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The role of demographics in citizens' behavioral intentions for participatory forest management planning

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This study evaluated the influence of demographic variables on Czech citizens' behavioral intentions (IN) to participate in forest management planning, by examining differences in the Theory of Planned Behavior (TPB) model across demographic groups. Structural Equation Modeling (SEM) with multi-group analysis was applied to test how age, gender, education, income, occupation, area of residence, and forest ownership moderated the relationships among attitude (AT), subjective norms (SN), and perceived behavioral control (PBC). The results revealed that gender, education, area of residence, and income significantly moderated the influence of TPB constructs on participatory intention, while age, occupation, and forest ownership inquiry showed weaker or non-significant effects. Females exhibited stronger SN effects ($\beta = 0.929$), whereas males relied more heavily on PBC ($\beta = 1.065$). Higher-income respondents (>1,600 EUR /month) demonstrated a stronger PBC effect ($\beta = 0.597$), while lower-income participants were more influenced by SN ($\beta = 0.933$). Participants with a high school education or less were slightly more influenced by SN ($\beta = 0.902$) compared to college-educated respondents ($\beta = 0.703$). Additionally, suburban and rural residents were slightly more influenced by PBC ($\beta = 0.671$), whereas urban residents were more influenced by SN ($\beta = 0.629$). These findings highlight the importance of demographic and experiential diversity in shaping environmental behavior and provide actionable insights for developing inclusive and effective participatory forest management strategies.

KEYWORDS

behavioral intention, Theory of Planned Behavior (TPB), demographic variables, participatory forest management planning, Czech Republic

1 Introduction

Forest management involves multiple stakeholders with diverse interests, values, and expectations, often leading to differing perspectives on ecosystem planning and governance. Participatory engagement has gained recognition, emphasizing stakeholder involvement from early planning through implementation (Cowling et al., 2014). Such approaches provide critical insights, helping forest managers and policymakers develop socially acceptable and sustainable strategies (Balest et al., 2016). In Europe, forests play a vital role in supporting rural livelihoods and providing urban ecosystem services, contributing to regional biodiversity conservation, carbon storage, and recreational opportunities in line with EU forest policy objectives (Forest Europe, 2020). Consequently, integrated forest management strategies developed through stakeholder consultation are increasingly prioritized (Bleu, 2019; Forest Europe, 2020). Reflecting this trend, the Czech Republic has implemented a national forest

program to promote sustainable forest management principles (Krejzar, 2011). As part of this framework, forest management plans in the Czech Republic are prepared on a standardized 10-year cycle, detailing current stand conditions, planned management activities, and anticipated timber yields (Ministry of Agriculture, Czech Republic, 2021). Research indicates that the Czech public increasingly values non-productive forest functions, such as biodiversity protection, climate regulation, and recreation, while preferences for wood production-oriented management are declining (Stachová, 2018; Šodková et al., 2020). Although forest owners and nature protection representatives are formally included, broader public participation lacks legal support and systematic implementation. Consequently, engagement varies and is influenced by socioeconomic and demographic factors (Panyavaranant et al., 2023), highlighting the need to understand these influences to design effective participatory strategies (Savari et al., 2023a, 2023b; Wambugu et al., 2017). Understanding of the factors influencing public participation are essential for enabling managers and policymakers to develop strategies that effectively align with the priorities, needs, and preferences of local communities (Motamedi Barabadi et al., 2020).

Extensive research has examined the psychological, social, and demographic factors that shape citizens' participation in forest management and environmental governance. Empirical evidence from various countries indicates that demographic characteristics such as age, gender, education, income, and prior experience with forest activities significantly affect individuals' willingness to participate in forest management programs (Obeng et al., 2024; Savari and Khaleghi, 2023; Stockmann et al., 2024). Stockmann et al. (2024) emphasized that small-scale forest owners' age, gender, residence, and property characteristics influence their engagement in both timber-related and non-commodity forest activities. Abdulai (2025) similarly found that age, sex, marital status, education, occupation, and income affect public willingness to participate in urban forest governance in Ghana, with prior conservation knowledge also playing a key role. Moreover, research on urban forest conservation demonstrates that cognitive, emotional, and experiential factors, including environmental awareness, social responsibility, and place attachment, further shape behavioral intentions (Maleknia, 2025; Maleknia et al., 2025; Maleknia and Svobodova, 2025). Galati et al. (2023) found that gender, income, household size, and frequency of visits to green spaces significantly influenced citizens' willingness to participate in urban forestry projects in Palermo, Italy.

Despite these contributions, studies examining the moderating role of demographic variables on participatory intentions in the Czech Republic remain scarce, highlighting the need for context-specific analyses. Demographic characteristics such as age, gender, education, income, occupation, area of residence, and forest ownership may influence how individuals form attitudes, respond to social norms, and perceive their capacity to participate. While Mohammadi et al. (2024) demonstrated that Theory of Planned Behavior (TPB) constructs collectively explain a substantial portion of Czech citizens' behavioral intentions, their study did not assess variations across demographic groups, leaving a critical gap in designing targeted and inclusive participation strategies. Addressing this gap, the present study applies multi-group Structural Equation Modeling (SEM) to examine how demographic factors moderate the relationships among TPB constructs. By identifying how different population segments respond to attitudinal, normative, and control-based influences, this

research provides actionable insights for developing context-sensitive and equitable participatory forest management policies in the Czech Republic.

The study aimed to evaluate the influence of demographic variables on Czech citizens' behavioral intentions to participate in forest management planning. Specifically, it examines how age, gender, education, income, occupation, area of residence, and forest ownership moderate the relationships among attitude, subjective norms, and perceived behavioral control within the TPB framework.

1.1 Theoretical framework

This study is grounded in the TPB (Ajzen, 1991), a widely applied framework for explaining human intentions and behavior in environmental and resource management contexts (Savari et al., 2023a, 2023b; Pham et al., 2023; Amare and Darr, 2023; Sapawi et al., 2024; Al Rousan et al., 2024). TPB asserts that behavioral intention, the most immediate predictor of actual behavior, is influenced by three core constructs: attitude (AT), subjective norms (SN), and perceived behavioral control (PBC). AT refers to an individual's positive or negative evaluation of performing a specific behavior. In forest management, a favorable attitude toward participation may arise from beliefs about environmental benefits, social recognition, or personal satisfaction (Savari and Khaleghi, 2023; Maleknia and ChamCham, 2024; Maleknia and Hälälüşan, 2025). SN represents perceived social pressure from important others, such as family, friends, community leaders, or professional networks, to perform or abstain from a behavior. Prior research has indicated that individuals are more likely to participate in forest management when they perceive social approval or expectations for engagement (Abdulai, 2025; Maleknia et al., 2025). PBC reflects an individual's perception of the ease or difficulty of performing the behavior, considering personal skills, resources, or external constraints. PBC is particularly relevant in participatory forest management, where knowledge, access to planning processes, and experience with forest activities shape the perception of capability to act (Stockmann et al., 2024).

While the TPB has been extensively applied in environmental studies, scholars have emphasized that its explanatory power can be improved by considering demographic variables that influence how attitudes, norms, and control beliefs translate into intentions (Ajzen, 2011). Accordingly, this study integrates demographic characteristics such as age, gender, education, occupation, area of residence, income, and forest ownership experience as potential moderators of the TPB framework. These variables are not merely descriptive; they shape individuals' cognitive, emotional, and experiential engagement with forest ecosystems and participatory processes. Gender highlights the differential impact of demographic variables on behavioral intentions (López-Mosquera, 2016), with other characteristics such as age, education, occupation, and income similarly contributing to variation in participatory behavior.

Gender has been shown to play a particularly distinct role in forestry operations, especially in developing countries (Duguma et al., 2022). Men and women often hold differentiated interests in forest and tree-based goods and services, with women's priorities typically oriented toward household needs such as food and energy provision, whereas men are more often motivated by commercial objectives (Muthee et al., 2021). Supporting this, López-Mosquera (2016) applied

an extended TPB model including moral norms to explore gender differences in willingness to pay for conservation in Spain. Similarly, Maleknia and Svobodova (2025) demonstrated that female high school students in Iran made significant contributions to urban forest conservation for climate change mitigation, where attitudes, PBC, environmental awareness, and social responsibility were strong predictors of intention. Together, these findings highlight the importance of gender-sensitive approaches in participatory forest management.

Age also emerges as a critical factor shaping behavioral intentions. Maleknia et al. (2024b) showed that age moderates the relationships among TPB constructs and forest-related behaviors, while Nichols and Holt (2023) stressed that analyzing intentions within generational cohorts offers valuable insights for conservation planning. Younger individuals may bring enthusiasm but lack resources, while older cohorts may possess experience but exhibit different motivational structures. This suggests that forest participation strategies must be adapted to age-specific characteristics.

Education further strengthens the TPB framework by influencing cognitive and normative pathways. Maleknia et al. (2024a) observed that educational initiatives promote positive attitudes by highlighting ecological benefits such as biodiversity conservation and water quality protection. Education also enhances subjective norms by fostering shared values within communities and increases perceived control by equipping individuals with knowledge and practical skills (Holt et al., 2021). Thus, education not only supports sustainable behavior but also enhances the explanatory relevance of TPB.

Occupational status is another determinant that can shape engagement with forest management. Popa et al. (2019), studying Romanian forest institutions, found that employees' attitudes, norms, and PBC explained their intentions toward forest law enforcement, with professional training and institutional support strengthening their perceived control and commitment. This suggests that occupation-based roles can significantly affect intentions by mediating access to resources, knowledge, and professional networks.

Similarly, the area of residence influences TPB pathways. Urban residents may be more responsive to external social pressures from associations or policy directives, whereas rural and peri-urban residents often rely on place attachment and direct experience with forests, which in turn shape their attitudes and perceived behavioral control (Koskela and Karppinen, 2024). Consequently, area of residence provides an important contextual factor for understanding variations in participatory behavior (Karppinen and Berghäll, 2015). Häyrynen et al. (2015) also found that the more urban the residential area of a forest owner, the greater the influence of external normative pressures on their management decisions.

Economic factors also play a vital role. Income levels shape individuals' attitudes toward sustainable forest management, their sense of control over adopting conservation practices, and the social norms that guide decision-making (Hendrawan and Musshoff, 2024). Dependence on forests for livelihood and income, particularly among rural communities, has been shown to strongly influence behavioral patterns, often leading to unsustainable practices unless collective and systemic shifts toward sustainability are supported (Jannat et al., 2020; Schneiderhan-Opel and Bogner, 2021).

Finally, forest ownership and family involvement represent important experiential dimensions of TPB. Wagner and Miederhoff (2025) showed that intrinsic motivation and emotional ties to forests

within families foster stronger positive attitudes and long-term commitment to management, while lack of skills or time reduces perceived control. Eriksson and Fries (2020) further emphasized that ownership structures and residency size have less direct influence than subjective knowledge, forest values, and owner identity. Thus, ownership interacts with cognitive and social factors that directly affect TPB constructs. Taken together, these studies demonstrate that demographic and experiential variables interact with TPB constructs in diverse and meaningful ways. To examine these interactions in the context of participatory forest management planning, the present study proposes the following overarching hypothesis: H1. The influence of TPB constructs (AT, SN, and PBC) on citizens' behavioral intentions is hypothesized to be moderated by key demographic and experiential characteristics:

H1a: Age.

H1b: Gender.

H1c: Education.

H1d: Occupation.

H1e: Area of residence.

H1f: Income.

H1g: Forest ownership inquiry.

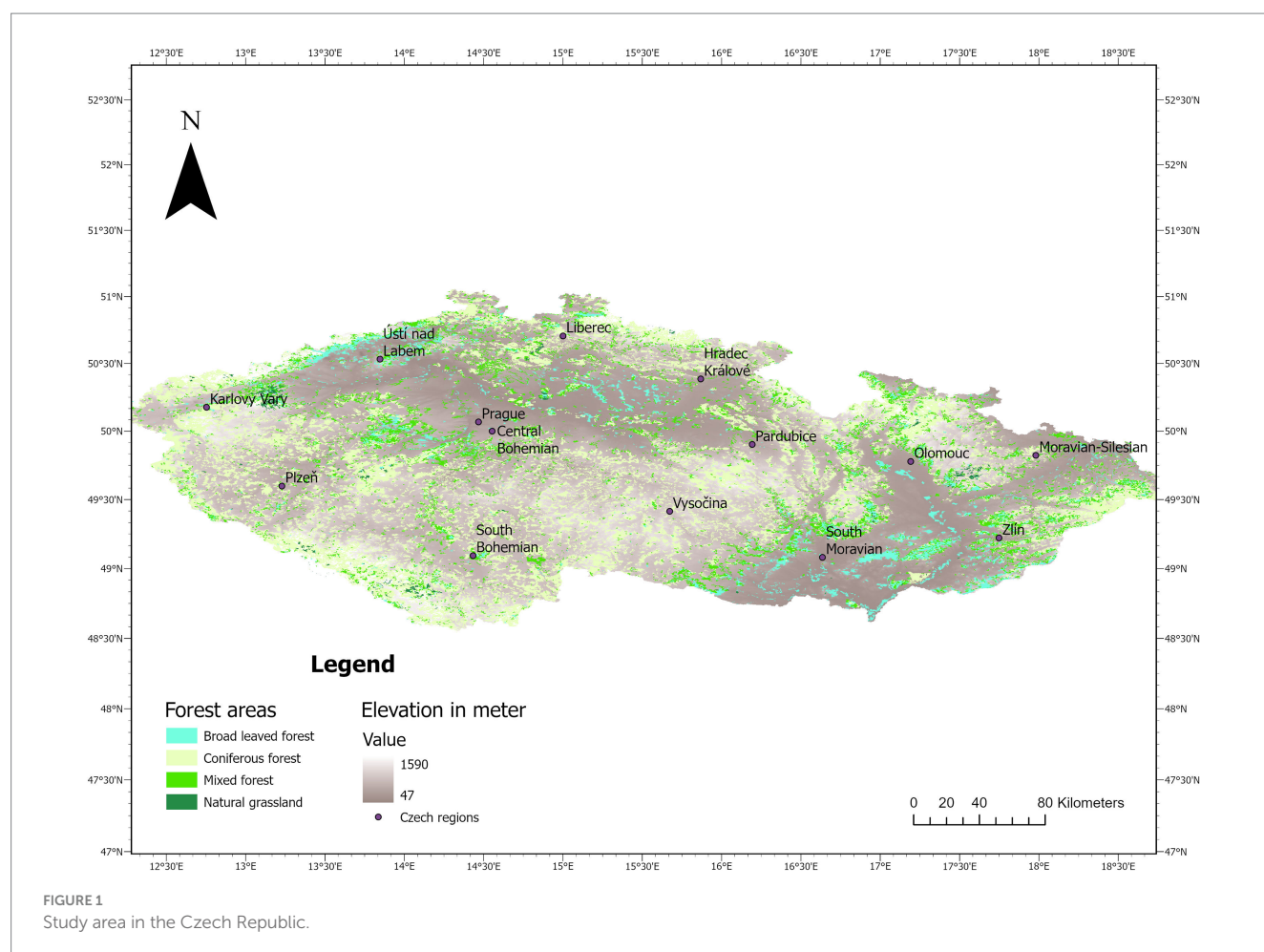
2 Materials and methods

2.1 Study area

The Czech Republic, located in Central Europe, covers 78,866 km², with forests accounting for approximately one-third of its territory (Forest Europe, 2020; Tolasz et al., 2007). The country's mean elevation is around 430 m above sea level, rising to 1,603 m at Sněžka, the highest peak, and descending to 115 m near Hřensko, where the Elbe River leaves the country. Vegetation varies with altitude, ranging from oak woodlands in the lowlands to mixed beech–fir forests at mid-elevations and spruce-dominated stands at higher altitudes (Chytrý, 2017) (Figure 1).

2.2 Participants and sampling

The required sample size for this study was calculated at 385 participants using Cochran's formula to achieve sufficient statistical precision (Cochran, 1977). To obtain the data, the research employed the services of the Czech National Panel, which is part of the European National Panels founded in 2012. This company manages a continuously updated panel of around 50,000 individuals across the Czech Republic, representing internet users aged 18–64. Data collection took place within the framework of the NET. BUS program, which administers surveys twice monthly and incorporates client-specific modules into each wave. A quota sampling approach was adopted to ensure the sample reflected the broader Czech population,



with quotas set for gender, age, education, and geographic region. Although the minimum required size was 385, a larger sample of 502 respondents was used to improve robustness and reliability. Participants were selected from the online panel to align with the demographic structure of the internet-using population, with panel updates conducted regularly to maintain representativeness. Surveys were delivered using Computer-Assisted Web Interviewing (CAWI), employing a structured online questionnaire administered uniformly to all respondents. The Czech National Panel provided the dataset in formats such as SPSS and Excel and tabulated outputs by key demographic variables to support analysis (Czech National Panel, 2023).

2.3 Data collection

The study utilized a structured questionnaire grounded in TPB (Fishbein and Ajzen, 1975; Ajzen, 1991) to examine how demographic characteristics shape the relationships between TPB constructs and citizens' behavioral intentions regarding participatory forest management. The instrument was adapted from a previously validated version developed by the lead author in an earlier study (Mohammadi et al., 2024), which modeled the direct effects of TPB constructs on intention. The first gathered demographic information, including age, gender, education level, income, occupation, area of residence, and

forest ownership or family involvement in forestry activities. The second section assessed the four core TPB constructs: AT, SN, PBC, and IN. All items were rated on a five-point Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree") (Table 1). The questionnaire was reviewed by forestry and environmental policy experts in both studies and refined for clarity and relevance to the general public in the Czech Republic.

2.4 Data analysis

2.4.1 Validity and reliability of items

Data analysis was performed in R Studio. Internal consistency of the multi-item constructs was assessed using Cronbach's alpha, with all values exceeding the recommended threshold of 0.70, indicating satisfactory reliability (Savari and Khaleghi, 2023). Convergent validity was evaluated through composite reliability (CR) and average variance extracted (AVE), with CR values above 0.70 and AVE values above 0.50, confirming that each construct adequately captured the variance of its indicators (Bowen and Guo, 2012).

2.4.2 Analysis of relationships

Structural Equation Modelling (SEM) was employed to examine the relationships between demographic variables and the TPB constructs. A multi-group SEM approach was applied to examine

TABLE 1 Survey items adapted from the theory of planned behavior to fit the context of participatory forest management in the Czech Republic.

Variable	Item	Item description	Sources
AT			Lacerda et al. (2012); Sagala et al. (2018); Arce (2019); Savari and Khaleghi (2023); Mohammadi et al. (2024)
	AT1	I believe participating in forest planning provides benefits to society.	
	AT2	Engaging in participatory forest planning contributes positively to environmental protection.	
	AT3	Participating in forest planning helps support nature conservation efforts.	
	AT4	Forest participation can have positive economic outcomes, such as job creation or local development.	
	AT5	I expect that participating in forest planning would be an enjoyable and rewarding experience.	
SN			Álvarez-García et al. (2019); Apipoonyanon et al. (2020); Mohammadi et al. (2024)
	SN1	People important to me would approve of my involvement in participatory forest planning.	
	SN2	I would participate if my friends support my involvement in forest management planning.	
	SN3	My family's opinion positively influences my intention to engage in forest planning.	
	SN4	I would take part if my colleagues consider participation in forest management valuable.	
PBC			Nathan and Boon (2012); Apipoonyanon et al. (2020); Mohammadi et al. (2024)
	PBC1	I feel confident that I could easily participate in forest planning activities.	
	PBC2	I have the necessary knowledge and skills to engage effectively in forest planning.	
	PBC3	Promoting the right to participate in forest management would be manageable for me.	
	PBC4	There are no significant obstacles preventing me from engaging in participatory forest planning.	
IN			Peerless (2020); Savari and Khaleghi (2023); Mohammadi et al. (2024)
	IN1	I plan to participate in forest management planning if given the opportunity.	
	IN2	I will make an effort to volunteer in forest planning initiatives as much as possible.	
	IN3	I am highly motivated to engage in forest planning to help protect our forest ecosystems.	

whether demographic variables moderate the model parameters. This technique enabled us to investigate differences across sub-populations by specifying SEM with group-specific or equal estimates across groups (West et al., 2023). Multivariate normality tests were conducted to ensure the suitability of the Maximum Likelihood (ML) estimation method in SEM (Kline, 2023). These tests assessed whether the data met the assumption of multivariate normality, which is critical for ML estimation. If significant deviations from normality were detected based on *p*-values, alternative estimation techniques or robust corrections were considered (Finney and DiStefano, 2006). Data was analyzed using the Lavaan package in R (version 3.6.17) (Rosseel,

2012). The ML estimator was employed to enhance the reliability of parameter estimation, even in cases of minor deviations from normality. Model fit was evaluated using several goodness-of-fit indices, including the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The CFI measures the fit of a specified model compared to an independent (null) model, with values closer to 1 signify a better fit. A CFI value of 0.95 or higher typically indicates a good fit (Bentler, 1990; West et al., 2023; Kline, 2023). The TLI, also known as the Non-Normed Fit Index (NNFI), assesses model fit by comparing the chi-square values of the

target model and a null model, with values above 0.95 generally considered to indicate a good fit (Tucker and Lewis, 1973; West et al., 2023; Kline, 2023). The RMSEA measures the discrepancy per degree of freedom for the model, with values less than 0.06 indicating a good fit and values up to 0.08 representing an acceptable fit (Steiger, 1990; Kline, 2023; Maydeu-Olivares et al., 2024). The SRMR indicates the standardized difference between observed and predicted correlations, with values below 0.08 typically considered a good fit (Hu and Bentler, 1999; West et al., 2023).

3 Results

3.1 Demographic characteristics of respondents

The demographic profile of the sample included a balanced distribution in terms of gender and age, with a slight predominance of individuals over 40 years old. Most respondents had a high school education or less and were employed during data collection. The majority lived in urban areas and earned less than 1,600 EUR per month. A smaller proportion reported having a background in forestry or forest ownership (Figure 2).

3.2 Reliability and validity results

The reliability and validity of the TPB constructs were assessed using Cronbach's alpha, Composite CR, and AVE. As shown in Table 2, all constructs exhibited satisfactory internal consistency, with Cronbach's alpha values ranging from 0.800 to 0.823, exceeding the commonly accepted threshold of 0.70. The CR values for all constructs were above 0.673, indicating acceptable construct reliability, with Attitude (0.883), Social Norm (0.814), and Intention (0.801) showing particularly strong reliability. The AVE values for Attitude (0.604), Social Norm (0.529), PBC (0.544), and Intention (0.575) all surpassed the recommended threshold of 0.50, demonstrating adequate convergent validity. These results collectively indicate that the items

chosen to measure each construct are consistent and effectively capture the intended theoretical dimensions. While PBC had a slightly lower CR (0.673) compared to other constructs, its AVE (0.544) still indicates that more than half of the variance is explained by the construct, supporting its validity. Overall, the findings affirm the reliability and validity of the TPB constructs, suggesting that the survey instrument is robust and suitable for further analyses, such as structural equation modeling.

3.3 Structure equation modelling (SEM) results

The model fit indicated a moderately acceptable fit across all demographic sub-groups, applying the TPB as a valid framework for analyzing participation in forest management planning. RMSEA values ranged from 0.081 to 0.089, slightly exceeding the ideal threshold but remaining within an acceptable range for model adequacy. CFI values ranged from 0.897 to 0.915, and TLI values ranged from 0.874 to 0.896, with most sub-groups approaching the conventional benchmark for a good fit. SRMR values ranged from 0.080 to 0.085, with some groups nearing the upper bound of acceptable levels (Table 3). Although the CFI values did not fully reach the more conservative threshold of 0.95, the overall pattern of fit indices indicates that the model fit was acceptable, supporting the interpretability of the SEM results. These results demonstrate that the TPB model exhibited sufficient configural validity across the demographic variables examined, thus allowing for meaningful multi-group comparisons in the subsequent analysis.

Table 4 showed that covariances among the key TPB constructs (AT, SN, and PBC) varied across demographic sub-groups. Younger individuals (<40) exhibited stronger interrelationships between AT–SN (0.176) and AT–PBC (0.182), suggesting that social expectations and perceived behavioral capacity are more closely aligned with their attitudes toward participation. In contrast, older participants (>40) reported weaker associations, particularly between AT and PBC (0.088), indicating a less integrated relationship between personal beliefs and perceived control.

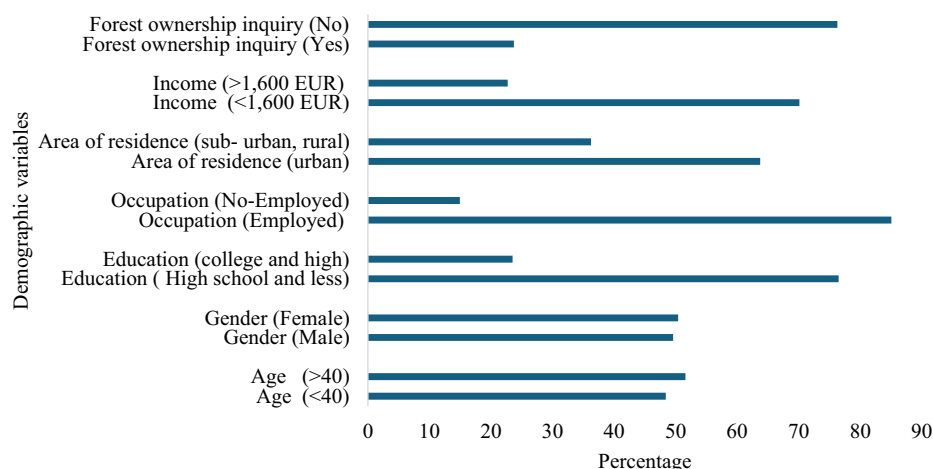


FIGURE 2
Demographic characteristics of respondents.

TABLE 2 Internal consistency and convergent validity of the theory of planned behavior constructs.

Construct	Cronbach's α	CR	AVE
AT	0.819	0.883	0.604
SN	0.823	0.814	0.529
PBC	0.800	0.673	0.544
IN	0.800	0.801	0.575

TABLE 3 Model fit indices for multi-group structural equation modeling by demographic variable.

Demographic variable	RMSEA	CFI	TLI	SRMR
Age	0.089	0.901	0.879	0.082
Gender	0.089	0.897	0.874	0.081
Education	0.081	0.915	0.896	0.080
Occupation	0.085	0.907	0.886	0.081
Area of residence	0.088	0.901	0.879	0.084
Income	0.087	0.904	0.883	0.085
Forest ownership inquiry	0.085	0.904	0.883	0.081

RMSEA, CFI, TLI, and SRMR values indicate acceptable fit of the structural models across sub-groups.

TABLE 4 Covariance estimates among the theory of planned behavior constructs by demographic sub-group.

Variable	Level/category	AT $\leftrightarrow$ SN	AT $\leftrightarrow$ PBC	SN $\leftrightarrow$ PBC
Age	>40	0.114	0.088	0.162
	<40	0.176	0.182	0.185
Gender	Male	0.124	0.113	0.139
	Female	0.174	0.182	0.217
Education	High school and less	0.195	0.142	0.205
	College and higher education	0.050	0.146	0.100
Occupation	Employed	0.137	0.141	0.167
	Non-employed	0.188	0.161	0.203
Area of residence	Urban	0.169	0.175	0.197
	Sub-urban and rural	0.093	0.095	0.131
Income	< 1,600 EUR	0.124	0.129	0.173
	> 1,600 EUR	0.238	0.240	0.216
Forest ownership inquiry	Yes	0.139	0.167	0.179
	No	0.218	0.040	0.153

Higher values indicate stronger alignment between attitudinal, normative, and control beliefs.

Gender differences were also evident, with females displaying consistently higher covariances across all construct pairings (e.g., SN–PBC = 0.217), reflecting a more cohesive belief structure underlying IN. Higher-income respondents (>1,600 EUR) reported the strongest correlations between constructs (e.g., AT–SN = 0.238; AT–PBC = 0.240), suggesting greater internal alignment, whereas lower-income individuals showed comparatively weaker associations.

Educational attainment and occupation further influenced these relationships. Respondents with lower education reported stronger covariances, particularly between AT–SN (0.195) and SN–PBC (0.205), compared to their higher-educated counterparts (0.050 and 0.100, respectively). Similarly, non-employed individuals exhibited higher intercorrelations among TPB constructs (AT–SN = 0.188; SN–PBC = 0.203) relative to employed respondents, suggesting a more tightly connected belief structure in these groups.

Urban residents exhibited stronger inter-construct associations (AT–SN = 0.169; AT–PBC = 0.175; SN–PBC = 0.197) compared to their sub-urban and rural counterparts (0.093–0.131). Forest ownership status further moderated these relationships, with non-owners reporting a notably weaker AT–PBC covariance (0.040) relative to owners (0.167).

Table 5 presented the SEM results examining the influence of demographic variables on IN within the framework of the TPB. The structural path estimates for the three latent constructs (AT, SN, and PBC) varied significantly across demographic sub-groups, as detailed in Table 3.

Younger participants (<40 years) relied strongly on SN ($\beta = 1.137$, $p < 0.001$) and AT ($\beta = 0.330$, $p < 0.001$), whereas PBC was not statistically significant ($\beta = 0.313$, $p = 0.071$). Older participants (>40 years) were more strongly influenced by PBC ($\beta = 1.175$, $p < 0.001$) and showed significant AT ($\beta = 0.299$, $p < 0.001$), while SN was not significant ($\beta = 0.113$, $p = 0.618$). Although these differences suggested variation in predictors by age, the overall moderation effect of age was not statistically significant.

Male respondents demonstrated significant effects for AT ($\beta = 0.372$, $p < 0.001$), SN ($\beta = 0.391$, $p = 0.013$), and PBC ($\beta = 1.065$, $p = 0.001$), with PBC as the strongest predictor. Female respondents exhibited significant effects for AT ($\beta = 0.242$, $p < 0.001$), SN ($\beta = 0.929$, $p < 0.001$), and PBC ($\beta = 0.342$, $p = 0.024$), showing stronger reliance on social norms and a balanced contribution of all TPB constructs. These results indicated that gender significantly moderately influence of TPB constructs.

Participants with high school education or less were significantly influenced by AT ($\beta = 0.332$, $p = 0.004$), SN ($\beta = 0.902$, $p = 0.021$), and PBC ($\beta = 0.676$, $p = 0.003$). College-educated participants also showed significant effects for all constructs, but SN ($\beta = 0.703$, $p = 0.001$) and PBC ($\beta = 0.517$, $p = 0.013$) were slightly weaker, suggesting that education moderated the influence of TPB constructs, with lower-educated individuals relying more on social norms and perceived control.

Employed participants demonstrated significant effects of AT ($\beta = 0.368$, $p < 0.001$), SN ($\beta = 0.627$, $p < 0.001$), and PBC ($\beta = 0.653$, $p < 0.001$). Non-employed participants exhibited weak and mostly non-significant effects (AT: $\beta = 0.178$, $p = 0.092$; SN: $\beta = 1.075$, $p = 0.110$; PBC: $\beta = 0.211$, $p = 0.723$), indicating that occupation did not consistently moderate the influence of TPB constructs.

Urban residents showed significant effects for AT ($\beta = 0.279$, $p < 0.001$), SN ($\beta = 0.629$, $p < 0.001$), and PBC ($\beta = 0.610$, $p = 0.001$). Suburban and rural residents exhibited stronger AT ($\beta = 0.459$, $p < 0.001$) and SN effects ($\beta = 0.670$, $p = 0.050$), while PBC was marginally significant ($\beta = 0.671$, $p = 0.003$). These findings indicated that area of residence moderated the influence of TPB constructs, with urban residents more responsive to social norms and suburban/rural residents more influenced by perceived control and attitude.

Lower-income participants (<1,600 EUR /month) showed stronger effects for AT ($\beta = 0.346$, $p < 0.001$) and SN ($\beta = 0.933$,

TABLE 5 Structural equation modeling estimates of the theory of planned behavior constructs on behavioral intention by demographic sub-groups.

Variable	Level/ category	AT			SN			PBC		
		Estimate (β)	Std. err	p- value	Estimate (β)	Std. err	p- value	Estimate (β)	Std. err	p- value
Age	>40	0.299	0.069	0.000	0.113	0.227	0.618	1.175	0.293	0.000
	<40	0.330	0.075	0.000	1.137	0.276	0.000	0.313	0.174	0.071
Gender	Male	0.372	0.078	0.000	0.391	0.264	0.013	1.065	0.318	0.001
	Female	0.242	0.062	0.000	0.929	0.211	0.000	0.342	0.152	0.024
Education	High school and less	0.332	0.115	0.004	0.902	0.391	0.021	0.676	0.225	0.003
	Collage and high	0.314	0.058	0.000	0.703	0.213	0.001	0.517	0.207	0.013
Occupation	Employed	0.368	0.056	0.000	0.627	0.165	0.000	0.653	0.152	0.000
	Non employed	0.178	0.106	0.092	1.075	0.672	0.110	0.211	0.596	0.723
Area of residence	Urban	0.279	0.056	0.000	0.629	0.173	0.000	0.610	0.187	0.001
	Sub-urban and rural	0.459	0.098	0.000	0.670	0.349	0.050	0.671	0.230	0.003
Income	<1,600 EUR	0.346	0.063	0.000	0.933	0.259	0.000	0.479	0.221	0.030
	>1,600 EUR	0.287	0.080	0.000	0.349	0.150	0.020	0.597	0.164	0.000
Forest ownership inquiry	Yes	0.308	0.055	0.000	0.525	0.186	0.005	0.787	0.183	0.000
	No	0.134	0.271	0.621	1.142	0.636	0.073	0.000	0.591	1.000

Higher estimates indicate stronger influence of attitude, subjective norms, and perceived behavioral control on participatory intention.

$p < 0.001$), with a modest but significant PBC effect ($\beta = 0.479$, $p = 0.030$). Higher-income participants (>1,600 EUR /month) displayed stronger PBC ($\beta = 0.597$, $p < 0.001$) and weaker effects for AT ($\beta = 0.287$, $p < 0.001$) and SN ($\beta = 0.349$, $p = 0.020$), indicating that income moderated the strength of TPB pathways, with lower-income individuals relying more on attitudes and social norms and higher-income individuals relying more on perceived control.

Participants with forest ownership experience demonstrated significant effects for AT ($\beta = 0.308$, $p < 0.001$), SN ($\beta = 0.525$, $p = 0.005$), and PBC ($\beta = 0.787$, $p < 0.001$). Non-owners showed non-significant effects across all constructs (AT: $\beta = 0.134$, $p = 0.621$; SN: $\beta = 1.142$, $p = 0.073$; PBC: $\beta = 0.000$, $p = 1.000$), indicating that prior ownership experience did not consistently moderate the influence of TPB constructs.

4 Discussion

This study investigated how demographic variables moderated the relationships among AT, SN, PBC, and IN to engage in participatory forest management planning in the Czech Republic. Multi-group SEM revealed the strength and statistical significance of the structural paths from TPB constructs to IN varied across demographic sub-groups. The observed differences showed that participatory intentions were not shaped uniformly across the population; instead, demographic profiles influenced how individuals evaluated, internalized, and responded to the motivational factors underlying participatory behavior. The results confirmed the relevance of the TPB framework in this context and highlighted the need for demographic-specific engagement strategies in forest policy and planning.

Although patterns differed by age group, with younger respondents more influenced by social norms and older respondents more influenced by perceived control, the overall moderation effect was not statistically significant across all constructs. Thus, H1a was not supported. Nonetheless, subgroup analysis revealed notable differences. Among younger respondents (<40), both attitude (AT) and subjective norms (SN) exerted substantial and statistically significant effects on intention, suggesting that this group was more responsive to internal evaluations and social validation. In contrast, while AT remained significant among older individuals (>40), SN lost its predictive power, indicating reduced sensitivity to social pressures. Instead, perceived behavioral control (PBC) emerged as the dominant driver of intention in this group, reflecting a greater reliance on self-efficacy and perceived capability. This pattern aligns with findings by Koskela and Karppinen (2024), who reported stronger control-based reasoning among older forest stakeholders, and is consistent with TPB literature linking age to increased autonomy in decision-making (Ajzen, 1991; Savari and Khaleghi, 2023).

The influence of TPB components on IN differed across gender groups. This pattern suggests that men's engagement in participatory forest management is primarily shaped by personal evaluations and perceived ability to act rather than social expectations. In contrast, female respondents exhibited a more socially attuned decision-making process, with AT, SN, and PBC all significantly influencing intention. This indicates that women's decisions are shaped by personal beliefs, social validation, and perceived approval from others. Given these results, H1b is supported as gender significantly moderates the influence of TPB constructs on citizens' behavioral intentions for participatory forest management planning. This gendered distinction aligns with prior

research. Savari and Khaleghi (2023) found that SN were more salient for women in sustainable forestry contexts, and Galati et al. (2023) reported stronger normative influences among female participants in urban forestry initiatives. Koskela and Karppinen (2024) further noted that female forest owners are more likely to integrate community expectations into their management decisions, reflecting a broader social orientation often observed in women's environmental behavior.

Education significantly moderated the relationship between the TPB components and IN to participate in forest management planning. All three TPB constructs significantly predicted IN among individuals with a high school education or less. Accordingly, H1c is supported, as education significantly moderates the influence of TPB constructs on citizens' behavioral intentions for participatory forest management planning. This pattern suggested a strong, multifaceted influence of internal beliefs, social approval, and perceived ability among lower-educated individuals. Conversely, among respondents with college-level education, the same three constructs significantly influenced intention, but to a slightly lesser degree. These findings indicated that while TPB constructs were robust predictors across educational groups, individuals with lower educational attainment were more strongly guided by social norms and control beliefs. These results aligned with a study by Maleknia and ChamCham (2024), which found that lower education-level individuals exhibited stronger correlations among TPB constructs, indicating a reliance on community norms and subjective assessments. Meanwhile, employed individuals exhibited a higher influence of AT and PBC, possibly reflecting stronger ties to professional networks, better access to information, and greater psychological empowerment. Tadesse and Teketay (2017) highlighted that education and occupation status significantly shape behavioral determinants in TPB models, further supporting these observations. This could be due to interest in knowing and participating in PFM, which increases with increased education.

The influence of TPB constructs on IN varied meaningfully based on individuals' occupational status. Among employed respondents, all three TPB components were strong and statistically significant predictors of IN. This pattern suggested that working individuals were cognitively engaged across affective, social, and control dimensions when forming their intentions to participate. In contrast, the results for non-employed individuals were markedly weaker and largely non-significant. Therefore, H1d is rejected, as occupation does not significantly moderate the influence of TPB constructs on citizens' behavioral intentions for participatory forest management planning across all groups. This divergence pointed to the importance of socioeconomic engagement in shaping forest-related intentions. Employed individuals may have greater access to networks, information, or decision-making opportunities, reinforcing perceived control and attitudinal confidence. Moreover, their regular exposure to institutional structures could enhance responsiveness to social expectations. These results aligned with Savari et al. (2023a, 2023b) and Stockmann et al. (2024), who reported that employment status was a consistent predictor of environmental participation and that employed participants were more responsive to the organization.

Area of residence emerged as a significant moderator of the IN in participatory forest management. Respondents from sub-urban and rural areas exhibited stronger relationships across all TPB components compared to their urban counterparts. Therefore, H1e is supported,

as area of residence significantly moderates the influence of TPB constructs on citizens' behavioral intentions for participatory forest management planning. The findings revealed that individuals in less urbanized settings may possess stronger pro-environmental orientations and a greater sense of communal responsibility and capacity to engage in forestry planning. This finding aligns with evidence that rural residents often have stronger place-based attachments and more direct dependencies on local ecosystems, leading to higher motivation and social alignment in environmental governance (Raymond et al., 2014; Buijs et al., 2016). The findings also resonate with TPB studies in natural resource contexts, showing that rural populations score higher on PBC due to familiarity with land-based practices and social reinforcement from local networks (Wauters et al., 2010).

The structural relationships among TPB variables varied notably according to income group. All three constructs showed statistically significant effects among individuals with lower income (<1,600 EUR). This indicated that internal evaluations and social reinforcement influenced this group, although their perceived acting ability remained moderate. Similarly, by Charnley et al. (2018) concluded that in low-income communities, social pressures and norms can significantly affect intentions to engage in forest management, as these populations often rely on forest resources for their livelihoods. In contrast, individuals with higher income (>1,600 EUR) showed significant effects on AT, while the influence of SN was relatively weaker. Accordingly, H1f is supported, as income significantly moderates the influence of TPB constructs on citizens' behavioral intentions for participatory forest management planning. The findings indicated that economically advantaged individuals relied more on autonomous reasoning and self-efficacy in shaping their IN toward forest participation. Similarly, Savari and Khaleghi (2023) reported that individuals with greater financial means often felt more empowered to act in environmental contexts due to fewer resource-related constraints. Patiro et al. (2024) studied how economic stability enhances perceived control over forest management practices, allowing individuals to feel more capable of implementing sustainable strategies.

The inquiry into forest ownership provided valuable insights into how familiarity with forestry activities influenced IN. All three TPB components showed strong and statistically significant effects among respondents who reported personal or family involvement in forest ownership or related activities. This pattern suggested that prior exposure to forest management enhanced internal motivation, perceived ability to engage, and sensitivity to normative expectations within their communities. In contrast, none of the TPB pathways were statistically significant for participants with no forest ownership background. Consequently, H1g is not supported, as forest ownership experience did not significantly moderate the influence of TPB constructs across all groups. Nonetheless, The findings highlighted the influence of experiential knowledge and social proximity to forestry on participatory readiness. Individuals with forest ownership experience likely had greater contextual awareness and confidence in navigating forest management processes, which were translated into more coherent and influential TPB constructs. This interpretation was consistent with previous studies showing that ownership history or proximity to forest resources fosters stronger behavioral engagement and decision-making capacity in environmental management contexts (Koskela and Karppinen, 2024; Charnley et al., 2018). Findings

underscored the importance of outreach strategies that educate and engage the broader public, particularly individuals without prior exposure, in participatory forest governance.

5 Theoretical and practical implications

This study offers important theoretical and practical contributions to understanding public participation in forest management planning. Theoretically, it demonstrates the value of integrating TPB with demographic moderation analysis, showing that the relationships among AT, SN, and PBC vary across demographic groups. Incorporating demographic factors as moderators extends TPB's applicability in environmental and participatory forestry contexts and provides a more nuanced understanding of how individuals form IN. From a practical perspective, the findings highlight the need for tailored engagement strategies that account for demographic differences. Women, who are more responsive to SN, may benefit from interactive digital platforms, social media campaigns, and participatory initiatives such as citizen science projects that emphasize collaboration and visible peer involvement. Higher-income groups, who rely more on PBC, may respond better to in-person workshops, hands-on demonstrations, or structured skill-building programs that enhance confidence and perceived control. Gender-sensitive approaches could include discussion groups or participatory committees for women, fostering collective engagement, while men may be more effectively reached through technical workshops or autonomy-focused initiatives that emphasize personal efficacy. Overall, these strategies inform the design of inclusive, equitable, and context-sensitive participatory forest management initiatives, ensuring that outreach mechanisms align with the cognitive, social, and experiential characteristics of diverse population segments.

6 Recommendations for future research and limitations

While this study provides valuable insights into demographic moderation of TPB constructs in participatory forest management, several limitations should be acknowledged. The study relied on a cross-sectional survey, which restricts the ability to infer causal relationships or capture changes in IN overtime. Data were collected through a CAWI survey, which may introduce selection bias and may not fully represent populations without internet access or individuals outside the 18–64 age range. The research focused exclusively on the Czech Republic, limiting generalizability to other cultural or institutional contexts. Additionally, all measures were self-reported, which introduces the possibility of response biases. Certain psychological, social, and contextual factors, such as EA, trust in institutions, or prior participation experience, were not included and may further explain variations in IN. Future research could address these limitations by employing longitudinal designs to track behavioral changes and exploring causal mechanisms. Expanding samples to include broader demographic groups and conducting comparative studies across regions or countries would enhance generalizability and depth of findings. Intervention-based studies could test the effectiveness of tailored engagement strategies for diverse population segments. Examining interactions between multiple

demographic factors, such as age and income or education and forest ownership, may uncover complex dynamics influencing IN. These directions will support the development of evidence-based, inclusive, and sustainable participatory forest management policies.

7 Conclusion

This study demonstrated the critical role of demographic and experiential diversity in shaping citizens' intentions to participate in forest management in the Czech Republic. The influence of attitudes, subjective norms, and perceived behavioral control varied across demographic groups, indicating that participatory intentions are not uniform. These findings highlight the importance of demographic and experiential diversity in shaping environmental behavior and provide actionable insights for developing inclusive and effective participatory forest management strategies. By extending the Theory of Planned Behavior to incorporate demographic moderation, this research offers both theoretical and practical guidance for fostering context-sensitive, equitable participatory forest governance. Overall, the results support the design of tailored engagement strategies and lay the groundwork for future studies exploring additional behavioral and contextual factors to enhance sustainable public participation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague (CZU). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ZM: Writing – review & editing, Software, Investigation, Resources, Writing – original draft, Visualization, Formal analysis, Validation, Data curation, Conceptualization, Methodology. JK: Project administration, Supervision, Writing – review & editing, Resources, Conceptualization, Funding acquisition. MT: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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