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# Urban Flood Mitigation and Peri-Urban Forest Management: A Study on Citizen Participation Intention

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**Abstract:** Urban flooding is a widespread and impactful natural hazard, presenting considerable challenges to urban areas. Integrating peri-urban forests (PUFs) into flood management strategies has emerged as a promising approach to mitigate flood hazards. Citizen engagement in PUF management can enhance flood risk reduction efforts. A notable research gap exists in understanding the factors influencing citizens' intentions to participate in PUF management for flood mitigation. To address this gap, this study investigates the determinants shaping citizens' intention to engage in PUF management efforts. Using an extended Theory of Planned Behavior framework—which incorporates environmental awareness and risk perception—this research surveyed visitors to PUFs in Tehran. Structural equation modeling with SmartPLS was applied to examine the relationships among these variables. The findings reveal that attitudes, subjective norms, perceived behavioral control, and environmental awareness significantly influence citizens' intentions. In contrast, perceived risk had no significant effect. This study highlights the importance of fostering positive attitudes toward PUF management, creating a supportive social environment, empowering individuals with knowledge and resources, and emphasizing environmental awareness in flood hazard reduction. The results provide empirical evidence supporting the inclusion of environmental awareness as a key determinant in an extended behavioral model. Enhancing citizens' understanding of the immediate benefits of PUFs is crucial for promoting active participation in flood mitigation initiatives.

**Keywords:** urban flood; environmental awareness; participatory forest management; risk perception; extended Theory of Planned Behavior; peri-urban forests



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## 1. Introduction

Urbanization has driven rapid city expansion, leading to the widespread conversion of natural landscapes into impervious surfaces [1]. This transformation has introduced numerous environmental challenges, with increased flood risk being among the most significant [2,3]. Urban areas are particularly vulnerable to flooding due to the concentration of impervious surfaces and the disruption of natural hydrological systems [4]. The combined effects of urbanization and climate change have exacerbated flood-related damages globally, impacting economies and human lives. For instance, flood damages in Italy between 1980 and 2020 amounted to approximately EUR 38 billion [5], while the 2023 flood in Beijing, China, affected 1.29 million individuals and resulted in 33 fatalities [6]. Consequently, urban planners, environmentalists, and policymakers have sought effective strategies to mitigate flood hazards and bolster urban resilience, including traditional grey infrastructure and green infrastructure solutions [7]. Nature-based solutions, such as green infrastructure, are gaining recognition as innovative flood mitigation strategies [8]. Peri-urban forests (PUFs), combining trees, parks, natural forests, and plantations on city outskirts, are valued for the range of ecosystem services that they provide, including climate regulation, recreation, soil and water conservation, and flood mitigation [8,9]. These areas act as natural buffers, intercepting and retaining rainfall [10], regulating runoff, and enhancing soil absorption [11], thereby reducing water discharge and the likelihood of floods [12,13]. Compared to traditional grey infrastructure, green infrastructure solutions often demonstrate greater effectiveness and cost-efficiency [6]. For example, research indicates that a 25% increase in urban green networks can result in a 40% reduction in flood-related damages [12]. Despite the growing recognition of PUFs in flood mitigation, several challenges hinder their effective integration into urban planning. These include limited space for forest expansion, competing land-use demands, and the need for long-term maintenance and management [9,14]. Addressing these complex flood-related issues necessitates collaboration beyond governmental efforts, requiring active public participation in sustainable natural disaster management [15,16]. Public engagement in PUF management represents a viable non-structural approach to flood mitigation, providing diverse perspectives and locally tailored solutions to flood challenges [17]. Moreover, public participation in PUF management can contribute significantly to flood mitigation by fostering ecological balance [18] and enhancing urban resilience [15,18].

Understanding the factors that influence citizens' intention to participate in PUF management for flood mitigation is a critical first step in developing effective participatory strategies. Citizen involvement in PUF management is shaped by socio-behavioral factors, including demographic and behavioral variables, which can be effectively analyzed using social psychological models such as the Theory of Planned Behavior (TPB). The TPB is a widely applied framework for assessing behavioral intentions across various environmental contexts, including forest-based ecotourism [19], forest conservation [20,21], geohazard mitigation [16], and urban forestry [22], as well as pro-environmental intentions and behaviors among hikers [23] and customers [24].

Despite the recognized benefits of PUFs for flood mitigation, limited research has applied the TPB specifically to understand citizens' intentions in this context. Existing studies have mainly focused on post-flood recovery efforts and adaptive behaviors [16,25–27]. This study addresses this gap by applying the TPB to examine the factors influencing citizens' intentions to engage in PUF management for flood mitigation. Hence, the research objectives were as follows: (1) to identify the factors influencing citizens' intentions to participate in PUFs for flood mitigation, (2) to extend the application of the TPB to include public participation in flood mitigation, and (3) to explore the influence of additional variables on individuals' intentions. The findings of this study offer valuable insights for managers and policymakers in designing collaborative programs to conserve PUFs. Moreover, the results highlight the key factors shaping individuals' intentions to engage in forest conservation efforts aimed at mitigating flood damage. These insights can inform the development of educational and promotional initiatives to enhance community participation in sustainable flood management strategies.

## 2. Theoretical Framework of the Study

### *2.1. Theory of Planned Behavior*

This study applied the TPB as its theoretical framework. The TPB, proposed by Ajzen in 1991, is a widely recognized psychological model that connects beliefs to behavioral intentions [28]. While other models, such as the value–belief–norm model, focus on behavior, the TPB is particularly well suited to assess behavioral intentions due to its flexible framework, which allows for the incorporation of additional variables to enhance predictive accuracy [29,30]. The TPB posits that three key components, including attitude, subjective norms (SNs), and perceived behavioral control (PBC), influence an individual's behavioral intentions. This model aims to explain how these components shape intentions and subsequent behaviors [31]. The TPB has been widely applied to research on adaptive behaviors in response to natural disasters. For example, it has been used to study adaptive responses to flooding [27], adaptation to droughts [32], disaster preparedness [25], and public intentions to engage in geohazard mitigation efforts [16]. Empirical validation of the TPB's constructs in these contexts underscores its relevance and applicability in understanding adaptive behaviors within disaster scenarios.

Attitude is a key determinant of intention, reflecting an individual's assessment of a behavior as either positive or negative. Research consistently shows that a positive attitude correlates with a higher likelihood of engaging in a behavior [21]. Specifically, in the context of PUFs' conservation for flood mitigation, both emotional responses and cognitive evaluations towards participation play a pivotal role [33]. Consequently, we hypothesize that individuals with a positive attitude towards PUF management will be more inclined to participate. Hence, our first hypothesis was formulated as follows:

**H1:** *Individuals' attitudes significantly influence their intention to participate in PUF management activities for flood risk mitigation.*

SNs, or perceptions of social pressure to perform a behavior, are shaped by beliefs about whether significant others approve or disapprove of the action [28]. This social influence is a critical factor in shaping intentions, as individuals often consider the expectations of close relationships—family, friends, and community—when making decisions [34,35]. In PUF conservation, the perceived support or opposition from these relationships can significantly affect an individual's intention to participate. Thus, the second hypothesis was formulated as follows:

**H2:** *SNs have a significant positive influence on individuals' intentions to engage in PUF management for flood risk mitigation.*

PBC reflects an individual's assessment of their ability to perform a behavior, considering both facilitating and hindering factors [28]. This component is crucial within the TPB, as it impacts both intentions and behaviors directly [36,37]. Evidence suggests that a strong belief in one's capacity to participate in PUF management enhances the willingness to do so. Thus, we propose the third hypothesis:

**H3:** *Individuals' PBC positively influences their intentions to participate in PUF management for flood risk mitigation.*

### 2.2. The Extended Theory of Planned Behavior

The TPB has been extended with additional factors to improve its predictive accuracy, especially for analyzing environmental behaviors. This extended framework, which incorporates environmental awareness and risk perception, has been successfully applied in various environmental contexts, including green purchasing [38], disaster risk perception [25], energy consumption [39], and forest conservation [40,41]. By integrating environmental awareness and risk perception, this study aims to provide a deeper understanding of the determinants shaping citizens' intentions to participate in PUF management for flood mitigation.

Environmental awareness, defined as an individual's knowledge and concern for environmental issues, is a strong driver of pro-environmental behaviors [36]. Studies demonstrate that environmental awareness can influence behaviors such as ecofriendly purchasing [42], organic food purchasing [43], green hotel usage [44,45], and willingness to pay for green products. These studies confirm the strong relationship between environmental awareness and both behavioral intentions and actual behaviors. While the role of environmental awareness in flood risk mitigation has yet to be widely examined, it is reasonable to expect that increased awareness may enhance intentions to participate in PUF management. Thus, the fourth hypothesis was developed as follows:

**H4:** *Environmental awareness positively influences individuals' intentions to participate in PUF management for flood risk mitigation.*

Risk perception, a key determinant of pro-environmental intention and behavior, reflects individuals' beliefs about the likelihood and severity of a potential threat [45,46]. Individuals' perceptions regarding specific issues can determine their intentions and behaviors [47,48]. In the context of natural disasters (e.g., flood risk), individuals' understanding of the likelihood and consequences of natural disaster may influence their intention to participate in PUF management [49]. This encompasses an individual's understanding and assessment of the potential harm, impact, and consequences posed by a specific hazard or threat [50]. Given its potential impact, risk perception is included in the extended TPB model to assess its role in shaping behavioral intentions. The fifth hypothesis was formulated as follows:

**H5:** *Individuals' perception of flood risk significantly influences their intention to participate in PUF management for flood risk mitigation.*

In summary, this study incorporates both the original and extended TPB models, as shown in Figure 1.

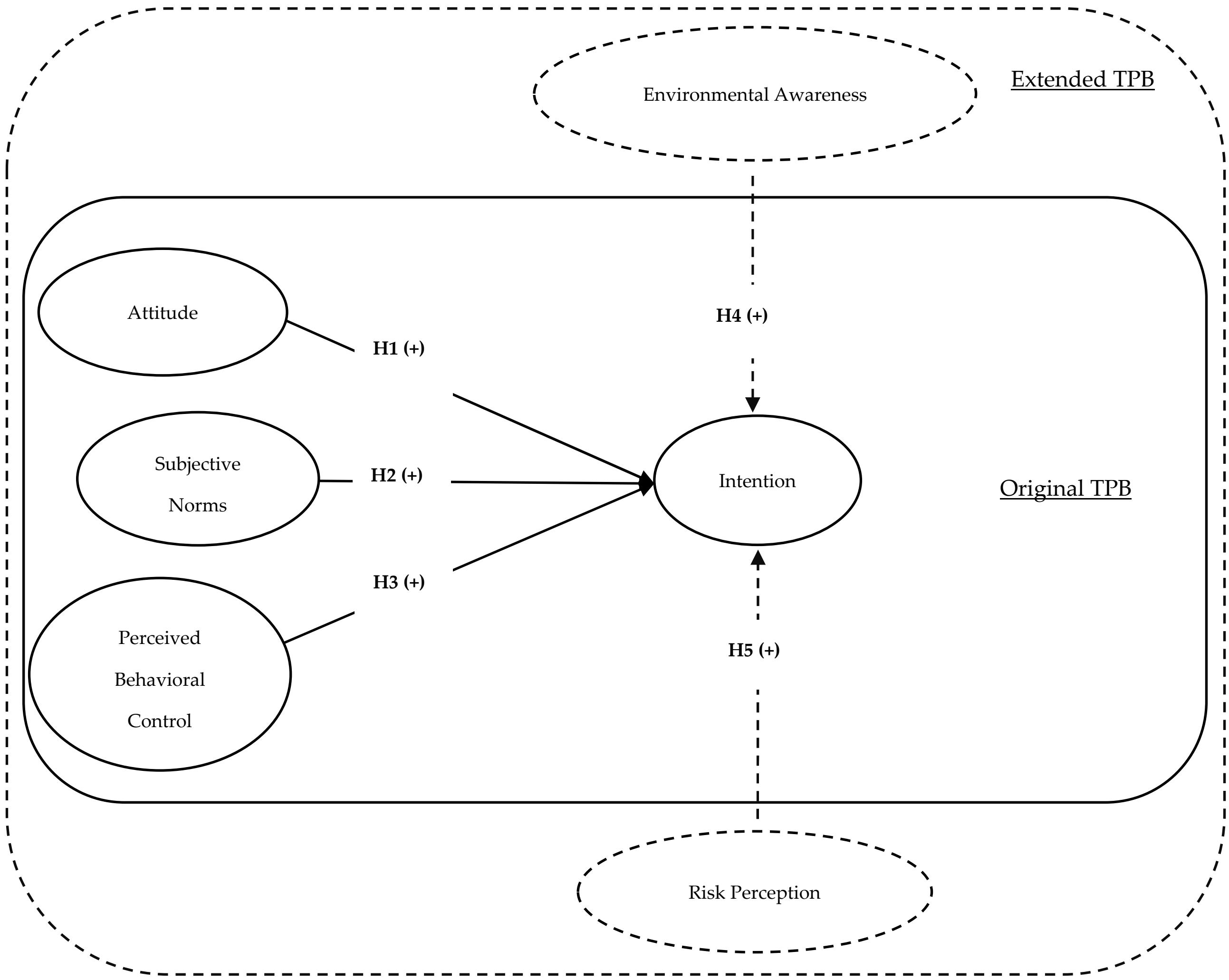


**Figure 1.** Theoretical framework of the study, illustrating the original components of the Theory of Planned Behavior (TPB) with solid arrows and the extended variables integrated into the model with dashed arrows. The "+" symbol indicates hypothesized positive impacts.

## 3. Materials and Methods

This section outlines the research methodology, which was conducted in multiple stages, as illustrated in Figure 2. Each stage is described in detail below.

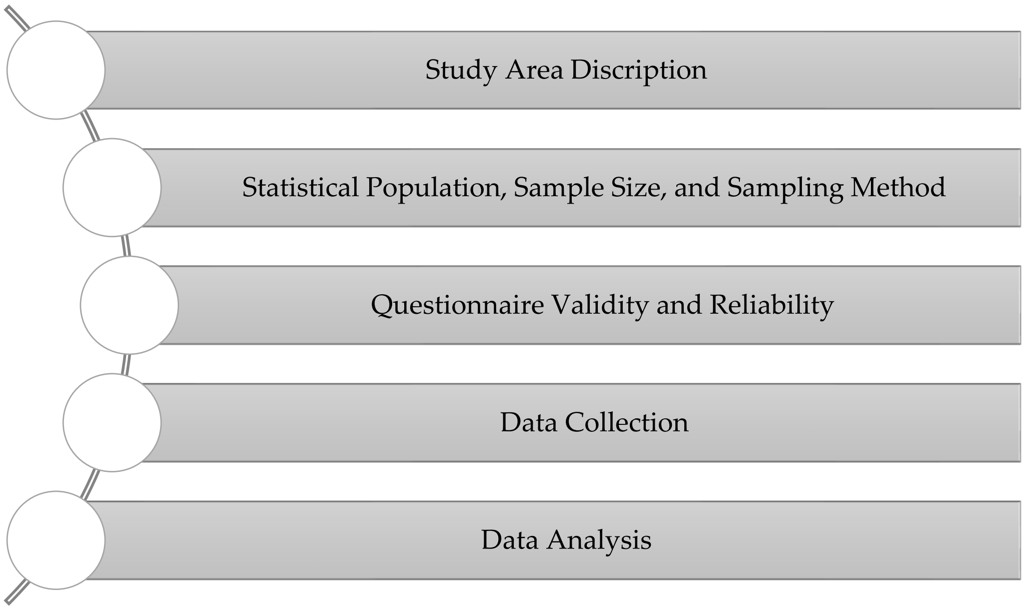


**Figure 2.** Flowchart illustrating the sequential stages of the study's methodology.

### *3.1. Study Area*

This study focuses on PUFs in Tehran (Figure 3)—the most populous city in Iran and Western Asia, and the second-largest metropolitan area in the Middle East—which are popular recreational spots for citizens, particularly for hiking. The northern part of Tehran is rich in streams and rivers, which have contributed to the development of mountainous villages and extensive orchards. Large-scale tree-planting efforts [51] have resulted in the formation of forested areas along river valleys. These valleys, with their vegetation consisting of orchards, rangelands, and forests, play an important role in environmental protection, safeguarding water and soil resources. Moreover, they contribute to the historical and cultural heritage of the city. The tree cover in these river valleys also affects Tehran's climate [51], making conservation efforts crucial for the city's sustainability. Tehran has experienced several devastating floods in recent decades, including notable events in 2010, 2012, 2015, and 2022 [52]. These floods caused casualties and significant damage [52], highlighting the city's vulnerability. Floods have also resulted in soil erosion and land degradation, exacerbated by deforestation [53]. While previous research has explored structural strategies to address floods in Tehran, such as river course modification, dam construction, and the building of levees [52,54], less attention has been given to nature-based solutions. Research findings suggest that nature-based solutions are both more effective and cost-efficient compared to traditional approaches [11]. Reforestation and the conservation of existing forests in upstream river areas near urban centers represent a particularly advantageous nature-based solution [9,55]. These strategies effectively retain water, reduce rapid runoff into downstream areas, and mitigate flood risks in urban regions [56]. The conservation and management of PUFs stand out as a nature-based strategy that provides a variety of ecosystem services [57] and serves as an effective approach for flood mitigation. Despite the potential of public participation in managing these resources for flood mitigation, no research has yet explored this aspect in the world.

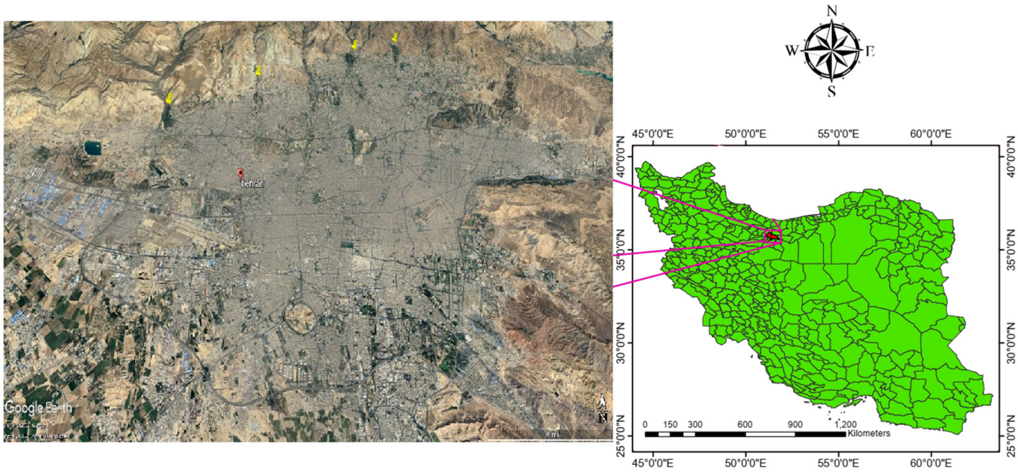


**Figure 3.** Study area, with sampling locations indicated by yellow dots.

## *3.2. Statistical Population, Sample Size, and Sampling Method*

This study specifically targeted individuals visiting PUFs in Tehran. To determine an appropriate sample size, the Krejcie–Morgan [58] table was used, which yielded a required sample size of 386 participants. This provides a standardized approach to ensure that the sample size is representative of the population, which enhances the generalizability of the findings. To further enhance the robustness of the results and account for potential non-responses, the researchers aimed to collect a larger sample. Consequently, after excluding 28 incomplete questionnaires, a total of 450 valid questionnaires were included in the final analysis (details provided in the Supplementary Materials). Data were collected using a stratified sampling method [59]. First, four PUF regions were selected from eight in northern Tehran. Each PUF region was considered as a separate class. The total sample size was then divided proportionally across these 4 regions, with random sampling conducted within each region.

## *3.3. Data Collection*

Data collection was conducted through a structural questionnaire, divided into three sections. The first section introduced an overview of the survey's objectives and detailed instructions for participants. The second section gathered demographic information, such as gender, age, educational level, and additional relevant variables. The third section assessed key theoretical constructs, such as attitudes, SNs, PBC, intentions, environmental awareness, and risk perception, using a 5-point Likert scale. The 5-point Likert scale ranged from "strongly disagree" to "strongly agree", providing a balanced range of response options [60]. This scale was chosen for its reliability, its ease of interpretation, and its frequent use in environmental science research to measure attitudes and perceptions [61,62]. The questionnaire underwent a two-step evaluation process before the main data collection phase. First, it was reviewed by a panel of 12 national experts from various relevant fields, including agricultural extension, education, environmental sciences, forestry, social sciences, and urban studies. The experts assessed the survey instrument for relevance and alignment with the research objectives. Their feedback was used to refine and improve the questionnaire. In the second phase, a pre-test was conducted with 30 participants to further evaluate the instrument. The analysis revealed that the Cronbach's alpha [63] for all constructs in the model exceeded the acceptable threshold of 0.7, indicating strong internal consistency. Following this two-step validation process, the questionnaire was finalized and used for the main data collection. Questionnaires were distributed through face-to-face interviews at various times of the day and week to ensure a representative sample. Each participant was informed about the study's purpose, and informed consent was obtained before they completed the survey. Participants were given adequate time to fully understand and respond to the questions posed. Data collection took place during the summer and fall of 2023, with an average completion time of 24 min per respondent.

### *3.4. Data Analysis*

This study employed a two-step method for data analysis to ensure the reliability of the measurement instruments and the validity of the results. In the first phase, the reliability and validity of the measurement scales were thoroughly assessed to confirm their suitability for analysis. Internal consistency was evaluated using Cronbach's alpha, with a threshold of 0.70 established as the minimum acceptable level [63]. This measure reflects the correlation among items within each construct, indicating the reliability of the scales. Additionally, Composite Reliability (CR) was calculated, providing a more refined reliability measure by accounting for the varying loadings of items within each construct. A CR value above 0.70 was considered adequate [64]. Construct validity was assessed through convergent and discriminant validity. Convergent validity was determined using the Average Variance Extracted (AVE), where an AVE value greater than 0.50 indicated that the items explained more than half of the variance in their respective construct, confirming they measured the same underlying concept [64]. Discriminant validity was evaluated using the Fornell–Larcker criterion, which requires the square root of the AVE for each construct to be greater than its correlations with other constructs in the model. This ensures that each construct is unique and not simply a reflection of another [65]. These assessments confirmed the reliability and validity of the measurement scales, providing a robust foundation for subsequent analyses.

In the second step, Structural Equation Modeling (SEM) was employed to examine the relationships among the variables in this study. SEM is a powerful statistical technique that enables the analysis of complex interrelationships between multiple variables within a single model. This approach facilitates comprehensive hypothesis testing while accounting for measurement errors. Its strength lies in its ability to analyze both observed and latent (unobserved) variables, providing deeper insights into the underlying constructs and their interconnections [66]. By utilizing SEM, this study achieved a robust determination of the underlying factors and their interactions within the theoretical framework. This technique allows for a nuanced exploration of the complex relationships between constructs, enhancing the interpretability of the findings [65]. SEM also supports the evaluation of the model's overall fit and the significance of individual paths or relationships among variables, enabling researchers to determine how well the proposed model aligns with the observed data. This includes assessing the strength and direction of specific relationships within the framework [50]. The data were analyzed using two software tools: SPSS (Ver. 24) for descriptive analysis, and SmartPLS (Ver. 3) for SEM.

## 4. Results

### *4.1. Demographic Characteristics of Participants*

The demographic characteristics of the study participants are illustrated in Table 1. The gender distribution was relatively balanced, with 227 participants (50.4%) identifying as female and 223 participants (49.6%) identifying as male. Regarding marital status, 212 participants (47%) reported that they were single, and 238 participants (53%) were married. The participants' ages were distributed as follows: 35 participants (7.7%) were under 20 years old, 108 participants (24%) were aged 21 to 30, 143 participants (31.8%) were between 31 and 40, 112 participants (24.9%) were aged between 41 and 50, and 52 participants (11.6%) were over 50 years old. In terms of educational level, none of the participants were illiterate. The majority held a bachelor's degree, with 187 participants (41.6%) holding a bachelor's degree as their highest education level. Other educational levels included middle school (32 participants, 7.1%), high school diploma (93 participants, 20.7%), associate degree (71 participants, 15.7%), and master's degree or higher (67 participants, 14.9%). In terms of occupation, the largest group consisted of full-time workers (245 participants, 54.5%). Other occupations included housewives (52 participants, 11.5%), part-time workers (90 participants, 20%), unemployed participants (35 precipitants, 7.8%), and students (28 precipitants, 6.2%).

**Table 1.** Demographic characteristics of the participants.

| | Categories | Frequency | Percentage |
|---|---|---|---|
| Gender | Male | 223 | 49.6 |
| | Female | 227 | 50.4 |
| Marital Status | Single | 212 | 47 |
| | Married | 238 | 53 |
| Age (years) | <20 | 35 | 7.7 |
| | 21–30 | 108 | 24 |
| | 31–40 | 143 | 31.8 |
| | 41–50 | 112 | 24.9 |
| | >50 | 52 | 11.6 |
| Educational Level | Middle school | 32 | 7.1 |
| | High school | 93 | 20.7 |
| | Associate degree | 71 | 15.7 |
| | Bachelor | 187 | 41.6 |
| | Above bachelor | 67 | 14.9 |
| Occupation | Full-time | 245 | 54.5 |
| | Housewife | 52 | 11.5 |
| | Part-time | 90 | 20 |
| | Unemployment | 35 | 7.8 |
| | Student | 28 | 6.2 |

### *4.2. Reliability and Validity*

Table 2 presents the results of the reliability and validity analysis for the survey instrument used in this study. The Cronbach's alpha values ranged from 0.77 to 0.97, indicating a high level of internal consistency and robust reliability [63]. Furthermore, the CR values for all constructs in the research model exceeded 0.87, providing additional evidence of their reliability [64]. The AVE values for all constructs exceeded the recommended threshold of 0.50, as proposed by Fornell and Larcker [65], confirming satisfactory convergent validity. The careful design and selection of the items used to measure the constructs contributed to these favorable reliability and validity outcomes. These results confirm the robustness of the measurement model, providing confidence in the reliability and validity of this study's results. Consequently, the credibility of the potential replicates and overall trustworthiness of the study's outcomes were significantly strengthened

**Table 2.** Constructs of the model, with reliability and validity results.

| Constructs | Measurement Items | Reliability and Validity * | References |
|---|---|---|---|
| Attitude | Participation in PUF management is important for reducing flood hazards in our community. | AVE: 0.940<br>CR: 0.979<br>α: 0.968 | [66] |
| | Participating in PUF management improves the overall quality of life in our neighborhood. | | |
| | Participation in PUF management is necessary to reduce flood hazards in our community. | | |
| Subjective Norms (SNs) | My friends and family think it is important for me to be actively involved in PUF management to mitigate flood hazards. | AVE: 0.704<br>CR: 0.877<br>α: 0.790 | [16,21,67] |
| | Community leaders and influential individuals in our area strongly support citizen participation in PUF management. | | |
| | There is a social expectation in our community to engage in activities that promote PUF management for flood hazard mitigation. | | |

**Table 2.** *Cont.*

| Constructs | Measurement Items | Reliability and Validity * | References |
|---|---|---|---|
| Perceived Behavioral Control (PBC) | I have the necessary knowledge and skills to actively participate in PUF management efforts to mitigate flood hazards. | AVE: 0.696<br>CR: 0.873<br>α: 0.786 | [67,68] |
| | There are ample opportunities available for me to contribute meaningfully to PUF management and flood hazard mitigation. | | |
| | I have sufficient resources and time to commit to activities related to PUF management for flood hazard mitigation. | | |
| Environmental Awareness | I am well informed about the ecological benefits of PUFs and their role in flood hazard mitigation. | AVE: 0.864<br>CR: 0.962<br>α: 0.947 | [46,69] |
| | I understand the potential consequences of not conserving PUFs on increasing flood risks in our community. | | |
| | I am aware of the ongoing environmental challenges in our region and recognize the importance of PUF management in addressing them. | | |
| Risk Perception | I perceive flood hazards as a significant risk to our community, and I believe that PUF management can help mitigate these risks. | AVE: 0.854<br>CR: 0.959<br>α: 0.943 | [16,25,49] |
| | I am aware of the potential negative consequences of not managing PUFs, such as increased vulnerability to flooding and property damage. | | |
| | I perceive the loss of PUFs as a risk factor that could exacerbate flood hazards and have long-term impacts on our community's well-being. | | |
| | I believe that active participation in PUF management can reduce the likelihood and severity of floods, enhancing our overall resilience to such risks. | | |
| Intention | I intend to actively participate in flood hazard mitigation efforts through PUF management. | AVE: 0.784<br>CR: 0.935<br>α: 0.908 | [34,66] |
| | I am motivated to contribute my efforts towards PUF management for flood hazard mitigation. | | |
| | I am committed to taking action and engaging in PUF management practices to mitigate the risks of flooding. | | |
| | I have a strong intention to support and participate in initiatives that focus on PUF management as a means to effectively address flood hazards. | | |

* AVE: Average Variance Extracted, CR: Composite Reliability, α: Cronbach's alpha.

### 4.3. Discriminant Validity

The discriminant validity findings demonstrated that all constructs exhibited acceptable levels of discriminant validity (Table 3), confirming that the constructs are distinct and measure different aspects or dimensions. This supports the validity of the measurement instrument used to assess individuals' attitudes, SNs, PBC, environmental awareness, risk perception, and intentions [65]. The confirmed discriminant validity indicates that these constructs effectively measure separate and independent concepts, allowing for a comprehensive analysis of relationships within the model. These results enhance confidence in the theoretical framework of this study, lending credibility to the relationships explored among the constructs. The validation strengthens the overall validity of the research findings, supporting the use of these constructs in studying flood hazard mitigation through PUF management.

**Table 3.** Results of discriminant validity test.

| Constructs | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Attitude | 0.970 | | | | | |
| Environmental Awareness | 0.409 | 0.929 | | | | |
| Intention | 0.551 | 0.656 | 0.885 | | | |
| Perceived Behavioral Control (PBC) | 0.491 | 0.426 | 0.614 | 0.834 | | |
| Risk Perception | 0.393 | 0.898 | 0.638 | 0.438 | 0.924 | |
| Subjective Norms (SNs) | 0.353 | 0.419 | 0.599 | 0.490 | 0.389 | 0.839 |

### *4.4. Research Structural Model and Hypothesis Testing*

The findings from the initial model, depicted in Figure 4, indicate that the variables of attitude, SNs, and PBC collectively account for 55.1% of the variance in individuals' intention to participate in PUF management for flood mitigation. This substantial variance suggests the significant influence of these variables on individuals' intentions. Among them, SNs (ƛ= 0.353) and PBC (ƛ= 0.305) have the greatest standardized impacts on individuals' intention to participate in PUF management for flood mitigation. Figure 5 presents the extended model, which incorporates the additional variables of risk perception and environmental awareness. The findings demonstrate that including these additional variables significantly enhances the explanatory power of the model, accounting for 65.2% of the variation in intention. This improvement suggests that incorporating risk perception and environmental awareness, as new constructs in the model, provides a more comprehensive understanding of the factors influencing individuals' participation intentions.

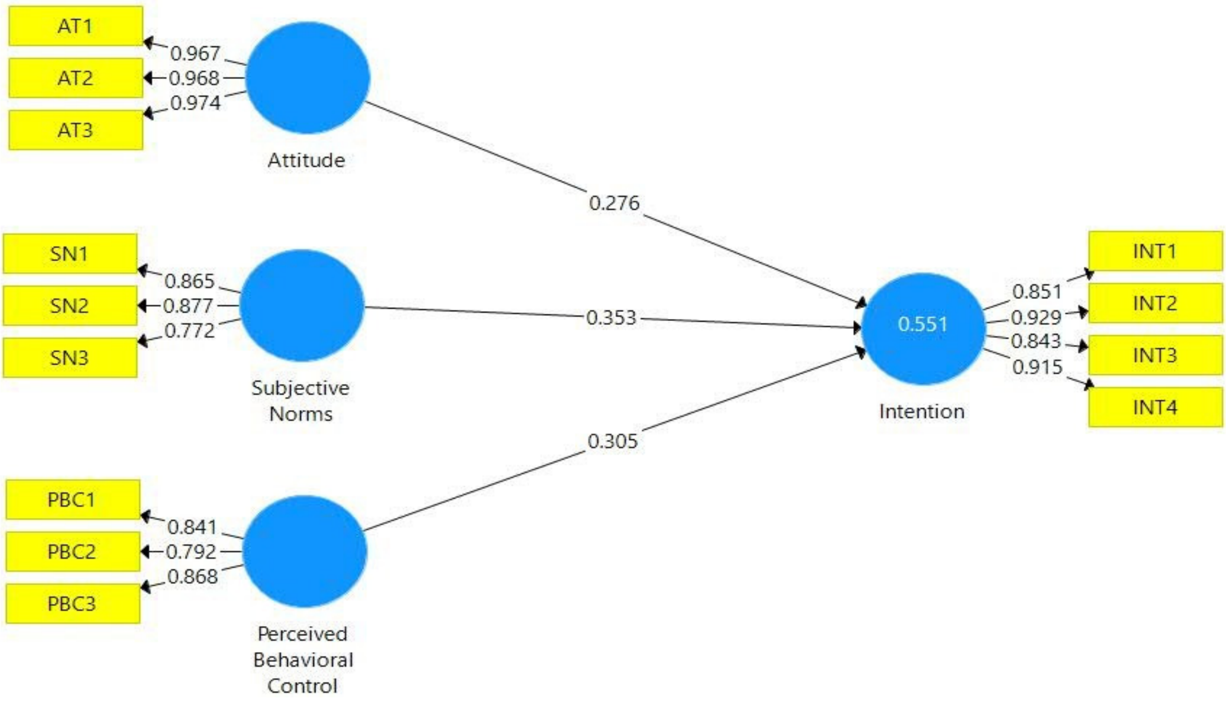


**Figure 4.** Structural model of the original Theory of Planned Behavior (TPB), with standardized path coefficients.

Path analysis was used to test the proposed hypotheses and examine the relationships between variables. The findings (summarized in Table 4) are as follows:

H1 posited a positive influence of attitude on intention. The analysis revealed a significant and positive path coefficient (t = 4.844, $p < 0.001$), confirming this hypothesis. These results underscore the crucial role of attitude in shaping individuals' intentions to participate in PUF management for flood mitigation

H2 proposed a positive impact of SNs on intention. The statistical analysis yielded a significant and positive path coefficient (t = 7.308, $p < 0.001$), supporting the hypothesis. This highlights the influence of social expectations on individuals' intention to engage in PUF management.

H3 proposed a positive influence of PBC on individuals' intention. The analysis showed a significant positive relationship (t = 5.765, $p < 0.001$), confirming the hypothesis. This result indicates the importance of individuals' perceived control over their actions as a determinant of their intention to participate in PUF management for flood mitigation.

H4 aimed to test the influence of risk perception on intention. However, the analysis showed no significant relationship (t = 1.683, $p = 0.093$), resulting in the rejection of this hypothesis. This suggests that risk perception does not have a direct effect on individuals' intentions regarding participation in PUF management for flood mitigation, calling for further investigation into its indirect effects.

H5 postulated a positive effect of environmental awareness on intention. The analysis revealed a significant positive relationship (t = 2.921, $p < 0.001$), thereby confirming the hypothesis. This reveals the importance of individuals' environmental awareness as a motivating factor driving their intentions to engage in PUF management for flood mitigation.

These results highlight the significant roles of attitude, SNs, PBC, and environmental awareness in shaping citizens' intentions to participate in PUF management for flood mitigation. While the inclusion of risk perception and environmental awareness significantly improved the explanatory power of the model, risk perception did not have a direct effect on intention.

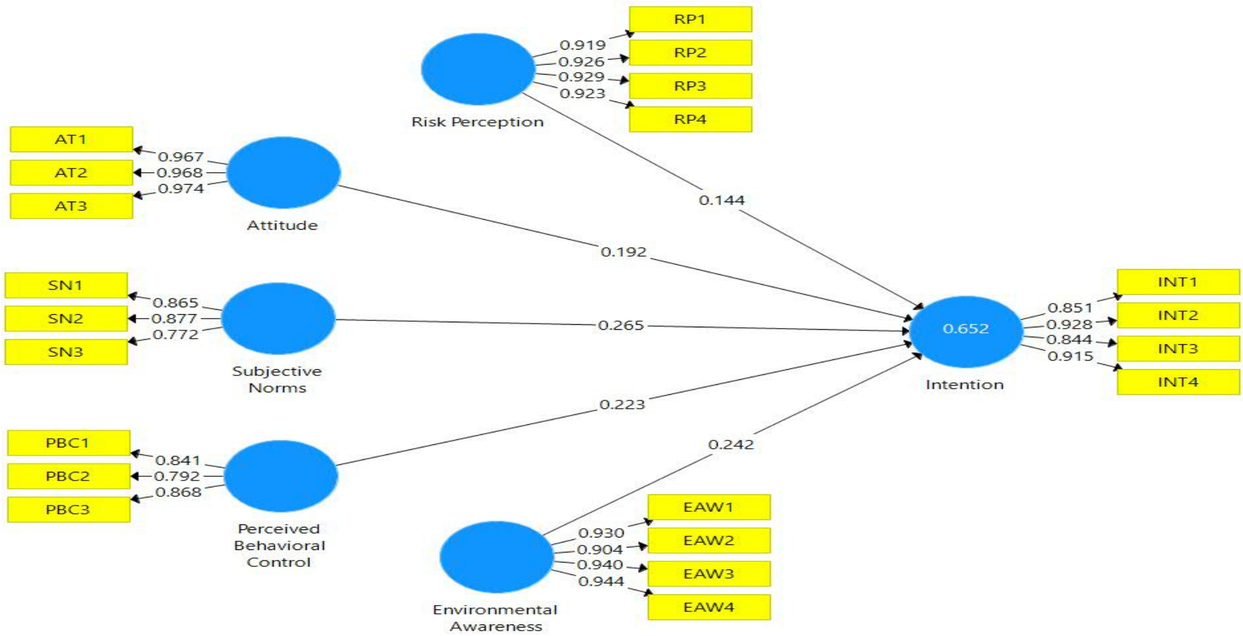


**Figure 5.** Structural model of the extended Theory of Planned Behavior (TPB), with standardized path coefficients.

**Table 4.** Results of the research hypothesis tests.

| Hypotheses | Path | t-Value | *p*-Value | Result |
|---|---|---|---|---|
| H1 | Attitude → Intention | 4.844 | 0.00 | Confirmed |
| H2 | Subjective Norms → Intention | 7.308 | 0.00 | Confirmed |
| H3 | Perceived Behavioral Control → Intention | 5.765 | 0.00 | Confirmed |
| H4 | Environmental Awareness → Intention | 2.921 | 0.00 | Confirmed |
| H5 | Risk Perception → Intention | 1.683 | 0.09 | Rejected |

## 5. Discussion

### *5.1. Advantages of the TPB Model and Key Findings from the Study*

This study used the TPB to investigate citizens' intentions to participate in PUF management, specifically in the context of flood hazard mitigation. The study aimed to improve the TPB model by introducing two additional constructs—environmental awareness and risk perception—to explain the intended outcomes more effectively. The results support the theoretical foundation of the TPB, highlighting the significant influence of core variables—attitudes, SNs, and PBC—on citizens' intentions to participate in PUF management for urban flood mitigation. Additionally, the inclusion of risk perception and environmental awareness as new constructs in the extended model improved its explanatory power. These findings underscore the importance of considering these additional factors when designing strategies to promote citizens' engagement in PUF management. The results align with those of previous research that evaluated pro-environmental intentions across various domains, such as payment for ecosystem services in urban forests [70], ecofriendly purchasing intentions [71], ecotourism [29], and consumer behavior related to food management [50]. Several studies have similarly applied extended TPB models to pro-environmental activities, particularly in forest conservation [22,40]. Consistent with those studies, the current findings demonstrate that the extended model is valuable for understanding and predicting pro-environmental intentions. Overall, this study reveals the effectiveness of the TPB in explaining citizens' intentions to participate in PUF management, particularly in the context of flood hazard mitigation.

The results of the hypothesis tests were as follows: The findings for hypothesis 1 (H1) confirmed a significant positive influence of attitude on intentions. The influence of attitude on intentions has been consistently emphasized in previous studies [27,37], which have regarded attitude as a key factor in understanding individuals' intentions. This finding highlights the human dimension of environmental engagement, suggesting that individuals who recognize the importance of conserving natural spaces for flood mitigation are more likely to take concrete steps toward their preservation. The significant impact of attitude on intention emphasizes the need to focus on attitude formation and promotion when encouraging citizen participation in PUF management. However, in this study, the influence of attitude on intention was weaker compared to that of SNs, PBC, and environmental awareness. This could be due to specific factors related to the complexity and effort required by the behavior under investigation. The behavior of participation in PUF management for flood mitigation may be perceived as effort-intensive, requiring significant time, resources, and commitment. In such cases, individuals might rely more on their perceived ability to perform the behavior and the social support or pressure that they receive [72].

The confirmation of the second hypothesis (H2) highlighted the significant influence of SNs, including the support and expectations from important individuals such as friends and family, on participants' intention to engage in PUF management for flood hazard mitigation. These findings align with those of previous research indicating the impact of SNs on individuals' intentions to pay for urban forest conservation [40]. Similarly, studies in the context of geohazard mitigation have shown the crucial role of SNs in shaping individuals' intentions [16]. The results of this study highlight the robust influence of social pressures and communal norms in motivating individuals to participate in PUF management as a strategy for mitigating flood risk in urban areas. It can be argued that the participation of influential individuals in forest conservation efforts can encourage others to become involved in management activities [21]. Therefore, encouraging participation from socially influential individuals can strengthen the behavioral intentions of others to engage in these initiatives. Individuals must also believe that they have the capability to perform the behavior [21]. Therefore, promotional and educational programs should be designed and implemented to enhance individuals' skills and capabilities for participating in forest management programs, ultimately increasing their perceived ability to engage in such behaviors.

PBC, which reflects individuals' beliefs about their capabilities and available resources, was found to significantly influence intention (hypothesis 3, H3). The literature [73,74] indicates that individuals who perceive themselves as possessing the necessary knowledge, skills, and resources are more likely to have a strong intention to engage in pro-environmental behaviors, especially in forest management. This suggests the importance of providing educational and training programs that empower individuals and enhance their perceived control over their ability to participate in PUF management. However, having a positive attitude or experiencing social pressure alone may not be sufficient to translate into behavioral intentions and actual participation [73].

Environmental awareness was identified as another significant factor influencing individuals' intentions (H4). This finding aligns with prior research, which highlights the substantial impact of environmental awareness on individuals' intentions to engage in pro-environmental behavior [34,36,39]. The results of this study support the notion that individuals who recognize the crucial role that PUFs play in mitigating flood hazards are more inclined to actively engage in their conservation. Studies have also shown that this environmental awareness can influence other behavioral factors and indirectly shape individuals' intentions and actions [69]. Therefore, investigating the impact of this factor on individuals' attitudes could be a promising research topic for future studies. This underscores the importance of environmental education and communication in promoting active participation in forest conservation.

The inclusion of risk perception as a new construct in the extended TPB model did not show a significant effect on individuals' intentions to participate in PUF management (H5). While some research has shown the influence of risk perception on individuals' intentions [25,41,75,76], other studies have found that risk perception is not a reliable predictor of environmental behavior [46]. It has been indicated that risk perception is more context-specific [49], and those participating in this research may not have faced the direct threat of flooding in their neighborhoods. In some studies, risk perception has been examined as a mediating factor [77–79], but it can be influenced or moderated by variables such as personal flood experience [26]. Some studies suggest that individuals' perceptions of factors such as climate change or agricultural practices can significantly influence their intentions and behaviors [47,48]. Variations in research findings may arise from differences in the specific conditions and contexts of each study. Given that floods do not uniformly affect all urban areas, this variability may explain the lack of a significant effect on behavioral intentions in this study. Educating citizens about the indirect effects of floods—such as the strain on public budgets for compensation, impacts on healthcare costs, traffic disruptions, and unplanned closures, all of which have economic implications for citizens' lives—can enhance their understanding of flood risks. Consequently, this could increase individuals' intentions to participate in flood risk reduction programs, including forest management initiatives. This highlights the importance of linking PUF management with flood hazard mitigation benefits in educational and awareness campaigns. Citizens should understand a city as a complex, interconnected system and perceive flood risks as a threat not only to specific areas but to the entire urban environment.

### *5.2. Implications*

#### 5.2.1. Theoretical Implications

This study makes a significant theoretical contribution by extending the TPB to the domain of PUF management for urban flood mitigation. While the TPB has been widely used to explore pro-environmental behaviors and conservation efforts, its application in understanding participatory forest management within the context of flood risk reduction remains underexplored. This research addresses this gap by incorporating environmental awareness and risk perception as additional constructs, enhancing the explanatory power of the TPB and offering a more comprehensive framework for analyzing citizen participation in PUF management. A key contribution of this study is its integration of nature-based solutions into behavioral models, emphasizing the pivotal role of PUFs in urban flood mitigation. By connecting these environmental strategies to individual behavioral intentions, this research advances the applicability of the TPB in addressing urban sustainability challenges. This integration illustrates how psychological constructs can inform practical approaches to disaster risk reduction through public engagement. Environmental awareness emerged as a critical determinant in this study, aligning with a growing body of literature that highlights its role in motivating pro-environmental behavior. By incorporating this construct, this research enhances the TPB's predictive accuracy and underscores the importance of ecological knowledge and concern. Our findings reveal that individuals with greater environmental awareness are more likely to engage in conservation behaviors, offering actionable insights for designing educational and promotional initiatives aimed at fostering public participation. Another significant contribution lies in contextualizing risk perception within the framework of flood hazard mitigation. Although widely acknowledged in the disaster preparedness literature, risk perception's role in participatory forest management has been underexamined. By investigating its influence, this study provides a nuanced understanding of how individuals' beliefs about flood risks shape their willingness to engage in PUF management. This study's integrated framework validates the combined effects of attitudes, SNs, PBC, environmental awareness, and risk perception on behavioral intentions. This approach not only enhances the TPB's explanatory power but also establishes a robust theoretical foundation for future research on participatory environmental management. Finally, this study provides context-specific insights by focusing on Tehran, a megacity that is acutely vulnerable to flooding. By examining the socio-psychological dynamics driving citizen participation in PUF management within a developing region, this research contributes to the global discourse on urban resilience and sustainable forest management amidst the challenges of climate change. These findings have broader implications, offering a pathway to integrate nature-based solutions and behavioral insights into urban planning and policy development.

#### 5.2.2. Empirical and Policy Implications

The findings of this study have important empirical and policy implications. First, policymakers and practitioners should prioritize the development of targeted educational and awareness programs to enhance public understanding of the ecological benefits provided by PUFs and the risks associated with their degradation. Emphasizing the role of citizens in mitigating flood hazards through active participation in forest conservation is crucial to achieving sustainable outcomes. Second, efforts should focus on creating a supportive social environment by engaging community leaders, influential individuals, and social networks to promote and endorse citizen participation in forest management activities. Community engagement initiatives, public awareness campaigns, and participatory platforms can facilitate collaboration, build trust, and encourage collective action. Third, it is essential to equip individuals with the resources, skills, and opportunities needed to actively participate in PUF management. Capacity-building programs, hands-on training workshops, and the provision of incentives and support mechanisms can empower citizens to contribute meaningfully to conservation efforts and long-term flood mitigation strategies. Lastly, integrating these findings into flood risk management policies and strategies is crucial. Recognizing the role of PUFs in reducing flood hazards and encouraging citizen participation in their conservation can enhance the resilience and sustainability of urban areas. By embedding these insights into policy frameworks, urban planners and policymakers can create more effective, inclusive, and adaptive approaches to disaster risk reduction. This study provides valuable insights into the factors shaping citizens' intentions to participate in PUF management for flood mitigation, offering practical guidance for promoting public engagement. Further research is needed to explore the effectiveness of different strategies and interventions in fostering sustained citizen participation in PUF management over the long term.

### 5.3. Research Limitations and Future Research

This study has several limitations, and some suggestions are provided here for future research. First, its quantitative nature focuses primarily on establishing causal relationships between variables, potentially overlooking the nuanced understanding of community members' knowledge and intentions. Incorporating qualitative research alongside quantitative analysis in future research could provide a more comprehensive understanding of the factors influencing citizen participation. Second, relying on self-reported data may introduce biases, such as social desirability effects. To mitigate this, future research could include objective measures or behavioral observations. Additionally, the generalizability of the findings may be limited due to specific contextual and sample characteristics. Future studies should aim to use more diverse samples and examine multiple contexts to enhance external validity. Lastly, this study considered two additional factors (i.e., environmental awareness and risk perception). Including more factors in future studies could further enhance the model's predictive capability for understanding behavioral intentions.

## 6. Conclusions

This study investigated the factors influencing citizens' intentions to participate in PUF management for urban flood mitigation, utilizing an extended TPB framework. The findings confirmed that attitude, SNs, PBC, and environmental awareness significantly influence citizens' intentions, while risk perception did not exhibit a direct effect. Hypothesis testing revealed that attitudes positively influence intention, highlighting the importance of fostering favorable perceptions of PUF management. SNs emerged as a critical factor, underscoring the role of social expectations and the support of influential individuals in motivating participation. PBC also demonstrated a significant effect on intention, indicating that enhancing individuals' confidence in their ability to contribute meaningfully is essential for promoting engagement. Environmental awareness was identified as a key determinant, emphasizing the need to raise public awareness of the ecological benefits of PUFs and their vital role in mitigating flood risks. Interestingly, risk perception did not show a direct effect on intention, suggesting that while individuals may recognize flood risks, this awareness alone is insufficient to drive active participation. These findings underscore the need to address both psychological and social drivers to encourage citizen participation in PUF conservation. This research provides a robust theoretical foundation for developing targeted strategies that leverage attitudes, SNs, PBC, and environmental awareness to foster public engagement. Future studies should investigate the potential indirect effects of risk perception and explore additional variables to deepen our understanding of participatory behaviors in PUF management.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/f15122156/s1: the questionnaire used in this study.

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