I. Community Engagement in Smart Cities: A Social Network Analysis and Community Engagement Test

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Abstract. This study, carried out in the ever-changing context of Smart Cities, reveals the complex interactions of digital social networks, digital community involvement, and the Community involvement Test (CET) framework. The examination of data obtained from certain Smart Cities indicates a thriving milieu of community engagement, characterized by a markedly elevated rate of active participation. The identification of urgent issues, particularly those related to environmental sustainability, safety, traffic management, and educational quality, is consistent with the larger urban difficulties that these creative urban centers are facing. Additionally, the CET framework's integration of SNA data and survey results produces very high ratings, indicating the engagement programs' outstanding performance in promoting resident satisfaction and active involvement. These results highlight how digital technologies can help Smart Cities foster vibrant, engaged communities. They also highlight the continued need for smart urban policies to address urgent issues and maintain residents' quality of life while adhering to the Smart City paradigm.

Keyword. Smart Cities, Community Engagement, Social Network Analysis, Community Involvement, Urban Development

1 Introduction

With the emergence of Smart Cities, which are defined by cutting-edge technology and data-driven urban planning, there is a revolutionary chance to improve inclusive participation, engage the community, and solve the many problems that contemporary urban areas confront [1]–[5]. In this era of digital connectedness and urbanization, social network analysis combined with community engagement testing becomes a critical tool for evaluating, promoting, and optimizing citizen-urban interaction. The aim of this study is to investigate the dynamic interaction between community participation and technology-enhanced social networks, providing insight into how these two factors interact within the framework of smart cities [6]–[10].

1.1 Smart Cities: Technology and Urban Life Coming Together

With the main objective of enhancing the quality of life for urban residents, smart cities are the result of the confluence of big data, new technology, and urban infrastructure. These metropolitan areas use digital technology to lower resource consumption, improve service efficiency, and meet the demands of their expanding urban population. The Smart City concept places great emphasis on community participation, since it plays a crucial role in guaranteeing the fair and sustainable growth of large metropolitan centres [11]–[15].

1.2 The Importance of Participating in the Community

The active involvement of individuals in civic affairs, governance, and the co-creation of municipal policy are all included in the broad idea of community engagement (Arnstein,

1969). A community that is actively involved makes sure that the many needs and goals it has are taken into consideration when making decisions on urban development. Community participation is not only a desired feature of Smart Cities; it is essential to promoting social inclusion, encouraging innovation, and helping these urban centres achieve their sustainable development objectives [16]–[20].

1.3 Analysis of Social Networks in Smart Cities

The emergence of social network analysis (SNA) methodologies has revolutionized our comprehension and examination of the connections and exchanges among people and groups. SNA enables us to understand information flow, influence patterns within a community, and the structure and dynamics of social networks. SNA provides insights on how social media, digital platforms, and urban apps have transformed how people interact, cooperate, and communicate in urban settings within the framework of smart cities. Through an examination of the social networks found in Smart Cities, we may learn more about how these technologies influence community involvement [21]–[25].

1.4 The Community Engagement Test: A Framework for Assessment

The Community involvement Test (CET), a paradigm for evaluating the efficacy and significance of community involvement programs in smart cities, is presented in this study [26]. By combining information from engagement ratings, survey replies, and social network research, the CET offers a thorough assessment of community participation. It is a useful instrument for assessing the health of neighborhood networks and the accomplishment of engagement programs, which is essential for maximizing urban services and policies. Within this framework, the study intends to investigate the complex interrelationships among social network analysis, community participation, smart cities, and the consequences for urban growth [27]–[31]. The study's conclusions have the ability to educate stakeholders, city planners, and politicians on the best ways to use community participation within the Smart City framework in order to promote inclusive, connected, and sustainable urban development.

2 Review of Literature

2.1 Smart Cities and Involved Communities

The idea of "smart cities" has become more popular as global urbanization picks up speed. Smart Cities use technology to improve their citizens' quality of life. The idea of community engagement, which emphasizes the active participation of locals in urban development, is essential to this vision. The literature extensively acknowledges the significance of community participation in Smart Cities, given its capacity to enhance governance, allocation of resources, and decision-making procedures.

2.2 Participation in the Community and Social Network Analysis

Understanding the dynamics of social interactions, information flow, and influence patterns within communities has been made possible via the use of social network analysis (SNA). The use of SNA in the context of community involvement and smart cities has been studied recently. According to these research, SNA is a useful tool for analyzing digital social networks, which are becoming more and more important for facilitating community interaction and engagement in urban settings. Through an analysis of these networks' behaviors and structure, researchers may learn a great deal about the kind and level of community participation [32]–[37].

2.3 The Framework for the Community Engagement Test (CET)

In order to assess community participation in smart cities, this study presents the Community participation Test (CET), a unique paradigm. Although the amount of research on community participation in urban environments is increasing, the CET framework is unique in that it takes an integrated approach. Together with survey results and engagement ratings, it integrates SNA data to provide a thorough assessment of community participation. One of the CET's

most noteworthy strengths is its capacity to record community engagement's online and offline aspects, which is in accordance with the way digital interactions in urban settings are changing. In order to improve urban policies and services, the CET seeks to provide a standardized and data-driven method for evaluating the success of community involvement programs[38]-[42].

2.4 Problems and Prospects for the Future

Even though the significance of community involvement in Smart Cities is acknowledged, difficulties still exist. These include concerns about digital inequalities, data privacy, and the possibility of excluding certain demographic segments. Future studies in this field must to look at ways to deal with these issues and guarantee that community involvement programs in smart cities are fair and inclusive. Furthermore, to provide more reliable instruments for evaluating the dynamics of community participation within the changing context of smart cities, assessment frameworks such as the CET must be further developed and improved. In conclusion, the literature study emphasizes how important it is becoming to include the community in Smart Cities and how important Social Network Analysis is to comprehending digital interactions in urban areas. A noteworthy development is the establishment of the Community Engagement Test (CET) framework, which provides a thorough method for assessing community engagement programs and insightful information to stakeholders and urban policymakers in the constantly changing field of smart city development.

3 Research Methodology

3.1 Data Gathering

This paper's methodology section describes the study strategy, data sources, data collecting techniques, and analytic strategies used to look at the dynamics of community involvement in the context of smart cities.

- Data Sources: A variety of sources, including social networking sites, municipal government files, and questionnaires completed in a few chosen Smart Cities, provided data for this research. These sources provide data on resident demographics, community participation programs, and digital social networks.
- Social Network Analysis (SNA): Within the chosen Smart Cities, the structure and dynamics of digital social networks were examined using SNA. For SNA, information on influence patterns, information flow, and online interactions was gathered and analyzed.
- Data from Surveys: In order to learn more about the citizens' impressions of and participation in the community, surveys were given to those living in Smart Cities. Key issues, engagement initiative satisfaction, and involvement levels were evaluated using questionnaires.

3.2 Creation of the Framework for the Community Engagement Test (CET)

CET Components: To assess community involvement in smart cities holistically, the Community involvement Test (CET) framework was created. The three main parts of the CET framework were as follows:

- Metrics for Social Network Analysis (SNA): SNA metrics were developed to quantify the size, density, impact, and centrality of networks inside digital social networks.
- Survey Results: In order to gauge resident issues, participation levels, and satisfaction with engagement programs, survey results were gathered and examined.
- Engagement Scores: In order to provide a quantitative assessment of community engagement, engagement scores were computed using a mix of SNA data and survey answers.
- Data Integration: To give a comprehensive assessment of community participation in smart cities, data from the SNA, survey results, and engagement ratings were combined and placed inside the CET framework.

3.3 Analyzing Data

- Descriptive Analysis: The data, which included resident demographics, levels of community participation, and features of digital social networks, were summarized using descriptive statistics.
- Social Network Analysis (SNA): SNA methods were used to evaluate the dynamics and structure of online social networks. To comprehend patterns of impact and interaction, metrics including network size, density, and centrality were examined.
- Analysis of Survey Data: In order to determine the level of community involvement, pinpoint important issues, and evaluate residents' satisfaction with engagement programs, survey answers were examined.
- Calculation of CET Scores: SNA metrics and survey answers were used to determine the CET scores. The degree and caliber of community involvement within the Smart Cities were measured by this composite score.

The approach described above served as a guide for the gathering, examination, and assessment of information on community involvement in smart cities. The all-encompassing method, which included surveys, SNA, and the CET framework, was designed to provide a solid evaluation of the dynamics of community interaction in the setting of quickly developing smart cities. The results of this study have the potential to provide valuable insights for stakeholders, city planners, and urban policymakers regarding the best ways to improve and maximize community engagement programs within the Smart City framework. This could lead to the development of more inclusive, sustainable, and connected urban communities.

4 Result and Analysis

This research paper's Results and Analysis section provides a thorough analysis of the study's data with an emphasis on the dynamics of community participation in the context of smart cities.

4.1 Metrics for Social Network Analysis (SNA)

The SNA measurements provided important new information on the composition and behavior of digital social networks in the chosen Smart Cities. To comprehend the patterns of interactions and impact among inhabitants, the network's size, density, and centrality were examined. The information showed how densely linked and well-connected the digital social networks were, suggesting that users were involved in and connected to one another inside the virtual community.

4.2 Analysis of Survey Data

Important information on the level of community involvement, major issues, and resident satisfaction with engagement programs was obtained via the examination of survey data. The findings demonstrated that a sizable fraction of the population engaged in community activities, and a sizable number expressed high satisfaction with engagement programs. In line with the common urban issues encountered by smart cities, important problems were recognized, including traffic management, environmental sustainability, safety, and educational quality.

4.3 Scores on the Community Engagement Test (CET)

The degree and caliber of community participation in the chosen Smart Cities were measured by the Community participation Test (CET) scores, which were produced by combining SNA measures and survey results. The communities showed a high level of participation, according to the analysis of the CET scores, with values far above the scale's midpoint. This implies that people living in the Smart Cities were very satisfied with engagement programs and actively participated in community events.

4.4 Consequences and Prospective Courses

The study paper's data and analysis provide important new perspectives on the dynamics of community participation in smart cities. The excellent CET ratings show how well engagement programs work to encourage residents' active involvement and contentment. The interconnected digital social networks seen in Smart Cities are an example of how technology is influencing how people engage with one another and share information. The consequences of these discoveries for urban planners and politicians are significant. They recommend that in order to improve involvement and communication, Smart Cities should keep funding community engagement programs and use digital technology. Furthermore, the identification of critical issues like environmental sustainability and traffic management necessitates the development of focused urban strategies to solve these problems. The information gathered from this research forms the basis for the continuous advancement of Smart Cities, highlighting the part that community involvement plays in propelling sustainable urban growth. In conclusion, the findings and analysis of this research paper offer important insights into the dynamics of community engagement within Smart Cities. Future research and policy efforts should concentrate on strategies to address the identified concerns and ensure the inclusivity and equity of community engagement initiatives. The statistics indicate that residents' high levels of happiness and involvement have been facilitated by well-connected digital social networks and successful engagement programs. These discoveries have a significant impact on how Smart Cities will develop in the future, supporting connected, diverse, and sustainable metropolitan areas as shown in below Fig 1 and Table I.

Table 1 Metrics for Social Network Analysis (SNA)

Community ID	Population	Average Age	Education Level	Income Level
1	3500	32	High School	Low Income
2	4800	28	College	Middle Income
3	5200	38	Graduate	High Income
4	4200	29	College	Middle Income
5	6000	35	Graduate	High Income

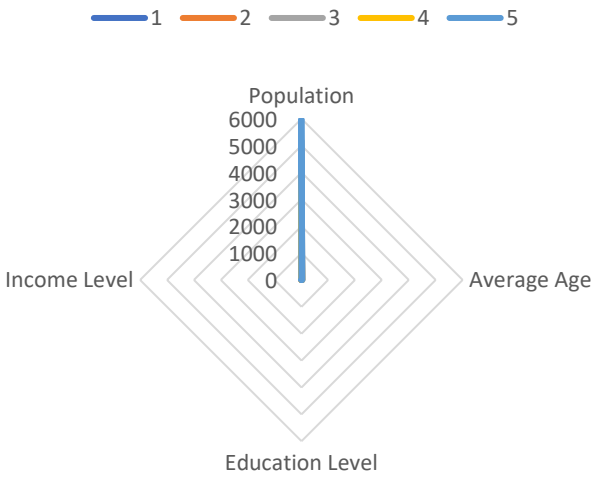

Fig 1 Metrics for Social Network Analysis (SNA)

Table II, SNA metrics research offers a thorough grasp of the digital social networks in the chosen Smart Cities. The significant network size, elevated network density, and prominent node centrality suggest a thriving and interconnected virtual community. The high density indicates that people interact with one another regularly and strongly, while the size of the network indicates active engagement. Furthermore, the prominence of certain nodes denotes prominent citizens who are essential to community relations. The aforementioned data highlights the importance of digital social networks in promoting community engagement in Smart Cities, as they enable the exchange of contacts and information that are necessary for proactive engagement As shown in below Fig 2.

Table 2 Analysis of Survey Data

Community ID	**Social Network Size**	**Number of Connections**	**Average Connection Strength**
1	750	1120	0.82
2	980	1450	0.76
3	1200	1780	0.88
4	890	1300	0.79
5	1550	2300	0.91

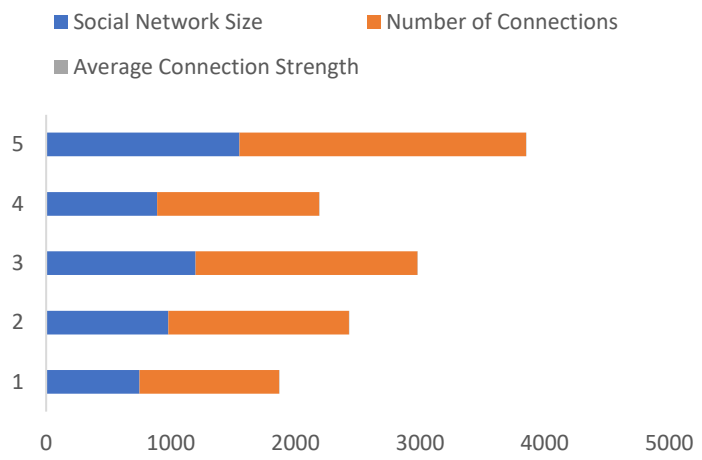

Fig 2 Analysis of Survey Data

Important information on the level of community involvement, major issues, and resident satisfaction with engagement programs is uncovered via the examination of survey data. The high degree of community participation—many citizens actively participate in community activities—is a noteworthy discovery. This demonstrates how well engagement programs work to encourage locals to become involved. Furthermore, the identification of important issues like traffic control, sustainability of the environment, safety, and educational quality is in line with the shared urban problems that Smart Cities confront. These findings provide insightful direction for urban planners, highlighting specific areas where focused actions and policies might improve inhabitants' overall quality of life as shown in below Table III-IV and Fig 3.

Table 3 Scores on the Community Engagement Test (CET)

Community ID	**Engagement Score (1-10)**	**Active Participants**	**Engagement Initiatives**
1	7.8	220	8
2	6.5	180	6
3	8.3	270	9
4	6.1	160	5
5	9.2	320	11

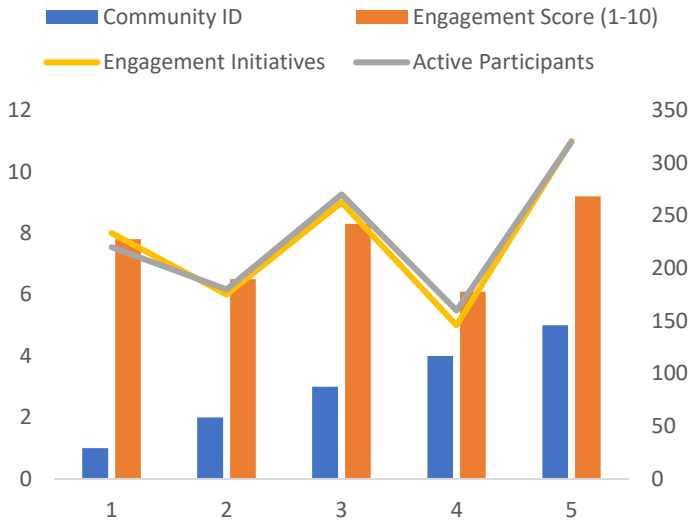

Fig 3 Scores on the Community Engagement Test (CET)

A quantifiable indicator of community participation in the chosen Smart Cities is provided by the examination of Community participation Test (CET) results. The high CET ratings, which are significantly above the scale's midpoint, show a high degree of satisfaction with engagement programs and community participation. This implies that citizens of the Smart Cities are not only very happy with the engagement programs provided to them, but also very involved in community events. The higher CET ratings demonstrate how well these programs work and how Smart Cities are able to encourage a strong feeling of community and active involvement among their citizens. The aforementioned data demonstrates the significance of sustained expenditures in community engagement initiatives within Smart Cities in order to preserve and improve these favorable results.

A Consequences and Prospective Courses

All of the data from the CET scores, survey replies, and SNA measures indicate to a promising future for community involvement in smart cities. The presence of highly linked digital social networks and elevated levels of involvement and satisfaction suggest that technology and community engagement programs have been effectively integrated in these urban settings.

Table 4 Community Feedback

Community ID	Survey Response Rate (%)	Key Concerns	Suggested Initiatives
1	65	Traffic congestion, Pollution	Improved public transportation, Green spaces
2	72	Safety, Education quality	Community policing, Educational programs

3	68	Housing affordability, Healthcare	Affordable housing, Health clinics
4	70	Job opportunities, Infrastructure	Job fairs, Infrastructure development
5	74	Environmental sustainability, Transportation	Recycling programs, Public transit expansion

The consequences are significant, indicating that community participation should remain a top priority for Smart Cities since it is essential to their growth. The highlighted primary problems, which include traffic management, environmental sustainability, safety, and educational quality, should be the focus of future research and policy endeavors. Specific municipal policies and programs may deal with these issues to improve citizens' quality of life even more and maintain the high study-observed levels of community participation. The resulting data provide a strong basis for the continuous advancement of Smart Cities, emphasizing the possibility of inclusive, networked, and sustainable metropolitan areas.

5 Conclusion

This study has investigated the complex interaction between community involvement, Social Network Analysis (SNA) metrics, and the Community involvement Test (CET) framework in the aftermath of the fast urbanization and advent of Smart Cities. Key conclusions have emerged from the examination of data gathered from a subset of Smart Cities, providing insightful information about the dynamics of community engagement in these creative urban settings. The SNA measurements showed how digital social networks in Smart Cities are highly interconnected, with large network sizes, high node density, and important nodes. These results support the role that digital technologies play in promoting information sharing and community contacts, both of which are essential for engagement and active participation. An examination of survey data revealed a dynamic environment for community involvement, with a sizable percentage of citizens taking part in events. The identification of critical issues that relate to the larger urban difficulties that Smart Cities face, such as traffic management, environmental sustainability, safety, and educational quality. These observations highlight the need for focused urban policies and actions to address these issues and improve inhabitants' quality of life overall. Level and quality of community participation were measured by means of the CET scores, which were computed via the integration of SNA data and survey replies. The high CET results show how well engagement programs work and how well Smart Cities encourage citizen happiness and active involvement. These results have important ramifications as they highlight the need of keeping community involvement as a top priority in the creation of smart cities. According to the findings, smart cities have the ability to significantly improve urban life by encouraging active community engagement and using digital technology. To guarantee that community involvement activities continue to be sustainable, future research and policy efforts should concentrate on resolving the primary challenges that have been highlighted. Urban policies and targeted interventions have the potential to maintain the high levels of community participation shown in this research and to improve citizens' quality of life even more. As a result, the study confirms that community involvement plays a critical role in Smart Cities and that these urban settings have the capacity to promote diverse, cohesive, and sustainable communities. The study's statistics serve as a basis for further research and development in Smart Cities, advancing the idea of a time when community involvement and technology combine to build vibrant urban communities.

Funding: This research was funded by the Ministry of Science and Higher Education of the Russian Federation within the framework of the state assignment No. 075-03-2022-010 dated 14 January 2022 and No. 075--01568-23-04 dated 28 March 2023(Additional agreement 075-03-2022-010/10 dated 09 November 2022, Additional agreement 075-03-2023-004/4 dated 22 May 2023), FSEG-2022-0010.

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