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Article

Understanding the Multi-faceted Barriers to Residents' Adoption of Green Infrastructure: The case of Villakent, Izmir

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ABSTRACT

Impermeable surfaces have increased due to urbanization, leading to environmental problems in urban areas. To address these challenges, more municipalities are turning to green infrastructure strategies. Municipalities need to implement green infrastructure on public land and encourage residents to adopt it on their private properties. While previous research has explored factors influencing residents' willingness to install green infrastructure, little attention has been given to the combined barriers to implementation, particularly social barriers. This study aims to develop a comprehensive understanding of the factors affecting residents' willingness. An online survey was created utilizing a previously employed scale, and regression models were used for each green infrastructure strategy. The study area was selected as Villakent, Izmir, and the responses of 123 participants were analyzed. The findings suggest that municipalities can facilitate greater adoption of green infrastructure by organizing seminars and training sessions in addition to existing incentives.

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INTRODUCTION

The development and expansion of cities over the years have led to significant changes, notably the increase in impervious surfaces. Increased impervious surfaces within urban areas lead to stormwater runoff, which has negative effects on aquatic ecosystems and water quality (Walsh et al., 2005). To address this issue, municipalities are turning to green infrastructure (GI)—comprised of natural and semi-natural ecosystems constructed within urban areas—as a decentralized approach to managing stormwater runoff problems (Wise, 2008). Unlike conventional stormwater management methods that quickly move stormwater runoff away via pipes and drains, these strategies called green infrastructure (GI) reduce the amount and volume of stormwater before it reaches water bodies (Adesoji & Pearce, 2024). Moreover, GI is an appealing solution for cities dealing with stormwater problems since it may be used on a smaller scale and offer multiple benefits in terms of ecological, social, and economic (Mell, 2019; Ekren, 2021).

Planners and practitioners are beginning to appreciate the advantages of green infrastructure for cities and local communities. Many countries, including Türkiye, are actively engaging in green infrastructure initiatives. In Türkiye, one notable project is the "Adaptation to Climate Change through Rain Harvest Project," which

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was completed in 2017. This project, led by the Landscape Research Society (PAD) in partnership with Çankaya Municipality and the Humanitarian World Association, aimed to raise awareness about rainwater retention through the development of a guide called "Introduction to Rain Harvesting Practices" (Adaptation, 2021). Additionally, Türkiye has implemented green infrastructure measures such as rain gardens and permeable concrete walkways as seen at the Ministry of Environment and Urbanization's central campus by the 2018 regulations (Adaptation, 2021). The Izmir Metropolitan Municipality is currently focusing on developing green infrastructure plans at the metropolitan level, particularly emphasizing river corridors that connect urban and peri-urban areas. However, these strategies have yet to be fully integrated into comprehensive plans (Hepcan, 2019). Unfortunately, the absence of comprehensive approaches to implementing green infrastructure prevents the development of a lasting solution to the issue.

However, there are major obstacles that need to be overcome to switch from conventional stormwater management systems to green infrastructure techniques. According to some research, green infrastructure methods need the involvement of a broader range of stakeholders than traditional stormwater infrastructure does (Turner et al., 2016). This collaborative approach can contribute to the development of sustainable communities, a primary objective of green infrastructure strategies. Private property owners and residential area inhabitants are among the many stakeholder groups that must be involved in municipal green infrastructure plans for them to be implemented successfully at the city or regional level (Keeley et al., 2013). Even in cases where free infrastructure or incentives are provided, local involvement in municipal green infrastructure projects has frequently been restricted.

While numerous authors have examined barriers to implementing green infrastructure strategies, some focus on government-level obstacles while others investigate challenges at the public level. However, relatively few studies have examined the involvement of residents in green infrastructure initiatives as well as the obstacles preventing homeowners from participating. This research aims to address this gap in the literature by analyzing the variables influencing residents' desire to adopt green infrastructure strategies. Specifically, it explores how environmental values, perceptions, and attitudes affect the adoption of green infrastructure. For these purposes, the Villakent neighborhood in Izmir was selected as a study area and an online survey was distributed to residents in the area to measure the factors influencing the implementation of green infrastructure.

Integrating Green Infrastructure into Urban Planning

The objective of stormwater management is to safeguard urban infrastructure and aquatic ecosystems by effectively managing the flow of runoff, aiming to slow it down and store it (Parker & Zingoni de Baro, 2019). Urban areas with impervious surfaces generate stormwater runoff, leading to issues like flooding, erosion, and a decline in water quality in both urban environments and neighboring ecosystems (Young et al., 2014). The prevalence of impervious surfaces in urban settings leads to an increase in stormwater runoff, exacerbating issues such as flooding, erosion, and deterioration of water quality within cities and neighboring ecosystems. GI offers an environmentally friendly strategy for managing urban growth, minimizing land consumption, and enhancing the resilience of urban environments (Liotta et al., 2020). Figure 1 illustrates examples of green infrastructure components integrated into urban areas.

Within the European Commission framework, the implementation of GI is viewed as a top priority for urban adaptation. The main component of European institutions' plan to achieve a climate-resilient Europe and protect natural habitats for the sake of ecosystems is GI, and they are completely dedicated to putting this policy into action (Adaptation, 2021). A policy encouraging investments in ecosystem services to mitigate the increasing risk of climate change and improve GI in urban spatial planning was adopted by the European Commission in 2013. Over the past two decades, there has also been significant interest in green infrastructure in the United States, in part due to

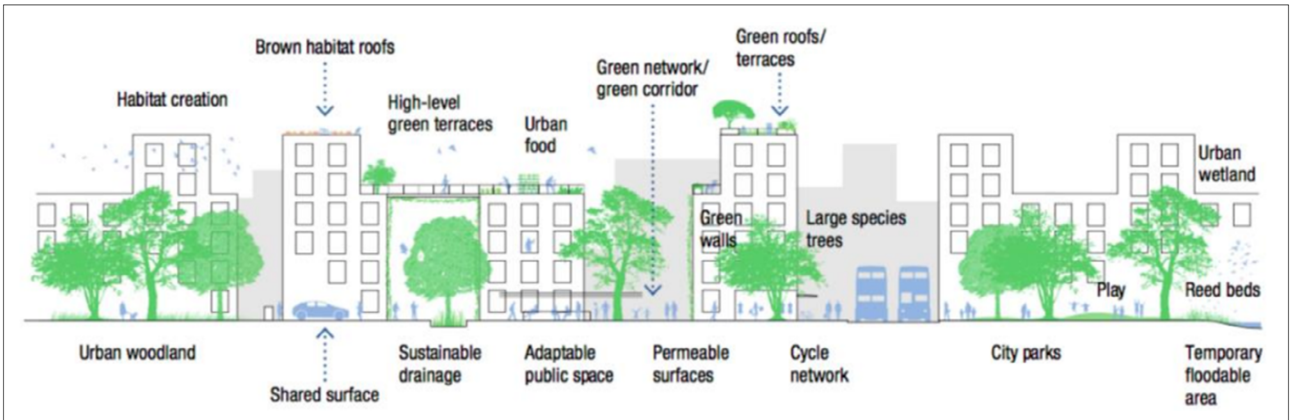

Figure 1. Urban-integrated Green Infrastructure System (Hepcan, 2019).

changes in federal legislation (Wise, 2008). Large US cities have implemented policies aimed at incorporating GI into urban planning to solve issues related to stormwater runoff and meet the requirements of the Clean Water Act (Turner et al., 2016). Prince George County in Maryland was among the pioneers in implementing Green Infrastructure (GI) policies, allocating $1.2 billion for retrofitting 4,000 acres of impervious surfaces during the 1990s. In recent years, cities like Seattle and Philadelphia have also launched GI programs to address stormwater issues, particularly related to combined sewer overflow issues. Seattle aims to manage 700 million gallons of stormwater annually through GI measures, while Philadelphia aims to reduce stormwater entering waterways by 85% (Seattle Public Utilities, 2016; Philadelphia Water Department, 2016). Though they go by different names, interest in green infrastructure approaches is growing in other regions of the world as well.

Türkiye is one of the countries implementing national and local strategies to construct green infrastructure networks and enhance nature-based design solutions. For instance, since 2019, Izmir Metropolitan Municipality has participated in the Green Cities Programme initiated by the European Bank for Reconstruction and Development (EBRD) and initiated preparatory efforts for the "Izmir Green City Action Plan." This initiative aims to build a climate-resilient metropolitan region by utilizing green infrastructure across Izmir Province. For instance, the government requires buildings over 60,000 square meters to implement green roof systems. Another significant project undertaken by the central government is the Impact of Climate Change on Water Resources in Türkiye Project, which was completed by the Ministry of Forestry and Water Affairs in 2016. The consequences of climate change on surface and underground water resources were investigated. There were also additional recommendations for climate change adaptation in the agriculture and industrial sectors (GCAP, 2020). Moreover, The Ministry of Environment and Urbanization executed a project involving the application of permeable concrete on the central campus and the establishment of a rain garden alongside the roadside (Figure 2). The aim was to redirect rainwater to green areas and the rain garden. The Ministry suggests implementing similar initiatives in the gardens of other public institutions and remains committed to advancing such practices (Hepcan, 2019).

The Significance of Stakeholders in Green Infrastructure Projects

Implementing green infrastructure is an expensive and long-term endeavor that requires collaboration among multiple stakeholders (Alves et al., 2018). While the primary responsibility for managing green infrastructure typically falls on local and central government entities, the involvement of non-governmental organizations, residents, and volunteers in management processes enhances the adaptation. Furthermore, by raising awareness and creating solutions, users can play a pivotal role in adopting and preserving green infrastructure strategies.

Initially, green infrastructure planning in urban areas primarily targeted open spaces or public parks (Dreher, 2009). As cities expand, the reduction of open spaces presents difficulties in handling stormwater following intense rainfall. In suburban settings, most impermeable areas are linked to stormwater infrastructure, and lawns may not provide adequate stormwater absorption during intense rainfall events (Thurston et al., 2010). Consequently, implementing small-scale green infrastructure solutions has become vital in both urban and suburban areas to improve the effectiveness of green infrastructure and strengthen stormwater retention capabilities (Turner et al., 2016; Sutunc & Corbaci, 2020).

Figure 2. The implementation of permeable concrete and rain garden.

Private property owners are essential participants in green infrastructure projects. Only depending on public property to develop green infrastructure measures wouldn't suffice to meet cities' stormwater management objectives (Gundlach, 2017). For instance, New York City faces significant water pollution from stormwater runoff and sewer overflows, with billions of gallons of untreated sewage entering waterways annually (Gundlach, 2017). To address this, the City introduced a hybrid plan in 2012 combining gray and green infrastructure to capture storm runoff prior to its discharge into waterways (Gundlach, 2017). While DEP has primarily focused on implementing green infrastructure on public property like streets and sidewalks over the past six years, more than half of the targeted land area for green infrastructure projects is privately owned (Gundlach, 2017). Achieving their goals requires substantial support from private landowners.

Some cities provide incentives to increase participation in green infrastructure practices. The İzmir Metropolitan Municipality is the pioneering local government in Türkiye to adopt the designation of a sponge city. The Sponge City initiative commenced last year and encompasses the implementation of rain gardens, water retention ponds, permeable landscaping materials, and rainwater management systems within designated basins. With the Sponge City Izmir project, an incentive system for rainwater harvesting is being implemented along with the distribution of 5,000 rainwater tanks to 5,000 buildings and a campaign to establish 10,000 rain gardens in Izmir. The project aims to transform Izmir into a sponge city within five years with plans to reduce rainwater runoff in urban areas by 70% within that timeframe. Moreover, in the UK, regulations specify the pavement size and the type of paving material permissible for use in private properties, particularly residential gardens, with detailed guidelines provided. Permission is typically required for using impervious pavement exceeding five square meters in these areas. Moreover, there are incentives such as tax reductions aimed at promoting the increased utilization of pervious surfaces (DCLG, 2008; Interpave, 2013). Likewise, in cities like Portland (OR), Seattle (WA), and Philadelphia (PA), residents receive tax reductions for utilizing permeable pavements.

Overall, coordination between the many stakeholder groups that own and manage land in urban areas—including inhabitants and property owners in residential areas—is necessary for the success of both municipal and regional green infrastructure projects. Increased rates of involvement enable the disconnection of a greater number of impermeable surfaces, which may lead to more significant changes in the hydrology and biological function of the headwater streams receiving stormwater runoff (Green et al., 2012; Mayer et al., 2012; Bos & Brown, 2015). Residents depend on their surrounding environment for various aspects of their lives. Both built and natural environments should be planned and designed to facilitate these functions and enhance their overall quality of life.

Factors Influencing Residents' Willingness to Implement Green Infrastructure

The involvement of residents in municipal green infrastructure projects has remained low despite the availability of incentives or free infrastructure. This lack of participation is likely influenced by various institutional and sociocultural factors affecting residents' desire to adopt and maintain green infrastructure on their property (Baptiste et al., 2015). Municipalities need to assess residents' environmental knowledge and consider strategies to enhance it if necessary. Studies indicate that many residents are unaware of the environmental benefits of green infrastructure and its connection to stormwater management (Barnhill & Smardon, 2012; Mayer et al., 2012). However, once informed, residents are often more willing to embrace change.

Educational programs aimed at increasing residents' understanding of stormwater management and green infrastructure have shown promise in increasing willingness to adopt these strategies. While some studies suggest that education alone may not always motivate participation, others highlight its potential impact, particularly when residents share knowledge with their communities. Multiple research findings have indicated a favorable correlation between enhanced environmental awareness, a positive attitude, and behavioral shifts (Coyle, 2005). Increasing residents' awareness of stormwater management and green infrastructure techniques could influence the implementation of green infrastructure in residential environments (Faehnle et al., 2014; Dogmusoz et al., 2020). In conclusion, while knowledge is frequently cited as a significant obstacle to residents' willingness to implement green infrastructure (Baptiste, 2014; Baptiste et al., 2015; Barnhill & Smardon, 2012), other research has found no correlation (Turner et al., 2016; Robinson et al., 2008). Moreover, socio-cultural constraints such as social position and subjective norms were also discussed in the literature as a limitation factor to individuals' decision-making abilities and influence individuals towards particular choices. For instance, a study conducted by Sinasas (2017) revealed that subjective norms significantly influenced residents' willingness to engage. However, Dogmusoz et al. (2020) found out that subjective norms had no substantial influence on residents' intentions to implement green infrastructure. There is little knowledge of how socio-cognitive factors influence residents' willingness to adopt green infrastructure strategies. While attitudes toward green infrastructure didn't significantly affect residents' intentions to implement these strategies, social pressure played a crucial role (Sinasas, 2017). Turner et al. (2016), however, showed that attitudes and perceptions had a significant influence on participation in green infrastructure projects.

Additionally, the appearance of green infrastructure has been identified as an obstacle to their implementation at the resident level. According to this research, individuals are more ready to adopt visually appealing landscapes than those that are less aesthetically pleasing (Baptiste, 2014; Dogmusoz et al., 2020). Cost is recognized as a significant obstacle to the adoption of green infrastructure among residents. A study conducted by Barnhill and Smardon (2012) revealed that participants perceived the initial cost as a primary obstacle to their desire to install green infrastructure strategies. Furthermore, since the future costs and required time of green infrastructure maintenance are comparatively unclear, maintenance requirements are also identified as an obstacle to the adoption of these strategies (Hammitt, 2010; Foley, 2012; Dogmusoz et al., 2020). Health concerns, perceived control over property, and site suitability are also identified as potential obstacles to implementation (Barnhill & Smardon, 2012). Finally, socio-demographic factors such as age, gender, and income can also influence residents' willingness to implement green infrastructure, with older individuals and those in higher-income areas showing more interest (Baptiste, 2014; Locke & Grove, 2016; Dogmusoz et al., 2020).

The literature on green infrastructure implementation can be broadly categorized into two main groups: cognitive factors such as attitudes, beliefs, etc., and other influencing factors such as initial cost, required time to maintain, etc. While some research has focused on cognitive variables impacting green infrastructure adoption, others have examined the influence of other factors. However, very few studies have explored these factors together. Moreover, some studies have found weak or no association between these variables and willingness to adopt green infrastructure. These conflicting findings highlight the need for further investigation into the factors influencing property owners' and residents' desire to install green infrastructure strategies. This research aims to enrich this topic by examining these aspects comprehensively and addressing the existing gap in research by investigating them collectively.

METHODOLOGY

Study Area

The Villakent neighborhood, situated between Karşıyaka and Menemen in the Seyrek District of Izmir, was selected as a study area (Figure 3). Covering approximately 2.5 million square meters, it comprises 1,000 villas with various projects implemented on individual plots since 2003. These villas, ranging from 210 to 390 square meters in size, boast garden areas spanning 175 to 650 square meters (EgeKoop, 2008). As of 2023, Villakent's population stands at 2,137, with 49.3% male and 50.7% female residents. Around 59.6% of the population is married, and approximately 56% hold a bachelor's degree or higher. Izmir is a pioneering city in green infrastructure practices and, as mentioned above, has been providing incentives for rain gardens and rain barrel implementations in recent years. The reason for selecting Villakent as the study area is that residents here have the necessary spaces for green infrastructure practices, and there are opportunities for implementation if barriers are overcome.

Figure 3. Villakent neighborhood.

Sample

This study targeted the residents who live in the district of Villakent. Power analysis was used to estimate the minimum sample size. A power analysis is the method used to determine the minimum sample size required for an experiment based on a specified significance level, statistical power, and effect size. After entering the required information into the system, the minimum sample size was determined to be 116 to conduct the survey. To facilitate this endeavor, we reached out to the head of the Villakent community and requested them to distribute the survey through their official channels. Additionally, volunteers took the initiative to disseminate the survey among their neighbors. The primary target for the survey is the head of each household, although responses from their spouses are also welcome. For the purposes of this poll, only independent households are included. Adults who still live with their parents are not represented in the research in terms of housing preferences. In all, 262 people responded to the poll. A total of 123 surveys were prepared for analysis after non-replies were removed in order to reduce inaccuracy.

Survey

The web-based survey was created and distributed using the "Qualtrics" program. The survey questions were derived from Dogmusoz et al.'s (2020) study conducted in Raleigh, USA, in 2019. This study discussed the factors influencing residents' implementation of green infrastructure on their properties in Raleigh. Similarly, in this study, we examined the same factors. In both Raleigh and Izmir, incentives were provided to the public to encourage participation and adoption of green infrastructure. The current research employed the "Theory of Planned Behavior (TPB)" as the theoretical framework for developing the questionnaire. This choice was made because TPB is recognized for its ability to elucidate the essential processes underlying individuals' intentions and behaviors (Ajzen & Driver, 1992). According to TPB, attitudes, subjective norms, and perceived behavioral control collectively influence behavioral intention, subsequently impacting actual behavior. This theory has a strong empirical basis and has been successfully applied in various social behavior studies. The questionnaire employed closed-ended questions and was structured into various sections to evaluate respondents' knowledge, TPB constructs (attitudes, self-efficacy, subjective norms), factors influencing the willingness to adopt green infrastructure strategies, and respondents' demographic characteristics. The questionnaire comprised seven distinct parts. The survey questions were included in the Appendix section. The Izmir Katip Celebi University Institutional Review Board (IRB) examined and authorized the survey.

Analysis

Descriptive statistics were utilized to summarize the sample data by quantifying information briefly. Frequencies, mean values, and percentages were calculated to outline the characteristics of our data. Additionally, chi-square tests were employed to explore the association between willingness and other factors.

Confirmatory factor analysis was conducted in this study because a previously validated scale (from Dogmusoz et al., 2020's study) was utilized. Confirmatory factor analysis is a statistical technique that assesses the degree to which observed variables accurately reflect underlying constructs. The participants' responses were evaluated using a 5-point Likert scale, with 1 indicating strong disagreement and 5 indicating strong agreement. Factors were extracted based on the criterion that eigenvalues exceeded 1. In this instance, three eigenvalues collectively represented 63.03% of the variance. Factor 1 accounted for 31.6% of the total variance, Factor 2 for 18.9%, and Factor 3 for 12.4%. The rotated component matrix (Table 1) displays the factor loadings of each variable on each factor. A rotated component matrix is a table used in factor analysis, a statistical technique often used in the field of psychology, social sciences, and marketing research. The matrix displays the loadings of each variable on the different factors (or components) after rotation.

Cronbach's alpha reliability coefficients were calculated

Table 1. Rotated Component Matrix for Confirmatory Factor Analysis

	Component		
	1	**2**	**3**
Item 1. If my neighbors were to install green infrastructure on their property, I would be more likely to install it on my property.	0.563		
Item 2. When considering whether to install green infrastructure, I consider what my friends may be thinking.	0.632		
Item 3. If the people in my life whose opinions I value agreed that I should install green infrastructure on my property, I would be more likely to install.	0.777		
Item 4. I am confident that I could learn the skills required to install or maintain GI on my property.		0.542	
Item 5. I feel that the expense related to maintaining green infrastructure on my property would not be a burden.		0.569	
Item 6. I feel that the amount of time required to maintaining green infrastructure on my property would not be a burden.		0.563	
Item 7. I support the adoption/implementation of green infrastructure on my property.		0.570	
Item 8. I believe that green infrastructure strategies are easy to learn and implement.		0.550	
Item 9. I believe that installing green infrastructure on my property would not reduce the amount of polluted runoff going into local streams and rivers.			0.786
Item 10. I believe that green infrastructure at the resident level does not help improve the quality of water bodies.			0.731

for each component to determine the items' internal consistency. Cronbach's alpha coefficient was 0.70 for Factor 1 (subjective norm) and 0.71 for Factor 2 (self-efficacy). Both values demonstrated strong internal consistency. Compared to these two factors, Factor 3 (Attitudes) has a low Cronbach's alpha (0.51). Additionally, item-total correlations ranged from 0.51 to 0.72 for the subjective norm variable, ranged from 0.65 to 0.74 for self-efficacy, and ranged from 0.62 to 0.68 for attitudes, meaning that the items were consistent and assessed the same construct.

The mean score for the subjective norm influence factor (M = 3.33, SD = 1.14) revealed that respondents had moderate levels of subjective norm on implementing GI techniques. Furthermore, the mean value indicated that the participants on average would consider others' opinions about green infrastructure. The mean score for self-efficacy (M = 3.77, SD = .79) presented that respondents had a high perceived ability to install and maintain green infrastructure on their property. The mean score for attitudes (M = 3.12, SD = 1.01) indicated that respondents had moderately positive attitudes toward the effectiveness of green infrastructure.

Finally, logistic regression analysis was conducted to explore the factors that might influence participants' willingness to adopt green infrastructure on their properties. Participants were asked to indicate their likelihood of installing green infrastructure strategies on their property over the next five years using a 5-point Likert scale (1 = extremely unlikely and 5 = extremely likely), with higher scores indicating greater willingness to implement. The outcome variable (willingness) was recoded as a binary variable: 0 = not willing to implement and 1 = willing to implement. Given the three types of green infrastructure strategies (rain barrels, rain gardens, and porous pavement) examined in the study, separate models were created for each type of technique. The independent variables that remained significant in logistic regression models were included in a hierarchical logistic regression model (final complete model). Hierarchical regression combines many regression models in one step. This method determines if factors explain considerable variance in the dependent variable after controlling for other variables. The goal is to see if new variables significantly enhance model fit. Classification percentages were reported to evaluate the adequacy of predictors in predicting the likelihood of the outcome. Additionally, regression coefficients and odds ratios were interpreted. Statistical analysis was conducted using IBM SPSS Statistics for Windows version 25 with a specified significance threshold of $\alpha = 0.05$.

RESULTS

Sample Demographics

This study looked at the demographics of 123 respondents, with more women (62.6%) than men (37.4%). Table 2 displays demographic data for the participants. The results showed that 51.2% of the participants were in their late middle years (50-64). The sample's youngest age group, 18-29 years, accounted for a modest share (0.8%). 39.8% of participants completed a four-year program. The demographic statistics suggest that the majority of respondents (33.4%) reported a household income of more than $90K per year. Approximately 31% of respondents said that the market value of their home was between 20,000 TL and 40,000 TL. In terms of residency time, the biggest group consisted of 51 (41.5%) individuals who had resided in Villakent for 0-4 years, and approximately 86.2 percent of the participants were homeowners.

Logistic Regression Results for the Rain Barrels

The chi-square test of independence was performed to assess the relationship between willingness to implement rain barrels and other categorical variables. The results of the chi-square tests showed that there was a significant association between willingness to implement rain barrels and required time for maintenance ($\chi^2 = 3.902$, $p = 0.030$), visual appearance ($\chi^2 = 4.669$, $p = 0.020$), existing rain barrels ($\chi^2 = 3.032$, $p = 0.031$), age ($\chi^2 = 6.164$, $p = 0.024$), education ($\chi^2 = 3.716$, $p = 0.049$), income level ($\chi^2 = 3.037$, $p = 0.045$), general knowledge ($\chi^2 = 5.133$, $p = 0.014$). Each of these variables was examined in binary logistic regression models within their domains, and the significant ones were then included in the final full model in order by the theoretical framework of this study. The hierarchical logistic regression model contained three blocks of variables. The first block included gender and education; the second block had visual appearance and existing rain barrels, which were significant in preliminary regression analysis. Lastly, the third block contained all TPB measures as independent variables. The first levels of all categorical variables were specified as the "reference level" for ease of understanding and interpreting odds ratios.

The results are summarized in Table 3. The Hosmer-Lemeshow (H-L) test was used to assess the adequacy of the model to predict the category of participants based on the predictor variables. The test result ($\chi^2 = 3.578$, $p = 0.841$) for the final model revealed a good fit to the data. The overall correct percentage prediction rate was 78.6%. A "good fit" refers to how well a statistical model describes or approximates the observed data. In the final full model, the level of general stormwater knowledge had a significant effect ($\beta = 0.910$, $p = 0.011$) on predicting the likelihood of willingness to implement rain barrels. The odds ratio

Table 2. Demographics of participants

	Count (n)	Percentage (%)
Gender		
Male	46	37.4
Female	77	62.6
Age		
18-29 years	1	0.8
30-49 years	43	35.0
50-64 years	63	51.2
Over 65 years	16	13.0
Education		
Less than high school	2	1.6
High school graduate	15	12.2
Some college	24	19.5
2-year	6	4.9
4-year	49	39.8
Master degree/Ph.D.	27	22.0
Income		
<10000 TL	8	3.4
10001-20000 TL	34	27.6
20001-40000 TL	41	33.4
>40001 TL	33	26.8
Marital Status		
Married	113	91.9
Single	10	8.1
Number of children		
None	13	10.6
1	50	40.7
2	53	43.1
3 or more	7	5.7
Number of people in household		
1	4	3.3
2	47	38.2
3	46	37.4
4	15	12.2
5 or more	10	8.1
Length of residency (in years)		
0-4	51	41.5
5-10	38	30.9
11-15	23	18.7
16 or more	11	8.9
Number of cars		
None	10	8.1
1	72	58.5
2	34	27.6
3 or more	6	4.9
Home ownership		
Rent	16	13.0
Owner	106	86.2

*Sample size (N)= 123.

for general knowledge indicated that participants falling in the high-knowledge group were 3.19 times more likely to implement rain barrels than participants in the high-knowledge group. Additionally, the required maintenance time ($p = 0.037$) was a significant variable. Specifically, participants who feel the required maintenance time for rain barrels as a burden were 1.58 times less likely to install rain barrels on their property. Finally, attitudes ($\beta = 0.800$, $p = 0.031$) were positively associated with willingness. The participants who had a higher positive attitude toward rain barrels were 1.56 times more likely to implement rain barrels on their properties.

Logistic Regression Results for Rain Gardens

The chi-square test of independence was performed to assess the relationship between willingness to implement rain gardens and other categorical variables. The results of the chi-square tests showed that there was a significant association between willingness to implement rain gardens and required time for maintenance ($\chi^2 = 3.795$, $p = 0.049$), adequate space ($\chi^2 = 1.795$, $p = 0.018$), age ($\chi^2 = 3.626$, $p = 0.0305$), education ($\chi^2 = 5.330$, $p = 0.037$), and general knowledge ($\chi^2 = 8.708$, $p = 0.018$). Each of these variables was examined in binary logistic regression models within their domains, and the significant ones were then included in the final full model in order by the theoretical framework of this study. The hierarchical logistic regression model contained three blocks of variables. The first block included gender and education; the second block had visual appearance and existing rain barrels, which were significant in the preliminary regression analysis. Lastly, the third block contained all TPB measures as independent variables. The first levels of all categorical variables were specified as the "reference level" for ease of understanding and interpreting odds ratios.

Based on the results shown in Table 4, the final model's Hosmer-Lemeshow test (χ^2=19.869, p=0.424) revealed a satisfactory fit to the data. Required time to maintain (p=0.046) was a significant variable to predict respondents' willingness to implement rain gardens while holding other variables in the model constant. Participants who believed that the installation time for rain gardens had a high influence on their decisions were less likely to implement than those considering time was not an issue at all (OR=0.19). Additionally, the effect of adequate space ($p = 0.022$) was a significant variable. Primarily, participants who believed that the adequate space for rain gardens had a high amount of influence on their decisions were 7.35 times less likely to implement rain gardens on their property. Attitudes ($\beta = -2.439$, $p = 0.017$) also significantly affected participants' willingness to implement. For example, the odds ratio (OR = 0.87) was less than 1, meaning that the participants who had low levels of attitudes were less willing to implement.

Table 3. Hierarchical binary logistic regression for rain barrels

	Block 1			Block 2			Block 3			
	β	Std. Error	p	β	Std. Error	p	β	Std. Error	p	OR
(Constant)	-0.963	0.422	0.000	0.029	0.489	0.051	-0.038	0.392	0.923	
Age		0.846			0.960			0.974		
Age (1)	0.853	0.512	0.515	0.570	0.422	0.981	0.799	0.420	0.987	
Age (2)	1.208	0.504	0.483	0.516	0.539	0.981	0.938	0.420	0.987	
Age (3)	1.230	0.401	0.855	0.505	0.422	0.981	0.946	0.420	0.987	
General Knowledge				0.556	0.468	0.235	0.910	0.327	0.011*	3.19
Time to maintaim						0.302			0.304	
Time to maintain (2)				-1.065	0.510	0.042*	-0.350	0.436	0.037*	1.58
Time to maintain (3)				-1.726	0.597	0.183	-0.843	0.347	0.171	
Time to maintain (4)				-1.352	0.586	0.724	-0.758	0.822	0.477	
Self-efficacy							0.458	0.928	0.621	
Subjective norm							-0.278	0.585	0.316	
Attitudes							0.800	0.798	0.031*	2.25
H-L		1.025			6.658			8.965		
p		0.795			0.773			0.578		

*p < 0.05.

Table 4. Hierarchical binary logistic regression for rain gardens

	Block 1			Block 2			
	β	Std. Error	p	β	Std. Error	p	OR
(Constant)	-.153	0.853	0.000*	-0.153	1.877	0.007*	
Time			0.260			0.403	
Time (1)	-1.480	2.221	0.036*	-2.264	0.870	0.460	
Time (2)	-1.878	1.579	0.065	-2.830	0.808	0.088	
Time (3)	-1.352	1.920	0.481	-2.357	0.821	0.288	
Time (4)	-1.797	1.724	0.297	-1.944	0.821	0.035*	0.19
Space			0.304			0.392	
Space (1)	-2.203	2.238	0.325	-1.455	2.195	0.508	
Space (2)	-2.031	2.006	0.311	-3.100	2.437	0.203	
Space (3)	-2.268	1.789	0.205	-2.595	2.133	0.022*	7.35
Space (4)	-1.282	1.467	0.382	-1.995	1.617	0.217	
General knowledge	3.032	1.194	0.011*	2.979	1.578	0.049*	19.6
Self-efficacy				0.120	1.783	0.946	
Subjective norm				1.110	1.321	0.401	
Attitudes				-2.439	1.808	0.017*	0.87
H-L		17.070			19.869		
p		0.448			0.424		

*p < 0.05.

Logistic Regression Results for Porous Pavements

The chi-square test of independence was performed to assess the relationship between willingness to implement porous pavements and other categorical variables. The results of the chi-square tests showed that there was a significant association between willingness to implement porous pavements and visual appearance (χ^2 = 2.066, p = 0.015), maintenance cost (χ^2 = 3.112, p = 0.048), installation cost (χ^2 = 1.725, p = 0.046), gender (χ^2 = 3.678, p = 0.045), age (χ^2 = 1.609, p = 0.045), the garden area (χ^2 = 9.692, p = 0.042), education (χ^2 = 4.158, p = 0.042), income (χ^2 = 4.372, p = 0.035), and general knowledge (χ^2 = 1.646, p = 0.020). Each of these variables was examined in binary logistic regression models within their domains, and the significant ones were then included in the final full model in order by the theoretical framework of this study. The hierarchical logistic regression model contained three blocks of variables. The first block included gender and education; the second block had visual appearance and existing rain barrels, which were significant in the preliminary regression analysis. Lastly, the third block contained all TPB measures as independent variables. The first levels of all categorical variables were specified as the "reference level" for ease of understanding and interpreting odds ratios.

Based on the results shown in Table 5, the final model's Hosmer-Lemeshow test (χ^2=21.677, p=0.460) revealed a satisfactory fit to the data. Gender (β=-2.584, p=0.021) also significantly affected participants' willingness to implement porous pavement. For example, the odds ratio (OR=0.33) was less than 1, meaning that the male participants were less willing to implement porous pavement on their properties. The effect of maintenance cost of porous pavement also had an essential role in predicting the class of the outcome (p=0.039). The coefficient for the third level (professional) of education was positive (β=1.342, p=0.015), indicating that the higher concern related to the maintenance cost, the less likely they were willing to implement porous pavement on their properties. For instance, if a person had a higher concern of maintenance cost, they were 16.195 times less likely to implement porous pavement. Additionally, the effect of visual appearance (p=0.019) was significant. The coefficient for the last level (great influence) of visual appearance was negative (β=-4.649, p=0.019), indicating that the higher levels of concern about the visual appearance of porous pavement were related to a decreasing likelihood of willingness to implement. The odds ratio for this category (OR=0.207) was less than 1. This result indicated that participants who thought the visual appearance greatly influenced the adoption of porous pavements were less likely to be willing to implement them. Additionally,

Table 5. Hierarchical binary logistic regression for porous pavement

	Block 1			Block 2			Block 3			
	β	Std. Error	p	β	Std. Error	p	β	Std. Error	p	OR
(Constant)	1.609	0.658	0.003	2.993	1.352	0.027	5.335	2.245	0.017	
Gender	-1.099	0.658	0.95	-1.992	0.935	0.033*	-2.584	1.119	0.021*	0.75
Maintenance cost				-0.641	1.421	0.652			0.771	
Maintenance cost (1)				-0.641	1.421	0.652	-2.200	1.336	0.100	
Maintenance cost (2)				-2.564	1.245	0.040*	-2.200	1.336	0.100	
Maintenance cost (3)				-2.274	1.351	0.092	-2.852	1.580	0.071	16.195
Maintenance cost (4)				-2.067	1.165	0.076	- 2.785	1.406	0.048*	
Visual appearance						0.162			0.175	
Visual appearance (1)				-3.397	1.528	0.026*	-3.407	1.658	0.040*	0.33
Visual appearance (2)				-2.040	1.421	0.151	-2.877	1.596	0.071	
Visual appearance (3)				-3.017	1.470	0.040*	-3.971	1.744	0.023*	0.19
Visual appearance (4)				3.705	1.664	0.026*	-4.649	1.975	0.019*	0.10
Self-efficacy							-0.524	1.329	0.693	
Subjective norm							1.226	1.064	0.249	
Attitudes							-2.322	1.307	0.046*	0.10
H-L		3.039			17.046			21.677		
p		0.765			0.376			0.460		

*p < 0.05.

attitudes (β = -1.072, p = 0.003) were significantly linked to participants' willingness. Attitudes (β = –2.439, p = 0.017) also significantly affected participants' willingness to implement. For example, the odds ratio (OR = 0.87) was less than 1, meaning that the participants who had low levels of attitudes were less willing to implement.

DISCUSSION

The study examined the role of factors that have been discussed in the literature to predict willingness to implement green infrastructure (GI) strategies. Studies in academic literature suggest that attitude plays a role in shaping actual behavior (Guagnano et al., 1995; Rauwald & Moore, 2002). This study supports these findings for all three different green infrastructure strategies. The results of this study align with Turner et al. (2016)'s research indicating that attitudes had an influence on residents' overall intentions to implement green infrastructure on their properties. Essentially, participants' perceptions of the effectiveness of green infrastructure impacted their decision to adopt it. Conversely, our findings are inconsistent with Sinasas's (2017) and Dogmusoz et al.'s (2020) study, which proposed that attitudes did not have the greatest influence on residents' involvement. It is significant to remember that the scale measuring a particular environmental activity (like GI implementation) frequently differs from the scale used to measure general environmental attitudes. The different results might be because of the different measures used. However, the difference in results despite using the same scale as Dogmusoz et al. (2020)'s study can be explained as follows: (1) the location of the study or (2) low variance between participants. If respondents' opinions varied much from one another, the impact of attitudes on behavioral intention may be more obvious.

In the current study, the subjective norm was not a significant predictor for all three green infrastructure strategies. These results contradict other studies (Sinasas, 2017; Dogmusoz et al., 2020). In Sinasas's (2017) study, green infrastructure was examined holistically rather than focusing on specific types. This might be the reason for the different results. However, Dogmusoz et al.'s (2020) study also examined the relationship between subjective norm and willingness separately, similar to the current study, and employed the same scale. Nevertheless, the reason for the different outcomes could be explained by people in different cultures feeling varying degrees of societal pressure. Moreover, self-efficacy was not the strongest predictor of the willingness to adopt these three green infrastructure strategies. Actually, based on the strong self-efficacy scores, I predict relatively high levels of green infrastructure adoption. These findings contradict some prior research (Baptiste et al., 2015; Dogmusoz et al., 2020; Moan & Rise, 2011; Mullan et al., 2013). In other words, participants' perceptions of their ability to engage in a certain action had no impact on their willingness to install green infrastructure. This could be attributed to variations in the measurement scales used to assess self-efficacy. However, despite using the same scale, the current study and Dogmusoz et al. (2020)'s study yielded different results. This could be because of the study being conducted in different locations as well as differences in the number of participants and demographics.

Knowledge was also regarded as an independent predictor of willingness to install green infrastructure. In this study, it was observed that residents' stormwater management knowledge significantly predicted the desire to install rain barrels and rain gardens but not the installation of porous pavement. While these results support studies (Baptiste et al., 2015; Foley, 2012) which suggest that participants who had a high level of knowledge of environmental issues show more willingness to participate in those issues, they also conflict with other research (Dogmusoz et al., 2020; Turner et al., 2016; Heimlich & Ardoin, 2008). The differences might be because of: (1) different measures used or (2) the measure might determine not the level of knowledge but instead the level of awareness. The current study and Dogmusoz et al. (2020) also conflict in terms of porous pavement. While the level of knowledge was not a predictor for porous pavement in the current study, it was significant for porous pavement in Dogmusoz et al. (2020)'s study. The reason might be the different locations of the study areas. For instance, in Izmir, there are no incentives provided for porous pavement, whereas incentives are offered for rain gardens and rain barrels. Since then, people might be more familiar with other types of green infrastructure strategies instead of porous pavement.

In this study, specific knowledge regarding green infrastructure strategies did not emerge as a predictor of willingness to implement, which contradicts findings from other studies in the field but aligns with Dogmusoz et al. (2020)'s study. For example, Foley (2012) identified specific green infrastructure knowledge as a significant predictor of implementation. However, Foley's approach to measuring knowledge involved using only one statement for each type of green infrastructure. The variance in results between this study and others in the green infrastructure domain may be attributed to differences in the scales used to assess knowledge levels.

The visual appearance was identified as a potential obstacle to green infrastructure implementation. However, our findings suggest that while visual appearance doesn't predict the implementation of rain gardens or rain barrels, it does predict the implementation of porous pavement. This could be because participants generally prefer the appearance of rain gardens or rain barrels over porous pavement. The conflicting results could be attributed to variations in the aesthetic scales used across studies. Furthermore, differences in the images depicting green infrastructure strategies, including factors like background and color, might influence participants' aesthetic evaluations of the same types of green infrastructure. Studies on aesthetics have demonstrated that cultural factors influence our aesthetic preferences. Therefore, even if the same scale is used, research conducted in different locations may yield differences due to cultural influences.

The cost of installation was viewed as a possible obstacle to implementing green infrastructure. Surprisingly, in the current study, installation cost did not emerge as a significant predictor for any of the three types of green infrastructure. This might be because of two possible reasons: firstly, respondents in this study may have higher incomes, thus not perceiving cost as a barrier; or secondly, the City of Izmir's reimbursement program might be well-known among participants, mitigating concerns about installation expenses. The current study examined both installation and maintenance costs, whereas most literature focuses solely on installation costs, neglecting maintenance expenses. However, in our findings, maintenance costs were not significant for rain barrels and rain gardens but for porous pavement. This aligns with Foley's (2012) research, which also found that maintenance costs did not affect respondents' decisions to implement green infrastructure. The lack of significance regarding maintenance costs in the current study may be due to two potential reasons: firstly, respondents in our study may have higher incomes, diminishing the perceived barrier of cost; or secondly, participants might perceive that The City of Izmir's initiatives effectively cover maintenance costs for the rain garden and rain barrel but not for porous pavement.

Rain gardens and rain barrels showed a significant relationship with necessary maintenance time in the current investigation; porous pavement did not show a meaningful correlation. The participant's employment situation may be the cause of the discrepancy in the literature. Surveys commonly inquire about whether individuals perceive "required time" as a barrier without considering their employment status (employed or retired). Those in the workforce might have limited time available for maintaining green infrastructure. Participants could also believe that maintaining porous pavement will need expert assistance, and this might save them time.

Furthermore, health concerns about green infrastructure have been recognized as a barrier to implementing such measures in earlier research (Hammitt, 2010; Foley, 2012). However, issues related to health did not emerge as predictors for installing green infrastructure in the current study. This finding aligns with Baptiste's (2014) and Dogmusoz et al.'s (2020) research, which similarly found that health concerns did not influence the implementation of green infrastructure strategies. The lack of space was significantly associated with the desire to install rain gardens but not for rain barrels and porous pavement. Another explanation could be that participants may perceive rain gardens to occupy more space compared to porous pavement and rain barrels.

Finally, socio-demographic factors have been considered as barriers to the adoption of these strategies. This study supports the research indicating the relationship between socio-demographics and the willingness to implement green infrastructure in this field (Ando & Freitas, 2011; Baptiste, 2014; Pincetl, 2009). In the current study, gender emerged as a significant predictor only for porous pavement. The findings indicate that females are more inclined to install porous pavement compared to males. The lack of significant results for rain gardens and rain barrels may be due to minimal variance among respondents who primarily have high income and education levels. Using a different sample could provide more accurate insights into how socio-demographic factors related to the adoption of green infrastructure.

CONCLUSION

This study addresses a gap in the growing literature on green infrastructure by examining factors influencing residents' willingness to install specific types of green infrastructure on their property. The findings indicate that attitudes have a significant influence on residents' intentions to adopt all three types of green infrastructure strategies. While visual appearance and maintenance cost are significant predictors for porous pavement, required maintenance time has an influence on residents' desire to install rain barrels and rain gardens. Additionally, general stormwater knowledge affects residents' intentions to implement rain gardens and rain barrels, not porous pavement. Encouragement from municipalities is crucial to help residents overcome perceived barriers to implementing green infrastructure. This research can guide municipal policymakers in targeting social constructs to promote residential green infrastructure adoption.

This study emphasizes the importance of attitudes, suggesting that a person's feeling about the effectiveness of green infrastructure can increase their willingness to adopt it. Municipalities can effectively communicate the benefits of green infrastructure to the community and the environment based on scientific research conducted in this field. Since general knowledge about stormwater management is a significant predictor, municipalities can also organize seminars and workshops to increase public awareness about stormwater management, which is the main cause of the issue and why green infrastructure is needed.

Furthermore, required maintenance time for rain barrels and rain gardens and maintenance cost for porous pavement emerge as significant predictors, suggesting a need for municipalities to consider providing reimbursement for maintenance costs in addition to installation costs.

In this study, factors influencing the feasibility of green infrastructure adoption among participants have been investigated. For future research, further analysis of the significant factors identified in this study could provide insights and recommendations for green infrastructure designs. For example, it has been determined within the scope of this study that visual appearance is significant. However, factors such as color, texture, material, etc., which influence this appearance, could be addressed in future research.

Overall, green infrastructure strategies offer sustainable solutions to various environmental challenges, including water quality, flooding, urban heat islands, and climate change. To achieve these goals, it is essential to implement green infrastructure strategies at all scales. Studies conducted in different regions are all valuable and contribute to the literature.

Appendices: *https://jag.journalagent.com/megaron/abs_files/MEGARON-10734/MEGARON-10734_(5)_MEGARON-10734_Appendix.pdf*

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