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Research article

One in three or three in one: Integrating three competing theoretical models (TPB, VIP, and PADM) to explain the intentions to act/actions against climate change

Miri Kim [a], Seoyong Kim [b,*], Sehyeok Jeon [a,**]

[a] Social Science Research Institute, Ajou University, Suwon, 16499, Republic of Korea
[b] Department of Public Administration, Ajou University, Suwon, 16499, Republic of Korea

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ABSTRACT

This study examines multidimensional factors affecting climate change response behavior. It constructs an integrated model based on the theory of planned behavior, value–identity–personal norms model, and protective action decision model, as a single theory cannot capture the complex nature of human behavior. Recent studies have shown that integrating theories include various influencing factors and indicate higher explanatory power. Therefore, this study uses an integrated model to identify multidimensional influencing factors. The fit of the integrated model was confirmed to be excellent (Chi-square = 1271.866, p = .000, GFI = 0.930, NFI = 0.940, RMSEA = 0.060, TLI = 0.937, SRMR = 0.059), and identity exhibited the greatest effect on personal norms, followed by intention on behavior. The integrated model suggests the following path: ecological value → identity → personal norms → stakeholder awareness → intention → behavior and then ecological value → identity → perceived behavioral control → risk awareness → intention → behavior. The results of the integrated model suggest that a multifaceted approach is necessary to promote climate change response behavior. Various factors, such as ecological value, identity, personal norms, stakeholder awareness, perceived behavioral control, and risk awareness, interact and influence behavior. Policies and programs that comprehensively consider these factors should be established.

1. Introduction

This study analyzes the multidimensional factors influencing climate change response behavior by exploring three competing theoretical models. It was conducted for the following reasons. First, climate change is an important issue that must be addressed. The World Health Organization's 2021 State of the World Climate Report emphasizes that greenhouse gas concentrations and sea surface temperatures have reached record highs, underscoring the severity of climate change [1]. The Korea Meteorological Administration's 2023 Abnormal Climate Report details the effects of climate change in terms of long-term drought followed by heavy rain in summer, abnormally high temperatures in March, and extreme temperature fluctuations in September. Rainfall significantly increased to 660.2 mm in 2023 (compared with an average annual precipitation of 356.7 mm), and precipitation days increased to 22.1 days, 28 % higher

* Corresponding author.
** Corresponding author.
E-mail addresses: mirikim93@naver.com (M. Kim), seoyongkim@ajou.ac.kr (S. Kim), jeonsh5785@naver.com (S. Jeon).

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than the average year (17.3 days). Meanwhile, in terms of disasters, the number of "forest fire risk days," wherein over 10 forest fires occur per day, has increased significantly from the 10-year average of 8.2–17 in 2023, confirming that forest fires are becoming larger and more common.

Second, effective policy measures to increase climate change responses should be studies. In 2015, developed and developing countries signed the Paris Agreement on Climate Change—a joint promise to reduce greenhouse gases. Signatories to the Paris Agreement undertake to maintain the global average temperature increase to a level significantly lower than 2 °C compared with pre-industrial times, and to limit it to 1.5 °C. In October 2020, Korea's National Assembly adopted the 2050 Carbon Neutrality Act, assigning a target of net zero carbon emissions by 2050. Such policies as the Climate Response Fund and Carbon Neutral Cities are being promoted as the Framework Act on Carbon Neutrality, which went into effect in March 2022. Policies such as subsidies for purchasing energy-efficient home appliances, incentives for using renewable energy, and partial refunds for public transportation have failed to effectively promote individual behavioral changes in response to climate change. Owing to discrepancies between attitudes and behaviors, a lack of norms, and economic barriers, people are aware of climate change issues but are unable to change their behaviors [2]. This study examined ways to increase response behavior to government's climate change policies and proposed practical strategies to proactively respond to climate change.

Third, from a theoretical perspective, studies on climate change have primarily focused on mitigation research and technological solutions; however, recent studies on climate-friendly behaviors have focused on adaptation research [3]. Further, studies on the determinants of climate change response behaviors have primarily focused on demographic variables, risk perception, and personal values and beliefs [4–7]. However, few studies have examined how multidimensional causal factors specifically influence behaviors that focus on climate change responses. As environmental issues, such as climate change and energy, do not intuitively cause direct damage to individuals, it is necessary to examine individuals' cognitive processes based on multidimensional determinants to induce behavioral changes or participation.

Fourth, to better predict human environmental behavior, it is necessary to both integrate and expand behavioral theories. Traditional behavioral theories, such as the theory of planned behavior (TPB), norm activation model (NAM), and value–belief–norm (VBN) theory, are commonly used to explain and predict climate change mitigation and adaptationrepsonse [8]. However, as a single behavioral theory has limited capacity to explain climate change response behaviors, models need to be expanded or integrated to better predict human behavior. Recent studies have integrated TPB and VBN theory to predict climate change response behavior [9–13]. Models that integrate TPB and VBN theory have higher explanatory power than single models and can facilitate a comprehensive understanding and prediction [9,10,12]. Recent studies have integrated the value–identity–personal norm (VIP) model and TPB to cover more diverse explanatory variables. For example, Ateş [14] used 14 out of 16 hypotheses for the integrated model as theoretical grounds for determining the antecedents of pro-environmental behavior. Those studies impliest that a comprehensive and multidimensional approach is required to explain an individual's climate change response behavior. Thus, this study analyzed the factors affecting climate change response behavior and confirmed the underlying cognitive process by integrating the traditional TPB; the VIP theory derived from VBN, focusing on individuals' self-awareness; and the protective action decision model (PADM) that recognizes environmental risks and determines actions to respond to them. By integrating the TPB, VIP model, and PADM, a multidimensional approach was implemented that divided the factors affecting climate change response behavior into personal, social, and situational factors. Personal factors, such as values, beliefs, and norms, provide internal motivation; social factors provide external motivation through subjective norms or social influence; and situational factors promote behavior through risk perception.

This study asked, "Can the integration of TPB, VIP model, and PADM better explain climate change response behavior?" It combined the strengths of each theory to construct a comprehensive behavioral explanation model and confirmed whether the integrated model has useful explanatory power in promoting actual climate change response behavior and whether the main factors of each theory have a meaningful effect on climate change response behavior.

This study developed a comprehensive model that integrates the decision-making model for risk perception (e.g., PADM), traditional behavioral theory (e.g., TPB), and new behavioral theory (e.g., VIP). This comprehensive model emphasizes individual, social and contextual factors, focusing on climate change, to overcome the limitations of a single theoretical approach and explain the complexity of human behavior. Strategies and practical policy implications for promoting climate change response behavior were derived based on the results obtained through the integrated model. This study used structural equation modeling to identify the multidimensional influencing factors and cognitive processes that affect climate change response behaviors. Structural equation modeling is convenient because it makes it easy to verify complex causal relationships, analyze models with multiple mediating variables, and estimate the indirect effects of various paths. As this study integrated multiple theories and factors, structural equation modeling was deemed appropriate to verify the fit of the integrated model.

The remainder of this paper is organized as follows. Section 2 presents individual analyses of the theories explaining individual behavior (TPB, VIP model, and PADM), and constructs and discusses an integrated model based on these analyses. Section 3 presents an integrated research model and discusses the data collection and measurement items. Section 4 presents the descriptive statistical analysis results for each item, the correlation analysis results between variables, and the verification of the integrated model and existing model fit. Section 5 discusses the validation of the models. Section 6 synthesizes the research results and the implications of the study. Finally, section 7 concludes the paper.

2. Theoretical background

2.1. Theory of planned behavior

The TPB is based on the theory of reasoned action, which assumes that people are rational and systematically use the information available to them [15]. The theory of reasoned action emphasizes the importance of behavioral intention in predicting human behavior and assumes that the direct determinants of intention to act are attitudes toward the action in question and subjective norms related to the action [15,16]. This theory is a causal process model in which attitudes and subjective norms influence intentions to act, and intentions to act influence behavior. Relatedly, attitudes toward a behavior are defined as the positive or negative feelings or emotions that an individual has regarding that behavior. Attitude is a continuous and consistent evaluation of an entity, including oneself. The more positive the attitude toward a behavior, the stronger one's intention to act [17]. Subjective norms refer to the degree to which an individual believes that the other surrounding individuals expect them to behave in a certain way when choosing or acting on a behavior; in other words, subjective norms are social pressures that cause an individual to engage or not engage in certain behaviors [15,18]. A subjective norm is the level of expectation that others have of behavior, and greater subjective norms are associated with stronger intentions to act. Thus, greater subjective norms increase the likelihood of a behavior occurring. Behavioral intention refers to the intention to perform a given behavior. Behaviors are directly influenced by behavioral intentions, which, in turn, are influenced by subjective norms and attitudes toward the behavior [18]. The theory of reasoned action considers causal factors as determinants of attitudes toward specific behaviors and subjective norms. The evaluation of a behavior's consequences and the likelihood of these consequences are structured as antecedents of attitudes toward the behavior, whereas others' attitudes toward the behavior and an individual's motivation to meet the expectations of others are structured as antecedents of subjective norms. Beliefs, which are the information that an individual has about an object and provide a link between the object and its attributes, are the fourth factor [19]. However, because of the difficulty in distinguishing beliefs from personal attitudes in relation to behavior and the difficulty in measuring them, studies often exclude belief variables. Ajzen and Madden [20] presented the TPB to complement the theory of reasoned action. The TPB was developed because the theory of reasoned action assumes that an individual's behavior is always based on rational judgments. However, in reality, elements beyond the individual's will to perform the behavior create uncertainty, which makes it impossible for individuals to do the reasonable behaviors.

The TPB has the same elements as the theory of reasoned action: attitudes, subjective norms, behavioral intentions, and actions. However, because attitudes and subjective norms alone cannot predict human behavior and lead to uncertainty, the TPB also includes perceived behavioral control. The perceived behavioral control as the additional factor that can predict behavior compensates for the limitations of the theory of reasoned action. Perceived behavioral control is an individual's perception of their ability to perform a behavior that will lead to a specific outcome [21]; it serves as an antecedent of intentions to act and as a direct determinant of behavior [22]. Attitudes, subjective norms, and perceived behavioral control mutually influence each other such that greater attitudes and subjective norms lead to greater perceived behavioral control, which, in turn, leads to stronger intentions to act [23].

Studies have used the TPB to predict behavior, specifically identifying the psychological factors that influence individuals' pro-environmental behaviors [22]. Lee et al. [22] demonstrated that the constructs of the TPB and subjective norms are useful for understanding energy-conservation behavior. By conducting a meta-analysis of TPB studies published in major Korean journals in 2011, Sohn and Lee [24] found that attitudes, subjective norms, and perceived behavioral control explained 27.9 % of the variance in behaviors and 31.5 % of the variance in behavioral intentions, whereas subjective norms had less influence on behavioral intentions. Choi and Jung [25] applied the TPB to predict the eco-friendly behaviors of life sports participants and found that all factors, except perceived behavioral control, significantly affect eco-friendly intentions. Yim and Kim [26] demonstrated that, among the factors of the TPB, behavioral attitudes have the greatest influence on the intention to purchase eco-friendly agricultural products.

The TPB model strongly explains the relationship between attitudes and behaviors with clear interests, and emphasizes that the main determinant of behavior is the intention to perform a given behavior. However, individual's intention alone cannot fully explain pro-environmental behaviors. Ajzen [27] emphasized that, when the TPB is expanded to include additional variables, these new variables affect behavioral intentions independently of the original variables. In other words, the TPB can be extended to explain a wide range of behaviors; this model is called the "extended TPB" (ETPB) [27,22].

2.2. Value–identity–personal norms model

The VIP model is primarily based on the idea that ecological values influence personal norms through environmental self-identity, resulting in pro-environmental behavior [28,29]. Similar to the TPB, NAM, and VBN theory, the VIP model can predict and explain eco-friendly behaviors. However, the TPB focuses on rational behavior and does not consider individual moral norms, whereas the VIP model emphasizes individual moral norms. These norms may or may not influence the process of choosing pro-environmental behaviors. Like the NAM and VBN theory, the VIP model suggests that an individual's moral norms are important and that people are more likely to engage in pro-environmental behaviors when their personal norms are expressed. The NAM differs from the VBN theory by emphasizing two beliefs as antecedents to an individual's moral norms: (1) consequence perception, which is the degree to which an individual perceives the impact of performing or not performing a particular behavior on other individuals or the external environment, and (2) blame attribution, which is an individual's sense of responsibility for the negative consequences of not performing a particular behavior.

The VIP model is a more parsimonious version of the VBN theory and is more likely to predict a range of environmental behaviors, as it reflects general environmental considerations [30]. The VBN theory suggests that outcome perceptions depend on environmental paradigms that reflect people's perspectives on altruistic, selfish, and ecological values, as well as the relationship between people and nature [29]. Conversely, the VIP model states that personal norms depend on ecological values and environmental self-identity.

The VIP model categorizes green behavior according to value, identity, and personal norms. Values are ideas that regulate and influence human behavior; they are ideologies and principles that individuals, groups, and societies consider important, and they contribute to the formation of an individual's identity [31,32]. In the VBN theory, Stern [33] categorizes values as altruistic, selfish, or ecological, whereas the VIP model considers only ecological value. Ecological value refers to the value of the environment or ecosystem, apart from one's own value or that of other individuals, and prioritizes the preservation of ecosystems over humans. Ruepert et al. [28] emphasized that ecological value is an important and consistent predictor of pro-environmental behavior and that people's likelihood of engaging in this behavior depends on their ecological value.

Whereas values are general principles that do not change, identity refers to an individual's self-perception. Environmental identity reflects individuals' perceptions of themselves as part of nature, and environmental self-identity refers to individuals' perceptions of themselves as engaged in pro-environmental behaviors. In the VIP model, environmental self-identity reflects pro-environmental behavior more directly, making it particularly relevant to understanding this behavior. However, few studies have examined the relationships between ecological value, environmental self-identity, and pro-environmental behavior [30].

The VIP model considers the role of peersonal norm. The concept of personal norms refers to a sense of moral obligation to perform certain behaviors, such as pro-environmental behaviors [34]. Personal norms represent a sense of moral obligation or responsibility that a person feels toward an object or behavior, whereas subjective norms refer to other individuals' expectations of an individual's behavior. The NAM and VBN theory emphasize personal norms to explain human behavior. VBN studies have shown that personal norms have the greatest influence on individuals' eco-friendly behavior among the analyzed factors [35]. Personal norms are directly linked to pro-environmental behavior in that they generate a willingness to engage in the behavior by creating a moral obligation to act [33,36]. Uzzell and Räthzel [37] found that environmental self-identity positively influences pro-environmental behavior by reinforcing personal norms.

2.3. Protective action decision model

The PADM was first developed to explain people's protective actions in response to threatening situations such as natural disasters or environmental hazards. This model has been extended to explain long-term disaster adjustments [38]. It assumes that people exposed to various hazards or disasters receive warnings from external sources and that these warnings contribute to the formation of individuals' risk perceptions, which ultimately leads to protective behavioral intentions.

The PADM defines protective behaviors as intentional or unintentional actions that reduce the risk of extreme events in the natural environment. This model has been used to explore the determinants of individuals' protective behaviors. The PADM stage refers to making behavioral decisions to protect against environmental risks. It includes sequential steps, as in an information-seeking process; however, following all the steps of the model in exact order is impossible. In the absence of reliable sources of information or authority for implementation, these situations can be highly ambiguous. Therefore, individuals are likely to spend more time finding and processing information than preparing and implementing protective actions.

The PADM includes an examination of social, environmental, and psychological contexts. Environmental cues include sights, smells, and sounds that signal the onset of a threat, whereas social cues arise from observing the behavior of others. A warning is a message sent from a source to a receiver through a channel that depends on the characteristics of the receiver, which can be categorized into physical, cognitive, economic, or social resources.

The psychological context encompasses three activities: 1) pre-decision process; 2) three dimensions of awareness (i.e., environmental risk awareness, alternative protective behavior awareness, and stakeholder risk awareness); and 3) choosing protective behaviors. In the pre-decision process, people may receive disaster-related information, perceive it to some extent, pay attention to it, and understand it. The three steps are exposure, attention, and understanding. This process is mostly automatic and occurs unconsciously. In summary, people must be exposed to environmental or social signals, pay attention to them, and understand them before they can take appropriate protective actions. The PADM incorporates three dimensions of awareness (risk awareness, alternative protective behavior awareness, and stakeholder awareness) and assumes that individuals make automatic or reflexive judgments based on the extent to which their schemas provide easy access to and consistent beliefs about the target. According to Lindell and Perry [38], risk perception describes an individual's subjective assessment of risk, which fundamentally determines their protective behavior in response to a hazardous event. Terpstra et al. [39] found that a greater perception of risk is associated with stronger intentions to take preventive actions.

Alternative protective behavior perceptions are perceptions of natural disaster adaptations that can be categorized as risk- and resource-related attributes. Risk-related attributes emphasize the relationship between risk itself and risk adjustments, and can reflect perceived usefulness, which is the belief that protective measures can mitigate risk and that individuals are capable of taking these measures. In other words, risk-related attributes describe a behavior's perceived efficacy in protecting people. Resource-related attributes highlight the relationship between the required resources, such as time, cost, cooperation, and risk adjustments. Stakeholder perceptions vary widely depending on their expertise, credibility, and responsibility to protect, and they have a significantly positive relationship with intentions to engage in risky behaviors and the adoption of risk behaviors.

Once the pre-decision process is complete and core perceptions are activated, cognitive processing shifts to hazard identification, risk assessment, protective action exploration, protective action evaluation, and protective action implementation. At this stage, situational barriers and facilitators shape the actual implementation of behavioral responses.

Empirical studies have used the PADM to demonstrate the impacts of individual risk perceptions on people's willingness to adopt natural hazard mitigation measures based on research on the impacts of individual responses [38]. Using the PADM to explain flood preparedness intentions in the Netherlands, Terpstra and Lindell [40] found that risk-related attributes and risk perception are positively related to these intentions, whereas resource-related attributes are negatively related to these intentions. Liu et al. [41] used the PADM to analyze the adoption of electric vehicles as an eco-friendly behavior in relation to urban smog generation. They found that risk-related attributes—which describe the utility of electric vehicles—positively affect the social acceptance of electric vehicles, whereas resource-related attributes—which include costs—negatively affect the long-term acceptance and purchase intentions for electric vehicles. Only a few studies have considered the PADM in Korea. Lee et al. [42] analyzed risk perception processes and intentions to purchase wind and water damage insurance among residents in coastal areas, and partially used the PADM to demonstrate that risk perceptions affect intentions to purchase wind and water damage insurance. In the current study, we empirically analyzed the impact of individual risk perceptions on responses to climate change caused by global warming.

2.4. Navigating the unified model

The TPB adds or integrates various factors to explain a wide range of behaviors and suggests more comprehensive model such as the ETPB (Extended Theory of Planned Behavior). The explanatory power of behavioral theory increases when theories are combined or when factors are added, compared with the traditional TPB theory. Gao et al. [43] analyzed the TPB and ETPB to confirm individuals' energy-saving behavior; the TPB exhibited an explanatory power of 22.6 %, whereas the ETPB, which incorporated personal and explanatory norms, exhibited explanatory power of 34.9 %. Mouloudj et al. [44] constructed an ETPB model, including TPB, moral obligation, environmental awareness, and perceived risk in reducing drug waste, which exhibited a high variance of 73.40 %. Recent studies have expanded the TPB by using knowledge factors and demonstrating significant relationships [45,46]. Whitmarsh [47] included self-identity in the TPB, suggesting that a model that includes self-identity can predict environmental behavior better than a single TPB model. Tikir [48] integrated the TPB and the theory of culture to confirm the intention to engage in climate-friendly behavior and psychological processes, and established an explanatory power of 72 %. Zhang et al. [49] found a combined model of TPB and VBN theory to be suitable for predicting the intention of adopting low-carbon technology, and Gkargkavouzi et al. [9] emphasized the superiority of an integrated model to a single model. Chen [10] confirmed that the combined model of TPB and VBN exhibited a 47 % explanatory power for behavioral changes in local organic food consumption. Raghu and Rodrigues [11] and Carfora et al. [12] emphasized that integration can facilitate a comprehensive understanding and prediction.

The VIP model has been subjected to single-model verification and additional study. Lee et al. [50] expanded the VIP model by verifying the existing model and adding environmental self-efficacy variables. Their results proved the significance of applying the VIP model and confirmed the expansion of predictive power. Lee et al. [51] constructed an integrated framework using the VIP model and social responsibility variables and confirmed that the predictability of environmentally friendly behavior was enhanced. Ateş [14] integrated the TPB and VIP model to identify the factors influencing pro-environmental behavior. The integrated model confirmed that 14 of the 16 hypotheses were supported in determining the antecedents of pro-environmental behavior.

The PADM has primarily been used to determine protective behavior in risk situations and can be applied to natural disaster preparedness behavior and environmental protection behavior. It has also been verified and expanded. Health et al. [52] found that stakeholder awareness and protective action behavior predicted protective action decisions, while perceived risk did not. Molan et al. [53] used the PADM to examine responses to wildfire threats, and protective action awareness was found to be the strongest predictor of behavioral intention, whereas stakeholder awareness was not a significant predictor. Shi et al. [54] examined protective behavior by combining the PADM with risk perception and emotion models during the post-COVID-19 period. Their analysis confirmed that when perceived risk increases, people's intentions and frequency of engaging in protective behaviors directly decrease. Hudson et al. [55] integrated the protection motivation theory and the PADM to analyze flood prevention decision-making and confirmed that the core factors of the two theories were factors in taking flood preparedness actions. According to Lindell et al. [56], the risk adjustment attribute among the factors of the PADM was the same as the attitudes of TPA and TPB, suggesting that conformity to the behavior of others can affect an individual's protective behavior. However, few studies have explicitly addressed subjective norms emphasized by TRA and TPB [56].

The TPB, VIP model, and PADM have the following characteristics. First, constrasting with the traditional behavioral theory, i.e., TPB, the VIP model, which is relatively recent behavioral theories that focus on self-identity and personal norms, can predict behavior. Fewer studies have used the PADM to predict behavior compared with the other two theories. However, as noted by Lindell et al. [56], it is necessary to clarify the relationship with the factors of behavioral theories because fit with other people's behavior can affect an individual's protective behavior.

Second, the TPB, VIP model, and PADM can explain various human behaviors, including eco-friendly behaviors and policy acceptance. The VIP model—a concise integration of the TPB and the VBN theory—has been widely applied in various academic fields, such as nursing, psychology, and tourism, and the PADM is characterized by its ability to explain people's responses and information-seeking behaviors in crises, such as wind and water disasters.

Third, the TPB and VIP model are similar in that they emphasize norms but differ in that the TPB emphasizes subjective norms, whereas the VIP model focuses on personal norms. Subjective norms refer to the extent to which other individuals expect an individual to perform certain behaviors. Ajzen [15] defined subjective norms as social pressures that cause individuals to take certain actions. By contrast, personal norms are defined as an individual's self-imposed evaluation of the environmental standards of an action or object. Personal norms allow individuals to act in ways that are consistent with their personal values and generate a sense of moral obligation or responsibility to act in an environmentally friendly manner [36]. A major limitation of the TPB is that it does not account for personal norms. Many studies have explained human behavior by including personal norms through a modified version of the TPB.

Conversely, the PADM has been criticized for not considering subjective norms, suggesting that norms are fundamental in behavioral models.

Fourth, none of these theoretical frameworks include beliefs as an important variable. The perception of consequences, which affect others or the external environment when an individual performs or does not perform a certain behavior, and the attribution of responsibility, which is the sense of responsibility for any negative consequences that arise from an individual's failure to perform a certain behavior, have limited ability to predict various environmental behaviors. Thus, beliefs were excluded from the analysis in the current study to predict more diverse environmental behaviors.

This study examined the decision-making process for an individual's response to climate change by comparing and integrating the key factors included in the TPB, VIP model, and PADM. The research model shown in Fig. 1 is an analytical framework comprising factors that influence response behaviors based on the three models. The differences between three models welll appear in Table 1. The basic models of the three theories were tested separately.

Therefore, we hypothesized the following.

H1. A model that integrates TPB, VIP model, and PADM is a good fit to explain climate change response behavior.

H2. Ecological value affects identity.

H3. Identity affects personal norms, subjective norms, and perceived behavioral control.

H4-1. Personal norms affect risk perception, protective behavior awareness, stakeholder recognition, and intention.

H4-2. Subjective norms affect risk perception, protective behavior awareness, stakeholder recognition, and intention.

H4-3. Perceived behavioral control affects risk perception, protective behavior awareness, stakeholder recognition, and intention.

H5-1. Risk perception affects intention.

H5-2. Protective behavior awareness affects intention.

H5-3. Stakeholder recognition affects intention.

H6. Intention affects behavior.

3. Material and methods

3.1. Data collection

This study used data from a nationally representative survey conducted from May 30 to June 3, 2022, by a specialized polling agency in Korea. The survey methods comprised a web survey, with a survey URL sent via mobile phone, text, and email, and a self-completion method. The sample comprised male and female adults aged 19 years and older living in South Korea. The sampling frame was a master panel of approximately 760,000 people (as of May 2022) assembled by the research firm. Participants were recruited using a proportional sampling method based on region, sex, and age. The maximum allowable sampling error was ±2.5 percentage points at the 95 % confidence level, assuming random sampling, to ensure the representativeness of the sample. Accordingly, the total number of respondents was 14,532; the final sample size was 1571; and the response rate was 10.8 %. Quotas were set for age, sex, and region. In the first stage, respondents were chosen considering the region, and then the survey was conducted by filling in the age and gender. The self-administered questionnaire response method without the intervention of an interviewer, as used in for this survey, has

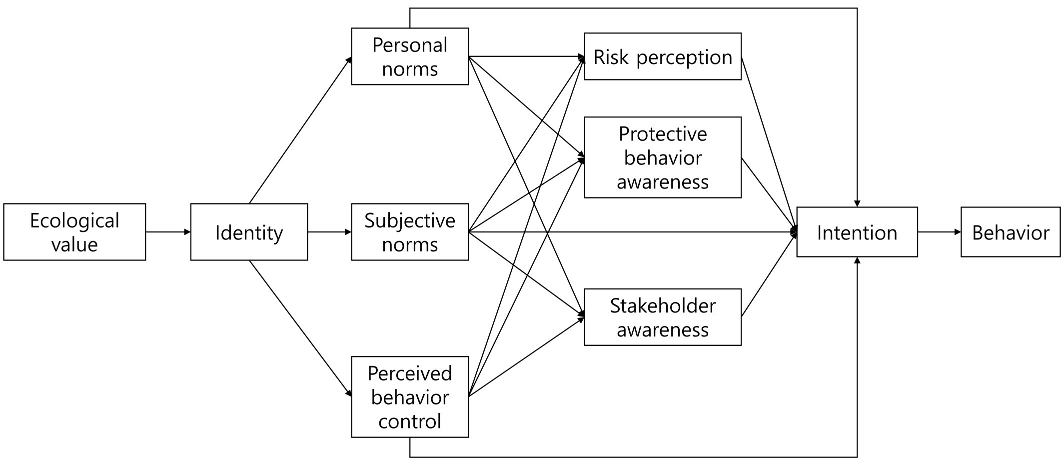
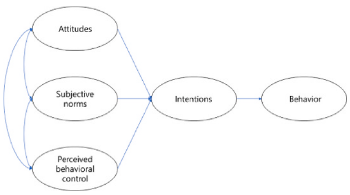
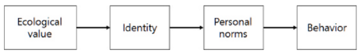
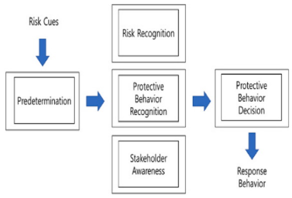


Fig. 1. Integrated research model.

Table 1
Comparison of the TPB, VIP model, PADM.

	TPB	VIP	PADM
Common points	• A social cognitive theory that predicts human behavior • Widely applied across various disciplines (e.g., nursing, psychology, and tourism) • Used to predict and explain behaviors, such as green behaviors, in many studies		
Scholars	• Ajzen [15]	• Ruepert et al. [28]	• Lindell & Perry [38]
Content	• Expands on the theory of reasoned action • Assumes that behavioral intentions are important when choosing to perform specific behaviors • Considers the opportunities or resources available to an individual for performing a behavior when taking an actual action	• Emphasizes personal norms and that ecological value and environmental identity precede personal norms	• Describes an individual's protective measures against environmental hazards and threatening events • Is mainly used to understand people's engagement in risk response behaviors in different situations • Considers the socio-environmental and psychological contexts, especially the latter • Follows the process: risk identification → risk assessment → protective behavior search → protective behavior evaluation → protective behavior implementation → information needs assessment → communication behavior evaluation → communication behavior implementation
Model			
Components	• Attitudes toward a behavior • Subjective norms • Perceived behavioral control • Behavioral intentions • Behavior	• Ecological value • Self-identity • Personal norms • Behavior	• Social and environmental cues • Pre-decision processes (i.e., exposure, attention, and understanding) • Risk, protective behavior, and stakeholder awareness • Protective behavior decision-making • Behavioral responses
Significance	• Strengthens the explanatory power of pro-environmental and pro-social behaviors by including the influence of perceptions of behavioral constraints on behavior	• More concise representation of the VBN theory • Easier to predict general environmental behavior	• Assumes that people exposed to hazards or disasters are informed and that warnings contribute to the formation of individuals' risk perceptions, ultimately leading to protective behavioral intentions • Mainly used in studies of hazardous situations, such as wind, water, or nuclear disasters
Limits	• Limited to social norms, with a focus on subjective norms, making it difficult to identify personal norms and behavioral intentions → Can be complemented by the ETPB	• Does not consider beliefs, making it difficult to strongly predict specific environmental behaviors	• Includes sequential steps, as in the information-seeking process, but individuals experience difficulty following all the steps in the correct order (more steps are omitted if the warning source is more reliable or the authority to enforce compliance is weaker) • Does not consider subjective norms

the advantage of maintaining anonymity but has the weakness of low response sincerity, which may lead to non-sampling errors.

Among the respondents, 772 (49.1 %) were male, and 799 (50.9 %) were female, with 255 (16.2 %) aged 19–29 years, 233 (14.8 %) aged 30–39 years, 294 (18.7 %) aged 40–49 years, 314 (20.0 %) aged 50–59 years, and 475 (30.2 %) aged 60 years or over. In terms of education, 792 (50.1 %) respondents had a high school diploma or lower, and 779 (49.6 %) had a college degree or higher. Finally, 1066 (67.9 %) respondents earned less than 6 million won and 505 (32.1 %) earned more than 6 million won.

This study collected responses for two or more variables from the same survey respondents using self-report methods. Consequently, the problem of common method bias may arise. Therefore, to verify whether such a bias exists, this study conducted Hanman's single-factor test [57]. A principal factor analysis by inputting measurement items for all variables used in this study, revealed that the first factor accounted for the largest explanatory power, at 42.199 %, which was less than 50 %. Accordingly, it was determined that the distortion phenomenon due to common method bias was not significant.

3.2. Measure and reliability analysis

The ecological variables were measured on a 7-point scale, and a 5-point scale was used for the other variables. Cronbach's alpha ranged from 0.744 to 0.914, confirming sufficient reliability. All of statements in questionnaire and their reliability show in Table 2.

4. Results

This study aimed to verify and test an integrated model. Validity and reliability analyses were conducted on the collected data. Confirmatory factor analysis was conducted to verify whether the data reflected the concept to be measured, and reliability analysis was conducted to secure the internal consistency of the questionnaire items.

Next, correlation analysis was conducted on the factors of this study, and verification and explanatory power were confirmed for the TPB, VBN theory, and PADM.

Subsequently, model fit was confirmed to verify the integrated model. Additionally, bootstrapping was used to analyze the direct, indirect, and total effects to confirm the detailed paths. Finally, the fit of the existing and integrated models was confirmed.

4.1. Descriptive statistics

This study conducted a bivariate correlation analysis of the psychological factors associated with climate change behavior (see Table 3). Pearson's correlation coefficient ranged from −1 to 1. As there is no absolute standard for defining how large or small a correlation is between variables, this study defines a high correlation as a correlation coefficient of 0.7 or higher. None of the variables in this study had a correlation coefficient value higher than 0.7. The variables with the highest correlation coefficient values were personal norms and protective action awareness at 0.639 ($p < .001$), followed by behavior and intention at 0.632 ($p < .001$).

Analysis of the TPB factors revealed that subjective norms and perceived behavioral control were positively correlated with behavioral intention and behavior.

Next, we analyzed the correlation coefficients between the behaviors and VIP factors. Ecological values, environmental self-identity, and personal norms were positively correlated with behavioral intentions and response behaviors. In particular, personal norms exhibited significant correlations with both response behaviors and intentions. The strong relationship between personal norms and response behavior suggests that people are more likely to engage in behavior when they perceive them to be right and morally

Table 2
Measurement, reliability and reference.

Concept		Statement	Cronbach α	Reference
Behavior		I participate in policy projects that respond to climate change even if there are many constraints. I cooperate with government policies that respond to climate change even if I face difficult situations.	0.871	Whitmarsh et al.[8]
Intention to behavior		I am willing to pay more in taxes to support government policies to address climate change. I am willing to pay the costs of implementing policies to address climate change.	0.740	Kim et al. [6]
TPB	Subjective norms	People I like think climate change is a serious problem. People I care about think climate change is important.	0.846	Ajzen [58]
	Perceived behavioral control	I can reduce my energy usage enough to solve environmental problems. I think that saving energy contributes to solving environmental problems.	0.840	Ajzen [58]ㅈ
VIP	Ecologism	Respect for the Earth: harmony with other species besides humans Being one with nature: living in harmony with nature Environmental protection: preserving nature Pollution prevention: protecting natural resources	0.914	Stern et al. [33,59] De Groot et al. [60]
	Identity	Being environmentally friendly is very important in my life. I belong to the group of people who practice environmentally friendly things	0.780	Whitmarsh et al. [47]
	Personal norms	I feel a moral obligation to address climate change for future generations. Personally, it is my ethical duty to address climate change.	0.807	Jansson et al. [61] Kim et al. [62]
PADM	Risk perception	Climate change is a very serious problem that cannot be compared to any other risk. The changes caused by climate change will cause a lot of damage to me and my family.	0.798	Linden. [63] Kim et al. [6] Valkengoed et al. [64] Kim et al. [62](
	Protective behavior perception	I can contribute to solving the climate change problem through various efforts. I can reduce the carbon dioxide that causes climate change through my daily actions.	0.796	Bandura et al. [65] Homburg et al. [66]
	Stakeholder perception	The government's goal to solve the climate change problem will be successful. The government's goal to solve the climate change problem is sufficiently achievable.	0.839	O'Connor et al. [67] Nelson et al. [68]

Table 3
Correlation analysis results.

Scale	Average	1	2	3	4	5	6	7	8	9
1. Behavior	3.09	1								
2. Intention	3.17	0.632***	1							
3. Subjective norms	3.38	0.412***	0.392***	1						
4. Perceived behavioral control	3.23	0.364***	0.302***	0.372***	1					
5. Values	5.41	0.267***	0.209***	0.347***	0.425***	1				
6. Identity	3.46	0.468***	0.369***	0.410***	0.467***	0.515***	1			
7. Personal norms	3.44	0.484***	0.444***	0.605***	0.496***	0.462***	0.503***	1		
8. Risk perception	3.67	0.332***	0.269***	0.492***	0.507***	0.504***	0.438***	0.560***	1	
9. Protective behavior awareness	3.43	0.520***	0.419***	0.567***	0.540***	0.388***	0.509***	0.639***	0.529***	1
10. Stakeholder awareness	3.56	0.474***	0.378***	0.433***	0.512***	0.425***	0.459***	0.569***	0.519***	0.547***

*p < .05, **p < .01, ***p < .001.

upright.

The analysis of behavioral and PADM factors found that three dimensions of awareness (i.e., risk awareness, protective action awareness, and stakeholder awareness) were positively related to response behavior intentions and response behavior. In particular, protective action awareness had the highest correlation with behavioral intentions and behaviors, suggesting that seeking information to protect oneself from the risks of climate change can lead to behavioral intentions and response behavior.

Considering TPB, VIP model, and PADM factors, the variables with the highest correlation coefficients with behavioral intention were personal norms, protective behavior awareness, and subjective norms. The variables that influence behavior are protective behavior awareness, personal norms, and stakeholder awareness. Overall, the correlation coefficient values of personal norms and protective behavior awareness affected intention and behavior.

4.2. Validation of existing models

This study tested the fit of a model that integrates TPB, VIP model, and PADM. Various criteria can be used to determine the fit of a theory-based model. In this study, we consider various fit indices: the absolute, incremental, and parsimonious fit indices (see Table 4). Absolute goodness of fit describes how well the model predicts the data, whereas incremental goodness of fit evaluates the extent to which the model is compared with a null model. Parsimonious goodness of fit uses the tradeoff between goodness of fit and degrees of freedom to evaluate whether a model has a high goodness of fit with as many degrees of freedom as possible.

Next, this study examined the suitability of the TPB-based process model for explaining climate change responses using climate change perceptions (see Fig. 2). In the Table 5, the fit indices of the model were found to be sufficiently large to explain responses to climate change (chi-square = 163.669, p = .000, goodness-of-fit index [GFI] = 0.975, normalized fit index [NFI] = 0.972, root mean square error of approximation [RMSEA] = 0.077, Tucker–Lewis index [TLI] = 0.955, and standardized root mean square residual [SRMR] = 0.049). The effect size of the path between intention and behavior was large ($B = 0.776$). Subjective norms had a larger effect on intention compared with perceived behavioral control.

The finding that subjective norms have a stronger effect on behavioral intentions than perceived behavioral control suggests that social factors and norms play important roles in driving climate change actions. This suggests that using subjective norms may be effective when designing strategies to address climate change.

Next, the appropriateness of the VIP model was analyzed (see Fig. 3 and Table 6). The significance of the model was confirmed (chi-square = 198.886, p = .000, GFI = 0.974, NFI = 0.978, RMSEA = 0.061, TLI = 0.971, and SRMR = 0.027).

Table 4
Model significance and goodness of fit.

Goodness-of-Fit Index		Criteria	Explanation
Absolute Conformance Indices	CMIN	x^2 Statistical table thresholds/p > .05	CMIN(Chi-square Minimization)
	D.F.		D.F.(Degree of Freedom)
	P		P(Probability Value)
	CMIN/D.F.	≤5	
	GFI	≥0.9	**GFI(Goodness of Fit Index)**
	RMSEA	≤0.06	**RMSEA(Root Mean Square Error of Approximation)**
	SRMR	≤0.10	SRMR(Standardized Root Mean Square Residual)
Incremental Conformance Indices	TLI	≥0.9	TLI(Turker Lewis Index)
	CFI	≥0.9	**CFI(Comparative Fit Index)**
	NFI	≥0.9	**NFI(Normed Fit Index)**
Simplicity Fit Indices	PNFI	≥0.6	**Parsimony NFI**
	ECVI	The closer to zero, the better	ECVI(Expected Cross Validation Index)
	AIC		AIC(Akaike Information Criterion)
	BIC		BIC(Bates Information Crierion)

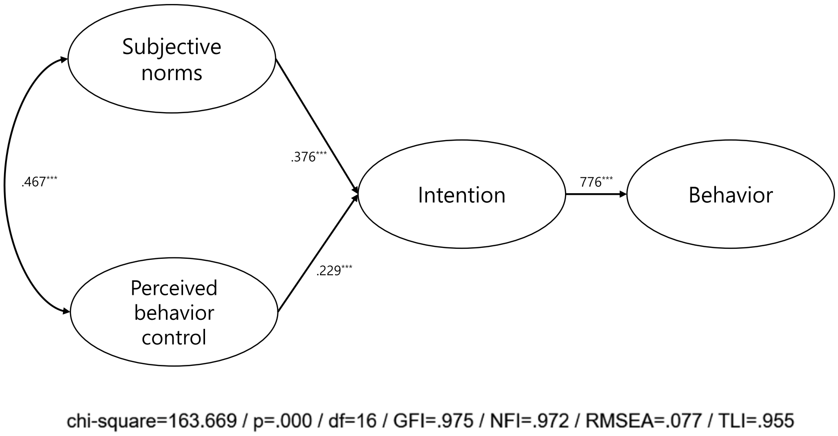


Fig. 2. Validating the TPB model.

Table 5
Verification of the effectiveness of TPB.

			Estimate	S.E.	C.R.	P	Std Beta
INTENTION	←	Subjective norms	0.422	0.037	11.341	***	0.376
INTENTION	←	Perceived behavioral control	0.315	0.047	6.716	***	0.229
BEHAVIOR	←	INTENTION	0.678	0.025	27.077	***	0.776

Estimate: Regression Weights.
S.E.: Standard Errors.
C.R.: Critical Ratio.
P: Critical Ratio & Confidence Value/*p < .05, **p < .01, ***p < .001.
Std Beta: Standardized Regression Weights.

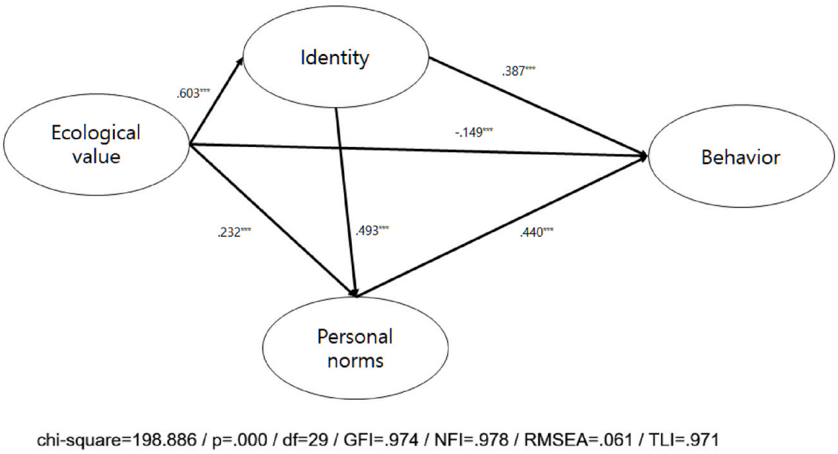


Fig. 3. Validation of the VIP model.

The paths from values, identity, and personal norms to behavior were all significant. The path from ecological value and identity exhibited the highest value (B = 0.603, $p < .001$), followed by the path from identity to personal norms ($B = 0.493$, $p < .001$), and from personal norms to behavior ($B = 0.440$, $p < .001$). Interestingly, ecological value and behaviors have negative effects. The protection of nature is a core ecological value, and the greater the emphasis on ecological value, the greater the behavioral passivity in response to climate change. This may be because of concerns that nature may be damaged in the process of responding to climate change. Moreover, the greater the emphasis on ecological value, the more negative the potential effect due to concerns about whether climate change response policies can be effectively implemented in a manner that protects nature or because of the difficulty in striking a balance between ecological values and climate change response policies.

In other words, this relationship is negative because protection of nature is a core ecological value. For example, the use of fossil

Table 6
Verification of the effectiveness of the VIP model.

			Estimate	S.E.	C.R.	P	Std Beta
Identity	←	VALUE	0.461	0.023	20.218	***	0.603
Personal norms	←	Identity	0.529	0.042	12.472	***	0.493
Personal norms	←	VALUE	0.19	0.028	6.722	***	0.232
BEHAVIOR	←	VALUE	−0.116	0.027	−4.342	***	−0.149
BEHAVIOR	←	Identity	0.393	0.047	8.431	***	0.387
BEHAVIOR	←	Personal norms	0.417	0.04	10.389	***	0.44

Estimate: Regression Weights.
S.E.: Standard Errors.
C.R.: Critical Ratio.
P: Critical Ratio & Confidence Value/*$p < .05$, **$p < .01$, ***$p < .001$.
Std Beta: Standardized Regression Weights.

fuels, the root cause of climate change, has led to global warming and extreme weather events. Renewable and eco-friendly energy power plants are being installed worldwide to replace fossil fuel energy sources; however, mountains and fields covered with solar power plants, a representative eco-friendly energy source, may frustrate the goal of nature conservation. Similarly, people with ecological values may perceive a gap between policies to respond to climate change and the goal of nature conservation. In other words, certain policies to respond to climate change may not necessarily be consistent with the goal of protecting nature and may even be environmentally harmful. This explains the inverse relationship between responses to climate change and nature conservation.

Next, the PADM was used to analyze the impact of risk perception on climate change. This study analyzed the impact of risk perception, such as perceived risk, alternative protective behavior perception, and stakeholder perception, on protective behavior decision-making (see Fig. 4). In Table 7 the analysis confirmed that the model fit was good (chi-square = 322.991, $p = .000$, GFI = 0.961, NFI = 0.960, RMSEA = 0.082, TLI = 0.941, and SRMR = 0.066).

Examining the relationship between the models, the path from behavioral intention to behavior exhibited the largest effect size ($B = 0.791$, $p < .001$). Examining the paths of the three elements of risk perception and intention, protective behavior awareness exhibited the largest effect size ($B = 0.447$, $p < .001$). People may exhibit a greater active intention when they believe that their behavior effectively contributes to solving a problem. In other words, when people recognize the seriousness of climate change and believe that their actions play an important role, their willingness to participate in climate change efforts may increase.

Perceived risk negatively affected intention ($b = -0.106$, $p < .05$). Climate change is a serious problem that cannot be avoided; it directly harms individuals and families. Therefore, once individuals identify actions to take, they can decide on how to respond and they are likely to cooperate with government policies.

4.3. Validating the unified model

To check the convergent and discriminant validity of the latent variables, the CR value, average variance extracted (AVE) value, and correlation coefficients between the latent variables were calculated. The analysis confirmed that the standardized coefficients were all greater than 0.7 and that the AVE and CR values met the required criteria, confirming convergent validity (see Table 8). Regarding discriminant validity, some correlation coefficients between latent variables were found to be greater than 0.6; however,

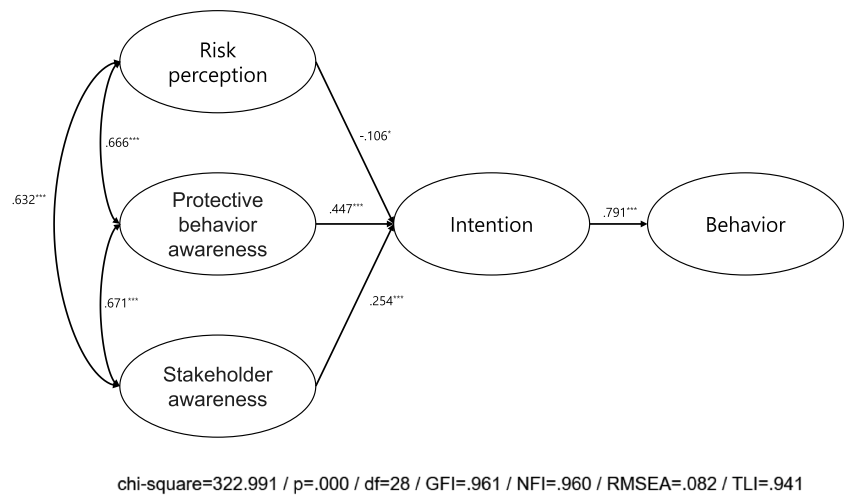


Fig. 4. Validation of the PADM.

Table 7
Verification of the effectiveness of PADM.

			Estimate	S.E.	C.R.	P	Std Beta
INTENTION	←	Risk perception	−0.133	0.055	−2.432	0.015	−0.106
INTENTION	←	Protective behavior awareness	0.558	0.061	9.209	***	0.447
INTENTION	←	Stakeholder awareness	0.286	0.048	5.946	***	0.254
BEHAVIOR	←	INTENTION	0.689	0.026	26.548	***	0.791

Estimate: Regression Weights.
S.E.: Standard Errors.
C.R.: Critical Ratio.
P: Critical Ratio & Confidence Value/*p < .05, **p < .01, ***p < .001.
Std Beta: Standardized Regression Weights.

Table 8
Standardized regression coefficient values of measured variables.

			beta	B	S.E.	T	AVE	CR
q2_12	←	Ecological value	1	0.899			0.769	0.93
q2_11	←	Ecological value	1.053***	0.931	0.025	41.861		
q2_10	←	Ecological value	1.018***	0.888	0.033	31.148		
q2_9	←	Ecological value	0.883***	0.781	0.036	24.855		
q3_28	←	Identity	1	0.834			0.642	0.782
q3_29	←	Identity	0.937***	0.768	0.033	28.007		
q12_38	←	Personal norms	1	0.818			0.677	0.807
q12_39	←	Personal norms	0.991***	0.827	0.029	34.562		
q9_47	←	Perceived behavioral control	1	0.78			0.588	0.74
q9_46	←	Perceived behavioral control	0.943***	0.753	0.037	25.157		
q12_40	←	Subjective norms	1	0.834			0.735	0.847
q12_41	←	Subjective norms	1.054***	0.88	0.031	33.768		
q12_64	←	Risk perception	1	0.821			0.664	0.798
q12_65	←	Risk perception	0.957***	0.809	0.031	30.384		
q12_30	←	Stakeholder awareness	1	0.88			0.724	0.84
q12_29	←	Stakeholder awareness	0.897***	0.821	0.027	33.706		
q12_48	←	Protective behavior awareness	1	0.805			0.661	0.796
q12_49	←	Protective behavior awareness	1.02***	0.821	0.031	32.915		
q12_9	←	Intention	1	0.86			0.773	0.872
q12_10	←	Intention	1.017***	0.898	0.028	36.157		
q12_5	←	Behavior	1	0.784			0.668	0.801
q12_6	←	Behavior	1.06***	0.85	0.034	31.591		

CR: Construct Reliability.
AVE: Average Variance Extracted.
To check the convergence validity of the latent variables, we calculated the construct reliability (CR) and average variance extracted (AVE) values. As a result, the AVE and CR values were found to be excellent, confirming convergence validity.

when comparing the rooted AVE value and the correlation coefficient values between latent variables, we were able to distinguish the latent variables from each other (see Table 9).

Discriminant validity was further rigorously verified using the heterotrait-monotrait ratio of correlations (HTMT). HTMT is a method for evaluating the discriminant validity between latent variables in structural equation modeling. This evaluation technique was suggested by Henseler et al. [69], who noted that the standard for comparing the correlation coefficient between latent variables and the root of the AVE value, which has been commonly used as a conventional discriminant validity evaluation technique, lacked sensitivity. Clear discriminant validity exists when the calculated HTMT value between latent variables is lower than 0.85, and values below 0.9 is generally considered acceptable. The HTMT value in this study was 0.85 or lower, confirming discriminant validity (see Table 10).

The integrated model combines the TPB, VIP model, and PADM and analyzes the determinants of the decision-making process for climate change response (see Fig. 5). The results showed that this model had an appropriate fit (chi-square = 1271.866, p = .000, GFI = 0.930, NFI = 0.940, RMSEA = 0.060, TLI = 0.937, SRMR = 0.059).

The paths were generally significant, but perceived behavioral control and intention, subjective norms, and stakeholder awareness were found to be insignificant. Ecological value exhibited a significant path to identity ($B = 0.667$, $p < .001$), and identity exhibited a significant path to personal norms, subjective norms, and perceived behavioral control. In particular, identity exhibited the largest effect size on personal norms ($B = 0.816$, $p < .001$).

Next, identity exhibited an effect size with perceived behavioral control ($B = 0.738$, $p < .001$), and subjective norms had the smallest effect size ($B = 0.662$, $p < .001$). Personal norms were also found to be significant with perceived risk, protective behavior awareness, and stakeholder awareness; in particular, the path of stakeholder awareness had the largest effect size ($B = 0.455$, $p <$ .001). Personal norms also exhibited a significant effect size regarding the intention to participate in climate change response policies

Table 9
Validity analysis.

	CR	AVE	1	2	3	4	5	6	7	8	9	10
1. Ecological value	0.93	0.769	**0.877**									
2. Identity	0.782	0.642	0.598***	**0.801**								
3. Personal norms	0.807	0.677	0.521***	0.634***	**0.823**							
4. Risk perception	0.798	0.664	0.575***	0.557***	0.697***	**0.815**						
5. Intention	0.872	0.773	0.220***	0.439***	0.529***	0.319***	**0.879**					
6. Protective behavior awareness	0.796	0.661	0.438***	0.642***	0.798***	0.665***	0.500***	**0.813**				
7. Subjective norms	0.847	0.735	0.384***	0.505***	0.733***	0.594***	0.457***	0.690***	**0.857**			
8. Perceived behavioral control	0.74	0.588	0.506***	0.612***	0.642***	0.661***	0.369***	0.703***	0.469***	**0.767**		
9. Behavior	0.801	0.668	0.312***	0.583***	0.610***	0.428***	0.751***	0.652***	0.510***	0.478***	**0.817**	
10. Stakeholder awareness	0.84	0.724	0.478	0.567	0.692	0.63	0.438	0.669	0.51	0.646	0.591	**0.851**

CR: Construct Reliability.
AVE: Average Variance Extracted.

Table 10
Validity analysis (HTMT Analysis).

	1	2	3	4	5	6	7	8	9	10
1. Ecological value										
2. Identity	0.61									
3. Personal norms	0.538	0.634								
4. Risk perception	0.591	0.555	0.697							
5. Intention	0.234	0.447	0.53	0.322						
6. Protective behavior awareness	0.455	0.646	0.798	0.664	0.503					
7. Subjective norms	0.395	0.505	0.733	0.599	0.457	0.691				
8. Perceived behavioral control	0.517	0.615	0.641	0.659	0.375	0.703	0.47			
9. Behavior	0.312	0.593	0.604	0.417	0.757	0.652	0.502	0.474		
10. Stakeholder awareness	0.485	0.567	0.691	0.634	0.441	0.669	0.514	0.65	0.579	

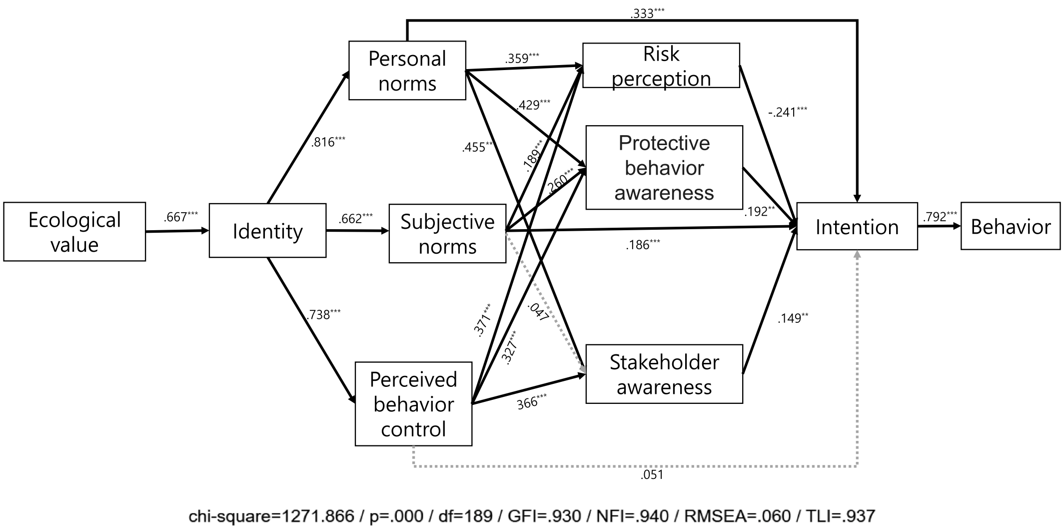


Fig. 5. Validation of the unified model.

(B = 0.333, $p < .001$) (see Table 11).

Subjective norms were found to be significant for perceived risk and perceived protective behavior but not for stakeholder awareness. Subjective norms exhibited the largest effect size, with a path of protective behavior awareness ($B = 0.260$, $p < .001$). Subjective norms showed a significant effect on the intention to participate in climate change response policies ($B = 0.186$, $p < .001$).

Perceived behavioral control was found to be significant with perceived risk, perceived protective behavior, and stakeholder awareness; in particular, the path of perceived risk showed the largest effect size ($B = 0.371$, $p < .001$). However, perceived behavioral control was not significant for the intention to participate in climate change response policies.

Perceived risk, perceived protective behavior, and stakeholder awareness exhibited significant values for behavioral intention. Perceived risk negatively affected behavioral intention and protective behavior awareness, whereas stakeholder awareness positively affected them.

Intention was confirmed as a significant path in policy actions for climate change responses (B = 0.792, p < .001).

When the TPB, VIP model, and PADM are integrated, the variables of the VIP model exhibited the strongest path and the largest effect size. The integrated model confirmed that environmental self-identity positively influenced future responses to climate change by strengthening personal norms.

The total, direct, and indirect effects were confirmed based on the integrated model (see Table 12). The analysis revealed that most of the paths were significant. However, for the paths of perceived behavioral control and intention, subjective norms and intention, and personal norms and intention, the value of the direct or indirect effects was 0, indicating that at least one path was not significant. Therefore, this study estimated the significance of the indirect effects using an integrated model.

The indirect effect estimates of the multiple mediation model are as follows (see Table 13). There are four paths from personal norms to intention, and the direct effect is 0.382. There are three indirect effects, (1) the indirect effect value of personal norms → risk perception → intention is −0.099; (2) the indirect effect of personal norms → protective behavior perception → intention is 0.094; (3) the indirect effect of personal norms → stakeholder perception → intention is 0.078. Total effect is 0.073 if the indirect effect values (−0.099 + 0.094 + 0.078) are summed. The path from personal norms to intention exhibited significant direct and indirect effects. Hayes [70] emphasized that even if the relationship between a predictor and a criterion variale is not signficant, a variable may significantly mediate the relationship between variables.

Table 11
Verification of the unified model.

			Estimate	S.E.	C.R.	P	Std Beta
Identity	←	VALUE	0.383	0.016	23.296	***	0.667
Subjective norms	←	Identity	0.779	0.038	20.478	***	0.662
Personal norms	←	Identity	0.987	0.04	24.702	***	0.816
Perceived behavioral control	←	Identity	0.741	0.036	20.71	***	0.738
Risk perception	←	Personal norms	0.347	0.037	9.416	***	0.359
Protective behavior awareness	←	Personal norms	0.381	0.032	11.972	***	0.429
Stakeholder awareness	←	Personal norms	0.423	0.036	11.894	***	0.455
Risk perception	←	Subjective norms	0.188	0.031	6.142	***	0.189
Protective behavior awareness	←	Subjective norms	0.238	0.026	9.078	***	0.26
Stakeholder awareness	←	Subjective norms	0.045	0.028	1.574	0.115	0.047
Risk perception	←	Perceived behavioral control	0.433	0.045	9.609	***	0.371
Protective behavior awareness	←	Perceived behavioral control	0.35	0.038	9.276	***	0.327
Stakeholder awareness	←	Perceived behavioral control	0.409	0.042	9.673	***	0.366
INTENTION	←	Risk perception	−0.286	0.06	−4.794	***	−0.241
INTENTION	←	Protective behavior awareness	0.248	0.086	2.881	0.004	0.192
INTENTION	←	Stakeholder awareness	0.184	0.056	3.303	***	0.149
INTENTION	←	Personal norms	0.382	0.07	5.47	***	0.333
INTENTION	←	Subjective norms	0.219	0.045	4.872	***	0.186
INTENTION	←	Perceived behavioral control	0.07	0.077	0.908	0.364	0.051
BEHAVIOR	←	INTENTION	0.693	0.026	26.443	***	0.792

Estimate: Regression Weights.
S.E.: Standard Errors.
C.R.: Critical Ratio.
P: Critical Ratio & Confidence Value/*p < .05, **p < .01, ***p < .001.
Std Beta: Standardized Regression Weights.

The direct effect of subjective norm → intention was 0.219, and the mediating path can be largely divided into three types; (1) the path of subjective norm → risk perception → intention, and (2) the path of subjective norm → protective behavior perception → intention were significant because the lower and upper values did not include 0, whereas (3) the path of subjective norm → stakeholder perception → intention was insignificant because it included 0.

In the case of perceived behavioral control, all indirect effects were significant; however, the direct effect of perceived behavioral control → intention was insignificant. An analysis of the four paths for personal norms and intentions revealed the direct effect to be 0.382, and the upper and lower limits did not include 0, which was significant. Analysis of the three mediating paths confirmed that all had significant values.

5. Validation of all four models

The significance and goodness of fit of the TPB, the VIP model, PADM, the integrated model, and the alternative model were tested. Most individual and integrated models met most of the target index values (Table 14). The fit indices of the TPB, VIP model, and PADM were compared with those of the integrated model. The GFI, RMSEA, and SRMR are absolute fit indices that measure how well a research model predicts the data. These values meet the acceptability criteria. The TLI, CFI, and NFI are incremental fit indices that assess how much better a model is than the null model; they also meet the acceptability criteria.

The parsimony fit index uses the trade-off relationship between the degree of fit and the degrees of freedom to evaluate whether the model has the highest degree of freedom and a high level of fit. The parsimony normed fit index (PNFI) showed that the integrated model had the highest value of 0.769. However, when the Akaike information criterion (AIC) and Bayesian information criterion (BIC) values are analyzed, the values of the existing model are closer to 0 than those of the integrated model.

The integrated model was designed to provide a more comprehensive and detailed analysis by combining the TPB, VIP model, and PADM. As multidimensional predictive factors were inputted compared with the existing model, the complexity increased, and accordingly, the values of AIC and BIC increased compared with the existing simple model. This is because the model includes more variables, which increases the data fit and is a result of its complexity.

Although the AIC and BIC values were high, the integrated model provided richer insights by considering various variables. This enables a more accurate and detailed understanding of climate change response behaviors and can provide important information to policymakers and researchers. In particular, the high explanatory power of the integrated model enables a multifaceted analysis that individual models cannot provide.

Additionally, the fit indices (e.g., GFI, NFI, RMSEA, and TLI) of the integrated model were good. This suggests that the model explains the data well and indicates that the integrated model is a suitable analytical tool. The validity of the model can be supplemented by emphasizing the goodness-of-fit indices.

Although AIC and BIC are useful indicators for model comparison, the fit indices and explanatory power of the model may be more important when considering the purpose of the integrated model and the context of the analysis. In particular, when dealing with complex issues, such as responding to climate change, it is essential to consider various variables and their interactions. An analysis of

Table 12
Effect analysis.

Variables			Direct	In-direct	Total	Lower	Upper	Standard-ized direct	Standard-ized in-direct	Standard-ized total	Lower	Upper
Ecological value	→	Identity	0.383	0	0.383	0	0	0.667	0	0.667	0	0
	→	Perceived behavioral control	0	0.284	0.284	0.249	0.319	0	0.492	0.492	0.442	0.542
	→	Subjective norms	0	0.298	0.298	0.26	0.336	0	0.442	0.442	0.393	0.487
	→	Personal norms	0	0.378	0.378	0.34	0.417	0	0.545	0.545	0.501	0.587
	→	Stakeholder awareness	0	0.289	0.289	0.256	0.324	0	0.448	0.448	0.405	0.49
	→	Protective behavior awareness	0	0.314	0.314	0.28	0.348	0	0.51	0.51	0.467	0.548
	→	Risk perception	0	0.31	0.31	0.273	0.346	0	0.462	0.462	0.416	0.507
	→	Intention	0	0.272	0.272	0.236	0.306	0	0.342	0.342	0.3	0.382
	→	Behavior	0	0.188	0.188	0.157	0.224	0	0.271	0.271	0.229	0.316
Identity	→	Perceived behavioral control	0.741	0	0.741	0	0	0.738	0	0.738	0	0
	→	Subjective norms	0.779	0	0.779	0	0	0.662	0	0.662	0	0
	→	Personal norms	0.987	0	0.987	0	0	0.816	0	0.816	0	0
	→	Stakeholder awareness	0	0.755	0.755	0.67	0.85	0	0.672	0.672	0.629	0.716
	→	Protective behavior awareness	0	0.82	0.82	0.733	0.92	0	0.764	0.764	0.723	0.802
	→	Risk perception	0	0.81	0.81	0.716	0.915	0	0.692	0.692	0.647	0.736
	→	Intention	0	0.711	0.711	0.613	0.818	0	0.512	0.512	0.454	0.567
	→	Behavior	0	0.492	0.492	0.406	0.594	0	0.406	0.406	0.344	0.469
Perceived behavioral control	→	Stakeholder awareness	0.409	0	0.409	0	0	0.366	0	0.366	0	0
	→	Protective behavior awareness	0.35	0	0.35	0	0	0.327	0	0.327	0	0
	→	Risk perception	0.433	0	0.433	0	0	0.371	0	0.371	0	0
	→	Intention	0.07	**0.038**	0.109	−0.076	0.152	0.051	0.028	0.079	−0.054	0.114
	→	Behavior	0	0.075	0.075	−0.02	0.18	0	0.062	0.062	−0.016	0.147
Subjective norms	→	Stakeholder awareness	0.045	0	0.045	0	0	0.047	0	0.047	0	0
	→	Protective behavior awareness	0.238	0	0.238	0	0	0.26	0	0.26	0	0
	→	Risk perception	0.188	0	0.188	0	0	0.189	0	0.189	0	0
	→	Intention	0.219	**0.013**	0.232	−0.053	0.082	0.186	0.011	0.197	−0.045	0.069
	→	Behavior	0	0.161	0.161	0.081	0.239	0	0.156	0.156	0.077	0.232
Personal norms	→	Stakeholder awareness	0.423	0	0.423	0	0	0.455	0	0.455	0	0
	→	Protective behavior awareness	0.381	0	0.381	0	0	0.429	0	0.429	0	0
	→	Risk perception	0.347	0	0.347	0	0	0.359	0	0.359	0	0
	→	Intention	0.382	**0.073**	0.455	−0.055	0.187	0.333	0.064	0.397	−0.049	0.162
	→	Behavior	0	0.315	0.315	0.209	0.426	0	0.314	0.314	0.213	0.418
Stake-holder awareness	→	Intention	0.184	0	0.184	0	0	0.149	0	0.149	0	0
	→	Behavior	0	0.128	0.128	0.026	0.224	0	0.118	0.118	0.025	0.207
Protective behavior	→	Intention	0.248	0	0.248	0	0	0.192	0	0.192	0	0
	→	Behavior	0	0.172	0.172	0.03	0.32	0	0.152	0.152	0.026	0.285
Risk perception	→	Intention	−0.286	0	−0.286	0	0	−0.241	0	−0.241	0	0
	→	Behavior	0	−0.198	−0.198	−0.301	−0.104	0	−0.191	−0.191	−0.289	−0.102
Intention	→	Behavior	0.693	0	0.693	0	0	0.792	0	0.792	0	0

Table 13
Indirect effect estimation.

Parameter				Estimate	Lower	Upper
Ind1	Personal norms	Risk perception	Intention	−0.099	−0.169	−0.046
Ind2	Personal norms	Protective behavior awareness	Intention	0.094	0.017	0.179
Ind3	Personal norms	Stakeholder awareness	Intention	0.078	0.016	0.134
Ind4	Subjective norms	Risk perception	Intention	−0.054	−0.095	−0.023
Ind5	Subjective norms	Protective behavior awareness	Intention	0.059	0.009	0.117
Ind6	Subjective norms	Stakeholder awareness	Intention	0.008	−0.005	0.027
Ind7	Perceived behavioral control	Risk perception	Intention	−0.124	−0.196	−0.064
Ind8	Perceived behavioral control	Protective behavior awareness	Intention	0.087	0.013	0.174
Ind9	Perceived behavioral control	Stakeholder awareness	Intention	0.075	0.015	0.142

Table 14
Adjusted goodness-of-fit index values for all models.

Goodness-of-Fit Index		Criteria	Goodness-of-Fit Index Value			
			TPB	VIP	PADM	Unified Model
Absolute Conformance Indices	CMIN	x^2 Statistical table thresholds/p > .05	163.669	198.886	322.991	1271.866
	D.F.		16	29	28	189
	p		0.000	0.000	0.000	0.000
	CMIN/D.F.	5 or fewer	10.229	6.858	11.535	6.729
	GFI	≥0.9	0.975	0.974	0.961	0.930
	RMSEA	≤0.06	0.077	0.061	0.082	0.060
	SRMR	≤0.10	0.049	0.027	0.066	0.059
Incremental Conformance Indices	TLI	≥0.9	0.955	0.971	0.941	0.937
	CFI	≥0.9	0.974	0.981	0.964	0.949
	NFI	≥0.9	0.972	0.978	0.960	0.940
Simplicity Fit Indices	PNFI	≥0.6	0.555	0.630	0.598	0.769
	ECVI	The closer to zero, the better	0.130	0.160	0.240	0.892
	AIC		203.669	250.886	376.991	1399.866
	BIC		310.858	390.232	521.697	1967.030

the existing and integrated models revealed that this study's integrated model has a superior actual model fit and relationship between variables.

6. Discussion and implication

The purpose of this study is to explore the various factors that influence climate change response by integrating various behavioral theoretical models. Although there are various behavioral theories that explain human behavior, single theories such as TPB, VIP, and PADM have the following limitations in explaining complex human behavior. First, TPB's main limitations include the gap between behavioral intentions and actual behavior and the lack of explanatory power of independent variables [71], and VIP theory is a model that explains human behavior by focusing on environmental self-identity, but it emphasizes only personal norms, which raises the need to expand behavioral patterns [72]. The PADM model primarily explains the disaster-related protective behavior decision-making process, but it does not include social factors in general, and its focus on phased response behaviors limits its ability to address long-term behavioral sustainability [56].

While each single theory requires various complementary points to explain human behavior, in recent years, integrated studies such as the Theory of Planned Behavior, VBN model, and VIP model have been conducted to better predict human behavior [9–12,49]. TPB, VIP, and PADM models have been extended with a variety of variables. The previous studies have confirmed that integrated models have higher explanatory power [9,14,43,44,47,48,51,53,54],. However, most of the integrated models focus on specific behaviors, such as eco-friendly behavior, consumption, and recycling, which limits the scope of the research and relies on the variables proposed in existing models [14]. For a comprehensive analysis of climate change response behavior, it is necessary to consider contextual factors and intentions along with the expansion of the integrated model.

This study aims to explore various factors that influence climate change response and integrates the TPB, VIP, and PADM models. The significance of the integrated model is that it can take into account individual characteristics and situational factors such as values, identity, and behavioral awareness. The results of the integrated TPB, VIP, and PADM models showed that the model fit was superior compared to the single model. The Root Mean Square Error of Approximation (RMSEA) value of the integrated model was 0.06. RMSEA is an index of absolute goodness of fit that was developed to address the problem that the chi-square value becomes problematic as the number of samples increases. It is considered acceptable when the value is in the range of 0.05–0.08, which is the smallest compared to the existing three models.

We found that the TPB, VIP, and PADM variables actually have a significant effect on climate change action behavior. The indirect effect of subjective norms→stakeholder perception→intention was not significant, and the direct effect of perceived behavioral control→intention was not significant, but otherwise significant.

The theoretical contributions of this study are as follows. First, by integrating the TPB, VIP, and PADM models, we present a comprehensive model to explain climate change response behavior. It complements the limitations of the single theories and provides a theoretical framework that can better explain complex human behavior. Second, the factors in the integrated model include personal and situational factors. While previous single theories have focused primarily on individual factors, the integrated model expands to include personal characteristics such as values, identity, and behavioral perceptions, as well as contextual factors. This allows for a more comprehensive understanding of climate change adaptation behavior. Third, this study provides a clearer understanding of the relationship between risk perception and climate action behavior. We demonstrate that risk perception can negatively affect climate change adaptation behavior and theoretically show that risk perception does not always lead to action, providing a new perspective that has not been addressed in previous studies. Finally, we show that the fit of the integrated model is better than that of the single model, thus theoretically demonstrating that the integrated model is more valid for predicting behavior.

The policy contributions of this study are as follows. First, it suggests the need for a multifaceted approach to policy design. This study emphasizes the need for an integrated policy design that considers various factors such as ecological values, identity, personal norms, and risk perceptions, thus providing a basis for more effective design of climate change response policies. Second, it is necessary to set policy directions to promote ecological values. We have theoretically demonstrated that ecological values and identity play an important role in climate change response behavior. By highlighting the importance of educational programs and campaigns that can promote ecological values and strengthen individuals' environmental identity, the evidence can be used by policy makers to formulate practical strategies that can drive climate change response behavior in the long term. Third, it can suggest strategies for responding to risk perceptions. We find that climate change risk perception may not lead to action, suggesting that governments should design policies that provide psychological reassurance and clear behavioral guidance. Finally, it can contribute to the development of comprehensive action promotion measures. We found that policies that comprehensively consider various factors are needed to promote climate change action. It can provide a basis for governments to develop and implement effective climate policies that take into account complex factors in policy implementation.

However, future research should conduct longitudinal studies to clarify changes over time and causal relationships, and should use a variety of data collection methods other than self-reporting to minimize individual differences and inconsistencies. Furthermore, the generalizability of the findings should be increased by considering different cultural backgrounds.

7. Conclusion

This study aimed to explore the different factors that influence climate change responses by integrating different models of behavioral theory into a unified model to explain human behavior.

TPB is the most representative behavioral theory. Recent studies have applied it to pro-environmental behavior, and it is often used in conjunction with the NAM and VBN models [22]. However, there are limitations in the explanatory power of the independent variables used in the TPB and the gap between behavioral intention and behavior [71]. Schwartz's [34] study emphasized the importance of personal norms for pro-environmental behavior, but the TPB overlooked personal norms. Harland's [73] study analyzed changes in behavior by including personal norms and found that the explanatory power was higher in the model that included personal norms, suggesting that personal norms may play an important role.

The VIP model is a simplified version of the VBN model and is useful for explaining behavior in general situations. It is also useful for explaining pro-environmental behavior using ecological values, environmental self-identity, and personal norms variables. In contrast to the TPB, the VIP model emphasizes personal norms and therefore does not address subjective norms. Also, the VIP model emphasizes identity, and it is necessary to understand cognitive, motivational, and structural factors and processes in order to understand an individual's pro-environmental behavior patterns [72].

The PADM model primarily describes the protective behavior decision-making process that people follow after they actually experience disaster-related information. The model emphasizes the influence of risk perception, protective behavior perception, and stakeholder perception on protective behavior decision-making. Unlike the TPB and VIP models, the PADM model has been studied mainly in the context of protective behavioral decision-making in response to risk. However, as Lindell et al. [56] emphasize, the behavior of others can influence an individual's protective behavior, and there is a need to identify the relationship between the factors of the TPB and the factors of the PADM. In other words, PADM has limitations in that it does not fully consider the influence of social factors or collective behavior on individual protective behavior, and its focus on short-term coping behaviors limits long-term behavioral persistence.

In this study, we focus on the strengths and complementarities of TPB, VIP, and PADM and integrate them. The TPB, VIP, and PADM models can play complementary roles with each other. In particular, the PADM model can complement the TPB and VIP models to influence psychological processes. Through the integration of the TPB, VIP, and PADM models, this study found that factors that influence climate change response behavior can be classified into personal, social, and situational factors. Personal factors are intrinsically motivating factors such as values and norms, social factors are extrinsically motivating factors such as subjective norms and social influences, and situational factors are behavioral promotion through risk perception.

H1 was accepted because the integrated model showed similarly good fit compared to the single theories despite its increased complexity (Chi-square = 1271.866, p = .000, GFI = 0.930, NFI = 0.940, RMSEA = 0.060, TLI = 0.937, SRMR = 0.059). Ecological values influence identity (accepted H2), and identity influences personal norms, subjective norms, and perceived behavioral control (accepted H3). We find that personal norms influence risk perception, protective behavior perception, and stakeholder awareness, and directly influence climate change action intention (H4-1 accepted). Subjective norms have a significant effect on risk perception, protective behavior, and climate change action intention, but not on stakeholder awareness (H4-2 partially rejected). Perceived behavioral control has a significant effect on risk perception, protective behavior perception, and stakeholder awareness, but not on climate change action intention (H4-3 partially accepted). Risk perception influenced intention (H5-1 accepted), and protective behavior perception influenced intention (H5-2 accepted). Stakeholder perception also influenced intention to act on climate change (H5-3 accepted). Finally, climate change response intention influenced climate change response behavior (H6 was accepted).

In this study, intention to act had the highest B-value, followed by identity and personal norms, and identity and perceived behavioral control. The highest B-value for intention to act means that intention is the most important predictor of actual behavior. This shows that when people have strong intentions to take climate change action, they are much more likely to actually do so. Policy design and education programs should therefore focus on strengthening people's intentions. The strong effect of identity on personal norms means that the stronger an individual's environmental identity, the stronger their pro-environmental personal norms. This suggests that when individuals perceive themselves as environmentalists, they feel a sense of moral obligation or responsibility and are more likely to take action to address climate change. Therefore, it is important for education and campaigns to help individuals develop a strong identity with environmental protection. Identity had the next largest effect on perceived behavioral control, suggesting that individuals with a stronger environmental identity feel more likely to take climate action. This suggests that people with stronger identities believe that their actions will actually work, and are better able to identify and leverage resources and opportunities for action. This suggests that strengthening identity can promote climate change action by increasing perceived behavioral control.

The most significant pathway in the integrated model was ecological values → identity → personal norms → stakeholder awareness → intention → behavior, followed by ecological values → identity → perceived behavioral control → risk perception → intention → behavior. The results of the integrated model suggest that a multifaceted approach is needed to promote climate change action. As various factors such as ecological values, identity, personal norms, stakeholder awareness, perceived behavioral control, and risk perception interact to lead to behavior, it is necessary to build policies and programs that integrate these factors.

As for the limitations of this study, it was determined that the distortion caused by the same method bias was not significant, but there may be individual differences or inconsistencies because the study was conducted by self-reporting. We did not include demographic variables in the structural equation model for efficiency of analysis and clarity of results. Finally, since we only focused limited variables based on TPB, VIP and PADM, we did not include various value, perception, culture, structural context, resources, and communication, all of which play a role in explaining the behavior [74–87].

CRediT authorship contribution statement

Miri Kim: Validation, Project administration. **Seoyong Kim:** Writing – original draft, Formal analysis. **Sehyeok Jeon:** Writing – review & editing, Conceptualization.

Data Availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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