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Article

Civic Engagement in a Citizen-Led Living Lab for Smart Cities: Evidence From South Korea

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Abstract
Smart cities have emerged in the hope of solving growing urban problems. In addition, unlike past citizen participation in tokenism, new technologies in smart cities have shed light on creating cities with high levels of civic engagement. However, contrary to expectations, technology-centric smart city development has resulted in a lack of opportunities for citizen participation. Consequently, smart cities are increasingly adopting a citizen-centric living lab methodology. Previous research on living labs has emphasized the significance of civic engagement and the potential as a collaborative platform for governments, businesses, and citizens. However, keeping individuals engaged and motivated during the living lab process might be challenging. This study examined the significance of citizens' active participation and determined the elements that influence the level of participation in a living lab. In this study, the first citizen-led living laboratory in South Korea was selected as the subject of a case study. An empirical analytic approach was adopted and a survey was conducted among living lab participants regarding their level of participation and the sociocultural elements that may impact it. Our findings revealed that living lab activities were associated with enhanced civic self-esteem and positive attitudes toward smart cities. Moreover, they display the socioeconomic elements that influence the degree of participation. This study offers evidence that living lab activities encourage citizen engagement by giving participants a sense of empowerment during the co-creation process with multiple stakeholders, boosting civic competency through learning activities, and improving a sense of community ownership.

Keywords
civic engagement; living labs; participatory approach; smart city; urban planning

Issue
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1. Introduction

Cities are heading toward the critical point caused by continuous urbanization and global climate change. According to a United Nations (2018) report, the global urban population is expected to reach 68% by 2050, and urban problems will worsen accordingly. The crisis caused by urbanization and global issues that may occur in cities is complicated to solve using only one approach. Various stakeholders and diverse political, societal, and economic issues are intertwined in the context of urban problems. Therefore, it is an urgent but burdensome problem for governments to take responsibility for solving urban issues. In the context of rising urbanization and new urban challenges, smart cities have emerged as a response to these problems and opportunities to reduce the anticipated complexities and expenses accompanying future urbanization (Albino et al., 2015). However, it was pointed out that technology-oriented urban development at the time of the smart city introduction caused a lack of citizen participation (Lim et al., 2018). According to a survey on cooperation with stakeholders

in smart city development, 65% of respondents indicated that the lack of political consensus among stakeholders was an obstacle to the success of smart city governance (Capgemini Research Institute, 2020). In addition, technocratic smart city development has led to a paucity of essential elements in terms of social sustainability, such as empowerment, participation, and inclusion (Bouzguenda et al., 2019; Cardullo & Kitchin, 2019; Merritt et al., 2021). The World Bank report on smart cities proposes using the living lab approach as a test bed for the cooperative activities of governments, businesses, and citizens in the planning stage for new infrastructure and government services (World Bank, 2016). In addition, the European Commission highlighted the priority of living lab methodology for innovation activities in smart cities in 2006 (Cardullo et al., 2018). Urban living labs experimenting with smart city innovation have been active in Europe (Baccarne et al., 2014).

Changes in the urban environment due to the advent of smart cities provide new opportunities for citizens to participate in politics (Pritchard & Gabrys, 2016). For example, ICT in smart cities is expected to overcome the time and physical constraints limiting factors for citizen participation (Baraniewicz-Kotasińska, 2022). The infrastructure using ICT in a smart city raises expectations that it will contribute to creating a more progressive city that prioritizes citizens' interests, going beyond the tokenism level of citizen participation in the past urban development process (Arnstein, 2019; De Lange & De Waal, 2013; Hollands, 2008). The expanded citizen participation services of smart cities can be the key to their success in a way that ensures an increase in citizens' quality of life with a people-centered approach to urban innovation. Understanding the needs of citizens in the wave of new technological innovations applied to infrastructure is essential to create a citizen-centered smart city.

Recently, the development of smart cities has been consistent, as reflected in the conceptualization and implementation of living labs. According to recent research, the concept of smart cities has gained significant attention and momentum in recent years, with a focus on the integration of technology and innovation to address urban challenges and improve the quality of life of citizens (Al-Nasrawi et al., 2016; Kitchin, 2015; Nam & Pardo, 2011). Consequently, living labs have emerged as a promising approach for developing smart cities, offering a platform for co-creation and collaboration among government, industry, academia, and citizens (Eade, 1997; Falco & Kleinhans, 2018; Liedtke et al., 2012). The literature has established a close association between implementing urban living labs and developing smart cities (Greve et al., 2021; Huang & Thomas, 2021). Urban living labs provide a collaborative platform for co-creating and co-designing technology-based solutions for urban environments, involving the participation of residents, the government, and the private sector. Through such a participatory approach, individuals can actively engage in designing and implementing smart city initiatives, potentially leading to more inclusive and sustainable solutions. Citizens, researchers, and policymakers have been experimenting with living labs, an open and citizen-centric approach to tackling persistent urban challenges. The European Network of Living Labs states that "living lab methodology is user-centered [and consists of] open innovation ecosystems based on a systematic user co-creation approach in public-private-people partnerships, integrating research and innovation processes in real-life communities and settings" (Steen & van Bueren, 2017). The living lab originates from technological innovation but has emerged as a new citizen participation platform for social innovation in many studies (Brock et al., 2019; Cardullo et al., 2018; Leminen et al., 2017). Previous studies on living labs have emphasized the importance of citizen participation (Baccarne et al., 2014; Cardullo et al., 2018; Cellina et al., 2019; Kareborn & Stahlbrost, 2009; Leminen et al., 2017). The living lab is a concept in which citizens participate in co-creation and innovation processes with stakeholders to create public good for society (Siljanoska, 2020). In addition, learning and participation in the living lab create an inclusive environment and encourage changes in citizens' behavior (Huang & Thomas, 2021; Leminen et al., 2015).

Developing a smart city involves implementing various solutions, projects, and initiatives to enhance urban systems and services' efficiency, sustainability, and inclusivity (Brock et al., 2019). These solutions can range from smart transportation systems and energy grids to digital services and platforms for citizen engagement and governance (Sweeting et al., 2022). However, it is essential to note that the development of a smart city is not limited to the implementation of discrete solutions but instead requires a holistic and strategic approach that considers the complexity and interdependence of urban systems and stakeholders (Hollands, 2008; Nam & Pardo, 2011; Sweeting et al., 2022). Figure 1 illustrates the process of implementing an inclusive smart city by stakeholders, such as people, governments, companies, and research institutes, through multiple living lab projects. The process begins with empowering citizens more than other stakeholders in the co-creation process. Then, each entity conducts various living lab projects to achieve its purpose, and iterative feedback is provided. As citizens' repeated feedback and multiple living lab results are deployed as new services and infrastructure of the smart city, citizens' needs can be reflected in approaching an inclusive smart city where no one is left behind.

Through the living lab project, the government will have the opportunity to attain the legitimacy of policy implementation, companies will obtain business opportunities or test beds for new products, and citizens will have the chance to reflect on their own needs or their community's. Thus, new infrastructure, citizen services, and devices that are not technology-oriented but are citizen friendly will be created in smart cities. In addition, citizens confront the information given in a specific project during the co-creation process with stakeholders within

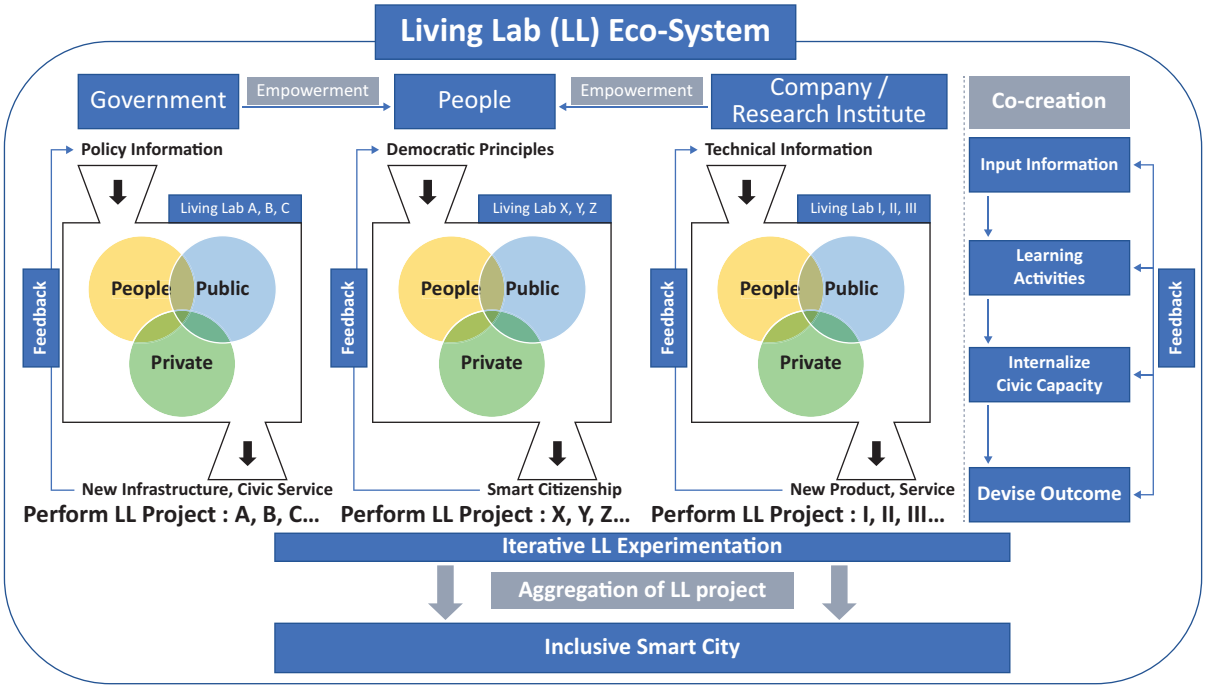

Figure 1. Living lab's eco-system and the smart city.

the living lab. By learning information and internalizing it into their knowledge, they can enhance their competency to enjoy the new smart city service fully. In other words, smart citizenship is nurtured through the learning process in a living lab (Callari et al., 2019).

Many studies have been conducted on the effects of citizen participation and learning in a living lab. Civic engagement and learning within a living lab refers to the process by which policy and technical information to achieve project tasks is internalized into the capacity of participating citizens through the activities of the living lab (de Hoop et al., 2021; de Witte et al., 2021; Huang & Thomas, 2021; Mastelic et al., 2015; Park & Fujii, 2022; Seo, 2002). Prior research generally confirms the importance of citizen participation in the living lab (Barata et al., 2017; Campailla & Titley, 2019; Leminen et al., 2015, 2017). Simultaneously, challenges exist in retaining participants and maintaining their motivation for an extended period (Habibipour et al., 2018; Lievens et al., 2014; Schmidthuber et al., 2019).

A previous study (Jones, 2007) defined citizen participation as government and local authorities' inclusion of people in the formal decision-making process. Living labs prioritize co-creating solutions to urban problems and fostering innovation through the active participation of stakeholders, particularly citizens, in the decision-making process (Barata et al., 2017). Consequently, the efficacy of living lab initiatives is primarily contingent upon the citizens' voluntary engagement and participation level, as their feedback is a vital aspect of the co-creation process (Falco & Kleinhans, 2018). Studies have examined the degree of participation in citizen engagement in urban planning and smart city development (Cardullo & Kitchin, 2019; Puskás et al., 2021). In empirical studies on factors influencing civic participation, various socioeconomic factors such as gender, educational background, and average annual salary have been identified as influential (Noguchi-Shinohara et al., 2020; Schlozman et al., 1994). Moreover, the number of family members, environmental policies, and political tendencies are also significant factors (Muddiman et al., 2019). In this study, we explored the importance of citizens' active engagement and identified the factors affecting their level of participation in a living lab to induce active civic engagement.

1.1. Seongdaegol Living Lab

The Seongdaegol Living Lab (SLL) started as a community of local mothers to establish a children's library in 2010. It became Korea's first citizen-led living lab in 2015 (Figure 2). While establishing and operating a small library in the village, the library became a hub for local mothers' exchange activities, and a local community for public purposes was formed. After the Fukushima nuclear accident in Japan in 2011, the community operating a library started an energy-saving movement for children's future and became interested in renewable energy. At that time, the Seoul Metropolitan Government started the "One Less Nuclear Power Plant" initiative. It promoted a policy to replace nuclear with solar power (Gunderson & Yun, 2021).

Along with the local government's policies, the village movement changed into a self-sufficient energy movement. In addition, the energy transition movement began in earnest after the selection for the Energy Independent Village Support Project of the Seoul Metropolitan Government. Since then, the citizen-led

energy independence movement has received attention domestic and international attention, receiving several awards. The energy movement of Seongdaegol Village introduced the living lab methodology in 2015. In the initial living lab, the university, research institute, and local government participated in the co-creation process.

Consequently, mini-solar panels suitable for collective housing in urban areas were produced, and financial products were developed in conjunction with local credit unions to increase the penetration rate. The successful experiences of these citizen-led living lab movements were extended to attempt to establish a local virtual power plant and received the central government's attention (Seongdaegol Village, 2020). According to an interview with the founder, SLL spontaneously started as a village movement. Participants refer to each other as "village researchers," taking pride in being local problem-solving experts. Therefore, the selection of topics and the composition of educational programs within the living lab should be made by participants rather than external experts or local government officials. Above all, the founder emphasized the importance of empowerment for citizens. The co-creation process of living labs can only work properly when ordinary people in the village feel equal to experts with doctoral degrees or government officials with administrative authority.

1.2. Questionnaire Description

Table 1 illustrates the questionnaire aimed to identify the demographic and socioeconomic factors of the participants and their relationship with the improvement of civic participation. Despite recognizing socioeconomic factors as critical determinants of civic participation in current empirical research, few studies examine the role of family dynamics in influencing individual participation in civic activities (Muddiman et al., 2019). Additionally, the absence of empirical studies that consider accessibility to living labs and environmental and political factors has been noted in the literature. It is unclear whether these factors were adequately accounted for in previous studies. Therefore, the decision to consider variables for selection was based on the unique demographics of the SLL participant group, which consisted solely of residents of Seongdaegol Village and initially began as a group of mothers working to establish a children's library. As a living lab with the long-term goal of addressing climate change, considering these factors was deemed essential in the variable selection process. Due to the pandemic, the survey was conducted online from December 30, 2021, to March 5, 2022. The questionnaire was distributed to almost 100 participants via the social media of the SLL participants with the founder's permission. The survey was targeted only to those who had participated in the living lab project as SLL members, and questionnaires were sent randomly among those participants. Insufficient responses were excluded, and 30 completed questionnaires were collected and used for analysis.

1.3. Statistical Analyses

Descriptive statistics were calculated for all demographic characteristics and responses, including means with standard deviations for continuous variables and frequencies and percentages for categorical variables. To explore the importance of civic engagement, we asked participants to respond to (1) the elevation of civic pride through living lab participation and (2) their attitudes toward applying a living lab to smart city development, with scores ranging from 1 to 5. The scores of the three groups according to engagement levels (low, medium, and high) were compared using Wilcoxon rank-sum tests. Wilcoxon signed-rank tests compared possible factors affecting participation. A quantitative research methodology such as regression analysis could be employed to comprehend the characteristics of living labs. Before conducting the regression analysis, the data needed to be normally distributed. However, in our case, the data did not fulfill this requirement. The objective of this study was to conduct a comparative analysis of the factors associated with the level of participation. Therefore, we conducted a comparative analysis using the Wilcoxon rank-sum and Wilcoxon signed-rank tests in conjunction with descriptive statistics to examine the differences between various factors. All statistical analyses were performed using R software (version 4.1.1; R Foundation for Statistical Computing,

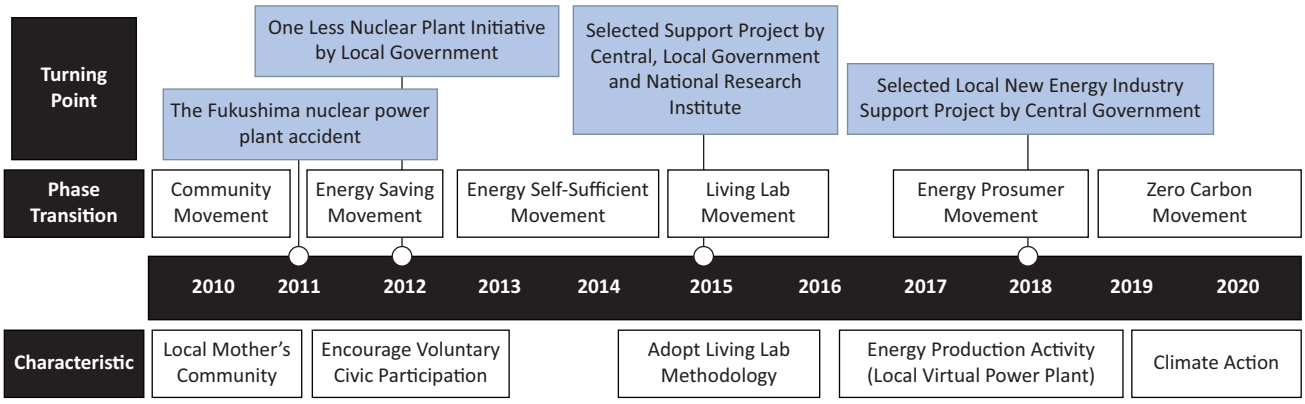

Figure 2. Timeline of SSL activities.

Table 1. Survey questionnaire.

	Question	Answer
1	How would you rate your level of participation in the SLL activities?	1 (Very passive) to 5 (Very active)
2	After participating in the SLL's activities, I felt proud of being a resident.	1 (Strongly disagree) to 5 (Strongly agree)
3	Do you believe developing smart cities will thrive using the living lab methodology?	1 (Strongly disagree) to 5 (Strongly agree)
4	How many members are in your household, including you?	( ) persons
5	How would you rate your level of civic engagement in the village through SLL activities?	Low/Medium/High
6	What is your sex?	Male/Female
7	What is your highest level of education?	Elementary/Middle/High/Undergraduate/Grad.
8	What is your occupation?	Housewife/Salaried Worker/Self-employed/No occupation/Student
9	What is your average annual income?	< USD 15,800/< USD 31,600/< USD 47,400/< USD 63,200/≥ USD 63,200
10	How do you travel to the SLL from home?	Bicycle/Car/Public Transportation/Walking
11	How long does it often take to travel from home to the SLL?	( ) min.
12	How long have you been a resident of Seongdaegol?	( ) years
13	How long have you been participating in SLL's activities?	( ) years
14	What is the most important for improving participants' motivation?	Contribution to village development/Interest in social issues such as energy and climate change/Interest in village activities and community engagement/Personal interest in photovoltaic technology/Recommendations from others
15	What would you say your political inclination is?	Conservative/Outsider Right/Neutral/Outsider Left/Progressive
16	How likely are you to support environmental policies?	Conservative/Outsider Right/Neutral/Outsider Left/Progressive

http://www.R-project.org). All p-values were two-sided, and statistical significance was set at $p < 0.05$.

2. Results

A survey was conducted to identify variables within the living lab that may be associated with civic engagement. Table 2 shows the variables used to explore the research questions of this study, such as socioeconomic background factors, participation level scores, self-esteem improvement, attitudes toward introducing the living lab methodology to smart city development, participation motives, political tendencies, and environmental policy tendencies. The proportion of women and self-employed people among SLL participants is relatively high, presumed to be attributable to its foundation as a gathering of local mothers and its location near an old traditional market.

The active engagement group showed a higher mean score (4.75) in the elevation of civic pride through living lab participation than the low (4.1; $p = 0.0244$) and medium (4.08; $p = 0.0568$) groups (see Figure 3a). Among the three groups, participants who actively engaged in the living lab had the highest mean score (4.62) on their positive attitudes toward applying the living lab to smart city development. The scores of participants in the high engagement group were significantly higher than those in the low engagement group (4.00; $p = 0.0306$) and medium engagement group (3.58; $p = 0.0113$), while there was no significant difference in scores between the low and medium engagement groups ($p = 0.26$; see Figure 3b).

Figure 4 shows the participation scores by sex, number of family members, education level, types of jobs, and average annual family income. We observed an increasing trend in participation scores as the number of

Table 2. Descriptive statistics.

Participants (n = 30)	
Participation Score	
Mean (SD)	3.8 (1.0)
Civic Pride	
Mean (SD)	4.3 (0.7)
Attitude Toward Smart City	
Mean (SD)	4 (0.8)
Number of Family Members	
Mean (SD)	3.5 (1.1)
Civic Engagement	
Low	10 (33.3%)
Medium	12 (40.0%)
High	8 (26.7%)
Sex	
Male	12 (40.0%)
Female	18 (60.0%)
Education Level	
Middle	2 (6.7%)
High	10 (33.3%)
University	17 (56.7%)
Grad. or higher	1 (3.3%)
Job	
Housewife	6 (20%)
No occupation	1 (3.3%)
Salaried Worker	9 (30.0%)
Self-employed	10 (33.3%)
Student	4 (13.3%)
Income (Annual)	
< USD 15,800 (KRW 20 Mil.)	14 (46.7%)
< USD 31,600 (KRW 40 Mil.)	3 (10%)
< USD 47,400 (KRW 60 Mil.)	5 (16.7%)
< USD 63,200 (KRW 80 Mil.)	6 (20.0%)
≥ USD 63,200 (KRW 80 Mil.)	2 (6.7%)
Transportation	
Bicycle	2 (6.7%)
Car	1 (3.3%)
Public Transportation	6 (20.0%)
Walking	21 (70.0%)
Travel Time	
< 10 min.	10 (33.3%)
< 30 min.	16 (53.3%)
≥ 30 min.	4 (13.3%)
Residence Period	
< 10 yrs.	14 (46.7%)
< 20 yrs.	9 (30.0%)
< 30 yrs.	4 (13.3%)
< 40 yrs.	2 (6.7%)
≥ 40 yrs.	1 (3.3%)
Participation Period	
< 3 yrs.	17 (56.7%)
≥ 3 yrs.	13 (43.3%)

Table 2. (Cont.) Descriptive statistics.

Motivation	
Contribution to village development	4 (13.3%)
Interest in social issues such as energy and climate change	14 (46.7%)
Interest in village activities and community engagement	6 (20.0%)
Personal interest in photovoltaic technology	4 (13.3%)
Recommendations from others	2 (6.7%)
Political Inclinations	
Conservative	2 (6.7%)
Outsider Left	22 (73.3%)
Progressive Left	6 (20.0%)
Environmental Policy Inclinations	
Outsider Left	21 (70.0%)
Progressive Left	9 (30.0%)

family members and education level increased, yet none showed statistical significance. Sex, types of jobs, and average annual income were not significantly associated with participation levels.

The variables with potential associations with participation levels are presented in Figure 5. The mean participation level score of the walking group (4.09) was significantly higher than that of the public transportation group (3.00; $p = 0.0493$; see Figure 5a). However, no significant relationship was observed between the participation score, the travel time to visit the living lab site (see Figure 5b), and the period of village residence (see Figure 5c). In addition, we observed that the participation score of the group that participated in the living lab for more than three years was higher than that of the group with less than three years (see Figure 5d).

No significant relationship was detected between participation scores and motivation (see Figure 6a). However, participation levels differed significantly according to the participants' political (see Figure 6b) and environmental policy inclinations (see Figure 6c).

3. Discussion

First, according to our findings, the higher the level of participation, the greater the resident's self-esteem while observing the region's development through living lab activities. According to a study on the change of citizens through living lab activities, they help improve the citizens' knowledge (Huang & Thomas, 2021; Siljanoska, 2020). In addition, in the co-creation process with stakeholders holding different opinions, such as other citizens,

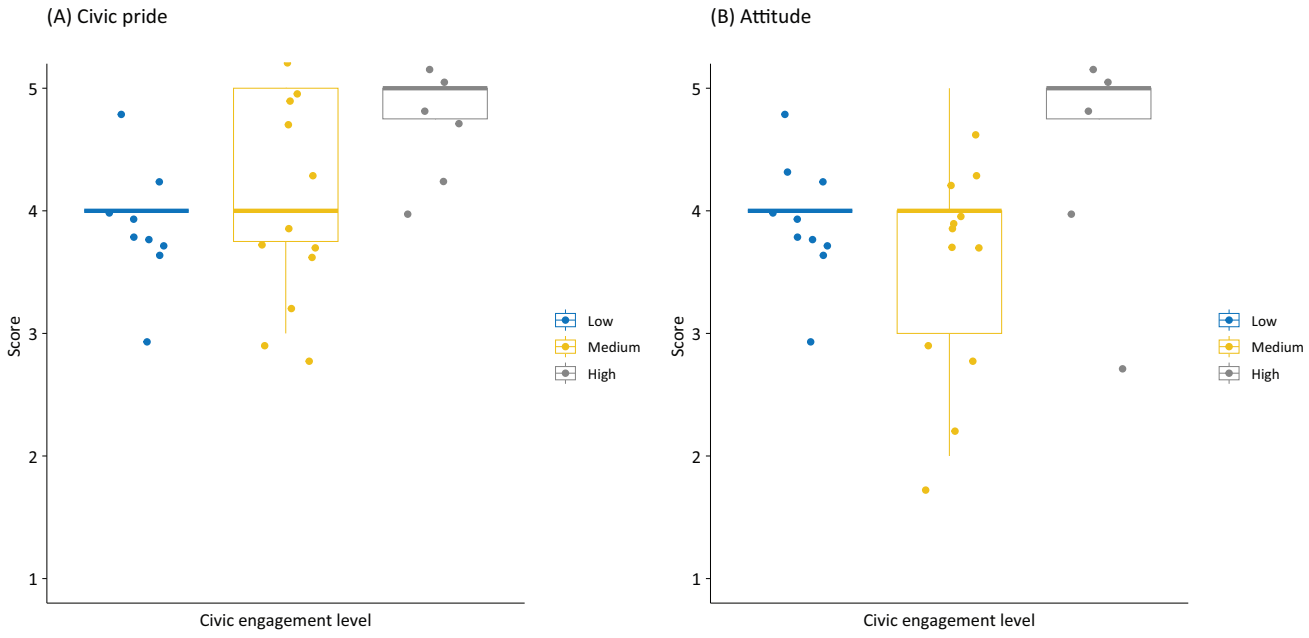

Figure 3. Scores of (a) elevation of civic pride through the living lab participation and (b) participants' attitude toward applying living lab to smart city development by civic engagement levels (low, medium, and high).

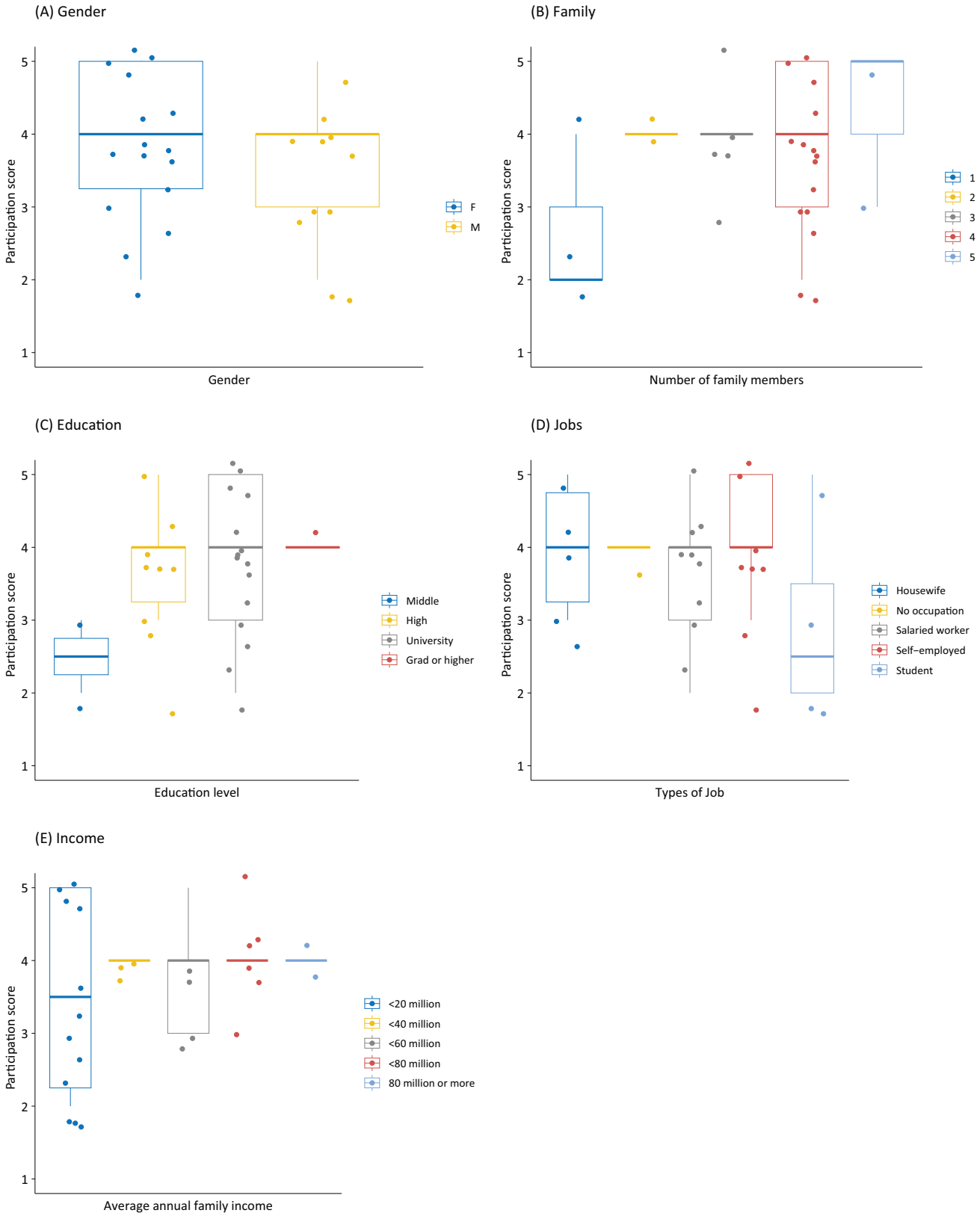

Figure 4. Participation scores by participants' demographic characteristics and socioeconomic status: (a) sex, (b) number of family members, (c) education level, (d) types of jobs, and (e) average annual income.

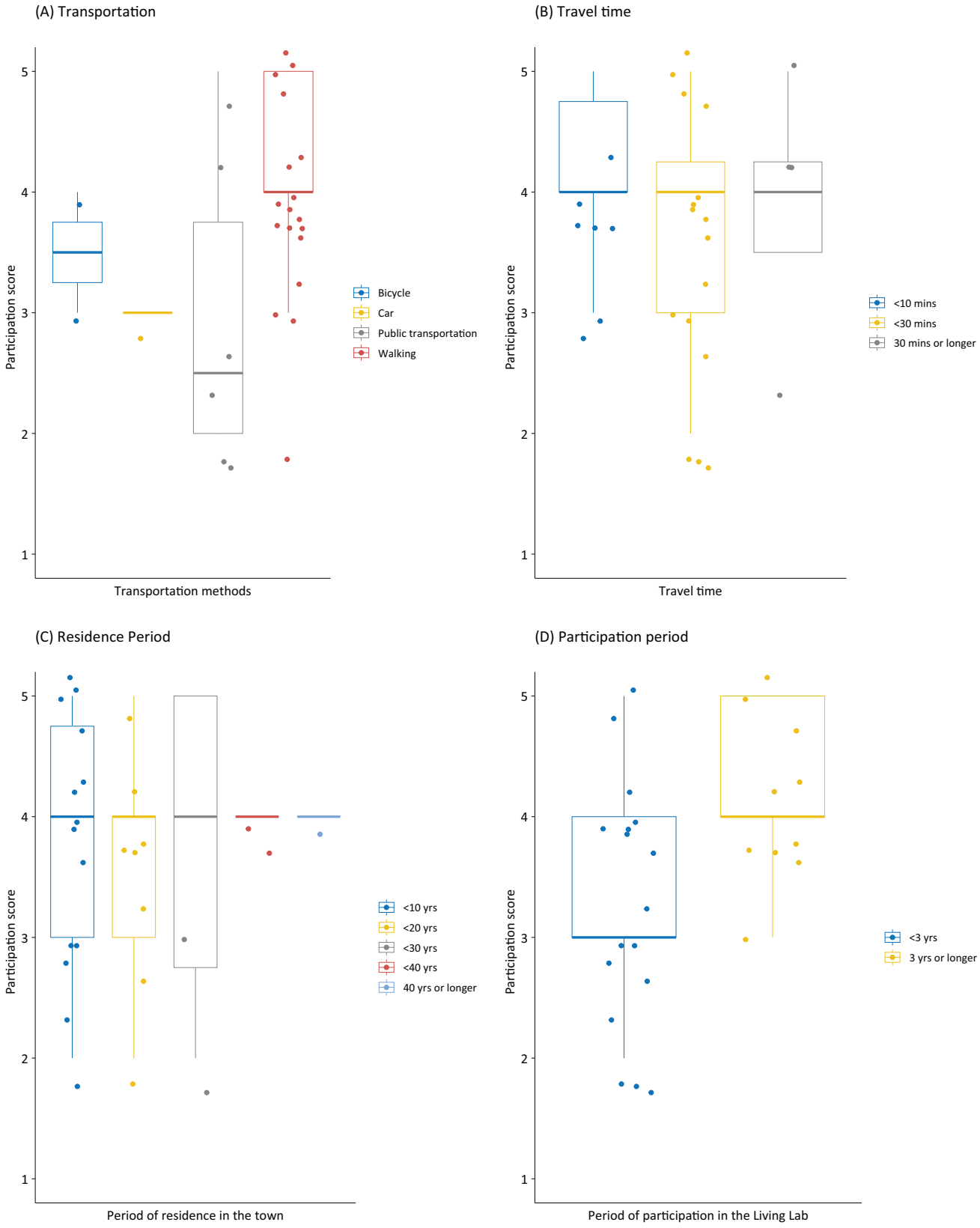

Figure 5. Participation scores by (a) transportation, (b) travel time, (c) residence period, and (d) participation period.

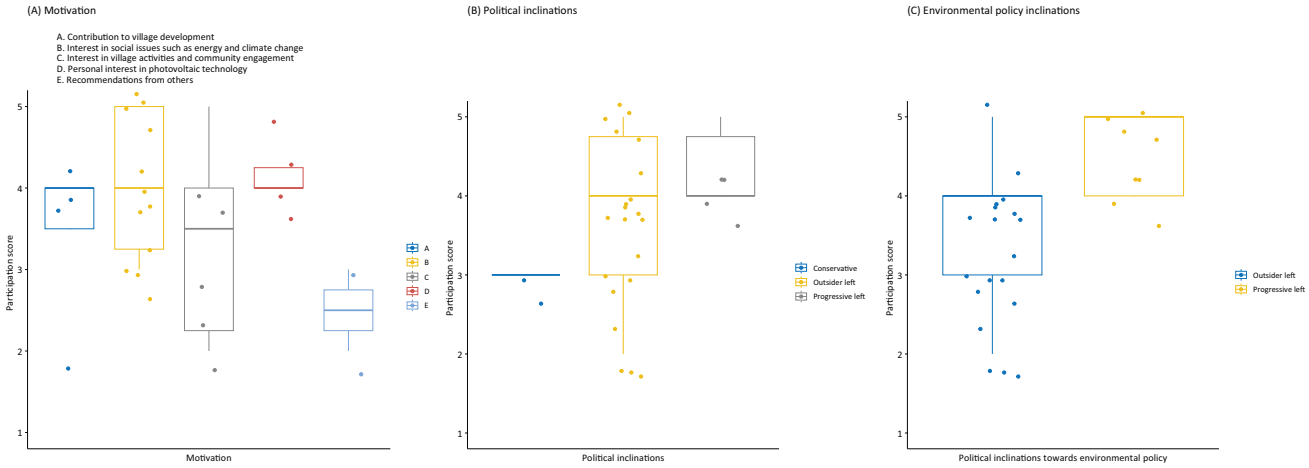

Figure 6. Participation scores by (a) motivation, (b) political inclinations, and (c) environmental policy inclinations.

government officials, and corporations, they experience democratic values and internalize citizenship (Cardullo et al., 2018; Sørensen & Torfing, 2011). The improvement of knowledge through living lab activities and the empowerment of citizens experienced in democratic procedures lead to an improvement in self-esteem. Furthermore, there is an effect of increasing pride by contributing to developing policies and infrastructure for the village and community.

Second, those who actively participated in the living lab (those with a high level of participation) thought that applying the living lab methodology to smart city development would be effective. SLL had experience in urban regeneration projects, such as housing retrofit projects and mini photovoltaic panel projects. However, no living lab experiments were performed on topics related directly to smart cities. However, the group that actively participated in the living lab would have felt the efficacy of user empowerment through the living lab as compared to the lower group (Eade, 1997). The results suggest that groups highly involved in living lab activities have positive expectations for their potential as platforms for effective civic engagement in smart cities (Leminen et al., 2017).

Third, we investigated whether the socioeconomic background of the living lab participants affected their participation. Although their socioeconomic variables were not statistically significant, the participation score of the group with many family members was higher than that of a single family. In general, a notion exists that it is advantageous for single families to have spare time to participate in social activities. Hence, their participation rate can be high (Ruseski et al., 2011). In contrast, SLL started with mothers' gatherings, and some children were found to participate in cultural events and local activities held in the living lab with their mothers. As suggested by a study on the relationship between civic participation and participation of family members (Muddiman et al., 2019), the number of family members likely showed this trend in the socioeconomic background due to the origin of SLL. Although no statistical significance was found, the participant recruitment stage should be considered when attempting a living lab experiment in the urban planning project of family-sized housing complexes.

Fourth, the convenience of transportation and the period of participation in the living lab were identified as factors affecting the association with participation levels in a living lab. The participation level was significantly higher for the group visiting on foot than that using public transportation. Whether this was due to the physical proximity of walking or a personal preference cannot be determined. However, this result may suggest one of the factors to consider when increasing citizen participation when securing a base for living lab activities. In addition, the fact that the participation rate of the group with more than three years of participation was higher than that of the group with less than three years of participation suggests that efforts to prevent the dropout of living lab participants will be necessary to ensure active participation (Habibipour et al., 2018).

Fifth, contrary to expectations, we found no association between participation level and motivation. Various studies have shown that economic incentives are needed. Moreover, emotional satisfaction, such as that derived from contributing to regional development, is vital to motivating participation in the living lab (Antikainen & Vaataja, 2010; Leminen et al., 2015; Lievens et al., 2014). However, no statistical significance was found between the participants' motivation factors and participation levels in this study. Interestingly, our findings suggest that political and environmental policy inclination factors are associated with active participation. Generally, a sense of public contribution and personal interest, including economic gain, is recognized as a motivating factor. This finding is worth highlighting in terms of suggesting the possibility of another external factor beyond the sense of public contribution or personnel interest among the motivating factors for active participation in a living lab. The SLL experimented

with introducing solar power generation to villages for environmental protection and to respond to global climate change.

Regarding political stance and global climate change, studies suggest that a difference exists between right-wing and left-wing supporters (understanding political bias in belief in climate change, understanding and countering the motivated roots of climate change denial, and overcoming skepticism with education, interacting influences of worldview and climate change). Concerning political orientation, a statistically significant difference was found in participation between the progressive left and the conservative group. A statistically significant difference was observed in participation between the progressive left and conservative groups in environmental policy support tendency. The SLL does not disclose its political orientation publicly. However, they are mainly engaged in activities related to sustainable energy, zero-carbon movement, and climate action. According to existing research, organizations involved in climate action may be politically progressive by the general public (Mortoja & Yigitcanlar, 2022; Wong-Parodi & Feygina, 2020). This result suggests that active civic engagement can be elicited by sharing respondents' political inclinations or inclinations toward specific policies and the vision pursued by living labs.

These findings provide insights for governments promoting citizen participation in smart city development by introducing the living lab methodology. However, it may raise debate that respondents' political or environmental policy inclination showed a significant difference in the level of participation. In other words, if political and environmental tendencies have an exclusionary effect that limits the diversity of participants, this may contradict the value of living labs that pursue diversity. Studies on the homogeneity and heterogeneity in the composition of living lab participants are controversial. In the case of a type led by a corporation (utilizer-driven) or government (provider-driven), efficiency is often emphasized to meet the deadline for investment or policy implementation (Leminen, 2015; Schuurman et al., 2013). It has also been argued that selective inclusion and exclusion can be considered according to the background knowledge of the participants in a living lab experiment (Veeckman & Graaf, 2015). Since a city is not a place where only people with homogeneous tendencies live, applying the living lab to urban development requires a careful approach to possible bias. In particular, smart cities and all urban development projects cause personal economic losses and benefits. Research shows that problematic situations may arise when a person whose individual interests are affected participates actively in a civic group addressing their concerns (Cardullo & Kitchin, 2019).

4. Conclusion

This study explored the importance of civic engagement and sought possible factors affecting participation. We observed that active engagement elevated civic pride in their town through participation in living labs. In addition, those who actively participated were found to have a more positive attitude toward applying the living lab to smart city development. The empirical analysis also demonstrated that the visiting method, participation period, political, and environmental policy inclinations have a statistically significant effect on active engagement.

Existing studies suggest that higher citizen participation improves the quality of life of a community and contributes to the realization of an inclusive community (Baum et al., 2000). This study also found that participating in living lab activities can lead to a positive experience of community development and a more favorable attitude toward applying the living lab approach to smart cities. The standard socioeconomic model suggests that education and income levels positively relate to civic participation (Dowse et al., 1973). In this study, the degree of participation in the living lab was found to have a significant effect on the number of family members, mode of transportation, and participation period, among socioeconomic backgrounds. The relationship between the number of family members and participation level is due to the origin of the SLL as a mother's group and the fact that some children participated in cultural events and local activities held in the living lab with their mothers. This finding aligns with those of a study that revealed the effect of family solidarity on the improvement of civic participation (Muddiman et al., 2019). It suggests that involving family members in the living lab process may be an essential factor in driving active participation.

Furthermore, the more time and economic resources required for participation, the less likely an individual is to engage in the process (Schlozman et al., 1994). High participation in SLL also affected walking accessibility. Because living lab projects are usually regional rather than national, a study comparing accessibility factors with living labs of different scales should be considered in the future. Unlike the motivating factors of public contributions and personal interest, the influence of political and environmental tendencies was a significant factor in improving participation. It has been well established that political efficacy plays a significant role in determining an individual's level of participation in civic engagement and politics (Beeghley, 1986). While the SLL does not explicitly endorse any particular political party or ideology, it has been perceived as having progressive tendencies because of its activism against nuclear power plants and its efforts to address climate change. The results of this study suggest that shared political beliefs or a vision, including the living lab, may enhance participation.

The findings of this study provide insight into the government's implementation plan to incorporate the living lab approach in smart city development. Attempts to apply the living lab approach to the development of smart cities have been made transnationally over the past few years (Baccarne et al., 2014). The background

of this trend is that the government has incentives to introduce living labs into urban development, especially smart city development. For city governments, the living lab approach is effective in overcoming excessive bureaucracy and risk-averse attitudes and gaining legitimacy for government policy as a platform for civic engagement (Sørensen & Torfing, 2011). Above all, citizen-led living labs, such as SSL, enable more active citizen participation and ensure the sustainability of government policies (Eskelinen et al., 2015). Notably, in terms of urban planning, few cases exist where civic participation is reflected as an actual citizen control stage. Civic participation is often used as a tool to obtain political payoffs rather than citizen empowerment (Arnstein, 2019; Willis & Nold, 2022). A high-level transfer of empowerment to citizens in urban planning policies is feasible when civil society has sufficient organizational and technical capacities (Willems et al., 2017). From this perspective, to reach the "citizen control" stage, the highest on the participation ladder, strengthening citizenship is as important as the willingness of the government to transfer authority. Finally, activities in the living lab encourage citizen participation by providing an experience of empowerment in the co-creation process with various stakeholders, increasing civic competence through learning activities, and enhancing the sense of ownership of the village. This study proposes the potential of a living lab as a platform that can evolve the existing smart city into a smarter city with smart people.

Our study has several significant limitations. In the real world, considerable variation exists in context-based regional distinctions and sociocultural variations to implement the living lab experiment (de Hoop et al., 2021; Leminen et al., 2017; Overdiek & Genova, 2021). Furthermore, the heterogeneity of objectives and strategies of introducing the living lab methodology, different contexts underlying the background, and various unexpected feedback lead to diverse outcomes (Giang et al., 2018). For this reason, reaching a consensus on a universal definition of the impact and function of living labs is challenging. This study attempted to explore a citizen-led living lab located in Korea, which began with their introduction. This process may also be influenced by the sociocultural background and locality of the community where SLL is located. Furthermore, living lab research literature has highlighted the challenges associated with data collection, including the potential for bias in survey responses due to a pro-living ab methodological inclination among respondents (Dekker et al., 2021).

Studies have shown that living labs can facilitate the co-creation of solutions to urban problems, foster citizen engagement and empowerment, and enhance the sustainability and inclusivity of smart city initiatives (Overdiek & Genova, 2021). However, challenges and limitations to implementing living labs in smart cities remain, such as the need for transparent governance structures, management of diverse stakeholders, and scalability and transferability of solutions (Habibipour et al., 2018; Nam & Pardo, 2011). Therefore, policymakers and practitioners should carefully consider the potential and limitations of living labs in the context of smart city development and adopt a holistic and participatory approach to ensure the success and impact of such initiatives (Baccarne et al., 2014; Cellina et al., 2019). This study presents meaningful implications for civic engagement through the living lab in the smart city development planning stage.

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Conflict of Interests

The authors declare no conflict of interests.

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