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Determinants of Citizen Awareness and Participation in Smart City Initiatives: Insights from Sri Lanka

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ABSTRACT IN ENGLISH

Initiatives for Smart Cities present an acceptable solution to the issues of urban administration as urbanization gains increasing speed. However, the success of smart city initiatives depends on citizen awareness and participation. This study aims to identify the key determinants of awareness and participation in Smart City initiatives among Sri Lankan citizens. A cross-sectional survey was conducted using a structured self-administered questionnaire distributed via social media, with 200 respondents from all nine provinces. Convenience sampling was employed to ensure broad participation. Findings indicate that access to ICT, digital literacy, and community engagement significantly enhance awareness, which in turn fosters participation. Notably, perceived benefits do not significantly impact awareness but directly negatively affect participation, suggesting that concerns over potential risks may deter engagement despite increased awareness. These findings suggest that while community engagement, digital literacy, and access are useful for raising awareness, resolving citizens' concerns about the potential risks of smart city initiatives is essential to increasing participation. Policymakers must prioritize trust-building measures and community engagement to overcome barriers to Smart City adoption. Future research could examine these relationships longitudinally and explore additional factors such as trust in government and technology acceptance.

Keywords:
Citizen Participation; Community Engagement; Digital Literacy; ICT Access; Smart City Initiatives

1. INTRODUCTION

Increases in human population and migration from rural to urban areas are the main reasons for urbanization. Urbanization is an important global trend that presents sustainability and resource management concerns for cities. Urbanization has changed the shape of the world during the past century. In 1950, only about 750 million people, or less than 30% of the world's population, lived in cities; today, 4.4 billion people, or 56% of the world's population, live in urban areas. By 2050, about nine billion citizens, roughly 70% of the population, will reside in cities, mostly in Asia and Africa [1], [2], [3]. Globally, urbanization has caused various environmental and human health effects. Uncontrolled Urbanization resulted in increased levels of air pollution, with ozone, sulfur dioxide, and nitrogen pollution being the main causes of concern.

Particularly in cities with high populations, this increase in air pollution has been connected to several health problems, such as respiratory infections, cardiovascular disorders, and even premature deaths [4], [5], [6]. The quality of life, employment prospects, and perceived social inclusion of the local citizens are strongly correlated with the standards of its infrastructure, such as airports, train and road networks, schools, hospitals, water utilities, electricity grids, and telecommunications networks. All cities depend on their infrastructure for its continued operation. Many of the issues that developing countries' rapidly urbanizing cities face are mainly related to the availability and quality of infrastructure. However, the majority of industrialized economies also experience these problems as a result of inadequate funding for modernizing or replacing outdated infrastructure [7]. Even in well-run cities, integrating migrants into urban economies is not always simple. Furthermore, poverty could result from rapid urban growth. The increasing number of people moving into cities may make it challenging for local governments to provide enough amenities to all citizens as well as manage large volumes of waste. Higher living costs and greater job competition can also keep people in poverty. Rapid and unchecked urbanization can also quickly lead to an increase in crime, violence, and instability in society [7], [8].

Sustainable urbanization is crucial to mitigate these negative effects, as it can create employment opportunities, improve infrastructure, and enhance living standards such as education, health, water supply, electricity, etc. while preserving the environment [9]. Efforts to control air pollution, promote green spaces, and implement efficient urban strategies are essential to addressing the challenges posed by urbanization and ensuring a healthier and more sustainable future for urban dwellers.

Urbanization challenges can be addressed through various solutions proposed in the research papers. One effective approach is "re-urbanization with land readjustment," which aims to foster high-productivity activities benefiting from agglomeration while managing side effects like urban poverty and pollution [10]. Although climate change poses a risk to these initiatives, sustainable urban development plans using green infrastructure can reduce energy costs, improve stormwater management, and increase people's well-being [11]. Furthermore, Smart City initiatives that use Industry 4.0 and ICT technologies provide new approaches to address urban problems, improve quality of life, and support the Sustainable Development Goals developed by the United Nations (UN) [12], [13]. Smart technology reduces impacts on the environment, improves livability, and enhances sustainability, all of which are critical in solving the issues posed by urbanization. Utilizing information technology (IT), smart cities establish intricate digital networks that link people, organizations, structures, and objects [14], [15].

While the concept of smart cities lacks a universal definition, the common theme involves utilizing information and communication technologies (ICT) to drive technological innovation, support economic growth, and maintain a sustainable environment [16]. Furthermore, integrating smart technology into urban metabolism can enhance the quality of life and offer solutions for metropolitan regions that face rapid growth and the effects of global warming. Smart technology can assist cities in effectively managing the difficulties brought by urbanization by controlling social, environmental, and economic costs with the optimum use of resources [15], [17], [18].

Smart cities became accessible by combining ICT and the Internet of Things (IoT), which allows monitoring [19]. IoTs help to solve urban challenges, provide automation systems, and help to reduce the operational cost of smart homes and buildings [20]. Beyond simply technology, the concept of a "smart city" is an essential response to new threats and challenges in urban environments, ensuring improved conditions, comfort, and resilience to undetected problems [21], [22].

Establishing intelligent urban centers in emerging economies encounters obstacles, as outlined in scholarly investigations. Challenges like delayed investments, coordination difficulties among involved parties, constrained financial capabilities, lack of digital infrastructures, and obstacles in governance impede the advancement [23], [24], [25], [26]. Furthermore, simultaneous socioeconomic, human, legal, and regulatory changes are paramount for the effective achievement of technology-driven smart cities in developing areas. This underscores the significance of fundamental infrastructure

delivery, income generation, regulatory structures, human resource enhancement, digital inclusiveness, and environmental sustainability [23].

The participation of people in smart city initiatives is paramount for their effectiveness and inclusiveness. The research underscores the necessity of citizen engagement in formulating policies and establishing objectives and aspirations within smart city strategies. However, there exist difficulties in adequately involving citizens in the planning process, which could result in less comprehensive outcomes [27]. Local governments are currently examining a range of strategies to actively involve residents, encompassing both virtual and in-person endeavors in Canada, to solicit feedback on technological innovations and tackle the issue of unequal access to digital resources [28].

The participation of citizens in smart city initiatives is determined by a range of significant factors, such as citizens' behavioral intention towards smart city living, perceived usefulness, ease of use, involvement, testability, visibility, compatibility, willingness, and readiness to adopt smart city lifestyle are essential aspects [29], [30]. Community engagement is essential for the effectiveness of smart city initiatives in developing areas. Through the integration of intelligent technologies, infrastructure, and governance frameworks, urban centers can improve civic involvement and mitigate disparities [31].

The current awareness level of smart city technologies in Sri Lanka remains significantly low, as evidenced by research focusing on the adoption of smart building technologies [32]. Moreover, Sri Lanka faces challenges in implementing smart road systems and smart cities compared to developed countries, highlighting the need for advancements in this domain [33]. Furthermore, the usage and implementation of electronic Government services in the country remain inadequate, with limited levels of online applications for diverse services, emphasizing the overall slow progress in embracing digital solutions and technologies [34].

However, Municipalities in Sri Lanka are slowly adopting smart city programs to improve effectiveness, sustainability, and the welfare of people. Such programs involve tackling issues such as waste disposal by utilizing systems that measure and monitor waste quantities, alert individuals about inappropriate disposal practices, and assist in waste segregation [35]. Moreover, the utilization of privacy-preserving machine learning methodologies such as Federated learning is suggested for the identification of road conditions using crowd-sourced data to enhance the durability of infrastructure and promote creativity within the country [33].

The effective implementation of smart city initiatives is greatly dependent on the awareness and support from the citizens, as highlighted in numerous scholarly articles. The involvement and awareness of citizens are integral in fostering a feeling of accountability in smart city programs [36]. The significance of citizen science in increasing awareness regarding energy use, renewable energy, and climate change, ultimately enhancing urban sustainability and people's quality of life [37]. Additionally, stakeholders and citizens are recognized as essential to adopting technologies like big data in smart cities, highlighting the necessity of their support for smart city initiatives [38]. Citizen surveys in smart cities offer useful data about their perception and preferences for digital services and highlight the importance of knowing citizen awareness for effectively managing smart city programs [39].

Limited understanding of public awareness and participation has become a major issue for smart city projects. Due to a lack of understanding, transparency, and enforcement procedures, the countries face challenges in implementing national policies properly. This limitation hinders the integration of policy implementation, resulting in a deficiency in citizen engagement and support for smart city initiatives. Additionally, the need for central coordination is emphasized to address the decentralized duties [40]. [41], mentioned the importance of prioritizing human-centered requirements when developing AI applications for smart cities. It highlights the crucial role of enabling data utilization and citizen involvement in open Government data projects [42]. Moreover, citizen awareness and participation point out the issues in incorporating disaster risk reduction into local government frameworks in Sri Lanka, potentially affecting the resilience of Smart cities [43], [44] and the low adoption of e-government services in Sri Lanka highlights the need for more research on the variables affecting citizens' acceptance and use of digital services in the context of smart cities [34].

The research adopts a behavioral approach, contrasting with other studies that mainly highlight adoption rates and technology readiness, by investigating the interaction among ICT access, digital literacy, community engagement, and perceived benefits. By using Structural Equation Modeling (SEM) to examine both direct and indirect effects on citizen engagement, this study provides a more thorough methodological contribution that connects socio-behavioral viewpoints with technology adoption models.

However, limited research studies exist on understanding citizen awareness and participation in smart city initiatives in Sri Lanka, despite the importance of citizen awareness and participation for the success of such kinds of projects, as most completed studies are on determinants of adoption of the Smart City lives [45]. Therefore, it is important to investigate

the factors limiting citizen awareness and support for smart city initiatives within Sri Lankan municipalities. This study seeks to fill this gap, using Sri Lanka to contribute to the broader thematic area of Smart City initiatives.

The findings of this study benefit multiple stakeholders. For citizens, increased awareness of smart city initiatives can lead to more informed decision-making and active participation in urban development. Policymakers will gain data-driven insights into the key drivers of awareness and participation, enabling them to craft targeted policies. Urban planners, technology developers, and municipal authorities can use these findings to create citizen-friendly smart solutions that align with public concerns and expectations, ensuring that smart city projects meet societal needs effectively.

1.1 Hypotheses Development

The study's conceptual model is based on the Theory of Planned Behavior (TPB). This section briefly presents the development of hypotheses. Key constructs from TPB are access to ICT, digital literacy levels, Community engagement, and perceived benefits. Previous studies have demonstrated the role of digital literacy, ICT access, and community engagement in fostering participation in smart city initiatives. However, their combined influence, particularly in the Sri Lankan context, remains underexplored. The following hypotheses are developed based on empirical evidence from past research, ensuring a direct link between theoretical foundations and the study's objectives.

Access to ICT and awareness levels of Smart city initiatives

Access to ICT affects the quality and quantity of information shared in urban contexts, which has a substantial impact on citizens' knowledge of Smart city initiatives. According to previous studies, more citizen's access to ICT increases public knowledge and participation in smart city initiatives by improving the sharing of information and fostering an awareness of community among residents [46], [47]. Moreover, the incorporation of ICT into urban planning enhances stakeholder involvement and improves the sustainability of urban initiatives, thereby reinforcing the importance of informed citizenry in smart city development [48]. Accordingly, the following hypothesis is proposed:

H1: There is an influence of Access to ICT on awareness levels of Smart City Initiatives in Sri Lanka

Digital Literacy and awareness levels of Smart city initiatives

Digital literacy increases the ability of individuals to engage with and make efficient use of technology, which in turn improves awareness levels of smart city initiatives. Studies show that understanding and using information about smart technology also improves with increased digital literacy, which is crucial for informed participation in Smart city initiatives [49]. For example, a research study conducted in Palembang shows that digital literacy includes critical competencies like digital safety and ethics, which are necessary for citizens to use smart technology safely and effectively [50]. Moreover, according to the [51], knowledge of cybercrimes linked to digital literacy has a direct impact on how well technologies are used in Smart Cities. In general, encouraging digital literacy is crucial to enabling people to take an active role in and benefit from smart city initiatives [52]. Therefore, I proposed the following hypothesis:

H2: There is an influence of Digital Literacy on awareness levels of Smart City Initiatives in Sri Lanka

Community engagement and awareness levels and participation in Smart city initiatives

Community engagement plays a crucial role in the development and success of smart city initiatives. It enhances social sustainability and supports knowledge acquisition and urban development [53]. By using citizens as important stakeholders, effective community engagement techniques will help overcome implementation challenges for smart city projects [54]. However [55], indicates that ineffective citizen engagement creates low levels of awareness and participation in smart city initiatives. Accordingly, we propose the following hypothesis:

H3: There is an influence of Community engagement on awareness levels of Smart City Initiatives in Sri Lanka

H4: There is an influence of Community engagement on participation in Smart City Initiatives in Sri Lanka

Perceived benefits and awareness levels and participation in Smart city initiatives

More public awareness of smart cities increases the likelihood that residents will perceive benefits to the economy, culture, environment, and reputation, which will result in increased support [56]. The acceptability of smart cities may be impacted by people's concerns about risks and dangers [57]. While involving the public is essential for the successful implementation of smart cities, doing so is still a challenge. Several factors influence the public's willingness to participate in smart city programs. People's views are impacted by perceived benefits, which have a positive indirect impact on participation behavior [57], [58]. These findings highlight the importance of following developed hypotheses:

H5: There is an influence of perceived benefits on awareness levels of Smart City Initiatives in Sri Lanka

H6: There is an influence of perceived benefits on participation in Smart City Initiatives in Sri Lanka

Awareness and participation in Smart city initiatives

Variation in citizen awareness and endorsement of smart city initiatives is observed among different regions. [59] mentioned that a notable proportion of the population lacks familiarity with the concept of Smart Cities, as approximately

65% of survey participants in the Slovak Republic are not aware of its meaning. In metropolitan areas such as Saint Petersburg and Tomsk, there exists a notable awareness among residents regarding smart city services and technologies, demonstrating favorable attitudes towards addressing urban challenges and engaging in social aspects of city life [60]. According to Herrero-Crespo (2020), individuals in Santander, Spain, who possess knowledge about smart cities tend to recognize beneficial effects on economic, cultural, environmental, and reputational dimensions, consequently fostering a more positive stance and endorsement towards smart initiatives. Furthermore, the results derived from a specific urban area in Ireland known as Cork bring attention to the significance of involving citizens in projects aimed at developing smart cities. This underscores the necessity for implementing effective strategies for gathering input from stakeholders and enabling residents to engage in the decision-making procedures [61].

H7: There is an influence of awareness level on participation in Smart City initiatives in Sri Lanka

The adaptation of smart city initiatives varies significantly across countries due to differences in infrastructure, digital literacy, and governance structures. In Slovakia and Spain, studies indicate that citizens with higher awareness levels are more likely to participate in smart city programs. However, in Sri Lanka, despite increasing ICT access, awareness remains low, and concerns about risks deter participation. Unlike Ireland, where proactive citizen engagement models have been implemented, Sri Lanka lacks structured participation mechanisms, which could explain the lower engagement levels. Understanding these differences helps contextualize the findings of this study and underscores the need for localized policy interventions. Few studies have looked at how digital literacy, ICT access, and community involvement work together to influence awareness and participation, even though the research now in publication examines several factors that influence the adoption of smart cities. Furthermore, rather than focusing on behavioral and sociodemographic characteristics that influence participation, previous research has mostly examined technology readiness. To fill these gaps, this study combines socio-behavioral viewpoints with models of smart city adoption, offering a thorough analysis unique to Sri Lanka.

2. METHODOLOGY

A positivist approach was selected for the study to ensure objectivity, reliance on empirical evidence, and the application of scientific methodologies. This philosophy aligns with the objective of the study, which is identifying the determinants of awareness and participation in smart city initiatives in Sri Lanka. A cross-sectional survey was chosen for the study to collect data from a large sample of Sri Lankan citizens at a single point in time, allowing for statistical analysis and generalizable findings. Data was collected using an online structured self-administered questionnaire from citizens in Sri Lanka that represented all nine provinces and a few multiple questions for collecting background information on the respondent; seven-point Likert scale questions were included to evaluate the model constructs. The questionnaire was developed based on established measurement scales from prior studies on smart city participation and technology adoption. To ensure content validity, the initial draft was reviewed by three experts in Information Systems. Based on their feedback, minor modifications were made to improve wording and scale interpretation. This study used the Convenience Sampling technique by distributing the questionnaire through social media and sharing it, targeting participants who were easily accessible, and 200 respondents filled out the questionnaire. Several steps were taken to improve representativeness, even if convenience sampling may increase bias because of self-selection. To reach a broad demographic in terms of age, education, and geography, the survey was disseminated via several online platforms. Responses were monitored to ensure proportional representation from all nine provinces in Sri Lanka. The sample size of 200 was determined based on standard recommendations for Structural Equation Modeling (SEM), where a ratio of 5-10 respondents per observed variable is considered adequate.

2.1 Data Analysis Techniques

Data analysis was conducted using SPSS 26 for descriptive statistics and reliability analysis, while AMOS 24 was employed for Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM). To ensure internal consistency and validate constructs, reliability testing was conducted using Cronbach's alpha and Confirmatory Factor Analysis (CFA). Descriptive statistics were used to characterize sociodemographic characteristics and Likert-scale variables. The relationships and causal pathways between ICT availability, digital literacy, community engagement, perceived advantages, and awareness and participation in smart city efforts were then determined using path analysis, an instance of structural equation modeling. Reliability was assessed using Cronbach's alpha, with an acceptable threshold of ≥ 0.7 for internal consistency. Convergent validity was verified through factor loadings (≥ 0.5), Average Variance Extracted ($AVE \geq 0.5$), and Composite Reliability ($CR \geq 0.7$). Model fit was evaluated using several indices: CFI (>0.9), TLI (>0.9), RMSEA (<0.08), and SRMR (<0.08).

3. RESULT AND DISCUSSION

This section describes the statistics of the analysis done using data collected from the respondents to the questionnaire. 200 valid responses were obtained after distributing the questionnaire. With data collected from Google Forms, every

question was compulsory for submitting the form. Therefore, the data set was filled without any missing values. Table 1 summarizes the demographic variables of the respondents.

Table 1 - Demographic Variables

Demographics	Categories	N	%
Age	25-34 Years old	129	64.5
	35-44 Years old	49	24.5
	45-54 Years old	14	7.0
	55-64 Years old	7	3.5
	65 Years and above	1	0.5
Gender	Male	73	36.5
	Female	127	63.5
Education Level	12th Grade or Less	5	2.5
	Graduated high school or equivalent	23	11.5
	In some colleges, no degree	8	4.0
	Associate's degree	3	1.5
	Bachelor's Degree	111	55.5
	Post-Graduate Degree	50	25.0
Province	Western Province	25	12.5
	Central Province	29	14.5
	Southern Province	19	9.5
	Northern Province	18	9.0
	Eastern Province	21	10.5
	North Western Province	34	17.0
	North Central Province	23	11.5
	Uva Province	15	7.5
	Sabaragamuwa Province	16	8.0
Monthly Income	Less than 50,000	51	25.5
	50,000- 100,000	77	38.5
	100,000 – 150,000	23	11.5
	150,000 – 200,000	16	8.0
	Above 200,000	33	16.5

The demographic breakdown of the sample indicates that most respondents (64.5%) are aged between 25-34 years, followed by 24.5% in the 35-44 age group, with smaller proportions in older age brackets. Females make up 63.5% of the sample, while males represent 36.5%. In terms of education, over half of the participants (55.5%) hold a bachelor's degree, and 25% have a post-graduate degree, indicating a relatively well-educated sample. The respondents are distributed across all provinces in Sri Lanka, with the highest representation from the Northwestern Province (17%) and Western Province (12.5%). Regarding income, the largest group earns between 50,000 and 100,000 LKR per month (38.5%), with 25.5% earning less than 50,000 LKR, reflecting a diverse range of income levels among the participants. Most respondents (55.5%) hold at least a bachelor's degree, which may contribute to higher awareness levels. Similarly, individuals with higher monthly incomes might have better access to ICT, potentially impacting their engagement with Smart City initiatives. Future research could explore whether demographic factors significantly moderate these relationships.

3.1 Path Analysis

This analysis aims to understand how independent variables (access to ICT, digital literacy, community engagement, and perceived benefits) influence the Mediate variable (awareness level) and Dependent variable (participation in smart city initiatives) of Sri Lankan citizens. Data analysis and evaluation of the direct and indirect effects of these variables were conducted using statistical tools (SPSS and AMOS graphics).

Table 2 - Descriptive Statistics

	Mean	St. Dev	Skewness	AICT	DL	CE	PB	AL	PSC
AICT	5.468	1.896	-1.274	1					
DL	5.366	1.849	-1.328	0.76**	1				
CE	4.653	1.768	-0.586	0.51**	0.56**	1			
PB	5.575	1.754	-1.587	0.74**	0.82**	0.62**	1		
AL	4.882	1.717	-0.819	0.76**	0.82**	0.58**	0.75**	1	
PSC	3.756	1.885	0.116	0.37**	0.378**	0.58**	0.27**	0.53**	1

The researchers carefully examined each model construct to determine both face and content validity. The data distributions were examined using both graphical and numerical techniques. I looked at box plots and histograms. When kurtosis and skewness were examined, most distributions had skewness within ±1 and kurtosis within ±2. Based on this, the data's approaching multivariate normality was approved.

The descriptive statistics (Table 2) reveal that respondents generally have high access to ICT (5.468) and digital literacy (5.366), while participation in Smart City initiatives is notably lower (3.756). Correlation Analysis highlights strong relationships between awareness and factors such as Digital literacy (0.82), ICT access (0.76), and perceived benefits (0.75), emphasizing their importance in enhancing awareness. Community engagement plays a pivotal role in driving participation (0.58) and indirectly supports awareness and perceived benefits.

The study model offers a satisfactory fit, according to the model fit summary (Table 3) for the path analysis, which is shown in Figure 1. With CMIN/DF values between 1 and 3 (0.335) and an RMSEA value below 0.05 (0.000), the overall model fit was considered excellent. This is a commonly recognized cutoff point for a good fit, and the confidence intervals surrounding this estimate are tightly defined. A strong fit is indicated by several fit indices that approach or surpass 0.95. These findings showed that the route analysis model fits the data well and represents the relationships between the study's variables.

Table 3 - Results of Goodness of Fit Parameters

Key goodness of fit parameters	Value	Criteria
Chi-Square	0.669	
Degree of freedom	2	
Probability level (p-value)	0.716	
Comparative fit index (CFI)	1.000	>0.9
Tucker-Lewis index (TLI)	1.011	>0.9
Normed fit index (NFI)	0.999	>0.9
Incremental fit index (IFI)	0.001	>0.9
Root means square error of approximation (RMSEA)	0.000	<0.05

Since every standardized factor loading value is higher than 0.7 and statistically significant (p-values < 0.01), the indication reliability of each measurement item is validated. Cronbach's alpha was used to examine the model constructs' internal consistency reliability (Table 4). The results indicated that the data were internally consistent (> 0.7).

Table 4 - Reliability Analysis

Variable	Cronbach's alpha	No of Items
Access to ICT	0.849	3
Digital Literacy	0.900	4
Community Engagement	0.890	3
Perceived Benefits	0.943	5
Awareness Level of Smart City	0.917	2
Participation in Smart City initiatives	0.939	3
Overall	0.867	6

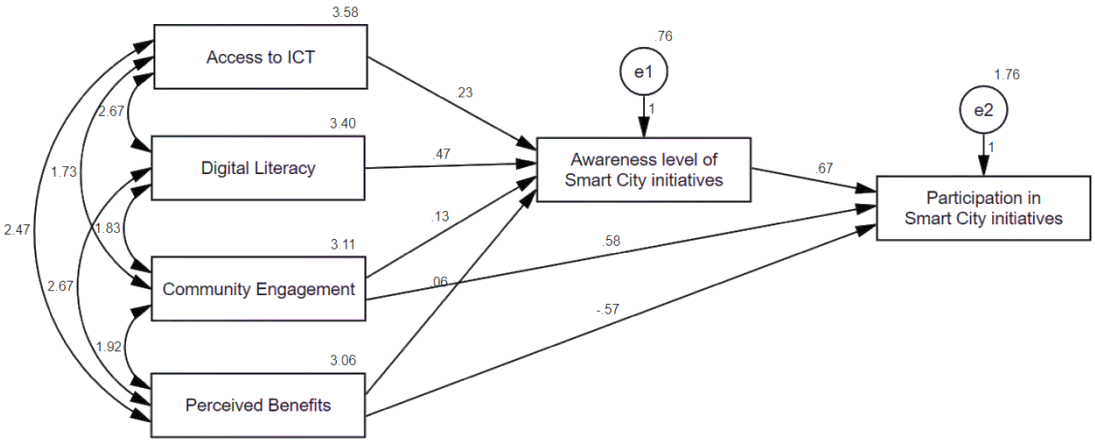

Figure 1 - Path Model

According to the path analysis results (Table 5), Sri Lankan citizens' awareness of Smart City initiatives is greatly increased by access to ICT, digital literacy, and community engagement. The standardized regression weights for these factors are 0.258 (p = 0.003), 0.505 (p = 0.000) and 0.130 (p = 0.013), respectively. The biggest beneficial effect is seen in digital literacy, suggesting that people with more digital proficiency are more knowledgeable about Smart City technologies. Furthermore, community engagement directly affects participation and raises awareness (estimate = 0.547, p = 0.001), indicating that involved communities are more inclined to participate in Smart City initiatives. Participation is strongly positively impacted by awareness (estimate = 0.614, p = 0.001) indicating that informed citizens are more likely to participate. However, there is an unexpectedly negative impact of perceived benefits on participation (estimate = -0.572, p = 0.000) indicating either unwillingness or perceived risks related to these programs. The need to address citizens' concerns and enhance digital access and literacy to promote more informed and active participation is highlighted by this specific perspective on perceived benefits as well as the beneficial effects of ICT access, digital literacy, and community engagement on awareness and participation.

Table 5 - Results of Hypothesis Testing

Hypothesis	Independent variable		Dependent Variable	Estimate	S.E.	C.R.	*p*	Outcome
H1	Access to ICT	→	Awareness Level	0.258	0.054	4.367	0.003	Significant
H2	Digital Literacy	→	Awareness Level	0.505	0.065	7.215	0.000	Significant
H3	Community Engagement	→	Awareness Level	0.130	0.045	2.802	0.013	Significant
H4	Community Engagement	→	Participation	0.547	0.070	8.342	0.001	Significant
H5	Perceived Benefit	→	Awareness Level	0.064	0.069	0.908	0.516	Not Significant
H6	Perceived Benefit	→	Participation	-.527	0.087	-6.509	0.000	Significant
H7	Awareness	→	Participation	0.614	0.086	7.824	0.001	Significant

Note: the findings of the bootstrapping method's hypothesis testing using 5000 subsamples, which are displayed in this table; Composite Reliability (C.R.) and Standard Error (S.E.); significant at p>0.05.

The direct effect of access to ICT and digital literacy on participation is not significant, suggesting that access to ICT has an indirect impact on awareness pathway participation. According to that approach, greater participation is not always a direct result of having access to ICT and digital literacy. Instead, citizens' participation in Smart City initiatives is supported by their greater awareness of these initiatives, which is made possible by improved access to ICT. The mediation by awareness level means that ICT access enhances knowledge and understanding of smart city projects, motivating citizens to get involved. The indirect effect emphasizes how crucial awareness is in converting ICT access into active involvement, understanding the significance of awareness raising as a link between civic engagement and technology access. For example, research by [62], and [47] highlighted that increased ICT access empowers citizens with information, thereby fostering community awareness and participation in urban projects.

Furthermore, Digital literacy improves citizens' understanding and familiarity with Smart City initiatives, it subsequently motivates them to participate actively. Therefore, efforts to improve digital literacy can effectively increase participation by first raising awareness levels among citizens. The positive effect of digital literacy on awareness observed in this study supports the findings of [51], who noted that citizens' understanding of smart technologies and digital safety—key components of digital literacy—is critical for informed participation.

Community engagement has a significant positive impact on awareness, suggesting that citizen who are more engaged within their community tend to be more knowledgeable about Smart City initiatives. This increased awareness, in turn, strongly influences participation, demonstrating that informed citizens are more likely to engage in these initiatives. Moreover, community engagement has a direct positive effect on participation, indicating that engaged citizens are not only more aware but are also directly motivated to participate. This partial mediation implies that while community engagement independently encourages participation, its effect is strengthened through the increased awareness it generates. Thus, fostering community engagement can both directly and indirectly, through awareness, enhance citizen participation in Smart City initiatives and align with previous findings [53], [54].

The results show that awareness level does not mediate the effect of perceived benefits on participation in Smart City initiatives. Perceived benefits have no significant impact on awareness, indicating that citizens' perception of the benefits

of Smart City initiatives does not notably influence their awareness level. However, perceived benefits directly and negatively affect participation, suggesting that concerns or perceived drawbacks might reduce citizens' willingness to participate, regardless of their awareness and while previous studies, [56], suggest that perceived benefits generally enhance participation by showcasing the positive economic, cultural and environmental impacts of smart cities, this study's findings suggest the opposite in the Sri Lankan context. The negative relationship between perceived benefits and participation may indicate that citizens are concerned about potential risks or drawbacks of Smart City initiatives. The negative impact of perceived benefits on participation suggests that while citizens recognize advantages, they may also perceive risks such as privacy concerns, financial costs, or lack of control over data. To counteract these concerns, policymakers should focus on transparent communication strategies, public awareness campaigns, and participatory decision-making processes to build trust in Smart City initiatives. Additionally, incentives such as digital literacy programs and smart service demonstrations could help mitigate resistance.

While studies from Western and European contexts (e.g., Spain, Ireland, and Slovakia) suggest that perceived benefits drive citizen participation, findings in Sri Lanka diverge due to sociocultural and governance-related factors. For instance, in Spain, smart city participation is facilitated by well-established digital infrastructure and transparent government policies [56]. However, in Sri Lanka, technological adoption often faces challenges related to affordability, digital literacy gaps, and trust in public initiatives. The resistance to participation, despite acknowledging benefits, is consistent with findings in other South Asian nations where top-down policy approaches without strong citizen engagement can create skepticism [40].

4. LIMITATIONS AND IMPLICATIONS

A key limitation of the study is its reliance on self-reported survey data, which can introduce response bias, as participants may overstate their awareness or engagement levels in Smart City initiatives. Additionally, the study is cross-sectional, capturing a single point in time rather than longitudinal changes, which limits our understanding of how awareness, engagement, and perceptions evolve. The sample, though representative of various provinces in Sri Lanka, may not fully capture the diversity of views across different socioeconomic groups, potentially affecting the generalizability of the findings. Furthermore, while the model incorporates important variables like ICT access, digital literacy, community involvement, and perceived benefits, other additional relevant factors like government trust or particular technology issues were not looked at, even though they could provide further illumination on aspects affecting participation.

The study's findings have several real-world implications for policymakers and Smart City planners in Sri Lanka. Efforts to improve digital skills and increase access to technology should encourage more participation in Smart City programs, given the beneficial effects of digital literacy and ICT access on awareness and participation. Involving the public in the planning process can increase support and involvement, as seen by the significant impact that community engagement gas awareness and participation. The unexpected negative relationship between perceived benefits and participation emphasizes how critical it is to address citizens' concerns and perceived risks, which may be by the implementation of transparent and open privacy, cost, and accessibility regulations. These observations provide insightful advice for creating citizen-friendly Smart City plans, especially in developing nations with low levels of Smart City engagement. To address citizen concerns about Smart City initiatives, policymakers should implement targeted interventions that foster engagement and trust. Public forums and town hall meetings can provide a platform for direct citizen participation, allowing residents to voice their concerns and receive clarifications. Interactive digital platforms can further enhance engagement by enabling real-time feedback and transparent access to Smart City project updates. Trust-building campaigns focused on data security, transparency, and inclusive decision-making can help alleviate skepticism. Additionally, incentivized digital literacy programs can bridge knowledge gaps, empowering citizens to actively participate in and benefit from Smart City initiatives.

5. CONCLUSION

In conclusion, this study offers insightful information about the factors that affect Sri Lankan citizens' awareness and involvement in Smart City initiatives. It focuses on how access to ICT, digital literacy, and community engagement greatly raise citizens' awareness, which in turn encourages involvement in Smart City projects. This emphasizes how important it is to promote community involvement, internet access, and skills to boost public participation in urban development projects. Significantly, the study shows a complicated relationship with perceived benefits. Although perceived benefits have a positive effect on engagement, they have a negative effect on participation. It indicates that concerns or perceived risks might be preventing citizens from getting involved even though awareness has been raised.

These results underscore that while technology and community factors are critical for raising awareness, addressing citizens' specific concerns around smart city initiatives is equally important for encouraging participation. This study's outcomes suggest that a comprehensive approach, combining increased digital access and literacy with active community involvement and transparent communication about Smart City and risks, is essential for successful citizen engagement.

Future research could further explore these dynamics over time and examine additional factors, such as trust and technological concerns, to develop a deeper understanding of citizen participation in Smart City initiatives. Future research could explore comparative studies across different cultural or geographic contexts to determine the universality of these findings. Investigating Smart City participation in other South Asian countries, such as India and Bangladesh, could provide insights into shared regional challenges. Additionally, examining participation trends in developed economies with higher digital literacy and infrastructure (e.g., Singapore, Estonia) may reveal key differences in adoption barriers and trust factors. Longitudinal studies tracking shifts in awareness and participation over time would also help assess the impact of evolving digital policies and emerging technologies.

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