

A Systematic Review of Integrating UTAUT2, Technology Readiness and Value Belief Norm Models in Explaining Pro-Environmental Behavior

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Abstract

This paper presents a systematic literature review exploring the integration of the UTAUT2 model, Technology Readiness (TR), and Value-Belief-Norm (VBN) in the study of pro-environmental behavior. The review synthesizes existing research published between 2015 and 2025 to identify key factors influencing pro-environmental behavior through the integration of these models. A quantitative methodology was predominantly employed, with a focus on consumer technology adoption, psychological readiness, and environmental values. Results highlight the synergistic influence of these models, with UTAUT2 addressing technology adoption, TR measuring individual readiness, and VBN emphasizing moral and value-based motivations. The paper contributes to theoretical understanding by integrating these models to explain sustainable behavior, offering implications for policy and practical applications in environmental technology adoption. Research gaps identified include the need for further exploration of these models in developing countries and across diverse green technologies.

Keywords: : UTAUT2, Technology Readiness, Value-Belief-Norm, Pro-Environmental Behavior, Sustainable Behavior.

Introduction Section

Driven by climate change and ecosystem degradation, the global environmental crisis is becoming more severe, with carbon emissions having exceeded 36.8 billion tons of CO₂ in 2023, according to the Global Carbon Project. Individual behavior modification towards pro-environmental living is a crucial factor in mitigating this issue, considering 60–70% of greenhouse gas emissions stem from household consumption activities. Therefore, understanding the psychological and technological determinants that foster pro-environmental behavior is increasingly vital. Latest research indicates pro-environmental actions are shaped by personal norms, social values, and the technological readiness supporting green innovation adoption (Jafar and Latiff, 2024; Panni et al, 2025). Hence, the integration of value and technological factors is pivotal for comprehensively understanding and predicting environmentally friendly behavior. Research into pro-environmental behavior holds relevance not just for advancing environmental psychology theory, but also for implementing sustainability policies and green technology innovations. Theoretically, the Value-Belief-Norm (VBN) model addresses altruistic values and moral awareness, while the UTAUT2 and Technology Readiness (TR) models cover individual readiness to adopt pro-environmental technology (Chen et al, 2021; Aini et al 2025). Integrating these models could produce a stronger framework for understanding sustainable behavior and offer practical implications for public policy and environmental communication design. Consequently, systematic research in this realm is vital for connecting theory and practice.

Research has utilized the UTAUT2 model to explore technology adoption in sectors like education, finance, and healthcare, emphasizing performance expectancy and social influence as major determinants (Janwantanakul et al, 2011 ; Xue et al 2024). Conversely, the Technology Readiness model has been used to explain psychological readiness for new technology, including the distinction between motivator and inhibitor dimension (Omar et al, 2022). VBN theory has been shown to explain the relationship between personal values, ecological beliefs, and moral norms concerning sustainable behavior within the environmental context (Lima et al, 2024). Recent studies explore the link between technology readiness and pro-environmental behavior, such as in adopting digital air quality monitors, showing a significant relationship between TR dimensions and behavioral intention (Aini et al, 2025). Conversely, a systematic review of NAM-based models suggests the need for integrating theories across fields to boost predictive capabilities (Jaffar and Latif, 2024). Few studies have thus far combined the UTAUT2, TR, and VBN models into one integrated conceptual framework.

Despite numerous studies examining technology adoption factors and pro-environmental behavior separately, research that integrates technological and psychological aspects within a single model remains limited. Most studies have primarily focused on social and cognitive factors without accounting for individuals' technology readiness [9].

Furthermore, the link between personal values, moral beliefs, and readiness for technological innovations in the context of sustainability has rarely been systematically explore (Panni et al 2025).

The central issue within this research domain is the absence of a comprehensive synthesis incorporating the UTAUT2, TR, and VBN models to explain pro-environmental behavior. Crucially, such an integration could offer profound insights into how psychological, social, and technological factors interact to drive the adoption of sustainable behavior (Lima et al, 2024). Should this issue remain unexplored, pro-environmental behavior model development will stay partial and less effective at predicting the adoption of green technology. This limitation may obstruct the effectiveness of sustainability policies and green communication strategies which rely on understanding individual behavior (Idris et al, 2024).

Research Objectives

The objective of this study are to:

- a. To perform a systematic literature review analyzing pro-environmental behavior using the UTAUT2, TR, and VBN frameworks.
- b. To identify inter-model integration patterns and the variables that foster the adoption of sustainable behavior.
- c. To formulate an integrative conceptual framework to serve as a foundation for advanced studies in the domain of environmental psychology and the adoption of green technology.

Academic and Practical Contributions

This study expands technology adoption and environmental behavior scope theories through comprehensive cross-model integration (Chen et al, 2021). Practically, the findings offer a basis for policymakers and organizations to design more effective technology-based interventions that drive public pro-environmental behavior (Aini, 2025). Based on the SLR Guide, Research Questions, and Research Methodology documents, and considering the topic “Integration of UTAUT2 Model, Technology Readiness, and Value–Belief–Norm in the Study of Pro-Environmental Behavior: A Systematic Literature Review”, the following are proposed Research Questions (RQs) compiled using the SPIDER approach and referring to the SLR guidelines for highly reputable journals (e.g. Scopus/WOS):

Elemen	Definition	In research context
S (Sample)	Population studied	Pro-environmental individuals or groups
P (Phenomenon of Interest)	research phenomenon	An Integrated Model of Pro-environmental Behavior Adoption: Combining the UTAUT2, TRA, and VBN Frameworks
D (Design)	The research design discussed	Empirical, quantitative, qualitative, or mixed studies
E (Evaluation)	Measured results	Factors influencing pro-environmental behavior
R (Research Type)	Research type	Empirical research testing pro-environmental behavior theory

Table 1. SPIDER framework

Research Question:

- a. RQ1: An analysis of main trends and key characteristics in research integrating the UTAUT2, Technology Readiness (TR), and Value–Belief–Norm (VBN) models to explain pro-environmental behavior between 2015 and 2025: Are there significant geographical variations?
- b. RQ2: How are variables from the UTAUT2, TR, and VBN models integrated to predict pro-environmental behavior in the literature, and how do their relationships mutually affect this behavior?
- c. RQ3: An investigation into the predominant research methodologies, designs, application contexts, and study populations in studies integrating the UTAUT2, TR, and VBN models for pro-environmental behavior: How do variations in these approaches impact research findings?
- d. RQ4: How are the interrelationships between variables from the integrated UTAUT2, TR, and VBN models in predicting pro-environmental behavior reported in the literature, and to what extent do these interrelationships have a significant influence on pro-environmental behavior?
- e. RQ5: What are the identified research gaps in the literature concerning the integration of the three models within the context of pro-environmental behavior, and how do these gaps open up opportunities for further research in understanding the factors influencing pro-environmental behavior?

Literature Review

Grand Theory: Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (Ajzen, 1991) provides the main framework for explaining individual actions, which are predicted by intention, attitude, subjective norms, and perceived behavioral control. Consequently, the TPB has been the conceptual underpinning for several technology-based and environmental behavior models, such as UTAUT2, Technology Readiness (TR), and Value–Belief–Norm (VBN). Within the context of pro-environmental behavior studies, the Theory of Planned Behavior elucidates how the intention to act in an environmentally friendly manner is shaped by outcome beliefs and perceived social pressure (Jaffar and Latiff, 2024). The TPB thus functions as a foundational framework connecting behavioral intention to external variables like personal values or technology readiness.

UTAUT2 Model

An extension of the 2003 UTAUT model, the UTAUT2 (Venkatesh et al., 2012) explains technology adoption through seven key variables: performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit. Within the context of pro-environmental behavior, the UTAUT2 serves to gauge the acceptance of various green technologies, such as electric vehicles and smart energy applications (Janwantanakul et al, 2011; Aini et al, 2025). Studies have empirically demonstrated that performance expectancy and social influence are the most potent determinants when forecasting the intention to adopt green technology (Abdoulaye et al, 2024). The theory's limitation lies in underestimating the value, moral, and emotional factors pertinent to pro-environmental behavior. Its role within an integrated framework is to provide the rational and social dimensions of green technology adoption.

TR Model

TR model (Parasuraman, 2000) delineates four dimensions (optimism, innovativeness, discomfort, insecurity) that determine psychological readiness for new technology. Recent empirical evidence confirms that TR significantly influences the adoption of green innovations, including air monitoring applications and renewable energy solutions (Omar et al., 2022); (Aini & Manongga, 2024). TR integration with UTAUT2 offers incremental value by explaining individual mental readiness for sustainable innovations. Individuals exhibiting high technological optimism, for instance, typically hold more positive performance expectations for eco-friendly products. TR's role in the integrated framework is to bolster the psychological facet of green technology acceptance in an environmental context.

VBN Model

VBN theory (Stern et al., 1999), grounded in Schwartz's (1992) value theory, proposes that pro-environmental behavior results from a causal chain progressing from basic values to ecological beliefs, then to personal norms, and finally to actions. Emphasizing moral motivation and altruistic values as the foundation of sustainable behavior, recent literature confirms the VBN model's efficacy in explaining energy conservation, waste management, and green consumption behaviors (Lima et al, 2023; Pani et al, 2025). VBN model's advantage lies in its unique ability to account for pro-environmental actions driven by moral imperatives, extending beyond rational choice or social pressure. Its role in an integrated framework is to supply the value, moral, and belief dimensions that motivate sustainable behavior, thus complementing UTAUT2 and TR.

Theoretical Integration: UTAUT2–TR–VBN

Integrating these three models seeks to produce a multidimensional framework that includes:

- 1) Rational Dimension (UTAUT2): behavioral intention and technology acceptance.
- 2) Psychological Dimension (TR): individuals' readiness toward green technology.
- 3) Value Dimension (VBN): moral motivation and ecological beliefs.

Research indicates that an integrative approach increases the predictive power of pro-environmental behavior by up to 20–30% compared to a single model. This model explains that technology readiness can strengthen the relationship between values and the intention to use green technology.

Conceptual Synthesis

The inter-model relationships reported in the literature are detailed as follows:

- 1) VBN are significant predictors of beliefs and attitudes regarding green technology.
- 2) TR functions as a mediator between beliefs and behavioral intention.
- 3) UTAUT2 dimensions of social and utilitarian factors intensify the actual intention to adopt pro-environmental technology.

This framework posits that sustainable actions are driven by a complex interplay of values, morals, and technology readiness, rather than purely rational calculation (Jaffar et al., 2024); (Aini & Manongga, 2024).

Aspect	Model	Primary Focus	Integration Role
Rationality	UTAUT2	Social expectations and influences	Predicting behavioral intentions
Psychology	Technology Readiness	Technology readiness and perception	Individual readiness mediator
Values & Morals	VBN	Values, beliefs, personal norms	Internal motivators

Table 2. Theoretical integration map (summary)

Empirical Relevance

While tested in a limited number of studies, the integration of these models has demonstrated positive results for enhancing the understanding of environmental behavior, particularly in the contexts of green technology, renewable energy, and sustainable transportation (Umrao et al, 2022 ; Panni et al, 2025). This literature review confirms that an integration of UTAUT2, TR, and VBN is capable of providing a holistic explanation for pro-environmental behavior by combining rational, psychological, and moral value dimensions. A systematic approach through a Systematic Literature Review (SLR) will help identify patterns of relationships between variables, yielding a new conceptual model that can enrich the theory and practice of sustainability.

Method

Research Design

This research used a Systematic Literature Review (SLR) method with reference to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines developed by Moher et al. (2009) and refined by Page et al. (2021). This approach was chosen for its systematic, transparent, and replicable framework, which allows for the comprehensive and unbiased identification, evaluation, and synthesis of prior research. Purpose of this SLR is to identify and analyze how UTAUT2, Technology Readiness, and VBN models have been integrated in consumer pro-environmental behavior research. It further aims to explore the factors influencing intentions and behavior towards green, sustainable, and eco-friendly products. To ensure a validity and reliability of the findings, a selection and analysis were conducted iteratively and verified according to PRISMA methodological guidelines. All included references originated from accredited and peer-reviewed scientific publications. Consequently, the synthesis results provide a conceptual foundation for subsequent research into the adoption of sustainable behavior using integrative models of technology and ecological values.

The submitted search queries objective was to identify and refine relevant scientific articles across topics including sustainability, green marketing, pro-environmental behavior, and green technology adoption. The initial step in the search query involved using keywords based on three major themes: green economy, green marketing, and digital engagement. System was used to find documents mentioning at least one of these keywords, aiming to identify articles relevant to sustainability, technology application in marketing, and digital engagement supporting pro-environmental behavior. System also sought articles connecting these topics with pro-environmental behavior and behavioral intention, specifically those mentioning relevant theories like UTAUT2, Technology Readiness (TR), and VBN. This measure ensured the search concentrated on articles combining behavioral aspects with the adoption of green technology.

The subsequent step involved restricting the search by publication date, specifically including only articles published within the 2015 to 2025 timeframe. This restriction was applied to acquire articles pertinent to current advancements within the study of pro-environmental behavior and green technology adoption. Thereafter, the retrieved articles were screened according to specific subject areas: business (BUSI), sociology (SOCI), environment (ENVI), economics (ECON), and computer science (COMP). This screening ensured the search focused exclusively on articles relevant to disciplines addressing sustainability topics, environmental management, and technology usage in business contexts. This search process implemented additional limitations, including the selection of only original research (ar) articles published in journals. A language criterion was also applied, ensuring all included articles were exclusively in English. Furthermore, the search strategy concentrated on identifying open access articles, thereby ensuring the findings are freely available to readers without subscription barriers. The query subsequently applied exact keyword matching including Sustainable Development, Marketing, Pro-environmental Behavior, Green Economy, and Public Attitude to refine the results to only those highly relevant to the core research topics.

After these restrictions were applied, the system searched for articles meeting all criteria. The first query process yielded 755 documents, which were then narrowed down with more limitations to produce 249 documents in the second query. The third query ultimately produced 90 documents that satisfied all more stringent relevance and quality criteria. These findings comprise articles highly pertinent to pro-environmental behavior, theories of green technology adoption, and green marketing innovations. Their open access status ensures they provide essential information for researchers and practitioners invested in the fields of sustainability and eco-friendly technology. Research phases, conducted in accordance with PRISMA protocol, comprise several key stages in undertaking a systematic review, including:

PRISMA Stages	Documents Count (n)	Explanation
Identification	755	The scope encompasses subjects identification pertinent to green economy, green marketing, digital engagement, pro-environmental behavior, and technology-driven behavior.
Filtering by study domain	249	Screening process filtered articles based on subject area relevance to Business, Sociology, Environment, Economics, and Computer Science.
Filtering by documents type	249	Selected document type: research article (ar).
Screening by publication type	249	Inclusion criteria specified that all records must be final publications and classified as journal articles.
Screening by language	249	Inclusion criteria were restricted to articles published in the English language.
Screening based on accessibility	249	Only documents published under an Open Access license were included in the final review.
Documents Accessibility	249	The final versions of record for all screened documents were freely available for access.
Included in qualitative synthesis	90	Following the screening of 249 documents, 90 were deemed eligible for qualitative synthesis due to their relevance to the specified keywords.

Table 3. PRISMA

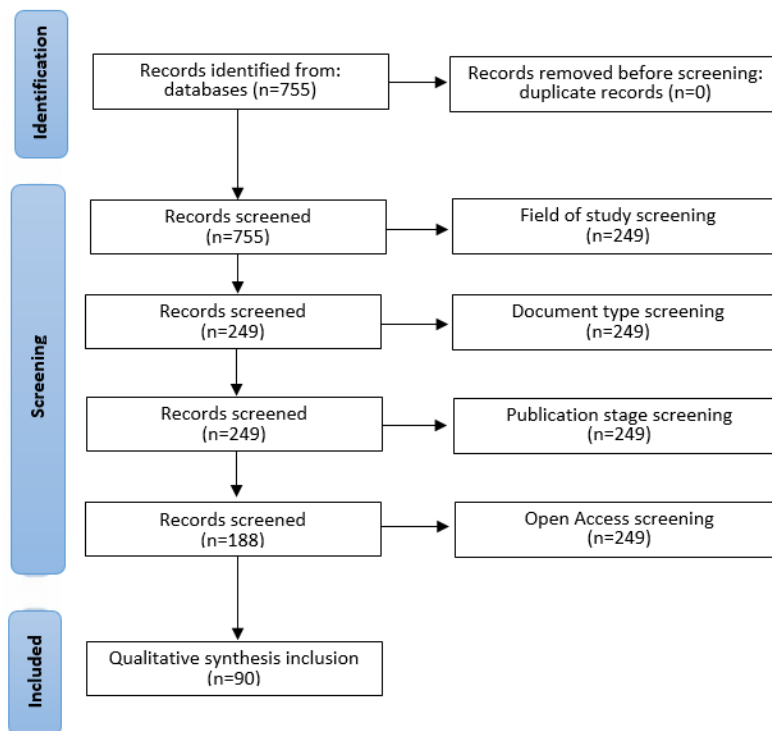


Fig. 1. PRISMA stage flowchart

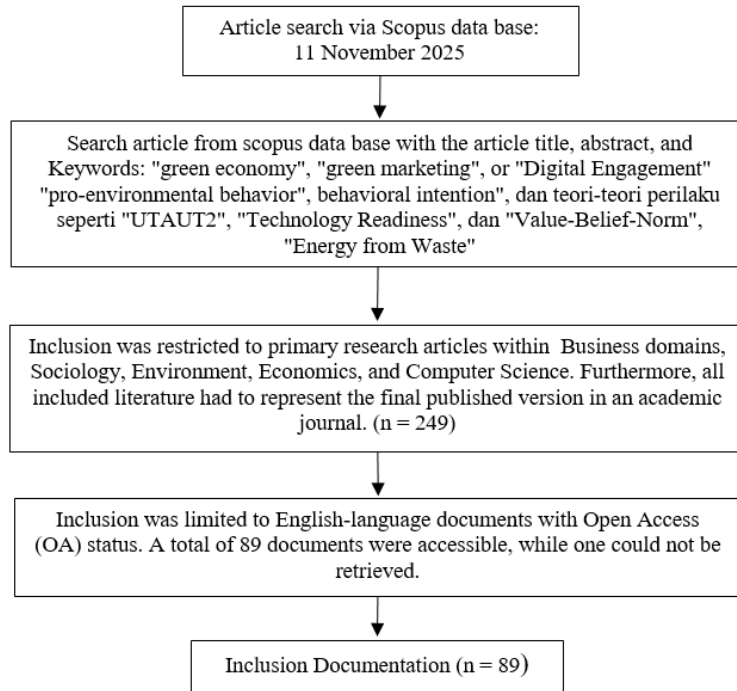


Fig. 2. PRISMA Flowchart

Result and Discussion

Result

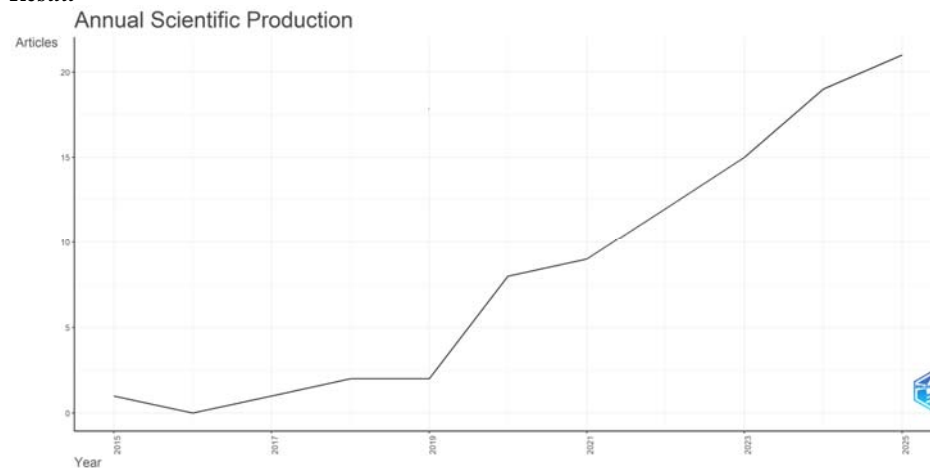


Fig. 3. Annual Journal Production

As shown in Figure 3, the annual scientific production trend displays varying numbers of articles published between 2015 and 2025. The period began with a single publication in 2015, followed by a sharp drop to zero publications in 2016. Between 2017 and 2019, the publication volume remained low, fluctuating between 1 and 3 articles per annum. Beginning in 2020, a substantial increase in publications was observed, with approximately 8 articles that year. This growth continued, with the number of articles rising moderately to surpass 20 by 2025. This trend suggests heightened interest and attention to the studied topics, likely driven by factors such as rising environmental consciousness, the adoption of new technological frameworks (e.g., UTAUT2, Technology Readiness, Value-Belief-Norm), and an increase in policy or funding support for research on sustainability and pro-environmental behavior. As shown in this graph, scientific production in this field has seen an exponential increase in recent years, highlighting the topic's growing relevance and importance within the global academic community.

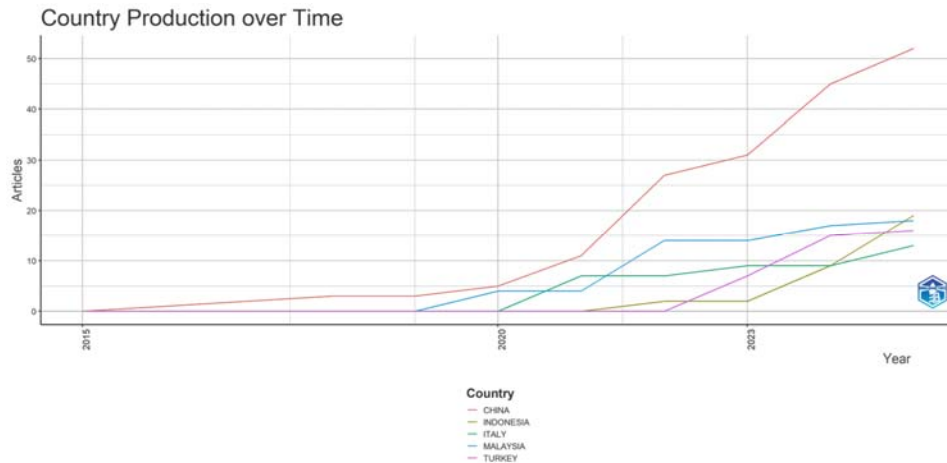


Fig.4. Country Production Over Time

As shown in Figure 4, the trends in published articles from 2015 to 2023 for China, Indonesia, Italy, Malaysia, and Turkey are presented. As depicted in the graph, a significant surge in scientific output across nearly all observed countries began in 2020, led by China. China's publications increased rapidly, exceeding 50 articles by 2023, which reflects major investment in research and development within the sustainability and technology sectors. While not on par with China's output, Indonesia's publication count also increased, reaching about 5 articles in 2023. This trend suggests a growing scholarly interest in pro-environmental topics within the nation. Italy also showed a positive, albeit more moderate, trend, with publications exceeding 10 articles by 2023. This reflects a heightened interest in environmental and sustainability topics. Consistent growth was observed in Malaysia; however, the volume remained low, fluctuating between 1 and 5 articles annually. This indicates that sustainability research within the nation remains relatively restricted. Publication growth in Turkey mirrored that of Malaysia, with a gradual increase culminating in approximately 7 articles by 2023. Collectively, the data indicates that China and Indonesia have seen substantial growth since 2020, contrasting with the more moderate development observed in Italy, Malaysia, and Turkey.

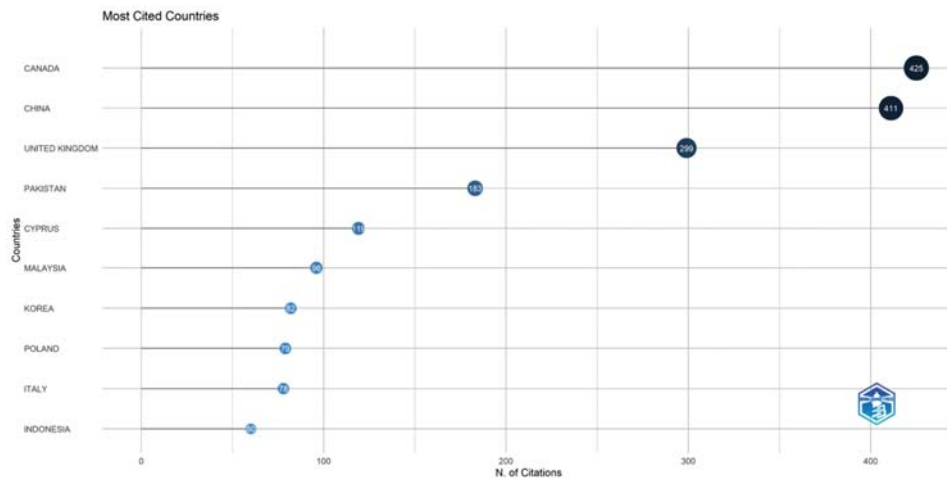


Fig.5. Most Cited Countries

Figure 5 displays a graph of citations received by articles from different countries, serving as a metric for the research impact of those nations within the global academic sphere. Canada ranked first with 425 citations, followed by China (411) and the United Kingdom (299), highlighting the significant influence of these nations in relevant research field. Despite having fewer citations (Pakistan: 183; Cyprus: 119), both nations exhibited a significant contribution to the global scholarly output. These nations: Malaysia (96 citations), Korea (82 citations), Poland (79 citations), and Italy (78 citations) exhibited a substantial impact. While lower than the top contributors, their influence remains significant. Indonesia ranked last among the observed nations with 60 citations. This suggests that despite a smaller contribution, the country's input to the scientific

literature is still valuable. Figure 5 highlights that Canada and China lead in scholarly impact concerning sustainability and technology topics. Other contributing nations exhibit moderate influence, indicating a diverse global distribution of research focus and output.

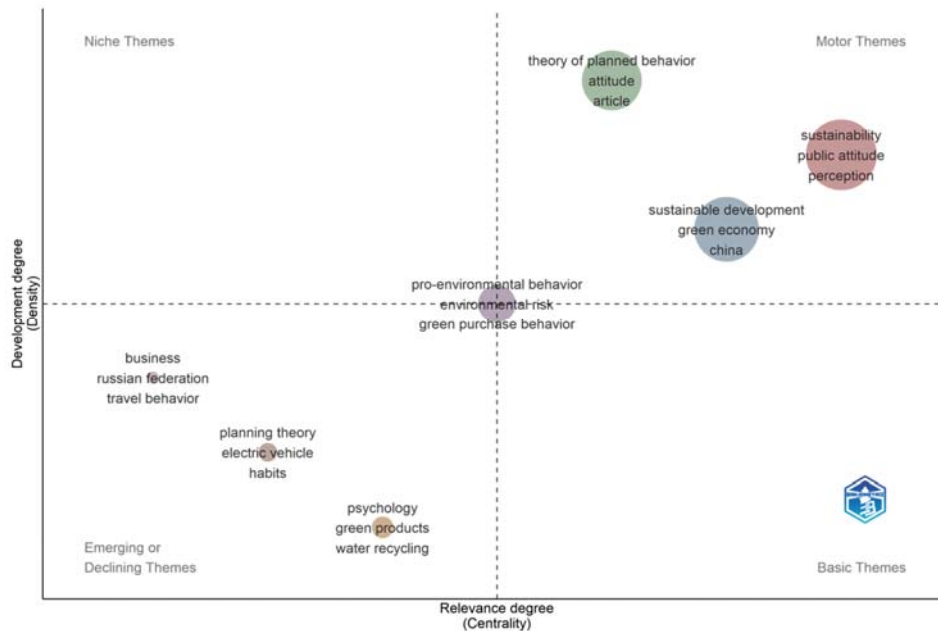


Fig.6. Quadrant Thematic Map

A thematic map is presented in Figure 6, positioning research topics across four quadrants based on two key metrics: development density (Y-axis) and relevance centrality (X-axis). This visualization categorizes themes by their level of maturity and importance within the field. Topics within the Motor Themes quadrant (upper-left) are highly relevant and well-developed (pro-environmental behavior, green purchase behavior, environmental risk, sustainable development, and the green economy). This suggests these themes are currently critical to the field, growing rapidly, and exerting considerable influence in the global academic community. China's position as a highly relevant and developed theme signifies the importance of research concerning the impact and adoption of green technology within the country.

Conversely, themes located in the upper-right quadrant (Basic Themes), namely planned behavior theory and attitude exhibit high relevance (centrality) but low development (density). This suggests these foundational theories are critical for comprehension of pro-environmental behavior, but their growth trajectory is slower than more applied topics. In the lower-left quadrant (Emerging or Declining Themes), topics like business, Russian Federation, and travel behavior exhibit high density (development) but low centrality (relevance). This suggests that these themes are developing, yet they hold less influence or centrality within the overall scope of sustainability research. Lastly, the lower-right quadrant (Niche Themes) contains topics with low development (density) and low relevance (centrality), including planning theory, electric vehicle, and habits. This suggests they are specialized areas that have yet to gain widespread attention in the broader academic literature. This map highlights the direction and focus of sustainability research, while also demonstrating the varied pace of development among themes within the scientific community.

Discussion

RQ1:

This study addresses the following research questions:

1. What are the main trends and characteristics in studies that integrate the UTAUT2, TR, and VBN models to explain pro-environmental behavior between 2015 and 2025?

2. Are there significant differences in the characteristics of this research based on specific geographical regions?



Fig.7. bibliometric analysis output

Data for the 2015-2025 period (N=90 documents) reveals that the field is expanding rapidly, characterized by a 35.59% annual growth rate. The low average document age (2.28 years) confirms that the majority of the literature is recent. An average citation rate of 28.16 per document indicates a substantial impact on the field's development. Collaboration is a prominent characteristic of the research landscape; single-authored papers are rare (n=5), and the average co-author count is 3.54. The high rate of international collaboration (40%) underscores the topic's widespread relevance and interconnectedness within the global academic community. Research articles constitute a publications bulk in dataset, consistent with typical scientific literature. The overall trend highlights substantial growth in publication volume alongside robust international collaboration, underscoring the necessity of cross-border cooperation to advance this field of study.

No	Trend/Characteristic	Region	Key Focus	Reference Source
1	Publications growing number that integrate UTAUT2, TR, and VBN models to explain pro-environmental behavior, focusing on green technology adoption, consumer technology readiness, and personal environmental values.	Global (General)	Green technology adoption, technology readiness (TR), and environmental value (VBN).	- [2] on UTAUT2 and VBN integration in electric vehicles adoption . - [14] on sustainable consumption applications adoption with UTAUT2 and VBN.
2	A divergence exists in research emphasis based on a country's development status: developed countries focus on technology adoption models (UTAUT2, TR), while developing nations highlight the importance of value-based norm changes (VBN).	Asia (Indonesia), Europe (China, other developed countries)	Adoption of green technology vs. changes in attitudes and social norms regarding sustainability.	- [15] concerning personal values and norms in China. - [16] focusing on pro-environmental behavior in Malaysia. - [17] regarding energy saving.

Table 4. Trends and Characteristics in Research on UTAUT2, Technology Readiness, and VBN in Pro-Environmental Behavior

Research landscape concerning an integration of UTAUT2, Technology Readiness, and VBN models to explain pro-environmental behavior underwent significant growth from 2015 to 2025. This expansion was characterized by an increased publication volume and a heightened emphasis on the factors driving pro-environmental actions. UTAUT2 model is commonly applied to explain consumer behavior regarding green technology adoption, including the uptake of electric vehicles and other environmentally friendly products (Espinoza et al 2024). TR is utilized to gauge consumer acceptance of new environmentally friendly technology. In contrast, VBN sheds light on the way personal environmental values can influence buying decisions and consumer action (Muna et al, 2025). One of the trends observed is the integrated use of

these three models to understand a more holistic influence on consumer decisions to adopt pro-environmental behavior, with an emphasis on the attitudes, intentions, and social norms that drive such behavior (Naparín et al 2025).

Contrasting findings emerge when examining geographical regions. For example, in technologically advanced areas like China and Europe, the research emphasis is heavily placed on the combined UTAUT2 and TR models for explaining green technology adoption (Adeel et al, 2024). Conversely, regions such as Indonesia and other developing nations prioritize the application of the VBN model to study pro-environmental behavior, emphasizing the underlying personal values and social norms driving green actions (Rebualos et al., 2024). The observed regional divergence in research highlights the influence of local contexts. Studies in technologically advanced countries tend to focus on adoption of technology, whereas the research emphasis in developing countries leans towards changes in attitudes and norms related to environmental sustainability (Suminar et al, 2024).

RQ2:

This study aims to answer the following questions:

1. How are the key factors of the UTAUT2, TR, and VBN models integrated within the context of pro-environmental behavior studies?
2. What is the nature of the relationships between these integrated variables and their influence on pro-environmental behavior, according to existing literature?

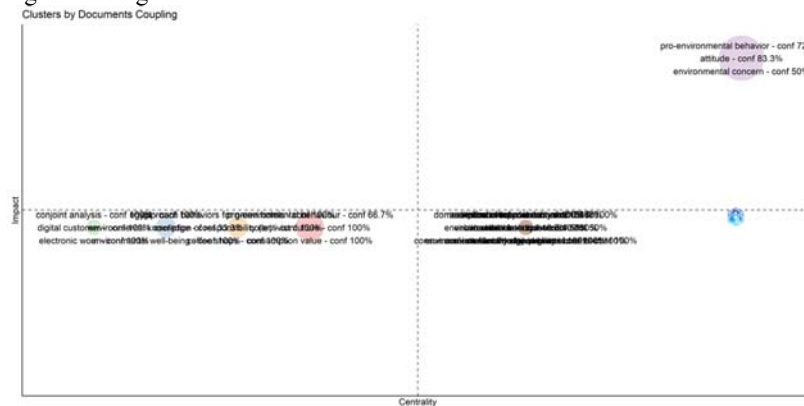


Fig.8. Clusters by Documents Coupling

Based on the visualization, pro-environmental behavior plays a pivotal role within the literature, demonstrating significant impact with a 72.7% confidence level. The findings show that these variables are interconnected within a unified framework, which helps elucidate the behavior. Within the UTAUT2 framework, performance expectancy and effort expectancy are instrumental in shaping an individual's intention to adopt green technology. Concurrently, social influence and facilitating conditions strengthen an individual's readiness to adapt to these new technologies. Conversely, TR highlights the importance of technology readiness; individuals with higher readiness scores show a greater propensity to proactively engage in pro-environmental behavior. VBN model focuses on personal values as the underlying factors for pro-environmental behavior. It suggests that strong environmental concerns and deeply held moral norms are crucial in motivating individuals toward sustainable actions. With a higher confidence level, attitude (83.3%) is a stronger predictor than environmental concern (50%), suggesting that established beliefs and norms better guide behavior than mere worry. This highlights the complex interplay between technology readiness, personal beliefs, and social norms in driving behavior that supports environmental longevity.

No	Model	Key Factors/Variables	Role in Pro-Environmental Behavior	Reference Source
1	UTAUT2	Perceived usefulness, performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic	External factors such as perceived ease of use and perceived benefits significantly influence green technology adoption.	- Shoheib and Shanab (2022), Technology adoption studies within commercial social settings. - Erlis and Zarlis (2024), Investigating the influence of UTAUT2 on autonomous vehicle adoption in Jakarta.

		motivation, price value.	- Widyastuti and Layaman, (2023), UTAUT2 analysis of e-wallet adoption among millennials.
2	TR & VBN	Optimism, innovativeness (TR) and values, beliefs, and norms about the environment (VBN).	Leveraging individual beliefs and social norms to foster pro-environmental behavior. - Widyastuti and Layaman (2023), Research on personal innovation factors in QR payments and adoption of new technologies. - Huang et al (2024), UTAUT2 Application in AI Adoption for Task Shifting within Healthcare.

Table 5. Integration of UTAUT2, TR and VBN models in pro-environmental behavior

From 90 analyzed documents, it is evident that integrating the UTAUT2, TR, and VBN models provides insight into the complex, mutually influential relationships among green technology adoption, technology readiness, and environmental values in driving pro-environmental behavior.

1. UTAUT2 framework outlines the core constructs affecting technology adoption decisions, specifically perceived usefulness, performance expectancy, effort expectancy, social influence, and facilitating conditions. Within the green technology context, the model incorporates additional variables: hedonic motivation and price value. These constructs determine the likelihood of an individual using green technology based on perceived added value and real benefits. TR serves to explain adoption readiness; individuals with higher TR scores are more likely to embrace green technology. This readiness is underpinned by optimism and innovativeness, which reflect positive beliefs about the value of new technology. Therefore, green technology adoption is not solely dependent on the technology's functionality, but relies heavily on the individual's readiness to embrace and utilize it (Espinoza et al, 2024).
2. VBN model core tenets focus on explaining pro-environmental behavior through individual values and beliefs. It posits a causal chain where personal environmental beliefs and awareness of consequences drive motivation to act according to relevant social norms. Research suggests a positive correlation between strong environmental values and pro-environmental behavior in the green technology context. Individuals aware of the impact of energy consumption or carbon emissions are more likely to select cleaner, more efficient technologies (Muna et al, 2025).

The interplay between UTAUT2, TR, and VBN highlights both external and internal drivers of green technology adoption. UTAUT2 and TR emphasize external factors (e.g., ease of use, technology readiness), while VBN focuses on internal motivations (personal values and environmental beliefs). The synergy of these models provides a comprehensive understanding of how these factors converge to shape pro-environmental behavior (Naparin et al, 2025).

RQ3:

This study aims to address the following questions:

1. What are the common methodologies, designs, application contexts, and populations utilized in studies integrating the UTAUT2, TR, and VBN models?
2. How do variations in these four aspects of research design influence the resulting research findings?

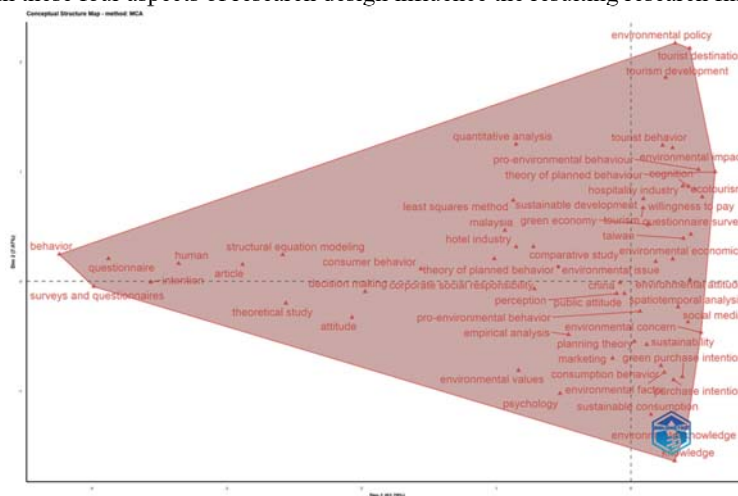


Fig.9. Thematic Evolution Map

Figure 9 depicts the interconnectedness of topics frequently used in studies that integrate the UTAUT2, TR, and VBN models concerning pro-environmental behavior. The visualization reveals that most studies utilize a quantitative approach, with a heavy reliance on surveys and Structural Equation Modeling (SEM) to examine individual attitudes, intentions, and perceptions of green technology (Espinoza et al, 2024). Cross-sectional and longitudinal designs are widely used, describing both observations at a single point in time and analysis of changes in behavior over time (Muna et al, 2025). Application contexts are typically centered on sustainability sectors like tourism, green energy, and hospitality. The study populations primarily consist of consumers and participants within green industries (Naparín et al, 2025). The observed divergence in research approaches between developed and developing nations highlights the influence of contextual factors. The former emphasizes technology adoption models (UTAUT2/TR), while the latter emphasizes the VBN framework, reflecting the impact of local culture and policies (Adeel et al, 2024).

Aspect	Description	References
Research methodology	A quantitative approach was used, employing surveys and questionnaires to collect data on individual attitudes, intentions, and perceptions toward pro-environmental behavior, as well as an experimental approach to test the influence of using green technology.	A quantitative methodology was employed in a study in Bangladesh, utilizing surveys to gather data from textile SMEs pertaining to green technology adoption (Hoissain et al, 2022).
Research Design	- cross-sectional design: Assessing the relationship between variables at a single point in time. - longitudinal design: Observing changes in behavior over time, particularly related to the adoption of green technology.	Findings from a Nigerian study indicate that green technology has a significant influence on pro-environmental behavior within the tourism industry, as analyzed via SEM (Hoissain et al, 2022).
Application Context	The study examines research concentrating on green technologies specifically electric vehicles, renewable energy, and apps designed to mitigate environmental impact	Findings from research in Nigeria's tourism industry indicate that Green Human Resource Management (GHRM) plays a significant role in fostering pro-environmental behavior (Elshaer et al, 2021).
Study Population	- Consumers and green technology users. - Employees and entrepreneurs in green industries, especially those focusing on sustainability and environmentally friendly technology.	Research in Pakistan highlights price and quality as key determinants in consumers' purchasing decisions regarding environmentally friendly products (Elshaer et al, 2021).
Approach Variations	Developed country tend to focus on green technology adoption studies, whereas developing nations more extensively investigate changes in environmental attitudes and values.	Findings from a study in the Zimbabwean tourism sector suggest that tourist behavior is influenced by both social media branding efforts and their acceptance of green technology (Elshaer et al, 2021).

Table 6. Summary of Research Methodological Aspects.

To address RQ3 regarding the methodology, design, application context, and population of studies integrating the UTAUT2, TR, and VBN models (2015-2025), the 90 reference documents reveal a consistent pattern. The prevalent methodological approach is quantitative, heavily relying on surveys and questionnaires to gather data on individual attitudes, intentions, and perceptions concerning pro-environmental behavior (Espinoza et al, 2024). The methodology employed allows researchers to directly measure specific variables: perceived ease of use and usefulness (UTAUT2), TR, and the relevant environmental values and norms (VBN) (Muna et al, 2025). Several studies employ an experimental design to examine the impact of green technology use on behavioral change. However, the predominant approach is cross-sectional, allowing researchers to assess variable relationships concerning pro-environmental behavior at a single juncture (Naparín et al, 2025). Longitudinal studies are utilized to monitor behavioral changes over time, with a particular focus on the adoption of green technology and the dynamics of environmental attitudes and norms (Adeel et al, 2024). Applications studied in this research typically concentrate on green technologies and products, including electric vehicles, renewable energy sources, and technology-driven applications for carbon footprint reduction (Rebualos et al, 2024). Common research sectors include energy, transportation, and hospitality. Specific studies investigate the adoption of green technology in sustainable hotels, the use of electric vehicles, and the implementation of renewable energy in residential settings. This study population primarily comprises consumers and technology users who either have experience with or a demonstrated interest in green technology use, or whose behavior is impacted by pro-environmental policies (Bauernschmidt et al, 2023).

Some studies also involve employees and employers in green industries, such as in the hotel sector and companies focused on sustainability. Variations across research methodology, design, and study population impact the resulting findings. Studies in developed nations (e.g., Europe and the United States) often highlight this, showing a greater emphasis on technology adoption models (UTAUT2 and TR) (Elshaer et al, 2021). In contrast, studies within developing nations predominantly investigate shifts in environmental attitudes and values, often relying on the VBN model. Local factors, including culture, technology acceptance levels, and government policies, are instrumental in shaping how green technology is embraced in these regions (Tanveer et al, 2024). These findings demonstrate that despite significant variations in methodology and design, integrating the UTAUT2, TR, and VBN models offers comprehensive insight into the drivers of pro-environmental behavior and how technology can reshape individual habits for sustainability.

RQ4:

This study addresses the following questions:

1. What is the nature of the inter-variable relationships within the integrated UTAUT2, TR, and VBN models used to predict pro-environmental behavior?
2. To what extent do these relationships demonstrate a significant influence on pro-environmental behavior, according to the literature?

Aspect	Description	References
Variable Interconnections	<ul style="list-style-type: none"> - UTAUT2: Focus on technology adoption factors, such as ease of use, expected benefits, and social influence. - TR: Measures individual readiness to adopt technology, including optimism and innovativeness. - VBN: Focusing on environmental values and the belief that individual actions impact the environment, which serves to motivate pro-environmental behavior. 	Penelitian yang menggabungkan model UTAUT2 dan VBN untuk adopsi kendaraan listrik di India dan Spanyol menunjukkan pengaruh signifikan dari masing-masing faktor dalam mempengaruhi niat adopsi kendaraan ramah lingkungan, dengan budaya negara memainkan peran penting dalam hubungan ini (Castillo et al, 2024).
Significant Influence on Pro-Environmental Behavior	These variable interconnections reveal a significant predictive power over pro-environmental behavior. The influence of environmental beliefs is amplified by factors such as ease of use and technology readiness, leading to greater individual engagement in green actions.	Studies focusing on the energy and transport sectors corroborate the VBN model's role in reinforcing pro-environmental intentions and attitudes among environmentally conscious consumers (Liu et al, 2018).
Other Findings	<ul style="list-style-type: none"> - In developed countries, technology adoption is a dominant factor in pro-environmental behavior. - In developing countries, personal values and social norms are more influential in decisions about environmentally friendly behavior. 	Studies in developed nations (e.g., Europe and the United States) often highlight this, showing a greater emphasis on green technology adoption models (UTAUT2 and TR) (Castillo et al, 2024). Conversely, studies within developing nations predominantly investigate shifts in environmental attitudes and values, often relying on the VBN model (Ghazali et al, 2019).

Table 10. Summary of Key Findings and Variable Interconnections

The attached data elucidates information from publications relevant to RQ4, which investigates the interplay between variables from the UTAUT2, TR, and VBN models in predicting pro-environmental behavior and the significance of their influence. The synthesis of the 90 documents reveals that the integrated framework (UTAUT2, TR, VBN) emphasizes external and internal determinants of pro-environmental behavior. The UTAUT2 model specifically outlines how factors like ease of use, performance expectancy, and social influence encourage green technology adoption (Espinoza et al, 2025). TR mengukur kesiapan individu untuk menerima teknologi baru, termasuk sikap terhadap teknologi (optimisme) dan keinginan untuk mencoba teknologi baru (innovativeness) (Muna et al, 2025). VBN emphasizes environmental values role and individual beliefs about their behavior impact on the environment, which encourages environmentally friendly actions (Cerqueira et al, 2025). These inter-variable connections highlight a synergistic effect: the influence of technology adoption factors (UTAUT2, TR) on a positive attitude is amplified by internal drivers (VBN). This integration ultimately generates a more significant predictive power over pro-environmental behavior. A significant influence on pro-environmental behavior was found in the relationship between variables from these three models, which showed a significant influence in predicting pro-environmental behavior. The findings suggest that a synergistic effect occurs when technology adoption

factors (UTAUT2), technology readiness (TR), and pro-environmental social norms (VBN) are combined. This integration enhances an individual's propensity for pro-environmental behavior (Yosthonggam et al, 2025). Perceived ease of use and performance expectancy are instrumental factors influencing the intention to adopt green technologies like electric vehicles and renewable energy sources. Other Significant Findings indicate that variations in approach and geographic context influence the relationships between these variables. Regional disparities show that in developed nations, technology adoption is the primary driver of pro-environmental behavior, whereas in developing nations, personal values and social norms hold greater sway. Collectively, the strong relationship between the three models highlights their crucial, complementary roles in predicting and explaining both green technology adoption and sustainable actions (Braima et al, 2025).

RQ5:

Elucidating the research gaps identified in the literature concerning the integrated use of the three models in pro-environmental contexts, and exploring how these gaps provide new avenues for future research into the determinants of pro-environmental behavior. Table 11 summarizes the research gaps identified from the 90 reference documents regarding the integration of the three models, which serve to highlight opportunities for future studies on pro-environmental behavior.

Research Gaps	Description	References
Limited Studies in Developing Regions	Most studies concentrate on developed nations with superior technological infrastructure. The limited research available on green technology adoption and sustainability in developing countries presents a clear opportunity for future studies.	Studies examining electric vehicle adoption challenges in developing nations like India and Spain underscore the impact of differing cultural factors on the uptake of green technology (Castillo et al, 2024 ; Guo et al, 2020)
Limited Focus on Specific Green Technologies	The prevalence of research on electric vehicles and renewable energy leads to limited attention on other green technologies critical to sustainability, such as waste management or sustainable agriculture technologies. This represents a significant research gap.	Research examining various types of green technology innovations demonstrates their contribution to sustainable economic growth and job creation (Khan et al, 2025 ; Guo et al, 2020)
VBN and TR Variables Integration in Technology Adoption	Despite the complementarity of TR and VBN, there is a paucity of research integrating these models within green technology adoption studies.	Studies that integrate the UTAUT2 and VBN models highlight the significance of this combined approach for understanding the divergence in electric vehicle adoption intentions across developed and developing nations (Castillo et al, 2024).
Social Factors Influence on Pro-Environmental Behavior	Limited research has profoundly investigated the extent to which social influence (from peers, family, or colleagues) either reinforces or impedes green technology adoption and pro-environmental behavior at the individual level.	Findings from a study on green technology adoption in construction sector underscore individual motivation significant role and environmental awareness in driving sustainable behavior (Boubker et al, 2024).
Limited Longitudinal Research	Cross-sectional designs are widely used, but studies employing a longitudinal approach which track changes in behavior and long-term impacts of green technology adoption remain extremely limited.	Research on electric vehicle adoption in developing nations highlights the need for a deeper understanding of long-term shifts in individual attitudes and perceptions (Boubker et al, 2024)

Table 11. Summary of Research Gaps

Several research gaps have been identified from the 90 literature sources concerning the integrated UTAUT2, TR, and VBN frameworks. These gaps provide clear avenues for future research into pro-environmental behavior. A primary research gap is the paucity of studies in developing countries. Research in these regions, characterized by unique infrastructural challenges, is necessary to broaden the understanding of green technology adoption. The current literature also suffers from a limited scope, primarily focusing on electric vehicles and renewable energy. Future research should explore other impactful green technologies, such as sustainable agriculture or waste management systems. Conversely, despite the potential complementarity of TR and VBN in understanding pro-environmental behavior, studies integrating the two within technology adoption contexts remain limited. This presents an opportunity to further investigate the interplay between personal values and technology readiness in shaping decisions to adopt green technology. Additionally, further

research is warranted to explore social influence in this domain, focusing on how interactions with others can either reinforce or impede pro-environmental actions.

Lastly, there is a paucity of longitudinal studies. Long-term research designs are necessary to gain deeper insights into behavioral evolution and the changing impact of green technology adoption over time. These identified gaps collectively offer significant opportunities to enhance our understanding of pro-environmental behavior drivers and provide a more comprehensive perspective on green technology uptake across diverse contexts and regions.

Conclusion

Conclusion

The findings from the systematic review suggest that a synthesized framework incorporating the UTAUT2, TR, and VBN models offers enhanced insights into the factors influencing pro-environmental behavior. UTAUT2 framework addresses technology adoption drivers, specifically perceived ease of use and performance expectancy (expected benefits). TR offers a complementary perspective by gauging individual readiness and attitudes (optimism and innovativeness) toward new technology. In contrast, VBN highlights internal motivations, such as personal values and social norms, which motivate individuals to engage in pro-environmental behavior. The synergy between UTAUT2, TR, and VBN models highlights that pro-environmental behavior is a result of the interplay between technological readiness, personal values, and social norms. These elements collectively provide a robust framework for predicting and strengthening an individual's motivation towards green technology adoption and sustainable behavior. Despite a significant findings from the integrated of three model research, several areas for further investigation remain apparent. A primary gap is the paucity of studies in developing nations, where factors like infrastructural limitations and lower technology readiness may impede green technology adoption. Moreover, the current literature suffers from a limited scope, primarily investigating electric vehicles and renewable energy sources. This indicates a necessity to diversify research attention toward other impactful areas for sustainability, such as waste management and sustainable agriculture technology. There is a paucity of research integrating TR and VBN. These models are complementary; therefore, this gap presents an opportunity to examine how technology readiness and personal values interact to shape decisions regarding environmentally friendly technology adoption.

The findings from this systematic review suggest directions for further investigation into the integrated framework (UTAUT2, TR, VBN) across expanded contexts. Future studies should incorporate cultural factors, social influence, and long-term sustainability to comprehensively understand pro-environmental behavior. Longitudinal studies are warranted to investigate the long-term impacts of green technology adoption. Furthermore, real-time experiments could offer more profound insights into immediate behavioral changes, enhancing our overall understanding. In conclusion, integrated UTAUT2, TR, and VBN models provide a powerful conceptual tool for explaining pro-environmental actions. This framework not only informs the creation of effective strategies for global green technology uptake but also directs future research efforts toward existing gaps across different geographical areas and industries.

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