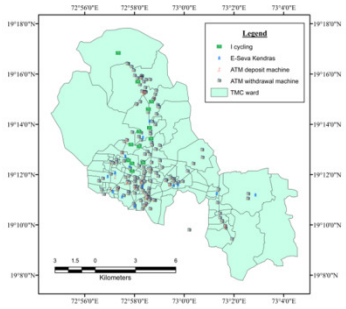

Fig. 1. Spatial variability of smart public infrastructural facilities.

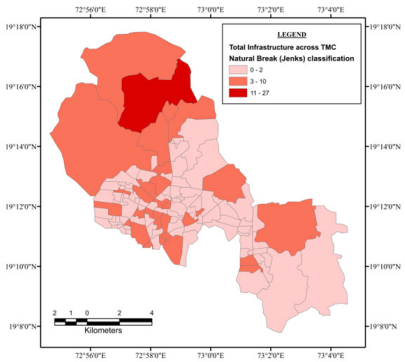

Fig. 2. Spatial distribution of all smart public infrastructures across TMC wards.

The hot-spot analysis (Getis-Ord statistics) map (z-score) too reveals that the western and south central wards are the growth centers of the development. While the whole of the eastern wards lies in the cold zone with the deficit of the smart public infrastructure (Fig 3). Hence, there exists a wide spatial disparity in the availability and access of the smart public infrastructural services. To understand this spatial concentration of the infrastructural facilities location quotient analysis is carried out.

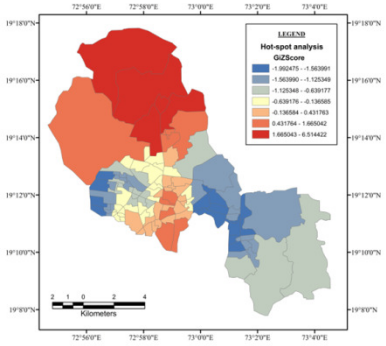

Fig. 3. Hot-spot analysis of smart public infrastructural facilities.

B. Spatial Concentration analysis through locational quotient analysis

In the formulation of the locational planning along with the development of new facilities, the spatial location analysis plays a significant role. Location quotient technique, besides, is well known for its simplicity and serves as an analytical tool to economic development analysis studies [53-58]. In the present study calculation of the location quotient is used in respect to the population in place of the areal extent to study the concentration of the facilities as the facilities are for people [46-48]. The location quotients (LQ) for all the available smart public infrastructural facilities are calculated (ATM deposit machines, ATM withdrawal machines, E-seva Kendra, smart cycling stands). The LQ values are divided into three classes; LQ>1 above average, LQ=1 average and LQ<1 below average class. In respect to ATM withdrawal machines, it provides a better picture in terms of spatial concentration. 44 wards (37.93%) out of 116 wards have above average concentration lying in the western and central parts of Thane. Though two eastern wards are also showing an above average concentration which lies at Mumbra Prabhag Samiti. While 10.34% comprising of12 wards are in average level, which signifies that the wards are self-sufficient. This variation is observed in central and eastern wards. The remaining 51.72 % (51 wards) have below average concentration. The LQ map of the ATM withdrawal machine highlights a fair spatial concentration of this smart public facility in terms of its availability across TMC (Fig. 4).

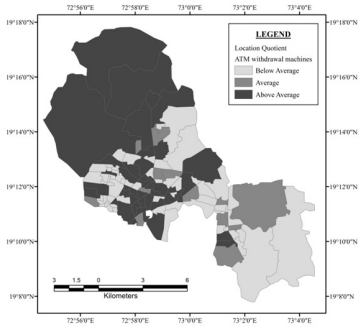

Fig. 4. Location quotient of ATM withdrawal facilities.

In respect to ATM deposit machines, the result reveals that out of 116 wards only 14 wards (12.07%) have above average concentration, which highlights that the per capita availability of the facility surpasses that of the city as a total. While the remaining 102 wards (87.93%) have insufficient facilities with LQ below average (Fig 5). From the map, it is witnessed that mainly at the western and few central wards the availability of the facility is in fairly good concentration.

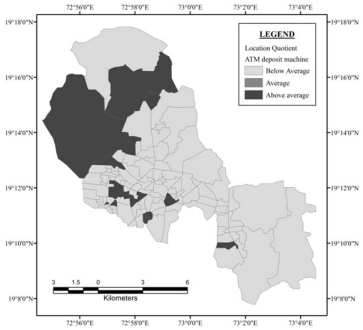

Fig. 5. Location quotient of ATM deposit facilities.

The LQ of e-sevakendras highlight that 103 wards (88.79%) out of 116 wards are having below average concentration and are devoid of any type of e-seva facilities. While in above average class 13 wards are there, this accounts for 11.21%. Though when the distribution is considered according to PrabhagSamiti wise, out of nine PrabhagSamitis all the seven Prabhags have the facilities (Fig. 6).

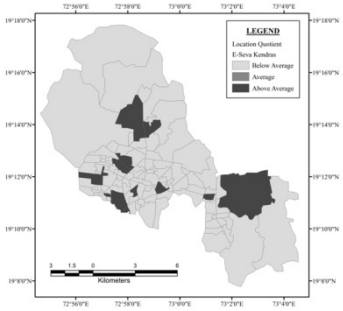

Fig. 6. Location quotient of E-SevaKendras facilities.

Smart cycling stands' LQ reveals that 10 wards are having above average concentration while the remaining lacks the facility. The map portrays that the smart cycling stands are spatially concentrated into the western wards mostly along side the Godhb under road and entertainment or shopping centers like Viviana Mall, Korum Mall and R- mall (Fig. 7).

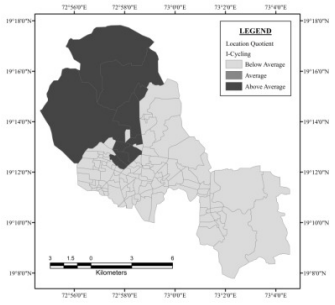

Fig. 7. Location quotient of smart cycling facilities.

So, a gap exists in the spatial concentration and distribution of the smart public infrastructural facilities

across different wards, as a result, identification of gap and prioritization of the wards based on the gap should be undertaken. The next analysis shows the gaps existing between wards and is prioritized for future planning.

C. Identification of gap

As per the standard and number of available smart public infrastructure, weightage has been given to different facilities to identify the gaps in the provision of smart public urban infrastructural facilities across the Thane Municipal Corporation. Then the aggregate weightage score is calculated to prioritize the wards as per the existing gap. To obtain a clear identification of the gap aggregate weightage score are classified into five classes (worse, bad, normal, good and better) according to the natural break (jenks) classification which is highly applicable in the studies under the geographical environment of the socio-economic factors, political and military, strategic resources and ecological environment [59, 60]. The lowest value is observed as 0 while the highest aggregate weightage score is 1283.85 for all the four smart facilities across 116 wards.

According to the prioritization map, only 2 wards, Kavesar & Waghbiland Premnagar & Daulatnagar enjoy the highest share of above-mentioned facilities followed by Patlipada & Dongri, Bramhand, Kavesar & Waghbil, Laxmi Nagar, Samanta Nagar & Lokmanya Nagar Pada No. 1 and Kacharalitalav of the western wards of the TMC. On the contrary, 71 wards (61.21%) suffer a shortage of smart public infrastructural facilities which are lying in the eastern wards. Among them, the worst hit is the 51 wards (43.97%) that lack the facilities completely. The map (Fig 8) portrays that from west to east the gap between the variation and concentration of smart public infrastructure is decreasing. The western wards are given more priority while the eastern wards fall below the average level of development in terms of availability of the smart public amenities.

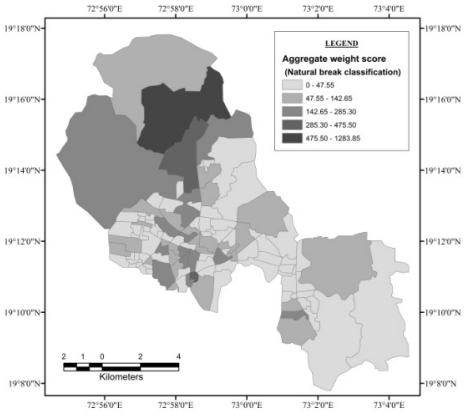

Fig. 8. Identification of gaps among the concentration of smart public infrastructures.

V. DISCUSSION

The analysis reveals a wide spatial disparity with respect to the spatial variability and concentration of smart public infrastructural facilities across TMC. All the results highlight that from west to east the gap in the availability of the smart amenities decreases. So, identifying the most probable reasons behind such existing gap becomes important.

The western wards presently are witnessing rapid urbanization; with new building projects, wide office spaces, better medical, education, and entertainment centers have been attracting a large number of people, which also has being identified as a zone of smart infrastructural development by the city planners. Besides, when the results are analyzed with respect to the demographic attributes of the wards, the western wards are in a better position in terms of low population density, less slum population, high literacy rate and higher percentage of working population. While the eastern wards are characterized by high slum population, lower share of working population and high population density. The less availability of unoccupied space and higher slum population probably have been the reasons why these areas were bypassed while planning and creating the development of smart public infrastructural facilities. Moreover, the smart facility usage is pre-supposedly judged based on the digital literacy level of the people and to an extent the income level also. Probably this is why the low literacy rate and lower income group section residing in the eastern ward are left out from the smart facilities.

The western wards and few south-central wards are the centers of floating population. With the availability of better and wider working spaces, public parks, presence of medical, entertainment and educational infrastructures attract the population from all over the Thane City and also from the neighboring cities as well. Like so, these additionally provide impetus to smart infrastructural development. In addition, the newer development projects providing better smart living spaces with gated community infrastructures, 24 hours CCTV surveillance, solar panel on the rooftop of the buildings providing 24 hours hot water supply and community parks are possible because of the wider available spaces in the western wards. Furthermore, presently metro railway line is under construction which will be running through Ghatkopar in Mumbai connecting Kasarvadali in Thane West. Thus, the rapid spread of urbanization and connectivity with the financial capital of India with faster smart transportation network encourages more developmental projects across these wards.

In the postcolonial contexts, the smart city initiative should be based on inclusiveness and convergence. But this digital urban turn is being hindered by infrastructural deficits and creating barriers to access the facilities among the traditional, marginalized and economically backward groups [61] leading to the development of the splintering cities [62-64]. So, though the socio-economic disparity in terms demographic characteristics, digital knowledge and literacy are existing between the eastern and western wards, effort should be made to take initiatives to bridge the digital divide and make the smart infrastructure accessible and available to all rather than concentrating it to fewer wards. Then only a smart city in a true sense can develop with better sustainability and quality of life.

VI. CONCLUSION

The spatial analysis of the distribution and concentration of smart public infrastructural facilities across TMC wards highlight that there is an unequal distribution of

these facilities and amenities which resulted in a lead-lag relationship among the different wards. The western and south-central wards are more development while the other wards lag far behind the average level of development of the city in terms of smart public infrastructures. The spatial variation in respect to the concentration and gaps emphasized that the present planning efforts could not provide a balanced development of the city. As per the smart livable city strategy, the city should have three main ingredients: resilience, which focuses on the ability to adapt to the requirement with time, i.e., city's flexibility; inclusiveness, the ability of the city to develop a sense of convergence between all the sections of the population, to evolve as a one community irrespective of age, gender, religion and income; and lastly authenticity, i.e., to maintain city's own local identity [20]. But the city is unwilling to keep up the notion of inclusiveness and convergence. This might lead to a widening of the existing gap conspicuously between high and low income groups, literate and illiterate and digitally literate and illiterate population within and among the wards. The eastern wards though lagging behind the western wards in terms of demographic characteristics, yet they should also get the benefit of being inclusive in availing the smart infrastructural services. The proper smart city development will take place only when there will be an upliftment of the backward and marginalized community by providing equal access to smart public infrastructural facilities and dissemination of digital knowledge and literacy. The policy should be framed for localization of smart infrastructures by incorporating the needs of local people and vulnerable groups for solving their everyday life problem. Hence, effective implementation of the inclusive plan should be undertaken by the local government to complete its journey toward the smart living city.

VII. FUTURE SCOPE

The study provides a brief in-look into the journey of Thane city towards smart city. The work will help in future development endeavors for planning and understanding the present status smart public infrastructural of the city. The study can be further expanded in its scope by including all other upcoming smart infrastructural facilities their availability as well as accessibility across all communities and socio-economic groups inhabiting the cities. This will help in providing a better picture of the city to urban planners and administrators for their future planning.

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