

# Mapping the Landscape of Pro-Environmental Behavior

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## Abstract

Pro-Environmental Behavior (PEB) is often used as an umbrella term to summarize a variety of behaviors, making synthesizing research difficult. We provide a framework to systemize the landscape of PEB. The framework differentiates between consequences (e.g., mitigation, conservation, restoration), pathways (e.g., sufficiency, efficiency), types (e.g., individual behaviors), and domains (e.g., recycling). We reviewed  $N=6,372$  PEB indicators from 874 studies and analyzed which aspect was measured, how it was measured, and the extent to which studies utilized novel, modified, or adopted indicators. We found that most PEB indicators addressed mitigation behaviors, whereas fewer represented conservation or restoration behaviors. Most measures captured individual behaviors rather than social impact or civic behaviors, and their domain usually referred to waste and energy-related behaviors. Most studies utilized novel or modified indicators, which can hinder the cumulation of findings. We created a database to search for measures and increase reuse rates.

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conservation behavior, preservation, restoration, ecological behavior, pro-environmental behavior, environmental psychology

## Introduction

Human behaviors continue to pressure planetary boundaries, for example, through biodiversity loss, climate change, freshwater depletion, and land-system change (K. Richardson et al., 2023). To counteract these negative developments, widespread behavioral changes are needed (Nielsen et al., 2024; Whitmarsh et al., 2021). In recent decades, researchers from various fields have investigated questions linked to Pro-Environmental Behavior (PEB), such as which individual, social, and contextual factors explain PEB (Bamberg & Möser, 2007; Blankenberg & Alhusen, 2019; Gifford & Nilsson, 2014; Wyss et al., 2022), how can PEB be promoted (Bergquist et al., 2023; van Valkengoed et al., 2022), and what are the correlates of PEB, such as emotions or health-related constructs (P. Hartmann et al., 2017; Krumm, 2024; Shipley & van Riper, 2022).

Even though PEB is of major interest in many social sciences (Farrukh et al., 2023), precise descriptions and conceptualizations are often neglected (Lange, 2024; Larson et al., 2015). PEB is usually broadly defined as behavior that either reduces harm to the environment or as behavior that benefits the environment (Steg & Vlek, 2009; Stern, 2000). Whereas the definitions are similar at the core, researchers measure different properties, namely *behavioral* properties and *person* properties (Lange, 2024). Moreover, the behavioral properties and person properties are studied in a wide range of domains such as transportation, energy use, and food choices and vary in specificity (e.g., using water-saving shower heads; making donations to environmental groups). Consequently, PEB is often used as a vague umbrella term under which different behaviors (e.g., mitigation or restoration behaviors), sustainability approaches (e.g., sufficiency, efficacy), types of behavior (e.g., private or public), domains (e.g., mobility, energy, food), and different antecedents of behavior (e.g., intention, willingness) are summarized. Heterogeneity in the labels related to PEB can also be observed in the search terms used in meta-analyses, including terms such as environment-friendly behavior, (pro-)ecological behavior, conservation behavior, environmentally protective behavior, environmentally significant behavior, green behavior, or environmentally conscious behavior (Shipley & van Riper, 2022; Whitburn et al., 2020). However, the existence of these various labels is largely unintentional because they overlap in many ways (Larson et al., 2015), thus

indicating a high risk of jingle-jangle fallacies (jingle: similar labels are used to describe different constructs or phenomena; jangle: different labels are used to describe the same constructs or phenomena; Elson et al., 2023). Related to this issue is the nominal fallacy—people infer the content of a measure from its name, making it challenging to synthesize research findings (Lilienfeld & Strother, 2020).

In addition, previous studies have reported a tendency to create new ad hoc measures without adequately considering existing measures. Markle (2013) and Świątkowski et al. (2024) found that around 80% of the studies in their samples used adapted or newly developed measures. Thus, as in other fields of quantitative research, research on PEB is confronted with low reuse rates of measures, known as the toothbrush issue (i.e., the tendency to develop or use self-developed instruments while avoiding measures designed by others; Anvari et al., 2024; Elson et al., 2023). This issue is important, as ad hoc measures are often redundant with existing measures and cannot adequately justify their incremental value (Hunsley & Meyer, 2003; Rosenbusch et al., 2020). Moreover, the impact of (un)disclosed measurement flexibility (e.g., dropping, adding, modifying indicators) on the psychometric properties often remains unclear. These issues and fallacies are major obstacles in the cumulative scientific process, as it is difficult to compare results, replicate studies, and synthesize research findings (Mischel, 2008).

To address some of these issues and avoid further fragmentation of the literature, reporting guidelines have been suggested to increase transparency, standardization, and reusability of measures (Elson et al., 2023; Flake & Fried, 2020). Correspondingly, several authors have stressed the importance of clarifying operationalizations and examining the range of possible behaviors (Rosa et al., 2023). Having a shared understanding of and a conceptual framework for the content validity is essential for advancing the measures of behavioral and person properties, identifying high-impact behaviors, refining theories of change for interventions, and synthesizing research findings.

## *Research Goals and Research Questions*

The objective of the present study is tripartite. First, we introduce a framework that integrates previous categorizations of PEB and expands them by integrating two additional categories, namely, the consequences of the behaviors (e.g., mitigation, conservation, restoration, adaptation) and the pathways through which PEB reduces human impact on the environment (e.g., sufficiency, efficiency, consistency).

Second, we use the framework to systemize the current landscape of PEB and address the following three research questions (RQs) in a systematic

review: RQ1: What behaviors are considered when behavioral properties and pro-environmental person properties are studied (i.e., consequences, pathways, types, and domains)? RQ2: How are the behavioral properties and person properties measured? This question addresses the types of measurement approaches (e.g., through self-reports, tasks, observational data, such as bills and records), the temporal scope of the measures (e.g., past behavior), general tendencies or actual behavior, future-oriented indicators (e.g., intention, commitment, or willingness), and the response format and units (e.g., physical units, level of agreement). RQ3: To what extent do researchers show a tendency to generate novel ad hoc measures, modify existing measures, or fully adopt existing measures of person properties and behavioral properties? We analyze and report all three RQs separately for person and behavioral properties.

Third, we provide a database so that existing measures can be easily found, analyzed, reused, or developed further. From our perspective organizing tools of measurement approaches should allow users to search and filter based on multiple features simultaneously. Hence, such tools need to contain information about what is measured and how it is measured. Other important features of measurement repositories may include a direct link to the source, allow searches by key terms, and provide the data in a reusable format. Ideally, such tools are also community-augmented so that the database remains updated, like projects for meta-analytic evidence (e.g., Bucher et al., 2023).

The proposed framework in combination with such a database serves four purposes. First, it can be used to systemize PEB and can later help researchers search for existing PEB indicators. Second, the framework can be used to identify target outcomes and possible pathways in more detail when designing intervention studies. Third, it can be used to evaluate the heterogeneity of PEB indicators when comparing or synthesizing search findings. Fourth, it is aimed at clarifying some of the theoretical terms and concepts, such as conservation or mitigation, as they are often used for theoretically different aspects of PEB (e.g., conserving a protected natural area/ecosystem vs. conserving energy; mitigating human impacts on the environment vs. mitigating potential risks of changes in the environment).

### *Heterogeneity of Measurement Approaches*

Most researchers define PEB broadly as behavior that either (a) reduces the negative effects on the natural and built environment (Kollmuss & Agyeman, 2002; Stern, 2000), (b) contributes to the protection or conservation of the natural environment and its associated wild organisms (Kothe et al., 2019; Soga & Gaston, 2024; Whitburn et al., 2020), or (c) harms the environment as little as possible or benefits the environment (Lange & Dewitte, 2019; Steg

& Vlek, 2009). Whereas the definitions of PEB are similar at their core, they differ in terms of intention and impact (Stern, 2000). Intention-oriented definitions emphasize that the behavior needs to be performed with the intention of reducing harm to or improving the environment, whereas impact-oriented definitions focus on the actual impact on the environment (Deltomme et al., 2023). Moreover, most definitions do not specify what part of the environment they refer to (e.g., natural, built, and social environment) but implicitly set the focus on the natural environment.

As pointed out by Lange (2024), phrases such as “measuring PEB” can be misleading, because pro-environmental behavior cannot be measured. If behavior is defined as an event in the physical world, we can measure its behavioral properties (e.g., duration, completion) and it can be classified as pro-environmental based on the impact or intention. Apart from the *behavioral* properties, many researchers measure pro-environmental *person* properties that are based on behaviors (e.g., propensities, preferences, or tendencies to engage in certain behaviors). Although *behavioral* and *person* properties are theoretically distinct, researchers often refer to them using the term PEB. In the present study, we use the term PEB indicator as it can be used for both classes of research. The indicator is the observable measurand that represents the property of interest, as pro-environmental behavior cannot be measured or observed (Lange, 2024). An indicator can be a questionnaire item, but it can also be an event (e.g., a person donating money to an environmental organization) or a property of that event (e.g., duration). One might argue that for behavioral properties the term indicator is not necessarily needed because there is no representation relation. While this may be true in some cases, a representation relation often does exist, as no behavior is inherently “pro-environmental” in itself. Moreover, the term PEB refers to a heterogeneous set of behaviors (e.g., food choices, showering, mobility), all of which constitute possible indicators drawn from a broader universe of behaviors. If shower behavior, for example, is the behavior of interest, “time” may be one possible indicator of the intensity of that behavior. Water consumption or energy consumption would represent alternative indicators of behavioral intensity for the same behavior. *Person properties*<sup>1</sup>: Measures in this branch of research aim to measure either behavior specific person properties (e.g., how often do you typically eat meat per week?) or general psychological person properties (e.g., generalized propensity to engage in pro-environmental behaviors; Lange, 2024). As measurands in the category are based on pro-environmental behavior(s), indicators in this class of research can be defined as PEB-based propensity indicators.

*Behavioral properties*: Measures in this branch of research capture one specific property of a behavior. A behavior itself cannot be measured as it has

no units, but different behavioral properties/features/characteristics of a behavior can be measured. As each behavioral property (e.g., shower duration) can be measured in multiple ways and the selected measure is one possible indicator for the behavioral property of interest. Further, the behavioral property can be an indicator of how strong/long/intense, etc. the behavior was.

Concerning what is measured, calls have been made to consider a wider range of high-impact behaviors (e.g., investing in a renewable heating system) instead of low-impact behaviors in everyday situations (e.g., turning off the lights when leaving a room) and to consider more behaviors beyond individual household behaviors (Nielsen, Cologna, et al., 2021, Nielsen et al., 2024). As collective environmental issues are caused by collective behavior, collective behavioral responses are required, such as campaigning for environmental protection bills (e.g., Fritsche et al., 2018; Kranz, et al., 2022; Whitmarsh et al., 2021). In addition, there is no clear consensus on whether ecological conservation behaviors (sometimes labeled pro-nature behavior) are a subcategory of PEB or a distinct category of behaviors (Barbett et al., 2020; Hughes et al., 2018; M. Richardson et al., 2020).

With respect to how behavioral and person properties are measured, researchers have suggested reducing the heavy reliance on self-reports, increasing the use of measures of actual behavior, when possible (Lange et al., 2023; Steg & Vlek, 2009), and clearly distinguishing between antecedents (e.g., commitment, willingness, or intention) and measures of actual behavior (Lange & Dewitte, 2019; Nielsen et al., 2024). Moreover, different studies reported limited convergence between different behavioral tasks (Bosshard et al., 2024; Deltomme et al., 2023) and various multi-item general PEB scales (Deltomme et al., 2023; Mónus, 2020). Furthermore, the number of dimensions and terms used to describe pro-environmental person properties vary greatly between studies, indicating that there is either little agreement about the structure or that many studies measure different aspects of PEB (Markle, 2013; Whitburn et al., 2020). Measurement instruments can be found for any number of dimensions, ranging from unidimensional scales (e.g., Brick et al., 2017; Kaiser, 1998) to multidimensional scales with two to eight subdimensions or factors (e.g., Dono et al., 2010; Gkargkavouzi et al., 2019; Larson et al., 2015; Mateer et al., 2022; Smith Sebasto & D'Costa, 1995; Whitmarsh & O'Neil, 2010). Whereas this variability might be a particular challenge for self-reports, even measurement approaches that assess behavioral properties show various underlying paradigms and a wide variety of measurement units (e.g., kilowatts, liters, weight, money), making it challenging to compare or synthesize results (Gelino et al., 2021; Lange, 2023).

Multiple studies have analyzed the impact of measurement approaches on effect sizes using heterogeneity and moderator analyses and have reported that it indeed matters what aspects of PEB are measured and how the person and behavioral properties are measured. For instance, previous research has emphasized that effect sizes depend on a measure's level of specificity (Daryanto & Song, 2021), the domain and behavioral plasticity (Bergquist et al., 2023; Nisa et al., 2019), the type of behavior that is analyzed (e.g., private and public behaviors; Cologna & Siegrist, 2020; Zawadski et al., 2020), and the type of measurement (Deltomme et al., 2023; Mackay & Schmitt, 2019; Maki et al., 2019; Mónus, 2021; Whitburn et al., 2020).

Considering the heterogeneity in measurement approaches, it is important to take a closer look at the *how* and *what* of the PEB measurements to (a) establish a shared understanding of the consequences, pathways, types, and domains of PEB, (b) advance measurement development, and (c) increase the comparability of PEB research findings across disciplines.

### *How Can PEBs Be Systemized?*

Due to the broad definition of PEB and research interest from multiple disciplines, a variety of behavioral indicators of PEB have emerged. The behaviors have been grouped in different ways, either by theoretical considerations or statistical methods. One of the most common categorizations was suggested by Stern (2000) and distinguishes between four categories: (a) private sphere environmental behaviors, (b) nonactivist behaviors in the public sphere, (c) environmental activism, and (d) other environmentally significant behaviors. Even though many researchers have referred to this classification approach, most have used a simplified version that distinguishes only between private and public behaviors (e.g., Cologna & Siegrist, 2020; Mateer et al., 2022).

Blankenberg and Alhusen (2019) adapted Stern's (2000) four categories slightly and added examples of existing behaviors. For instance, environmental activism and nonactivist behaviors in the public sphere were combined into one category with the lower order subcategories political environmental behavior and environmental citizen behavior. Similar to this categorization, Hamann and Masson (2020) distinguished between three types in their overview of sustainability behaviors, namely, (a) private behaviors related to the socioecological footprint (changing one's own personal behaviors), (b) indirect behavior with a focus on social impact (changing the behavior of others), and (c) civic and activist behaviors related to the concept of socioecological handprint (changing structures). In the context of climate action, similar models have been proposed, such as ones including citizenship behavior and behaviors of influence (Hampton & Whitmarsh, 2023). Other models do not

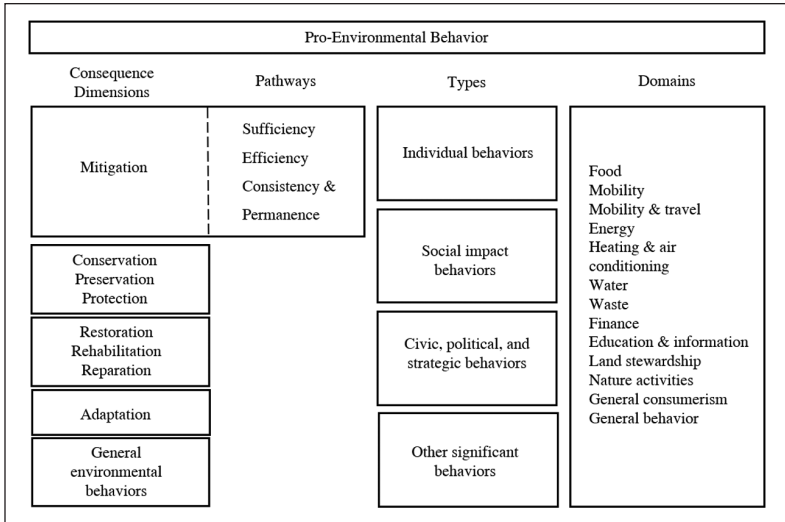
reflect the specific domain of the indicators but focus on agency dimensions, such as everyday versus strategic and individual versus collective behaviors (Otto et al., 2020). Additionally, some approaches distinguish between domain-general behaviors versus context-specific behaviors, such as those specific to tourism (Lange & Dewitte, 2019; Mateer et al., 2022). Others differentiate general versus place-specific behaviors, such as PEB in a particular nature reservoir or in the workplace (Daryanto & Song, 2021; Esfandiar et al., 2022; Halpenny, 2010).

In addition to these high-level classification approaches, PEB can be grouped by various behavioral characteristics, such as the difficulty of completing the behavior (Helferich et al., 2023; Molinario et al., 2020; Mónus, 2021), the level of cost/effort involved in conducting or sustaining the behavior (Lange & Dewitte, 2019; Ramkissoon et al., 2013; Song & Soopramanien, 2019), the visibility and signaling strength (Brick et al., 2017; Brick & Sherman, 2021), the actual impact (Cologna et al., 2022; Constantino et al., 2022; Ivanova et al., 2020), and the perceived impact (Bleys et al., 2018; C. Hartmann et al., 2021; Wynes et al., 2020). Beyond these categories, PEB can be described by a behavior's frequency (Brick et al., 2017; Cornelissen et al., 2008; Truelove & Gillis, 2018), behavioral plasticity (Dietz et al., 2009), level of physical activity (Rosa & Collado, 2020), pro- and anti-environmental behaviors (Topf & Speekenbrink, 2022), or perceived side-benefits (e.g., Innocent & Francois-Lecompte, 2018; Truelove & Gillis, 2018).

Whereas all these categorization approaches can be useful to describe specific features of PEB, they are less suited to systemizing the broad variety of indicators. Consequently, we focus on categories that can be applied to most existing PEB indicators, such as the consequences, pathways, types of behavior, and domains.

### ***Introducing a Framework for Systemizing Pro-Environmental Behaviors***

Building on previous approaches to categorizing PEB (e.g., Blankenberg & Alhusen, 2019; Hamann & Masson, 2020; Stern, 2000), we developed a framework for systemizing the PEB landscape. Our framework, as illustrated in Figure 1, contains four major levels to systemize each PEB indicator: the consequence dimension, the pathways, the types of behavior, and the domains. By integrating concepts from sustainability science and ecology (e.g., Huber, 2000; M. Richardson et al., 2020) the framework expands previous models that focused only on types of behaviors or domains. This approach makes it possible to relate social science research on PEB to ecological and



**Figure 1.** Framework for systemizing pro-environmental behavior.

sustainability research and thereby to better understand the different pathways and effects of PEB.

### Consequence Dimension

The first level of the framework describes the overarching consequences and environmental goals that the behavior intentionally or unintentionally contributes to. We refer to this level as the consequence dimension with the categories of mitigation, conservation, restoration, and adaptation. It does not necessarily reflect the specific goal of the person showing the behavior, as the measures often do not explicitly assess the underlying intention or motive.

**Mitigation Behaviors.** This category includes all behavioral indicators that reduce, limit, delay, or slow down the rate of undesired environmental changes (Colonna & Siegrist, 2020; IPCC, 2018). Mitigation behaviors that lower harm and save resources are for instance, avoiding meat consumption, using sustainable modes of transportation, using renewable energy sources, having an efficient heat insulation in place, but also supporting increased CO<sub>2</sub> taxes or convincing others to use less packaging material. In line with Stern et al. (2022), we distinguish between this category and adaptation behaviors that reduce the risks and impacts of environmental changes (see *Adaptation Behaviors*).

*Ecological Conservation, Protection, and Preservation Behaviors.* This category contains behaviors that conserve, protect, or preserve the natural environment from future damage and contribute to the health of the natural environment. These behaviors are sometimes labeled pro-nature behaviors (Barbett et al., 2020; M. Richardson et al., 2020), biodiversity conservation (Prévot et al., 2018), or nature conservation behavior (Martin et al., 2020). In contrast to mitigation, ecological conservation, protection, and preservation behaviors actively limit human interference with the natural environment and conserve and protect the status of the natural environment in general, an ecosystem, a specific place, or a species. Examples of behavioral indicators are supporting the limits of land sealing, building insect hotels, staying on paths when in nature, supporting nature reservoirs through memberships, financial support, petitions, or other forms of engagement (Halpenny, 2010; Van Riper & Kyle, 2014). In contrast to ecological restoration behaviors, which specifically aim to repair, recover, rehabilitate, and undo environmental damage from past behavior, conservation, protection, and preservation behaviors set the focus on preventing future losses.

*Ecological Restoration Behaviors.* Ecological restoration behaviors initiate or support the recovery, recreation, rehabilitation, reparation, remediation, or regeneration of an ecosystem that has been disturbed in the past (e.g., Ceballos et al., 2017; UNEA, 2019). Ecosystems can be disturbed by humans, for example through littering, extensive logging, intense agriculture, oil-spilling accidents, or by natural events, such as floods or wildfires (Vaughn et al., 2010). Thus, examples of restoration behaviors include planting activities, supporting the renaturation of areas, participating in cleaning activities for rivers or beaches, or removing invasive plant species. In contrast to *mitigation* and *conservation*, restoration occurs when the environment was already harmed or had deteriorated, and the consequence is to improve the quality of the natural environment and reverse it to an earlier state.

*Adaptation Behaviors.* Adaptation behaviors can be described as adjustments and preparatory behaviors for actual or expected changes in the environment, such as extreme weather events (IPCC, 2018; Whitmarsh et al., 2021). Planting diverse climate-resistant crops, creating water tanks/reservoirs for plants and animals, planting trees to increase shadow space, and removing dry wood from the house are a few examples of adaptation behaviors that are directly related to the natural and built environment. Other adaptation behaviors set the focus on the social environment, human needs, and well-being. For example, adaptation behaviors can minimize the impact of environmental changes on humans (e.g., keeping water stock during a heat wave) or infrastructure (e.g.,

floodproofing a house). Including adaptation behaviors in the framework can also help to reduce the confusion around the term mitigation. *Mitigation* behaviors lower the harm to the environment and aim to reduce changes in the environment, whereas *adaptation* behaviors aim to mitigate the risk or impact of the changes in the environment. In our framework, we distinguish the adaptation behaviors by the risk they aim to address, namely, water-related risks, heat-related risks, and other risks, such as hurricanes or climate change in general (Brody et al., 2017; Poussin et al., 2014). Furthermore, we used six behavioral categories to systemize the behavioral indicators: structural household measures (e.g., installing floodproof doors), community and social behaviors (e.g., helping other neighbors get prepared for a hurricane), agriculture- and business-related behaviors (e.g., cultivating more tolerant crops), information- and education-related behaviors (e.g., informing oneself about the risk of coastal flooding), behaviors related to insurance (e.g., possession of flood insurance), and other behaviors (e.g., keeping a first aid box ready).

**General Environmental Behaviors.** Whereas most indicators of PEB are domain-specific or even place-specific, some PEB indicators cannot be categorized due to their broad descriptions. For example, in the measures “donation to an environmental organization” or “being a member of an environmental group” it remains unclear whether it is an organization that contributes to mitigation, conservation, or restoration actions. In addition, the domain remains unspecific (e.g., does the organization focus on one domain such as organic farming, cycling paths, or renewable energy). As all these indicators could relate to any of the four previously described categories, we used this general category in the framework.

### *Pathways of Mitigation Behaviors*

The great variety of *mitigation* behaviors can be further distinguished by the pathways and underlying strategies through which the negative impact on the environment is reduced. According to models from sustainability research, there are at least three major pathways for mitigation behavior, namely, sufficiency, efficiency, and permanence/consistency-oriented behaviors (e.g., Allievi et al., 2015; Huber, 2000). We argue that including these categories to systemize PEB is useful, as the various behaviors differ in the mechanisms that underlie them (e.g., refraining from something is different from using something in an improved way and from changing to another resource) and in how other people perceive them (e.g., reducing car use is perceived differently from driving economically; a more efficient vehicle is perceived differently from driving with renewable energy). For example, previous research

distinguished between curtailment and efficiency-oriented behaviors (Truelove & Gillis, 2018) and identified curtailment behaviors, product choice, and technology choice as categories (Clayton & Myers, 2015; Farrukh et al., 2023) but did not relate these categories to the sufficiency, efficiency, and permanence pathways discussed in sustainability research.

*Sufficiency.* Sufficiency-oriented PEB sets the focus on behavioral change and addresses the questions of what one needs and how much is sufficient (Brinken et al., 2022; Princen, 2005). A lower negative impact on the environment is primarily achieved through changes in behavior patterns (e.g., reducing meat consumption, avoiding short-distance flights, lowering the room temperature in winter). The key mechanisms are in the behavior itself—such as avoiding something or engaging in harmful behaviors less frequently. These behaviors are also sometimes called frugal behaviors or curtailment behaviors, as this pathway does not necessarily require technological innovations or political changes (Muiños et al., 2015; Stanley et al., 1996).

*Efficiency.* By contrast, efficiency-oriented PEB focuses on the better use of resources and does not always require major changes in the target behavior (e.g., room temperature does not need to be lowered due to better insulation). These behavioral indicators are often based on technological advances (e.g., water-saving shower head, energy-efficient vehicle), or they change the behavior in such a way that resources are used in an improved way (e.g., using a pot lid when cooking, driving with optimal tire pressure). The underlying idea is that processes and products require fewer resources to achieve the same or similar outcome (Huber, 2000).

*Permanence and Consistency.* Permanence- and consistency-oriented PEB is based on the idea that resources are not depleted and that zero waste is produced (Huber, 2000). In contrast to efficiency-oriented behavior, which is more quantity-oriented (i.e., less resource consumption with a similar or better outcome), consistency-oriented behavior aims to change the quality of material and the flow of energy. This refers to substances, products, and technologies that are consistent with natural material cycles (Schmidt, 2008; WBGU, 2011).

Thus, these behaviors are linked to the life cycle of a product, how something is produced and used, and what happens after it is used. They build on circular processes and technologies that use different renewable resources and services of ecosystems without damaging them. Examples of consistency- and permanence-oriented behaviors are eating organic food, advocating for renewable energy sources, or using recyclable materials.

## *Types of Behavior*

In addition to the consequences and pathways, Stern (2000) distinguished between four types of behavior: private sphere environmentalism, nonactivist behaviors in the public sphere, environmental activism, and other environmentally significant behaviors. Whereas researchers often built on this typology, most distinguish only between the two categories of public and private behavior (e.g., Cologna & Siegrist, 2020; Zawadski et al., 2020), as the boundaries of the categories are often fuzzy. Indicators of public behaviors are, for instance, described with many terms, such as civic action, environmental citizenship, social impact behaviors, social environmentalism, political behaviors, or activism (e.g., Larson et al., 2015; Lee et al., 2013). As the terms private and public are also sometimes not clearly outlined (Barbett & Landmann, 2023), we integrated the classifications from Hamann and Masson (2020) and Otto et al. (2020), who focused on the target of the behavior or behavioral change, that is, personal behavior, the behavior of others, or systemic/political changes.

*Individual Behaviors.* This category captures personal behavior. It is sometimes called private sphere behavior or household behaviors and focuses on personal lifestyle changes that occur on the individual or household level, such as recycling, switching to a renewable energy provider, or picking up litter. These indicators reflect how an individual can modify their behavior to align with sustainable development goals (Lou & Li, 2023). These behaviors have direct positive effects on the environment, but they are often rather small because behavior changes in single individuals have only negligible effects (Stern, 2000).

*Social Impact Behaviors.* This category focuses on the social impact on people in their personal environment, such as family, friends, and peers (Hamann & Masson, 2020). The person completing this behavior explicitly aims to change the behavior of another person. It ranges from encouraging others to act more pro-environmentally friendly to calling out environmentally harmful behaviors. In contrast to civic, political, and strategic behaviors, social impact behaviors include informal ways of influencing others in the family or in one's close social environment. Social impact behaviors are less strategic than civic and political actions that focus on structural and systemic changes (Hampton & Whitmarsh, 2023; Otto et al., 2020).

*Civic, Political, and Strategic Behaviors.* This category contains PEB in the sociopolitical arena, which focuses on structural and systemic changes.

Examples of sociopolitical behaviors are signing petitions, supporting policies, voting, writing letters to politicians or companies, participating in demonstrations, and supporting environmental organizations (Hampton & Whitmarsh, 2023; Stern, 2000). These behaviors emphasize the transformative power of societies and the drive for more systemic changes. In contrast to the individual and social impact behaviors the category of strategic/political/civic behaviors includes behaviors that are either completed together with others or support a pro-environmental group, policies and structural changes. This category also overlaps with the concept of collective action (van Zomeren & Iyer, 2009). However, for most PEB indicators, it remains unclear to what extent the individual identifies with a group and works toward a common goal which is crucial in the concept of collective action.

*Other Significant Behaviors.* Finally, Stern (2000) proposed an additional category for other significant behaviors, such as behaviors at work or in other groups. In our proposed framework, this category includes all behaviors that do not fall under the first three types of behavior, for example, behavior at work (e.g., in the office, business travel, behaviors related to agricultural and forestry practices).

## Domains

PEB can be further systemized by the domains to which the behavior is related either by the domain of daily life (e.g., mobility, consumerism) or by the resource impacted by that behavior (e.g., water, energy). To systemize the PEB domains, we built on research from various domain-general scales that were designed to cover different areas (Blankenberg & Alhusen, 2019; Kaiser, 1998; Larson et al., 2015; Lee et al., 2013). These categories were compared with research findings on actual environmental impact (Ivanova et al., 2020) and behaviors reported by PEB researchers (Brick et al., 2024), resulting in 13 categories: (a) Nutrition, (b) Mobility, (c) Mobility and travel, (d) Energy (excluding heating), (e) Heating and air conditioning, (f) Water, (g) Finance, (h) Waste, (i) Information and education, (j) Land stewardship, (k) Nature activities, (l) General consumerism, and (m) General environmental behaviors for which the domain is not clear (e.g., signing an environmental petition). Finally, one category of “multiple” was added after the pilot ratings, as some PEB indicators can be assigned to multiple categories. For example, doing laundry only with full loads can be assigned to both the water and energy categories.

## Measurement Approaches

As the (dis)advantages of the various measurement approaches have been described in detail in previous research (Koller et al., 2023; Kormos & Gifford, 2014; Lange & Dewitte, 2019), we outline only briefly the most common measurement approaches relevant for the systematic review. With respect to measurement practices in the PEB literature, previous research has distinguished between self-reports (e.g., diaries, survey data), informant reports ranging from peer ratings of well-acquainted others (e.g., parents, partners, roommates) to trained observers, and laboratory observations (e.g., virtual shopping tasks, donation decisions, or social dilemma games). Previous research has also included measurements from devices (e.g., meters that measure water consumption; GPS data to assess mobility behavior) and company records, such as energy bills (Brick et al., 2024; Kormos & Gifford, 2014; Lange & Dewitte, 2019).

Related to the different modes of data collection, PEB properties can be quantified by different scales and measurement units. For example, PEB-based person properties are often assessed with Likert-type scales to measure the level of agreement with statements or the frequency of behavior. It can be measured with monetary values (e.g., amount donated to an environmental organization), time investment (e.g., time spent doing volunteer work), or physical units (e.g., kWh, weight of red meat consumed, CO<sub>2</sub> emissions). PEB properties can also be measured with dichotomous items concerning the use of relevant objects and assets (e.g., solar panels, fuel-efficient cars) or as the actual behavior itself (e.g., the participant signed an environmental petition).

In addition, PEB indicators can be grouped by the time span they aim to cover, such as (a) past behavior (e.g., energy consumption in the last 3 months), (b) typical behaviors (e.g., weekly meat consumption), (c) behavior during a specific situation (e.g., reusing towels in a hotel), or (d) future-oriented hypothetical behavioral indicators (e.g., likelihood of voting for a CO<sub>2</sub> tax increase, intention to take the bus to work).

Finally, PEB indicators can be grouped by their degree of novelty or level of modification. Previous research on the developmental stages of indicators in environmental research is rare. Initial research results suggest that most measures are novel and self-developed for a specific study (Markle, 2013; Świątkowski et al., 2024). There are sometimes good reasons to develop new measures for emerging topics for which no indicators exist (e.g., use of new plant-based food alternatives; new efficiency-oriented devices). However, it becomes more challenging to compare or synthesize findings across PEB indicators when reuse rates are low and the literature can become fragmented

(Elson et al., 2023). Such low rates are challenging in many areas of psychology, but so far, they have not yet been analyzed for measures related to PEB (Anvari et al., 2024). As other researchers have argued that a proliferation of measures can also help advance psychological research (Iliescu et al., 2024), it is important to first understand the current landscape of PEB indicators, the types of adaptations that have been made, and whether these adaptations have been explained.

To summarize, previous research has shown that different behaviors are summarized under the term PEB and are operationalized in various ways (Brick et al., 2024; Lange, 2024). While previous reviews have concluded that the landscape of PEB is rather heterogeneous (Lange, 2023; Lange & Dewitte, 2019), studies have not analyzed the behavioral indicators in terms of *what* aspects of PEB are measured and *how* they are measured—both being important questions for advancing measurement approaches and synthesizing research. To better address the heterogeneity of behavioral indicators, a shared understanding of the content areas is vital (Nielsen, Cologna, et al., 2021). According to Cronbach and Meehl (1955), content validity can be established by showing that the indicators of the measurement belong to the universe of indicators in which the researcher is interested. Thus, reviewing and outlining the universe of possible PEB indicators is an important first step so that researchers can systematically sample from it.

## Method

### *Sample and Procedure*

To address the RQs and provide a comprehensive picture of PEB landscape, we first searched for meta-analyses and systematic reviews of PEB. To be included, the meta-analysis or systematic review had to fulfill the following criteria: (a) refer to PEB in their title, keywords, and/or abstract; (b) provide the full list of articles used in their analyses and the inclusion process; and (c) be published in English not earlier than 2014. By using this approach, we ensured that the original studies and measurements focused on PEB and had already been addressed in syntheses of scientific literature. Furthermore, this approach ensured that different PEB research areas were covered (e.g., incentives, social norms, feedback). As shown in Table 1, our sample included 23 meta-analyses and systematic reviews resulting in 1,238 articles, including 130 duplicated studies that appeared in at least two meta-analyses or reviews. Overall, 82 studies listed in the meta-analyses and reviews could not be considered, as they referred to unpublished raw data or studies that were not available. There were 160 articles in which the authors provided only sample

**Table 1.** List of Included Meta-Analyses and Systematic Reviews.

No.	Meta-analysis/systematic review	Number of articles	No access	Foreign language	Indicator not available	Articles included
1	Bergquist et al. (2019)	77	3	0	0	74
2	Byerly et al. (2018)	64	7	0	1	51
3	Cologna and Siegrist (2020)	45	0	0	3	42
4	Daryanto and Song (2021)	38	0	0	8	30
5	Geiger et al. (2021)	30	2	0	1	27
6	Gelino et al. (2021)	50	1	0	0	49
7	Grilli and Curtis (2021)	68	19	0	10	39
8	Karlin et al. (2015)	42	9	0	1	32
9	Kormos and Gifford (2014)	16	1	0	0	15
10	Lange and Dewitte (2019)	33	1	0	1	31
11	Lange (2023)	107	4	0	3	100
12	Lou and Li (2023)	34	1	0	5	28
13	Mackay and Schmitt (2019)	61	13	2	13	33
14	Maki et al. (2016)	22	1	0	2	19
15	Maki et al. (2019)	18	3	0	2	13
16	Morren and Grindstein (2016)	67	2	0	15	50
17	Okumah et al. (2020)	109	5	0	16	88
18	Shiple and van Riper (2022)	27	0	0	9	18
19	Udall et al. (2021)	86	0	0	19	67
20	Van de Wetering et al. (2022) <sup>a</sup>	60	5	0	23	32
21	Van Valkengoed and Steg (2019) <sup>b</sup>	90	1	0	12	77
22	Whitburn et al. (2020)	26	2	0	4	20
23	Zawadzki et al. (2020)	68	2	2	12	52
		1,238	82	4	160	992
	No. of duplicates	130	1		11	118
	Total no. of studies included					874

Note. Studies are presented in alphabetical order.

<sup>a</sup>Only articles with behavior or intention were considered.

<sup>b</sup>This study was added separately to include adaptation behaviors in the framework as explained in the description of the adaptation behaviors.

indicators instead of full scales. Hence, these studies could not be included. Further, four studies were published in Spanish. As no member of the research team had sufficient Spanish skills, these four studies were excluded. The complete inclusion process is illustrated in Figure S1. Thus, our final sample consisted of  $N=6,372$  indicators from 874 articles.

### Data Extraction and Rating Procedure

As we were interested in the specific content and operationalizations, we extracted the information relevant to PEB on an indicator/item level from each of the 874 studies. We conducted two rounds of ratings to check whether the indicators could indeed be meaningfully distinguished by the categories brought forward in the framework. After one pilot rating, the three authors of this study independently rated a random sample of 300 indicators. Next, we used Krippendorff's  $\alpha$  (Hayes & Krippendorff, 2007) to assess the interrater reliability (IRR) for each category in the framework. The IRR was between .77 (95% CI [.71, .83]) for the category *pathway*<sup>2</sup> and .88 [.82, .92] for the category *type of behavior* (for details, see Table S12). Additionally, the confidence intervals were estimated with  $N=1,000$  bootstrapped samples. According to the interpretation guidelines (Hughes, 2021), values between  $.60 < \alpha \leq .80$  indicate substantial agreement. Thus, we interpreted the IRR as sufficient. The remaining indicators and items were coded by the first author.

### Data Availability Statement

In line with the FAIR data principles (Wilkinson et al., 2016), the data set, coding guidelines, and syntax are available in reusable formats.<sup>3</sup> In addition, we created an application<sup>4</sup> that can be used as a database by researchers and practitioners to search for existing measurement instruments. The application allows users to set multiple filters to easily find indicators.

## Results

We obtained  $N=6,372$  PEB indicators from 874 unique articles (thereof 96.80% published in journals) published between 1971 and 2021 from 23 meta-analyses and systematic reviews. In this section, we present our findings on what aspects of PEB indicators are used (RQ1), how the person and behavioral properties are measured (RQ2), and to what extent novel, modified, or fully adopted indicators are used (*toothbrush issue*; RQ3).

### What Behaviors Are Considered When Behavioral Properties and Pro-Environmental Person Properties Are Studied?

The results for RQ1 are presented in Table 2, which shows a majority of PEB indicators in both categories (i.e., person and behavioral properties) covering mitigation behaviors and lower numbers for conservation and

restoration behaviors. In total,  $n=767$  indicators were rated as general behaviors for which neither the environmental benefit nor the intention was clear (e.g., joining an environmental group). The person and behavioral properties covered all three pathways. Person properties included mostly sufficiency-oriented and consistency-oriented behaviors, whereas the behavioral properties were more equally distributed across the three pathways. Concerning the type of behavior, we observed that most indicators fell under the category of individual behaviors. Civic, political, and strategic behaviors were identified less frequently for both person and behavioral properties. Concerning the domains, a wide range of domains were covered. In the category of person properties, most indicators addressed the domains of waste, energy, general environmental behavior, mobility, and general consumerism. Behavioral properties were most frequent in the domains of waste, energy without heating, general environmental behavior, finance and donation, and general consumerism.

Concerning adaptation, the results suggested that all three risk categories appeared with similar frequencies. As presented in Table 3, most indicators captured actions taken to reduce the risk of property damage.

### *How Are Behavioral and Person Properties Measured?*

As Table 4 shows, most person properties were measured with self-reports, followed by indicators based on behavioral traces, and reports from others. Behavioral properties were mostly obtained through choice task/games/simulations, reports from others, and self-reports. Concerning the time scope, most person properties captured general propensities or set the focus on behavior intentions or past behavior. The behavioral properties focused on the behavior in a specific situation or captured past behavior. The indicators were captured with a variety of response formats and were quantified in different ways, ranging from frequency responses, monetary amounts, and product choices to physical units. Regarding the response formats of the indicators, the response options ranged from two response options (e.g., true/false) to 10 or more possible values (e.g., physical units).

### *Toothbrush Phenomenon: Novel, Modified, or Fully Adopted Indicators*

As presented in Table 5, most indicators of person properties and behavioral properties in our sample were rated as novel, meaning that they were newly

**Table 2.** Overall Frequencies of PEB Indicators in Each Category.

Category	N		Examples
	Person properties	Behavioral properties	
Consequence dimension			
Mitigation	3,930	282	Bought organic products; reduced car miles and total number of flights, voted for CO2 tax
Conservation	398	27	Signed a petition or donated money for conservation reservoir, compost in the garden
Restoration	83	14	Picked up litter, participated in planting activities
Adaptation	646	61	Installed flood protection, used crop rotation
General	709	58	Signed pro-environmental petitions, member of an environmental group
NA	41	11	
Pathway			
Sufficiency	1,055	56	Eat less meat, fly less, decrease room temperature in winter
Efficiency	868	76	Use energy-saving light bulbs, drive slower, buy domestic/regional products
Permanence & consistency	1,510	75	Buy organic, recycle, use renewable energy
Unspecific	470	73	Purchase sustainable products
NA	1,904	173	Not mitigation
Type of behaviour			
Individual	4,471	354	Sort trash, avoid plastic bags, walk or cycle
Social impact	168	8	Talk to others about environmental issues
Political, civic, & strategic	855	57	Sign petitions, group membership, donation, vote, policy acceptance
Others	287	26	Behaviors at work (office, farm, fishery, forest)

(continued)

**Table 2.** (continued)

Category	N	Person properties	N	Behavioral properties	Examples
NA	26		8		
Domain					
Nutrition	344		26		Buying organic fruits and vegetables, meat and dairy consumption
Mobility	531		16		Walk, cycle, public transport, car use/ownership
Mobility & tourism	78		1		Mode of travel, frequency of long-distance trips
Waste	1,208		94		Recycling behavior, amount of trash, litter
Energy (excluding heating)	663		48		Overall electricity consumption, turn off lights/screens/devices
Heating & air conditioning	184		7		Room temperature, type of heating/insulation
Water	310		37		Water consumption, turn off the tap while soaping hands
Finance & donations	109		33		Donate money, divest from fossil accounts
Information & education	219		12		Inform others, read about environmental issues
Land stewardship	73		1		Plant trees/plants, avoid chemical use in garden
Nature activities	83		11		Use designated paths in nature preserves
General consumerism	522		33		Repair things, use items for a longer period, purchase environmentally sound products
General environmental	662		25		Sign petitions, support an environmental organization
Multiple categories	145		21		Frequency of taking a hot shower
NA	676		88		

Note. Pathways subcategories apply only to the category of mitigation. The NAs in the category “domain” include the adaptation indicators, see Table 3. NA = missing value/information not available.

**Table 3.** Adaptation—Characteristics of PEB Indicators.

Category	N		Behavioral properties	Examples
	Person properties	N		
Risk category				
Water (e.g., floods, heavy rains, increasing sea levels)	207	22		Own sandbags or other water barriers. Adaptation as policy support: Protection and creation of wetlands.
Heat (e.g., fires, droughts)	189	24		Action taken/not taken: Increased home insulation. Removed overgrown bushes and plants and those growing under fences.
Other (e.g., general climate change, tornados, hurricanes)	250	15		Adaptation as policy support: Use carbon capture and storage sub-seabed to counteract climate change. Installation of a rainwater tank on my property.
NA	5,161	392		
Adaptation behavior				
Household adjustments	207	34		A pump was installed.
Community & social	81	0		I helped other neighbors or friends get prepared for the hurricane.
Agriculture & business	95	6		Cooperation with other farmers in cultivating more tolerant crops.
Information & education	103	13		I have informed myself about the risk of coastal flooding.
Insurance	23	4		Possession of flood insurance.
Others	137	4		Obtained emergency water.
NA	5,161	392		

Note. The NAs include the indicators from all other goal dimensions, see Table 2. NA = missing value/information not available.

**Table 4.** Characteristics of PEB Indicators.

Category	N	
	Person properties	Behavioral properties
Type of measure		
Self-reported	5,581	86
Choice task/ games/ simulations	0	204
Behavioral traces	150	18
Reported by others	53	110
NA	23	35
Time frame		
Past behavior/ Retrospectively	1,191	84
General propensity	3,212	0
During a specific situation	0	312
Future-oriented/hypothetical	1,368	3
NA	36	54
Response/ data format		
Willingness & intention	589	0
Level of agreement	1,832	0
Reported frequency	2,566	0
Amount of money	28	43
Amount of time	15	24
Examples		
		Questionnaire, diary, survey, interview
		Property was assessed in a lab setting via a task, game, or simulation.
		Property was measured with devices, company records, electricity bills
		Property was reported by spouse, parent, coworker, researcher
		Yesterday, last week, last month, last year
		How often do you. . . ?
		Product choice, decision in a behavioral paradigm
		Tomorrow, next week, next month, next year
		Very unlikely to very likely
		Disagree to agree
		Never to always; never to most of the time
		Amount in currency
		Time in minutes or hours

(continued)

Table 4. (continued)

Category	N		Behavioral properties	Examples
	Person properties	N		
Physical unit	180	22		Liters, weight, amount of GHG, distance, space, volume, kWh
Others	295	309		Product choice, Completion of something
Mixture	109	46		Completion, frequency, and/or willingness in the same response format
NA	195	8		
Scale level/ values				
2 points/options	1,022	65		True/false; yes/no
3 points/options	140	37		Yes (3), unsure (2), no (1)
4 points/options	390	2		Never (1) to always (4); Up to one fourth = 1; 4 = two full bins.
5 points/options	2,290	17		1 = strongly disagree to 5 = strongly agree
6 points/options	119	1		0 = never do this to 5 = always do this
7 points/options	1,041	7		1 = never to 7 = very often; 1 = very unlikely to 7 = very likely
8 points/options	14	0		1 = never to 8 = most days
9 points/options	32	1		1 = strongly disagree to 9 = strongly agree
10 points/options	38	0		0 (totally disagree) to 10 (totally agree).
> 10 points/options	325	119		0–20, number of one-way trips per week; Percentage, kg, mean water consumption
Others	104	196		Single-choice, multiple-choice, rank order
NA	292	8		

Note. NA = missing value/information not available.

**Table 5.** Developmental Stage of the PEB Indicators.

Status	N	Person properties		Behavioral properties		
		References without shared coauthors	References incl. at least one shared author	N	References without shared coauthors	References incl. at least one shared author
New (novel, developed)	2,884	469	150	304	27	0
Modified (shortened, selected, extended)	2,130	1,409	721	107	87	20
Reused/adopted (fully adopted, no changes reported)	739	444	295	36	10	26
NA	54	—		6		

Note. NA = missing value/information not available.

developed by the authors or the authors did not provide any reference. Secondly, a large proportion of the indicators of person and behavioral properties were rated as modified. Furthermore, we observed that in the category of person properties 33.9% of the modified and 39.9% of the fully adopted indicators used a reference with at least one shared author from the respective study. In the category of behavioral properties, 18.7% of the modified and 72.2% of the fully adopted indicators used a reference with at least one shared author.

### *Additional Analyses: Combination of Features*

In addition to our guiding research questions, we explored patterns across the levels of the framework and measurement approaches. We analyzed the data set in two ways, first by combining different levels from the framework (e.g., pathways by domain) and by combining *what* and *how* it was measured (e.g., measurement approaches by the types of behavior or by their degree of novelty).

When looking at the consequence dimension for each type of behavior, we observed that the indicators of mitigation were more on the individual level, whereas ecological conservation and restoration indicators were more frequently civic, political, and strategic behaviors (Table S13). Mapping the consequence dimensions by their domain, results revealed that ecological conservation indicators focused strongly on waste, and restoration indicators captured mostly waste related clean-up activities, planting, or general behaviors (Table S14).

Considering the domains for each pathway, the results showed that the most efficiency-related indicators were found for mobility, energy, and water.

Permanence-oriented indicators mostly covered waste-related behaviors, whereas sufficiency-oriented behaviors were distributed broadly across various domains (Table S15).

When analyzing the consequence dimensions across the measurement types, we observed that measures beyond self-reports were very rare for conservation, restoration, and adaptation behaviors (Table S16). Likewise, the indicators of social impact as well as civic/political/strategic behaviors were almost only self-reports (Table S17). Looking at the measurement units and domains, the results showed that physical measurement units appeared primarily in the domains of energy, waste, water, and mobility (Table S18). Finally, the results also revealed a tendency to utilize 7-point scales for future-oriented indicators (e.g., intention), whereas general and past behavior indicators were measured with 5-point scales (Table S19).

Concerning the novelty of the indicators, the results suggested that specifically the indicators for adaptation behaviors were newly generated (Table S20).

## Discussion

The goal of the present study was tripartite. First, we developed a framework based on previous categorizations to systemize the current landscape of PEB indicators. Second, we applied this framework and conducted a systematic review based on  $N=6,372$  PEB indicators from 874 unique articles. We used the proposed framework to rate each PEB indicator on consequence, pathway, type, and domain to describe what aspects of PEB indicators are captured. In addition, we rated how PEB is operationalized and to what extent novel, modified, or fully adopted indicators are used. Third, we built a database for future research on PEB measurement approaches.

### *What Aspects of PEB Are Measured?*

Our findings showed that most indicators covered behaviors related to the idea of mitigation, whereas indicators of ecological conservation and restoration were observed substantially less frequently. The ratios between mitigation, conservation, and restoration can be discussed in different ways. Mitigation behaviors and their respective indicators are urgently needed to lower the pressure on various planetary boundaries (K. Richardson et al., 2023), particularly in countries overstepping their ecological footprints (Chancel, 2022). However, as all consequence dimensions of PEB are needed for sustainable societies (Langhammer et al., 2024; Nielsen, Marteau, et al., 2021; UNEA, 2019), we conclude that indicators of conservation,

restoration, and adaptation behaviors are currently underrepresented in the PEB literature.

With respect to the pathways, our results showed that the indicators tapped into all three different pathways of sustainability. This point is important, as all pathways are needed and function together. For example, food behaviors are most sustainable when meat and dairy consumption is reduced (sufficiency), the food items are produced locally without unnecessary packaging (efficiency), and they are produced with sustainable farming practices (permanence/consistency). Whereas all pathways were represented in general, our results revealed that certain pathways were dominated by certain domains. Permanence was dominated by indicators related to waste, and efficiency indicators primarily addressed water, energy, and mobility. The framework and review provide a basis for identifying gaps and developing measures for currently neglected areas.

Our finding of an imbalance between individual behaviors and social impact as well as civic, political, and strategic behaviors is plausible, as many researchers are interested in high-frequency individual behaviors that apply to many people across contexts and that benefit the environment directly. Notwithstanding the importance of these behaviors, researchers need to be aware that only using indicators for individual behaviors also contributes to shifting the responsibility onto the individual. Privatizing sustainability and placing too much responsibility on individuals has been criticized, as collective responses and structural changes are needed to solve collective issues and bring about a transformation toward sustainability (Fritsche et al., 2018; Grunwald, 2010; Kranz et al., 2022; Schmitt et al., 2020).

Studying more social impact and political/civic/strategic behaviors also requires individuals to act and do something, but at the same time, these behaviors distribute responsibility and shift a part of the responsibility in the longer term so that completing certain behaviors becomes easier, for example, through lower emotional or financial costs. If someone, for example, actively supports structural changes and systemic solutions (e.g., introducing a packaging tax, the expansion of cycle paths, or longer warranty periods for products), it will be easier to complete these behaviors as an individual in the long term. In addition, if more measures in these categories are used, it can become clearer that individual lifestyle changes are not sufficient to deal with the environmental issues that global society is facing, and research in these categories can help to better understand to what extent necessary systemic changes are supported or even demanded by the population.

Concerning the domains, we provided evidence that some behaviors with high mitigation potential in countries of the global north are currently neglected (Constantino et al., 2022; Ivanova et al., 2020). Similar to

Lembregts and Cadario's (2024) results, the indicators of high-impact areas, such as heating (e.g., heating based on renewable energy), long-distance travel, and a vegan diet were used less frequently than indicators of waste, recycling, water, or electricity consumption. Most studies in our sample (either researching person properties or behavioral properties) often focus on low-cost and less demanding behaviors. From a measurement perspective, this focus is understandable, as infrequent high-cost behaviors are often prone to floor effects. However, at the same time, this focus limits the practical relevance of research findings as research does not address those behaviors that would contribute substantially to limiting ecological challenges. It might be a solution to measure those high-impact behaviors by shifting from individual to social or strategic PEB because the support of political measures or the contribution to collective actions might appear more frequently than individual high-impact behavior. Indeed, many individuals are unable to perform such high-impact behavior because they lack monetary resources or because it is beyond their scope of decisions (e.g., changing the heating system or insulation of their apartment). Regarding the question of why certain behaviors appear more often or less frequently, we do not make any claims as this is beyond the scope of our study. As reported by Brick et al. (2024) a variety of factors can influence the choice of behavior such as available funding, continuing research on the behavior, environmental impacts of the behavior, measurement ease, personal interest, or research norm of the target journal.

Finally, we found many vague PEB indicators (e.g., frequency of purchasing "environmentally friendly" or "green" products), so that no specific consequence, pathway, or domain could be assessed. Whereas such indicators might have advantages in large samples across countries or contexts, these indicators offer limited insight into the specific aspects of PEB they are intended to capture.

### ***How Are Behavioral and Person Properties Measured?***

The large number of self-report indicators to capture person properties might not be surprising, as previous smaller scale studies indicated that around 70% to 80% of PEB measures are self-reports (e.g., Byerly et al., 2018; Świątkowski et al., 2024).

In addition, our results underline how important it is to consider how PEB is measured when comparing research findings, as for example 23.7% of the indicators for person properties were future-oriented indicators (i.e., willingness and intention). Notwithstanding the good reasons to investigate these antecedents of behavior, we encourage researchers to clearly label them as

such (i.e., intention or willingness) in manuscripts. So far, it still seems to be common practice to refer to *behavior* instead of *intention* in the title, keywords, or highlights of an article (e.g., Cologna et al., 2024).

Furthermore, we observed other sources of measurement heterogeneity, such as the time that the indicators aimed to cover (e.g., ranging from “yesterday” to “have you ever” for past behavior and from “tomorrow” to an unspecified time in the future). Besides the time frame, we found a variety of measurement units and response formats. Acknowledging that the different response formats have their pros and cons, a recent study argued that findings in the social sciences and psychology might be more connectible to other disciplines and decision-makers when communicated in physical units (Brick et al., 2024). Our results showed that so far indicators with physical measurement units are not used frequently.

### *PEB and the Toothbrush Issue*

Our findings revealed that most indicators of PEB were either newly developed or modified. Moreover, the modified and fully adopted indicators often originated from a study with at least one author in common. These findings suggest that PEB researchers tend to develop and use their own indicators rather than reusing indicators from other research groups. This finding is in line with previous studies which examined this tendency in smaller samples (Markle, 2013; Świątkowski et al., 2024). Low instrument reuse rates can have important implications for the comparability and reproducibility of research (Anvari et al., 2024). Concerning the generation of new measures, we acknowledge that the results might have more information value for the measures of pro-environmental person properties (e.g. scales of pro-environmental person properties). However, as behavioral properties such as shower time can be measured in many ways (e.g., via devices, self-reports, observer ratings, a decision task, etc.) in different contexts with different levels of accuracy and external validity, we argue that a reference should still be provided. Otherwise, it remains unclear why the specific measurement approach was chosen whether the same or similar measurement approach was used in a previous study, why it is a meaningful, valid, reliable measure of the property of interest, and why the behavioral property can be considered as pro-environmental. We understand that there are sometimes good reasons to modify indicators due to emerging technologies related to PEB or because some indicators are rendered irrelevant due to policy changes. However, researchers should transparently report what types of adaptations were made, justify the need for these changes, and test the impact of these modifications on psychometric properties (Flake & Fried, 2020). Concerning the reasons

why researchers tend to develop or modify measures, more research is needed. There might be factors in the academic system (e.g., feeling pressured to distinguish oneself from others) contributing to the toothbrush phenomenon, as discussed by Mischel (2008). There may also be practical reasons, such as the time to find and review relevant indicators, particularly when multiple labels exist for PEB. We addressed such practical obstacles with our database, which enables users to quickly search for existing indicators, potentially reducing work time in research projects, as the development and piloting of a new instrument requires a considerable amount of time.

### *Limitations of the Framework, Strengths, and Implications*

Reviewing previous categorizations of PEB and adding categories from ecology (e.g., conservation and restoration) and sustainability research (e.g., sufficiency, efficiency, consistency pathways) enabled us to develop and validate a framework for systemizing the current landscape of PEB. In our review, we focused on studies that refer to the term PEB. As “sustainability” and “pro-environmental” behaviors are sometimes used synonymously since they overlap to some extent, focusing on PEB leads to exclusion of some behaviors that may be of interest for further research on the sustainability as a broader concept. In addition, we integrated only specific aspects from sustainability science in the framework such as the pathways (e.g., sufficiency, efficiency, and consistency/permanence orientation) and integrated concepts from ecology (e.g., conservation, restoration) which were neglected in previous categorization approaches. Doing so, we did not strive to outline all sustainability-related behaviors (i.e., behaviors related to the Sustainable Development Goals) as these would contain a wider range of behaviors such as pro-social, pro-health/well-being-oriented behavior. However, we believe that our framework and database are very good starting points to further explore sustainability-related behaviors.

Regarding adaptation behaviors, we emphasize that these behaviors often impact the natural/physical environment as well as the social environment. These behaviors are often closely related to human need satisfaction and well-being which are important aspects of sustainability. So far, the proposed framework does not reflect categories such as impacts on well-being or health as (perceived) co-benefits as most definitions of PEB do not explicitly include the social environment in their definitions. We invite researchers interested in these questions to further expand the framework or use our database as a source to answer these questions. Although we described and distinguished the individual categories in detail, some conceptual overlap between categories remains. For example, the three pathways of sustainability share

common features. Recycling behavior can be considered effectiveness-oriented behavior, as the material is used in an improved way, but it can also be categorized as consistency-oriented behavior, as it builds on the idea of a circular system where an object—depending on the material—could be fully recycled. Whereas the pathway might be theoretically distinguishable, the specific behavior will always leave some space for interpretation, as discussed in previous research (Fischer & Grießhammer, 2013). Through the guide and pilot rating, we strived to minimize these level interpretations and arrive at acceptable levels of interrater reliability (IRR). Establishing an IRR is only a first step when developing a category system and can be seen as a necessary but not sufficient condition. As we are aware that other category definitions are also defensible, we tried to make our descriptions as transparent as possible and provide the data so that all readers can comprehend the decisions we made or even re-analyze them using different approaches.

Moreover, we acknowledge that some of the domains could be aggregated or divided into more sub-categories (e.g. mobility overall vs. everyday mobility and travel; energy overall vs. energy and heating separately). We aimed to balance the number of categories with the practical needs of researchers searching for existing measures and strived to cover all areas that appeared in the sample.

We argued that previous categorizations should be expanded through the consequences and pathways, as the behaviors in these categories differed in many behavioral features, such as behavioral costs, plasticity, visibility, and perceived and actual impact (Cologna et al., 2022; Dietz et al., 2009; Truelove & Gillis, 2018). Relating empirical findings to more general categories like pathways can facilitate the development of theories that connect findings on different PEB. For example, such theories can in turn enable a detailed analysis of the predictors of behavior to plan interventions on this basis. Moreover, relating indicators of PEB to sustainable pathways is crucial because the impact of PEB on the environment can only be understood if they are interpreted along with findings from different disciplines. For example, efficiency-oriented solutions from other disciplines such as economics or engineering can achieve the desired effects only when sufficiency-oriented behavior indicators are considered; otherwise, there is a risk of rebound effects (Freeman, 2018). Our framework—particularly the coding of pathways along with the database of indicators—offers a useful tool for identifying connections between these categories. The extent to which the proposed categories are related to each other (e.g., the hierarchical order of the levels of the framework) needs to be tested in future research.

Whereas our analyses were built on a large sample of studies from different areas around PEB, we still covered only a small part of the full landscape of PEB research. By focusing on studies included in the meta-analysis

and systematic review, we ensured that the indicators we used were previously considered to be indicators of PEB and were already part of the scientific discourse. However, by applying this approach, we adopted the selection criteria from the meta-analyses and systematic reviews, meaning that the indicators originated primarily from journals in the global north, a common occurrence in PEB research (Babett & Landmann, 2023; Brick et al., 2024). In addition, there might be measurement approaches that are frequently used in the field but are not included in our sample. This point is not necessarily a limitation but needs to be considered when interpreting the results or using the database.

Altogether, the framework and the database can help reduce the development of redundant measures, lower the risk of jingle-jangle and nominal fallacies, and enable further research on existing measures. Thus, research on PEB will be more efficient, as resources for instrument development can be saved and as research findings can be integrated more easily: The database is designed in such a way that it can be used to easily search and filter specific PEB characteristics using multiple filters (e.g., mitigation + efficiency + individual) as well as the different measurement types (e.g., self-report). With the help of the framework, users can filter single measures, full scales, certain authors, or measurement approaches before developing new measures. The categories of the framework together with the app can help to navigate through the number of measures and help to narrow the search results. In addition, the database can be used for future research on the indicators, for instance, semantic analyses investigating similarities between scales (Rosenbusch et al., 2020) or to further systemize whether naturally occurring behaviors were studied (Lange, 2024), or whether the behavior or the product of a behavior was observed (Lange & Dewitte, 2019).

As the amount of research around PEB increases, it seems useful to have a dynamic community-augmented repository in the future so that the research community can add new or missing measurements to the database.

## **Conclusion**

To better understand the determinants and consequences of PEB, a shared understanding of PEB and reliable and valid behavioral indicators are needed. With this study, we did not intend to offer a normative stance on what PEB indicators should be used or how PEB should be operationalized. We aimed to provide a detailed overview of the current landscape of measurement approaches, including gaps so that they can be addressed adequately in future research. Due to the complexity of the concept, single instruments cannot cover every aspect of PEB. Moreover, PEB indicators will always remain context-specific, as PEB indicators can change their meaning over time, for


example, when new regulations or innovations arise. As argued by Brick et al. (2024), methodological diversity can also have advantages for a field. However, when too many conceptualizations and labels exist, communication difficulties arise between researchers, the synthesis of findings becomes more difficult, and the potential for science to cumulatively advance is constrained (Anvari et al., 2024). Hence, we strongly encourage researchers to document measurement indicators following open science practices and reporting guidelines (Elson et al., 2023; Flake & Fried, 2020) and situate the indicators in a broader PEB framework so that other researchers and decision-makers will have a better understanding of what aspects of PEB were considered and how PEB was measured. With our study, we aimed to move toward this goal by providing a framework, a systematic review of the landscape of indicators of PEB, and a database with a large pool of PEB indicators to sample from.

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## Data Availability Statement

Supplemental materials, data, and syntax are available at ([https://osf.io/kunpw/?view\\_only=8b5291db4bf4417a89941a867b8bbffd](https://osf.io/kunpw/?view_only=8b5291db4bf4417a89941a867b8bbffd)).

## Supplemental Material

Supplemental material for this article is available online.

## Notes

1. Supplemental Material Figure S22 and Table S23 provide further examples of how the same behaviors of interest are can be of interest in both branches of research.
2. The category “pathways” was adjusted after the pilot rating, as  $\alpha = .65$  (95% CI [.57, .72]) was close to the lower boundary of an acceptable IRR.
3. Supplemental Material: [https://osf.io/kunpw/overview?view\\_only=b2936b0054e849bfac64bdc634a1bcd1](https://osf.io/kunpw/overview?view_only=b2936b0054e849bfac64bdc634a1bcd1)
4. Shiny-App: <https://proenvironment.shinyapps.io/PEBdatabase/>

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