Routledge
Taylor & Francis Group

Urban, Planning and Transport Research
An Open Access Journal

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rupt20

CoMoDe-Matrix: introducing the contextual sustainable mobility decisions matrix

Michael Bissel, Maike Gossen & Sophia Becker

To cite this article: Michael Bissel, Maike Gossen & Sophia Becker (2024) CoMoDe-Matrix: introducing the contextual sustainable mobility decisions matrix, Urban, Planning and Transport Research, 12:1, 2418878, DOI: 10.1080/21650020.2024.2418878

To link to this article: https://doi.org/10.1080/21650020.2024.2418878

URBAN, PLANNING AND TRANSPORT RESEARCH
2024, VOL. 12, NO. 1, 2418878
https://doi.org/10.1080/21650020.2024.2418878

Routledge
Taylor & Francis Group

CoMoDe-Matrix: introducing the contextual sustainable mobility decisions matrix

Michael Bissel [a], Maike Gossen [a] and Sophia Becker [a,b]

[a]Technische Universität Berlin, Berlin, Germany; [b]Research Institute for Sustainability - Helmholtz Centre Potsdam, Potsdam, Germany

ABSTRACT

Individual decisions are pivotal to sustainable mobility. However, the disciplines of mobility research, sustainability research, and behavioral science typically explore this topic in isolation. For instance, there is no comprehensive framework for individual mobility decisions, and existing frameworks exhibit several significant shortcomings. Based on an integrative review of existing frameworks, this article therefore integrates concepts from all three perspectives into a novel framework, the CoMoDe-Matrix. The proposed framework emphasizes the importance of the decision context (i.e. private or professional context) and of differentiation between various decision types. Its integrative nature makes the framework a valuable tool for interdisciplinary mobility research, providing a cohesive foundation which could be applied, for instance, in systematic evidence syntheses. Furthermore, it offers practical guidance for policymakers seeking to promote sustainable mobility decisions.

ARTICLE HISTORY
Received 16 June 2024
Accepted 16 October 2024

KEYWORDS
Individual mobility decisions; sustainable mobility; climate change; behavior change; framework; integrative review

1. Introduction

In transport planning, individual mobility decisions are traditionally conceptualized as derived demand for which individuals seek to minimize costs and travel time (Banister, 2008). Recently, however, the increasingly pressing challenges of the transport sector regarding ecological, social, and economic sustainability have expanded the focus to other objectives (Jaramillo et al., 2022). With regard to the environment, the role of physical mobility as a major contributor to climate change positions it at the forefront of political and public discourse (Hickman & Hannigan, 2021; Schwanen et al., 2011). Sustainable mobility comprises actions to reduce these negative externalities. In line with the principle of sustainable development, the three overarching imperatives are respect for environmental limits, the satisfaction of human needs, and social justice. While this article is intended to have a universal scope that extends beyond the context of specific countries, the focus lies in the environmental dimension, which presents

CONTACT Michael Bissel Michael.bissel@campus.tu-berlin.de Technische Universität Berlin Straße des 17. Juni 135, Berlin 10623, Germany

Supplemental data for this article can be accessed online at https://doi.org/10.1080/21650020.2024.2418878

a pervasive challenge that is particularly pronounced in more affluent countries (Holden et al., 2020).

To address environmental issues such as climate change, it is crucial to consider both demand-side solutions and supply-side approaches (Creutzig et al., 2018). In this context, the relevance of behavioral change is stressed in view of the direct link between human behavior and demand (Jaramillo et al., 2022). Individual behavior also plays a marked role in the adoption of technologies such as electric cars (Steg & Vlek, 2009). Evidence syntheses underscore the substantial mitigation potential of individual decisions in the transport sector compared to other sectors. This comprises various decisions such as low-frequency, high-impact decisions (e.g. living car-free or purchasing an electric vehicle) and frequent decisions such as cycling instead of driving (Ivanova et al., 2020).

In this context, frameworks are invaluable for both researchers and practitioners (Creutzig et al., 2018; Geiger et al., 2018). They organize relevant aspects, such as mobility decisions, into mutually exclusive and collectively exhaustive categories (Münscher et al., 2016). Effective frameworks are marked by their comprehensiveness and internal consistency (Michie et al., 2011). For researchers, unifying and broadly accepted frameworks are pivotal to plan, conduct and synthesize research. For example, frameworks play an important role in evidence syntheses and facilitate comparisons between studies (Forberger et al., 2019; Reisch et al., 2021).

In the case of practitioners, selecting target decisions for interventions involves complex considerations. First, the impact of a potential carbon mitigation intervention depends on the carbon footprint of the target behavior, the extent to which it can be influenced by the intervention, and the number of individuals whose behavior could be modified (Nielsen et al., 2021; Stern, 2011). Second, heterogeneity of decisions necessitates different approaches for different types of decisions (Garcia-Sierra et al., 2015; Sussman et al., 2020). Third, potential interactions and spillovers between decisions on different time frames need to be taken into account (Nielsen et al., 2021). Therefore, the structured identification of target decisions is a complex yet crucial initial step (Steg & Vlek, 2009) in which frameworks can represent an essential support tool.

In the mobility context, individual decisions have been explored across various research fields. Numerous studies have investigated *determinants* of mobility actions (e.g. Klöckner & Blöbaum, 2010). Far less research, however, has focused on the *systematic categorization* of decisions. Thus, rather than discussing determinants, this study addresses the recent call for a more systematic description of impactful target decisions in the sustainability context, while taking into account the context in which they occur (Nielsen et al., 2024). However, it is essential to acknowledge that these decisions are shaped by a complex interaction of individual, social, and infrastructural factors and are, therefore, not always exclusively in the sphere of individual influence (Javaid et al., 2020; Nielsen et al., 2024).

As we will explore in this article, existing frameworks that focus on systematization often fall short in terms of their scope of decision types, their focus on specific transport modes like cars, or their level of granularity. They often emphasize technological progress and infrastructure development while overlooking important social and behavioral dimensions. Another problem is the limited integration of multimodal transport solutions and the insufficient focus on the environmental impacts of transport systems over the entire life cycle. In addition,

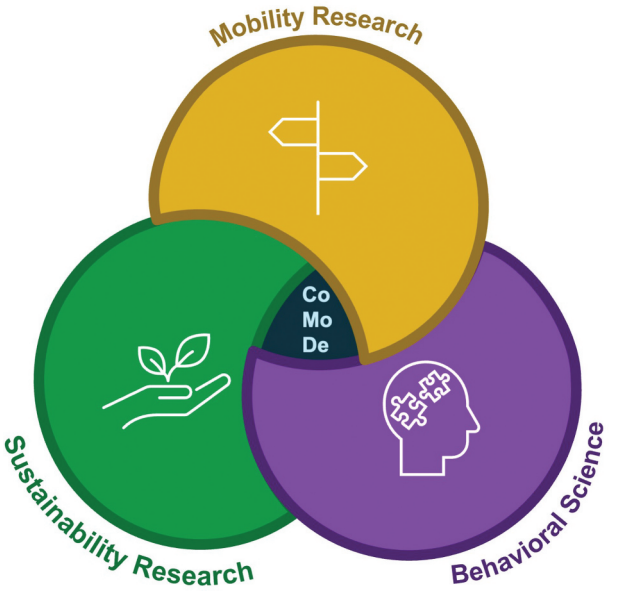


Figure 1. Overview of relevant perspectives (source: own illustration).

existing frameworks are often limited to concepts and theories of one specific discipline, limiting the potential for broader interdisciplinary adoption. Finally, mobility decisions are becoming increasingly fragmented and overlap with virtual communication, presenting opportunities for novel mobility solutions (Riggs, 2022; Sheller & Urry, 2006). These developments underscore the critical need for an up-to-date and comprehensive framework.

Against this background, this study synthesizes research from three perspectives relevant for sustainable mobility decisions: sustainability research, mobility research, and behavioral science. These perspectives complement each other and have overlaps in which the new framework, the *CoMoDe-Matrix*, emerges (see Figure 1).

In line with the objectives of integrative reviews (Snyder, 2019; Torraco, 2005), this article aims to:

(1) Critically review the literature on existing frameworks
(2) Combine approaches and insights from different fields and perspectives
(3) Develop a new systematic framework for sustainable mobility decisions.

The remainder of this article is structured as follows. After describing our research methodology, we summarize selected existing frameworks which informed the development of the new framework. We then present and discuss the new framework as well as the individual categories. Finally, the potential applications, benefits, and limitations of this framework are discussed.

2. Method

To address the research objective outlined in the previous section, our study synthesizes insights and concepts from existing frameworks based on a literature review. While systematic reviews (e.g. meta-analyses) are well-established for synthesizing evidence on pointed questions within a single field, they are not suitable for exploring broader, interdisciplinary topics. In such cases, an integrative research approach is more appropriate, particularly when the goal is to develop new conceptual frameworks rather than merely describing an existing field. Though integrative reviews are generally more creative and do not aim to cover all published research on a topic, they must still adhere to the same transparency standards as systematic reviews (Snyder, 2019; Torraco, 2005).

Building on the concept of integrative reviews (Snyder, 2019; Torraco, 2005), this study employs a multistage process that combines a structured literature search with iterative conceptualization and expert consultations to refine the proposed framework. As can be seen in Figure 2, the literature search provides a basis to retrieve an initial set of relevant frameworks. In view of the broad scope of potentially relevant concepts and literature, the subsequent step of expert consultations enabled additional input and suggestions to be obtained in a structured manner.

In order to focus on the conceptual aspects of this article and the discussion of the new framework, this section provides a concise overview of the methodology. Detailed information, such as the inclusion criteria of the literature search, the articles screened at full text, and information on expert consultations, can be found in the supplementary material to ensure transparency (Torraco, 2005).

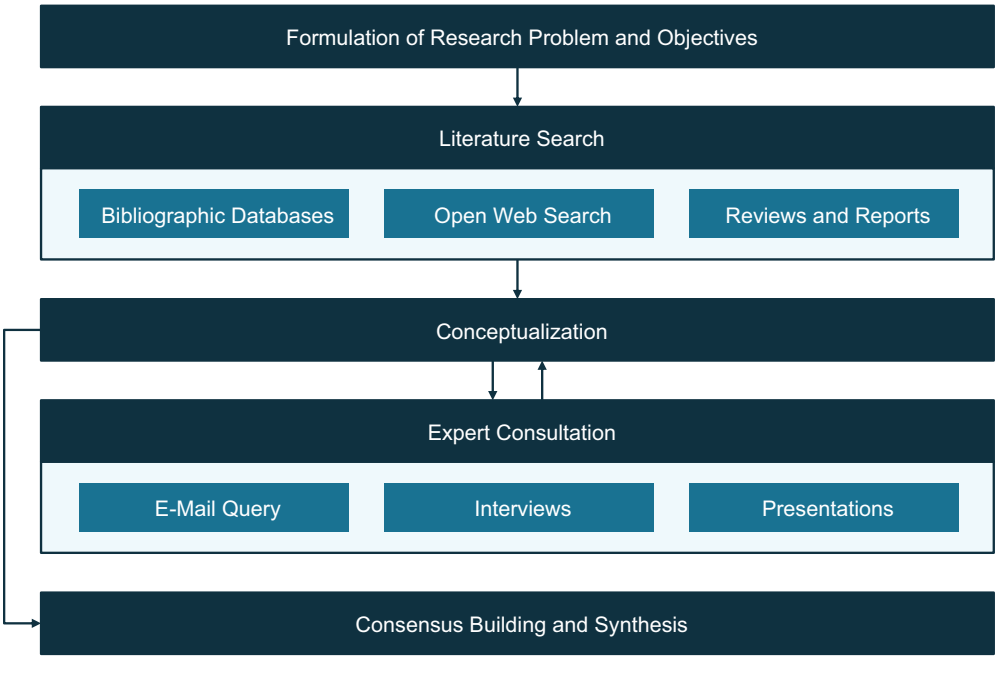


Figure 2. Overview of research process (source: own illustration).

In a first step, we defined the problem and outlined the research objectives. In doing so, as described in the introduction, we considered the potential of frameworks in general, the current lack of a holistic framework of mobility decisions as well as potential applications such as evidence syntheses.

To identify the relevant frameworks, we conducted a literature search using the bibliographic databases Scopus and Web of Science, applying a broad and intuitive search term ('mobility decisions framework'). This search yielded 4,837 entries (3,007 from Scopus and 1,830 from Web of Science). To complement this search, particularly with relevant grey literature such as practitioner reports, we conducted an open web search using the same term (Briscoe, 2015). Since this search resulted in more than 100 million results, we limited our review to the first 100 entries, following guidelines and best practices from previous research (Briscoe, 2015; Carr et al., 2011). All references were exported to ensure a transparent screening process. Additionally, five literature reviews and overview reports covering the three key perspectives of this study were identified and screened for relevant references as well as for frameworks used for synthesizing results (Composto & Weber, 2022; Jungell-Michelsson & Heikkurinen, 2022; Pawluk De Toledo et al., 2022; Sussman et al., 2020; Thorun et al., 2017). All retrieved articles underwent systematic screening at the title, abstract, and full-text level. We applied four predefined inclusion criteria to assess article eligibility relating to format, outcome, population, and study design (see *Table S 4* in the supplementary material for a more detailed description). 66 articles were included in the full text screening phase (see *Table S 5* in the supplementary material, which includes all articles screened at full text as well as the three pre-screened articles from reviews and reports). Building on the ROSES reporting standards (Haddaway et al., 2018), Figure 3 summarizes the entire process and the remaining number of studies after each step of the screening process.

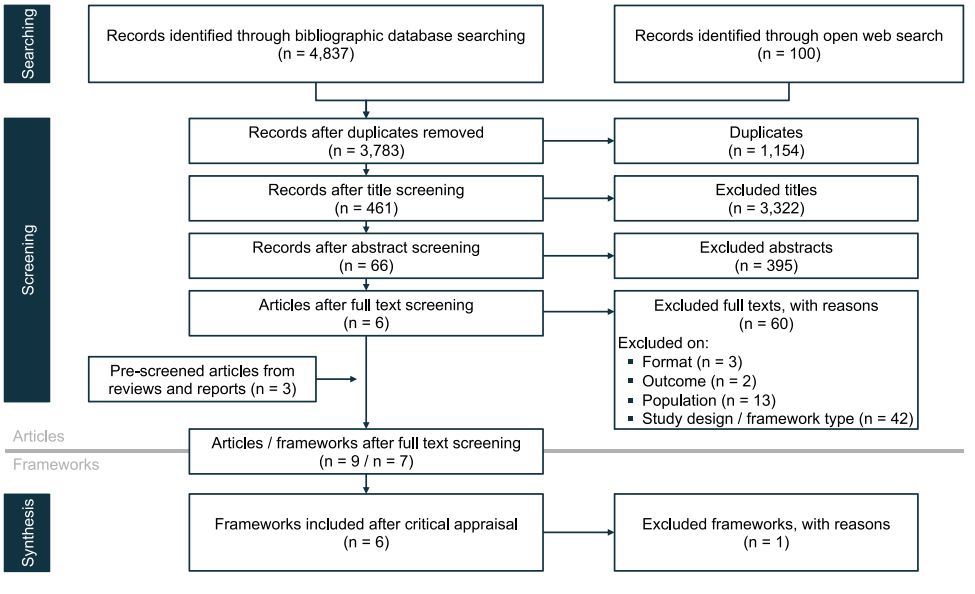


Figure 3. Flow chart of literature screening (source: own illustration based on Haddaway et al. (2018)).

Perspective	Subfield		Framework reference	Description	Main limitation
Mobility Research	Transport Policy	1	Avoid-Shift-Improve (ASI) Framework (Bongardt et al., 2019)	Three categories: avoid travel, shift transport modes, improve efficiency.	Abstract categories due to roots in transport policy.
	Travel Modelling	2	Framework of Residential Activity and Travel Decisions (Ben-Akiva & Bowman, 1998)	Three categories based on temporal dimension.	Car oriented and not focused on sustainability.
Behavioral Science	Psychology	3	Hierarchical Structure of Mobility Behavior (Schlag & Schade, 2007)	Three levels based on temporal dimension and decision types.	Car oriented and context not reflected.
	Behavioral Economics	4	Matrix of Transportation Behaviors (Sussman et al., 2020)	Two domains (personal vs. professional) and three decision types.	Broad categories without intuitive order and without detailed decisions.
Sustainability Research	Sustainable Behavior	5	Sustainable Lifestyle Framework (DEFRA, 2011)	Five key behaviors forming the headline behavior "travelling sustainably".	Unstructured list without mobility-specific logic.
	Sufficiency Behavior	6	Typology of four types of sufficiency consumption changes (Sandberg, 2021)	Four types of consumption change (including product longevity).	Efficiency-related behaviors (e.g., eco-driving) not included.

Figure 4. Overview of selected frameworks (source: own illustration).

Based on the literature search, seven frameworks were identified as relevant for the synthesis of the new framework (see Figure 3). While frameworks that were retrieved multiple times were excluded as duplicates, highly similar frameworks underwent a critical appraisal regarding redundancy. This resulted in the exclusion of one framework (see no. 3 in *Table S 5*). The remaining six frameworks, summarized in Figure 4, served as the foundation for an initial framework draft, which the authors developed in the first conceptualization step. Given the proven benefits of combining literature research with expert feedback for developing frameworks (Michie et al., 2011), several external stakeholders were involved in different formats to refine the framework. These expert consultations aimed to gather feedback on the selected frameworks and were a critical part of the integrative review due to their broad scope and interdisciplinary nature.

To ensure comprehensive coverage of perspectives, researchers were selected to reflect various viewpoints. This also includes diversity in nationality, age (operationalized by career stage), and gender. Some scholars were identified through the literature search, while others were directly approached using the authors' professional networks. For instance, one interviewee was identified via an existing literature review as an author of multiple studies on sufficiency in the context of sustainable mobility. By engaging multiple stakeholders, we aimed to assess both the prototypicality (fit within the perspective) and the establishment (use in research or practice) of the frameworks. In total, eleven researchers were contacted via standardized e-mail queries and/or participated in semi-structured interviews (see *Table S 6* in the supplementary material). Additionally, feedback gathered from presenting the framework at seven research group meetings and international conferences was incorporated (see *Table S 7* in the supplementary material). Research group presentations as well as conferences brought together participants from all three perspectives relevant to our study and took place in three different countries. The conference presentations were attended by both scientists and practitioners (including policymakers). All feedback was reviewed

by the authors and integrated to finalize the new framework. While the collected input helped to refine the framework, the selection of the original six frameworks remained unchanged (Torraco, 2005).

3. Review of existing frameworks

As described in the previous section, six existing frameworks were included for review and evaluation. These frameworks originate from different subfields which, in turn, correspond to the three perspectives deemed relevant for the purpose of this study. Figure 4 offers an overview of the selected frameworks. In this section, we provide a concise summary of each perspective and the synthesized frameworks. While these frameworks fulfilled all inclusion criteria, they still come with some limitations which are summarized in this section.

3.1. Mobility research

In the realm of *mobility research*, existing frameworks from two subfields were included. *Transport policy* focuses on questions concerning the management and regulation of transport activities and thus affects individual behavior and preferences (Creutzig et al., 2018). A widely used framework is the Avoid-Shift-Improve (ASI) framework. It aims at structuring policy options (Bongardt et al., 2019; Creutzig et al., 2018) but has also been applied to individual decisions (Composto & Weber, 2022; Hampton & Whitmarsh, 2023). The framework is structured around three strategic directions: (1) avoid (reducing motorized travel), (2) shift (switching to more sustainable modes of transport), and (3) improve (enhancing fuel and energy efficiency). Although widely used and conceptually simple and intuitive, the ASI framework is predominantly policy-oriented, which can limit its application to individual decision-making. Its categories, while distinct, encompass heterogeneous decisions. For instance, the 'improve' category comprises habitual decisions such as eco-driving as well as low-frequency, high-impact decisions such as purchasing electric vehicles.

Travel modelling, the second subfield, aims to understand and forecast travel (Auld & Mohammadian, 2009). The traditional focus has been on mode choice, but numerous models have been developed for decisions such as residential location, destination, or car ownership (Hensher & Stopher, 2021). For example, the 'Framework of Residential, Activity and Travel Decisions' proposed by Ben-Akiva and Bowman (1998) categorizes decisions into three temporally ordered categories: (1) mobility and lifestyle decisions (e.g. residential location, employment, car ownership), (2) activity and travel scheduling (e.g. sequence, mode), and (3) implementation and rescheduling (e.g. route, speed, parking). The same overall logic applies to a more recent framework by Zhu et al. (2018), which was not included separately to avoid redundancy (see Figure 3 and *Table S 5*). While the framework by Ben-Akiva and Bowman (1998) provides a structured approach, it predominantly focuses on car-related aspects, which limits its broader applicability in the mobility context (in contrast to, for example, the ASI framework). Additionally, certain decisions, such as parking choices, have traditionally been analyzed primarily with respect to their impact on efficiency rather than their environmental implications, indicating an insufficient focus on sustainability.

3.2. Behavioral science

While individuals are typically conceptualized as rational decision makers in traditional travel behavior models, theories from behavioral sciences like psychology and behavioral economics are considered important complements as they take psychological and social factors into account (Arentze & Timmermans, 2012; Chorus, 2012; Gärling, 1998).

Due to its inherent focus on human behavior, *psychology* plays a vital role in understanding sustainable mobility decisions (Gärling, 1998). At the same time, most psychological models focus on *explaining* instead of *systematizing* decisions (Higham et al., 2013; Sussman et al., 2020). In general, however, psychologists differentiate decisions depending on the level of habit and deliberation (Klöckner & Matthies, 2012). One psychological framework that systematizes mobility decisions, the 'Hierarchical Structure of Mobility Behavior' (Schlag & Schade, 2007) organizes decisions into three temporally structured categories: (1) superior decisions with consequences for mobility (e.g. residential location choices), (2) mobility behavior (e.g. route, frequency, mode choice), and (3) driving behavior. This framework offers a detailed and precise categorization of behaviors but is primarily oriented towards car-based mobility and lacks coverage of non-car modes or car-free living. Moreover, while it acknowledges environmental factors like infrastructure, it does not fully integrate other contextual factors such as professional environments.

Behavioral economics focuses on understanding deviations from rationality which is particularly pertinent for mobility decisions (Garcia-Sierra et al., 2015; Sussman et al., 2020). However, there are relatively few formalized frameworks within this discipline. One notable framework is the 'Matrix of Transportation Behaviors' by Sussman et al. (2020), which classifies decisions along two dimensions: the behavioral domain (personal or professional) and three types of behaviors: (1) efficient use of vehicles, (2) purchase behavior, and (3) mode switching or reducing travel. Thus, this framework is characterized by explicitly highlighting different contexts. It also stands out by a clear and intuitive structure. On the other hand, the categories are rather broad as, for instance, mode choice and travel reduction form one category. These decisions, however, differ in the difficulty of behavioral change (Composto & Weber, 2022). Furthermore, the framework focuses on policies rather than specific decision-making processes, and the ordering of categories lacks a clear, intuitive logic.

3.3. Sustainability research

Sustainability research addresses the overarching challenges mentioned earlier. Various disciplines contribute to the subfield of *sustainable behavior* which aims to understand and promote the behaviors that are conducive for the sustainability transition (Reisch & Thøgersen, 2015). A key framework is the 'Sustainable Lifestyles Framework' developed in the UK, which evolved from the 'Framework for Pro-Environmental Behaviours' (DEFRA, 2008, 2011). This framework categorizes behaviors into nine headline behaviors, subdivided into 30 key behaviors. For the headline behavior 'sustainable travelling', five key behaviors are defined: (1) cycling, walking, public transport and car sharing for short distances, (2) choosing lower emission models when buying a vehicle, (3) using travel alternatives such as video

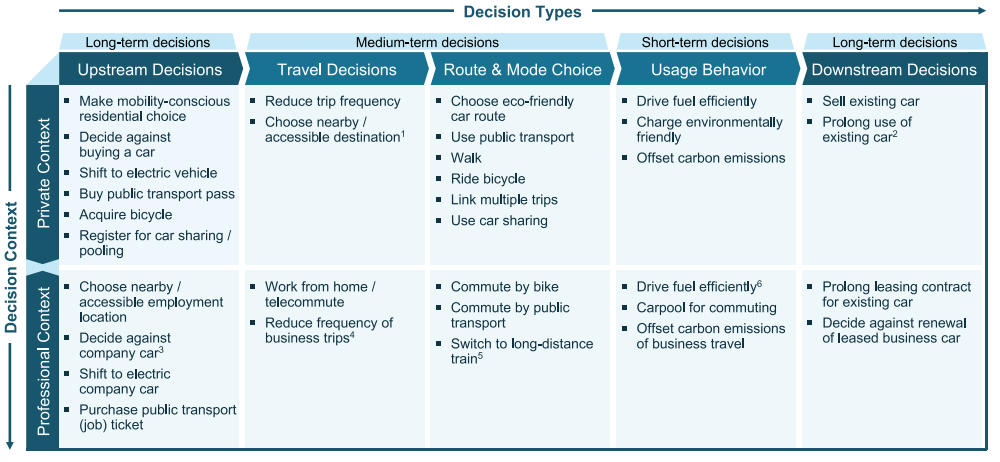
conferencing, (4) choosing lower carbon alternatives to flying and (5) driving more efficiently. These behaviors are labeled with decision types such as one-off purchasing decisions and habitual everyday lifestyle decisions (DEFRA, 2008). The DEFRA frameworks, alongside similar reports, have been influential in shaping policies (Barr, 2015; Barr et al., 2011; Shove, 2010). However, due to its broad scope covering different consumption domains, the framework does not reflect domain-specific peculiarities and rather provides unstructured lists.

The second subfield is *sufficiency behavior*. Sufficiency, as one of the three main sustainability strategies, is a broad construct aiming to reduce the absolute level of production and consumption to stay within the ecological planetary boundaries while ensuring a good life for all (Princen, 2005; Spangenberg & Lorek, 2019). While it has implications for society and the economy, the focus here is on individual behavior (Jungell-Michelsson & Heikkurinen, 2022). The sufficiency concept translates the avoid and shift (rather than improve) dimension of the ASI framework into demand-side behaviors (Arnz & Krumm, 2023). The latest taxonomy for sufficiency behavior provided by Sandberg (2021) defined the following four categories: (1) absolute reduction (e.g. shorter trips), (2) modal shift (e.g. shifting from cars to public transport), (3) product longevity (e.g. longer use of existing vehicles), (4) sharing practices (e.g. car sharing). This framework therefore adds value to our review by highlighting the role of demand reduction and product longevity. However, as the focus is on avoid and shift decisions, efficiency-related behaviors (e.g. eco-driving) are not included, thereby limiting its comprehensive applicability to all aspects of mobility decisions.

4. Introducing the CoMoDe-Matrix

Building on the existing literature, a new framework was developed: the *CoMoDe-Matrix*. CoMoDe stands for contextual sustainable mobility decisions matrix. This section introduces the framework structure and details each category. The framework is structured as a matrix, inspired by the framework of Sussman et al. (2020). It consists of ten categories resulting from five decision types in combination with two decision contexts. Figure 5 visually presents the framework, including examples of decisions for each category.

The horizontal dimension incorporates five *decision types*: upstream decisions, travel decisions, route and mode choice, usage behavior, and downstream decisions. These categories form a sequential chain reflecting the temporal logic and interdependencies of decisions, for instance, how upstream decisions influence mode choices. The categorization of decisions into long-term, medium-term, and short-term, as delineated by Schlag and Schade (2007), helps further specify the time-related aspects. The long-term decisions, so-called upstream and downstream decisions, refer to individual decisions made before or after mobility decisions in the narrower sense. This aligns with the broader context of carbon mitigation, applying its terminology to individual mobility decisions (Hampton & Whitmarsh, 2023; World Resources Institute & WBCSD, 2013). Furthermore, this relates to research differentiating between upstream and downstream *interventions*, which take place before or after behaviors and habits have been established (Verplanken & Wood, 2006).



Note: Illustration includes exemplary decisions. Professional = employee decision making (e.g., not including fleet managers). Decision types are partially interdependent.
1. e.g., for vacations; 2. if environmentally beneficial; 3. also in favor of more sustainable alternatives; 4. e.g., by switching to digital meetings; 5. instead of air travel; 6. for professional drivers

Figure 5. Overview of the CoMoDe-Matrix (source: own illustration).

The vertical dimension represents the *decision context* and distinguishes between the private and professional context. Notably, in some instances, both contexts overlap and impact each other. For example, a discounted season pass for public transport, a company car, or a mobility budget that were acquired in the professional context can also be used in the private context. Similarly, working from home, while primarily professional, can influence private mobility choices like mode selection for grocery shopping. For this reason, both contexts are illustrated as arrows pointing to each other.

4.1. Decision types

The CoMoDe-Matrix organizes the decision types into five categories, summarized in Table 1. The first category, *upstream decisions* refers to relevant preconditions and determinants of medium and short-term mobility-related decisions. Characterized by their low frequency, long-term perspective, and deliberate nature, these decisions are often related to substantial financial investments and/or impact (Nielsen et al., 2021; Sussman et al., 2020). Upstream decisions include choices such as investing in electric or more efficient vehicles, acquiring (cargo) bicycles, or opting against car ownership (Sussman et al., 2020). They also encompass long-term choices indirectly related to mobility, like residential or employment decisions (Ben-Akiva & Bowman, 1998; Garcia-Sierra et al., 2015) as well as actions like registering for car-sharing or pooling services (Creutzig et al., 2024) or purchasing public transport passes. These decisions are pivotal due to their direct and indirect effects (Gärling & Loukopoulos, 2008). By making such long-term decisions, individuals change the parameters for subsequent travel decisions, which leads to increased usage of the respective mode of transport (Garcia-Sierra et al., 2015). Similarly, the choice of residential location can significantly affect the availability of transport modes and the associated time and cost of daily travel (Bhattacharyya et al., 2019). Thus, while decisions such as car ownership are tightly linked to usage, the

Table 1. Summary of decision type categories.

	Upstream Decisions	Travel Decisions	Route and Mode Choice	Usage Behavior	Downstream Decisions
Definition	Long-term decisions with low frequency and high involvement. Precondition for other decisions.	Medium-term decisions on whether, where and how often to travel.	Medium-term decisions on route and mode choice. Often habituated.	Short-term, strongly habituated behavior that affects energy consumption of transport modes.	Long-term, low frequency decisions on existing possessions.
Relevance	• Purchase decisions affect mode choice (indirect effects) • Production (e.g. of cars) is resource intensive	• Avoiding unnecessary trips (e.g. air travel) is effective measure for emission reduction	• Car use related to high emissions • Trains superior to air travel for longer distances in terms of emissions	• Energy consumption depends on driving style and other usage-related behaviors	• Reduction in car ownership decreases car use • Short ownership spans increase the number of cars

influencing factors can differ (Schwanen & Lucas, 2011). Importantly, upstream decisions can have positive and negative spillover effects on subsequent decisions (Klöckner et al., 2013). Regarding quantitative impacts, living car-free represents the lever with the highest carbon emission reduction potential and shifting to electric vehicles can also result in substantial reductions (Ivanova et al., 2020). In addition, the impact of private car ownership on other aspects such as space consumption for parking must be considered (Creutzig et al., 2020).

Travel decisions describe medium-term decisions about whether to travel at all, which represents the first and most general travel-related question (Garcia-Sierra et al., 2015). These decisions range from frequent choices like commuting to work versus working from home to less frequent decisions regarding leisure travel (Sussman et al., 2020). Technological substitutes for physical travel, such as telecommuting, are mainly pertinent in professional contexts (Pawluk De Toledo et al., 2022), making it difficult to avoid travel for tourism and leisure (Composto & Weber, 2022; Higham et al., 2013). Therefore, considerations of trip frequency and destination choice, aiming to reduce trip frequency, shorten distances or utilize more sustainable transport modes are vital in this category (Sandberg, 2021). Travel decisions are of great importance as the decision not to travel usually yields a greater reduction in emissions than simply changing the mode of transport, with the avoidance of air travel being one of the most effective mitigation strategies (Composto & Weber, 2022; Ivanova et al., 2020).

The third category, *route and mode choice*, involves decisions that may be either intentional or habitual (Hunecke, 2015; Ruhrort & Allert, 2021). Frequent decision-making tends to reduce the impact of deliberate choices, as routines start to dominate (Klöckner & Blöbaum, 2010). These decisions influence daily mobility options, such as choosing between a car and public transport, as well as less frequent, long-distance travel choices, such as air versus train travel. Notably, however, even choices like air travel can become routine-driven (Higham et al., 2013). Route and mode choices are closely linked and often consolidated into a single step in navigation software. This category is important because it is usually easier to switch to alternative modes of transportation

than to avoid travel altogether (Composto & Weber, 2022). In terms of environmental impact, more than two-thirds of transport-related GHG emissions in the EU are attributable to road traffic, the majority of which is accounted for by cars (EEA, 2022). Opting for active mobility such as walking or cycling eliminates these emissions, and choosing public transport can reduce them by more than half on average (Ivanova et al., 2020). Moreover, while air travel is the most energy-intensive form of transport per distance, switching to long-distance trains can lead to significant emission reductions (Gössling & Dolnicar, 2023; Ivanova et al., 2020).

Usage behavior encompasses decisions made during the use of a transport mode or directly related to it. Thus, the objective is to 'improve' the environmental impact of a given mode rather than to switch modes. Often these behaviors are habitual and frequent (Sussman et al., 2020). In the context of cars, 'eco-driving' includes practices such as avoiding high speeds, driving smoothly, reducing idling, and maintaining the vehicle (e.g. checking tire pressure). For electric vehicles, this category also includes actions such as efficient charging. Additionally, reducing single-occupancy vehicle trips through carpooling (Sussman et al., 2020) and, beyond the car context, carbon offsetting for air travel fall into this category. Usage behavior is critical due to its significant environmental impact. For instance, eco-driving can lower fuel consumption of cars by up to 20% (Martin et al., 2012; van der Voort, 2001). For electric vehicles, energy reductions can reach 30% (Bingham et al., 2012). Finally, although the long-term feasibility is questioned (Higham et al., 2013), carbon offsetting is considered an approach to reduce the environmental impact of unavoidable air travel. Therefore, to summarize, while the separate impacts of usage behavior may be smaller compared to other categories like avoiding travel altogether, its cumulative effects can be substantial (Sussman et al., 2020).

Finally, *downstream decisions* are long-term and infrequent decisions that affect existing possessions and usually have significant environmental impacts. These decisions include divestment actions such as selling a car, but also extending the use of existing cars if this is more environmentally friendly than giving up a car with an internal combustion engine car and switching to an electric car, for example. In terms of (financial) consequences, frequency and indirect effects (e.g. impact on usage), downstream decisions are similar to upstream decisions. However, downstream decisions form a category of their own, as it is particularly difficult to give up an existing possession (Kahneman et al., 1991). For instance, while car ownership often increases with certain life events, it is a challenge to reduce car ownership after the reason for the purchase has ceased to exist (Clark et al., 2016). In line with this, Verplanken and Wood (2006) describe 'Downstream-Plus-Context-Change' interventions which leverage lifestyle changes to facilitate habit modification. While the sufficiency concept also promotes absolute reductions, improving product longevity can be beneficial. This is because short lifespans of cars in one household increase the total number of cars (Sandberg, 2021).

4.1.1. Mapping of decision types onto existing frameworks

The reviewed existing frameworks can be mapped onto the new decision type categories. Notably, as illustrated in Figure 6, the ASI-Framework (Framework 1; Bongardt et al., 2019) is the only framework that encompasses all the categories included in the

CoMoDe-Matrix. However, as previously noted, the ASI-Framework's level of analysis lacks specificity for the analysis of individual decisions. This results in multiple categories of the ASI-Framework mapping onto single categories in the CoMoDe-Matrix. Additionally, it is worth noting that upstream and downstream decisions are often either not represented at all or only partially reflected in current frameworks. For example, decisions to live car-free, such as choosing not to purchase a car or actively reducing car ownership, are not accounted for. Finally, several frameworks, particularly framework 2–4, include rather broad categories with low specificity that span multiple decision types in the CoMoDe-Matrix.

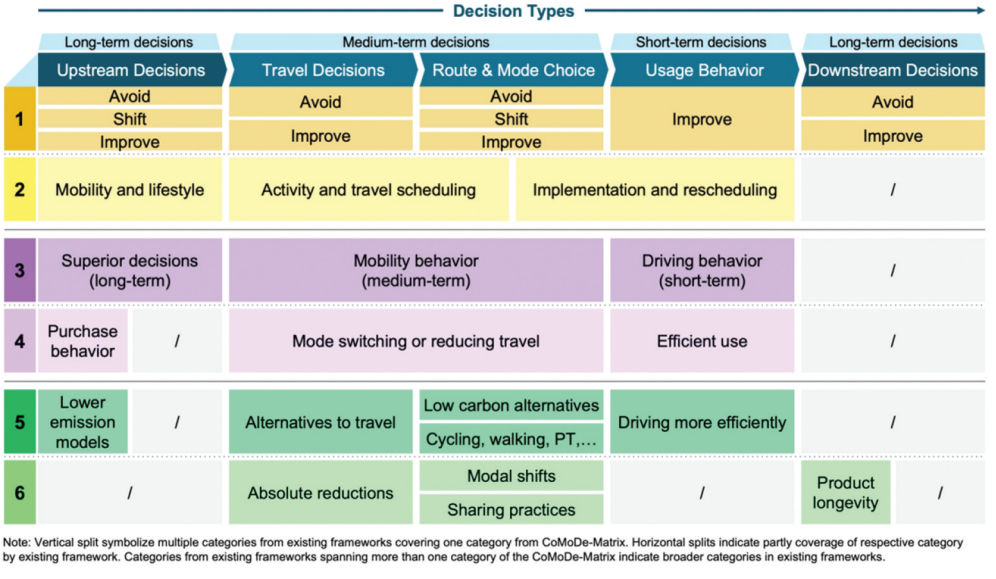


Figure 6. Mapping of existing frameworks on categories of the CoMoDe-Matrix. Numbers refer to Figure 4 (source: own illustration).

4.2. Decision context

The CoMoDe-Matrix distinguishes two main decision contexts – *private and professional* – as illustrated in Figure 5 and summarized in Table 2. Both categories are distinct but, as discussed, are interconnected and can overlap in everyday life.

Firstly, the *private context* includes all mobility-related decisions in an individual's role as a private consumer. It encompasses long-term decisions such as choosing a place of residence, which significantly impacts mobility patterns. The private context further comprises everyday mobility as well as long-distance leisure and tourism trips (Sussman et al., 2020). The latter represents a special setting which, however, is similar to everyday mobility in terms of specific socio-psychological predictors (Dütschke et al., 2022).

The private context is a relevant area given that most of the decisions with high mitigation potential (Ivanova et al., 2020; Sussman et al., 2020) occur mainly in the private domain. Despite being less frequent, tourism-related travel also contributes

Table 2. Summary of decision context categories.

	Private Context	Professional Context
Definition	All decisions in a person's role as private consumers. Includes personal everyday mobility, leisure travel as well as tourism.	All mobility-related decisions regarding individual mobility for working professionals with any form of work-related travel. This includes professional drivers, occasional job-related travel and commuting.
Relevance	• Most decisions take place in private domain • Leisure and tourism travel is related to high emissions in addition to everyday mobility	• Addressing few persons can have high impact • Positive and negative spillover effects to private context exist

significantly to emissions, accounting for approximately 5% of global CO_2 emissions (Scott et al., 2012). Secondly, the *professional context* differs with regard to financial aspects, corporate policies as well as organizational norms and routines (Lülfs & Hahn, 2014). In addition, the professional context often provides more direct opportunities for effective behavior change (Decrinis et al., 2023). Employer-led interventions are promising in view of the geographic proximity of work locations, the administrative resources of employers to set-up and manage interventions, the similarities and interaction between employees as well as self-interests of employers (Rosenfield et al., 2020). While Sussman's et al. (2020) conceptualization is limited to professional drivers such as taxi drivers or bus drivers, there are good reasons to extend this category to other professionals as well as the broader work context (e.g. commuting). With regard to the aforementioned characteristics of the professional context, it is notable that these aspects also hold true for occasional travel of professionals and, at least partly, for commuting. Commuting of employees also falls within an organization's Scope 3 emissions (World Resources Institute & WBCSD, 2013). Thus, adding to Sussman (2020), we define the professional context as encompassing mobility-related decisions of professional drivers and professionals in general, including commuting.

For the context of the framework, the professional context is relevant for multiple reasons. First, in some countries, work-related travel is responsible for more than half of working individuals' weekly travel distances (Hauslbauer et al., 2022). Company cars, which are typically larger and used more intensively, further add to road transport emissions and are discussed as a principal-agent problem (Graus & Worrell, 2008). Changes in the behavior of professional drivers can disproportionately affect overall emissions due to the high impact of altering a few individuals' behavior (Sussman et al., 2020). Also, with regard to air travel, business travel accounts for about 20% of the international flights (Gössling & Dolnicar, 2023). Finally, interventions in this context can have spillover effects into private behavior, amplifying their overall effectiveness (Kreil, 2021; Rutty et al., 2014).

5. Discussion

This article introduces the CoMoDe-Matrix ('contextual sustainable mobility decisions matrix'). This framework offers a comprehensive and integrative approach for systematizing sustainable mobility decisions. Developed based on an integrative literature

review, the framework integrates insights from various perspectives to offer a comprehensive view on mobility-related decisions. As the CoMoDe-Matrix aims at capturing the full spectrum of individual-level decisions relevant to sustainable mobility, it includes different decision types such as low frequency and high frequency decisions (Nielsen et al., 2021). The CoMoDe-Matrix is structured along two key dimensions: decision types and the decision context, which together form a matrix. The decision types reflect the temporal perspective found in the existing literature (see Figure 4).

The framework is both integrative and comprehensive: it is integrative in that it synthesizes diverse perspectives – such as sufficiency (Sandberg, 2021). It is also comprehensive because it encompasses more than a single mode or isolated decisions such as mode choice and provides a holistic approach to understanding and enhancing sustainable mobility through individual choices. Both factors result in the fact that, as illustrated in Figure 6, the CoMoDe-Matrix sets itself apart from previous frameworks in terms of comprehensiveness. In particular, the CoMoDe-Matrix is, to the best of our knowledge, the first framework on sustainable mobility that incorporates the entire set of sustainability strategies, including sufficiency, in one framework.

5.1. Implications for researchers and practitioners

Going forward, the CoMoDe-Matrix can be used in academia to systematically research decisions for behavioral change interventions in the mobility domain. In addition, it can serve as a basis for evidence syntheses. The latter could investigate determinants of decisions or the effectiveness of behavioral change interventions. For example, a project has already been conducted to examine the current state of research on behaviorally-informed interventions based on the CoMoDe-Matrix. This project served to test the framework in terms of validity and applicability. In this process, more than 200 studies were successfully mapped onto the dimensions of the framework, providing novel insights on existing research foci as well as research gaps based on the CoMoDe-Matrix as a valuable tool (Bissel et al., 2023).

In addition, the CoMoDe-Matrix provides implications for practitioners, particularly policymakers. It elucidates different decision types, contexts, and their interdependencies, thereby enhancing the development of targeted mobility intervention programs. Additionally, the CoMoDe-Matrix can serve as a robust tool for monitoring existing policies, helping to identify potential conflicts or gaps in current approaches. The advantage of the matrix compared to previous tools, particularly the practitioner-oriented DEFRA frameworks (DEFRA, 2008, 2011), is that the decision types and the layout can help to identify promising combinations of interventions across time-scales and also highlight decision types such as downstream decisions which were less prominent in previous frameworks. In addition, the distinction of the private and professional context increases the visibility for the potential of interventions in the professional context. As summarized in this article, this seems particularly valuable in view of more direct opportunities for interventions in the professional context as well as due to potential spillover effects of interventions to the private context.

5.2. Limitations

As outlined in the introduction of this article, frameworks like the CoMoDe-Matrix serve as valuable tools by systematizing specific topics. To maintain consistency and utility, frameworks must simplify the complex context they address and align with their stated objectives. The CoMoDe-Matrix aims to categorize decisions based on behavioral and contextual characteristics, resulting in some residual heterogeneity within categories on other dimensions. For example, the upstream decisions in this framework differ in terms of their financial commitment, but are unified by their long-term perspective, their deliberate nature, and their indirect influence on subsequent choices.

The focus on individual behavior makes the CoMoDe-Matrix particularly applicable for research aimed at behavioral change. However, it is important to acknowledge that this framework does not attempt to replace all reviewed frameworks for all applications. While it addresses certain limitations of these frameworks, it also recognizes some strengths. In the broader transport policy context, for instance, the simplicity of the ASI framework can hardly be surpassed with an alternative framework aiming to systematize the complex landscape of individual decisions.

In addition, the CoMoDe-Matrix systematizes sustainability-relevant decisions made by individuals in their roles as private consumers and professional users. While the first context is applicable to everyone, the latter and interactions between contexts are only relevant for professionals. Furthermore, the extent to which certain decision types are relevant can vary greatly depending on factors such as spatial conditions, gender or age. However, irrespective of these differences, the aim of the CoMoDe-Matrix is to offer a tool that is as universal as possible.

Finally, an integrative approach was chosen over a systematic review in light of the objective of our project. While the search and screening process followed a transparent process, it was neither the objective nor feasible to screen all frameworks ever proposed. It is therefore possible that alternative search strings or other databases will lead to additional results. While the predefined screening criteria must be applied consistently, they can also influence the results. For example, the excluded frameworks comprise both studies that support the central elements of the CoMoDe-Matrix (Müggenburg et al., 2015) and frameworks that suggest alternative categorization (Pinjari et al., 2011). This, however, underlines the value of an integrative process with an independent conceptualization that goes beyond a merely descriptive summary of existing frameworks.

5.3. Avenues for future research

The CoMoDe-Matrix aims at providing a comprehensive framework of individual mobility decisions. While frameworks explaining one specific decision type within this scope were excluded in our screening process based on our inclusion criteria, future research could use the CoMoDe-Matrix as a basis to develop a database of models and frameworks for each decision type, context or specific decisions. In the following, the tool could also be used to develop theory-driven interventions to address research gaps.

It is also important to recognize that individuals can influence environmental outcomes in additional roles, such as investors, citizens, or community members (Amel et al., 2017; Nielsen et al., 2021). This also includes the indirect impacts of consumer

decisions on mobility, such as online shopping and deliveries. Expanding the CoMoDe-Matrix to accommodate these aspects would have complicated its structure, potentially diminishing its simplicity and practical utility. Thus, the current scope of the framework strategically focuses on individual mobility-related decisions in the private and professional context to maintain clarity and usability. Future research, however, could develop similar frameworks for other roles.

Looking to the future, as technology continues to evolve in terms of technological innovations such as autonomous driving and urban air mobility (Kellermann et al., 2020; Riggs, 2022), it will be crucial for future research to continually review and refine the CoMoDe-Matrix and to integrate new decisions to ensure it remains relevant and effective.

6. Conclusion

This study introduces the CoMoDe-Matrix, a new framework designed to systematize sustainability-relevant mobility decisions. Integrating interdisciplinary insights from existing frameworks across three perspectives and six subfields, the CoMoDe-Matrix was developed through a multi-stage research process. It offers a conceptual and systematic overview of diverse decisions relevant in the context of sustainable mobility, moving beyond the existing focus on car-related decisions prevalent in earlier frameworks. In addition, the framework expands the focus of thinking about sustainable mobility by explicitly integrating the sufficiency perspective. It thus contributes to a more holistic understanding of sustainable mobility decisions of individuals and provides potentially valuable implications for researchers and practitioners. Future research directions should include applying and evaluating the CoMoDe-Matrix as well as developing similar frameworks for other relevant purposes.

Acknowledgments

We would like to express our gratitude to all individuals who contributed to this article with helpful comments and thoughtful advice within and beyond the expert consultations. The responsibility for the conclusions lies solely with the authors.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. MB acknowledges financial support from the Foundation of German Business (Stiftung der Deutschen Wirtschaft) and SB acknowledges financial support from the German Federal Ministry for Education and Research, FONA-program.

ORCID

Michael Bissel http://orcid.org/0009-0001-0390-3024
Maike Gossen http://orcid.org/0000-0003-0225-2714
Sophia Becker http://orcid.org/0000-0003-3893-5840

Author contributions

Michael Bissel: conceptualization, methodology, investigation, formal analysis, visualization, writing – original draft preparation, writing – review & editing.
Maike Gossen: investigation, writing – original draft preparation, writing – review & editing.
Sophia Becker: supervision, writing–review & editing.

Data availability statement

All data related to the literature review process are available in the supplementary material or will be provided by the corresponding author upon request.

References

Amel, E., Manning, C., Scott, B., & Koger, S. (2017). Beyond the roots of human inaction: Fostering collective effort toward ecosystem conservation. *Science*, *356*(6335), 275–279. https://doi.org/10.1126/science.aal1931

Arentze, T., & Timmermans, H. (2012). Travel demand modelling: Conceptual developments and perspectives. *Transportation Letters*, *4*(2), 79–92. https://doi.org/10.3328/TL.2012.04.02.79-92

Arnz, M., & Krumm, A. (2023). Sufficiency in passenger transport and its potential for lowering energy demand. *Environmental Research Letters*, *18*(9), 094008. https://doi.org/10.1088/1748-9326/acea98

Auld, J., & Mohammadian, A. (2009). Framework for the development of the agent-based dynamic activity planning and travel scheduling (ADAPTS) model. *Transportation Letters*, *1*(3), 245–255. https://doi.org/10.3328/TL.2009.01.03.245-255

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy*, *15*(2), 73–80. https://doi.org/10.1016/j.tranpol.2007.10.005

Barr, S. (2015). Beyond behavior change: Social practice theory and the search for sustainable mobility. In E. H. Kennedy, M. J. Cohen, & N. Krogman (Eds.), *Putting sustainability into practice*. Edward Elgar Publishing. https://doi.org/10.4337/9781784710606.00015

Barr, S., Shaw, G., & Coles, T. (2011). Sustainable lifestyles: Sites, practices, and policy. *Environment & Planning A: Economy & Space*, *43*(12), 3011–3029. https://doi.org/10.1068/a43529

Ben-Akiva, M., & Bowman, J. L. (1998). Integration of an activity-based Model system and a residential location Model. *Urban Studies*, *35*(7), 1131–1153. https://doi.org/10.1080/0042098984529

Bhattacharyya, A., Jin, W., Le Floch, C., Chatman, D. G., & Walker, J. L. (2019). Nudging people towards more sustainable residential choice decisions: An intervention based on focalism and visualization. *Transportation*, *46*(2), 373–393. https://doi.org/10.1007/s11116-018-9936-x

Bingham, C., Walsh, C., & Carroll, S. (2012). Impact of driving characteristics on electric vehicle energy consumption and range. *IET Intelligent Transport Systems*, *6*(1), 29. https://doi.org/10.1049/iet-its.2010.0137

Bissel, M., Gossen, M., Becker, S., Reisch, L. A., & Sunstein, C. R. (2023). *Systematic map protocol (preregistration)*. osf.io/7auhe

Bongardt, D., Stiller, L., Swart, A., & Wagner, A. (2019). *Sustainable urban transport: Avoid-shift-improve (A-S-I)*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). https://www.

transformative-mobility.org/wp-content/uploads/2023/03/ASI_TUMI_SUTP_iNUA_No-9_April-2019-Mykme0.pdf

Briscoe, S. (2015). Web searching for systematic reviews: A case study of reporting standards in the UK health technology assessment programme. *BMC Research Notes*, *8*(1), 153. https://doi.org/10.1186/s13104-015-1079-y

Carr, S., Lhussier, M., Forster, N., Geddes, L., Deane, K., Pennington, M., Visram, S., White, M., Michie, S., Donaldson, C., & Hildreth, A. (2011). An evidence synthesis of qualitative and quantitative research on component intervention techniques, effectiveness, cost-effectiveness, equity and acceptability of different versions of health-related lifestyle advisor role in improving health. *Health Technology Assessment*, *15*(9). https://doi.org/10.3310/hta15090

Chorus, C. (2012). What about behaviour in travel demand modelling? An overview of recent progress. *Transportation Letters*, *4*(2), 93–104. https://doi.org/10.3328/TL.2012.04.02.93-104

Clark, B., Lyons, G., & Chatterjee, K. (2016). Understanding the process that gives rise to household car ownership level changes. *Journal of Transport Geography*, *55*, 110–120. https://doi.org/10.1016/j.jtrangeo.2016.07.009

Composto, J. W., & Weber, E. U. (2022). Effectiveness of behavioural interventions to reduce household energy demand: A scoping review. *Environmental Research Letters*, *17*(6), 063005. https://doi.org/10.1088/1748-9326/ac71b8

Creutzig, F., Javaid, A., Soomauroo, Z., Lohrey, S., Milojevic-Dupont, N., Ramakrishnan, A., Sethi, M., Liu, L., Niamir, L., Bren d', Weddige, U., Amour, C., Weddige, U., Lenzi, D., Kowarsch, M., Arndt, J., Baumann, L., Betzien, J. ... Mendez, E. (2020). Fair street space allocation: Ethical principles and empirical insights. *Transport Reviews*, *40*(6), 711–733. https://doi.org/10.1080/01441647.2020.1762795

Creutzig, F., Roy, J., Lamb, W. F., Azevedo, I. M. L., Bruine de Bruin, W., Dalkmann, H., Edelenbosch, O. Y., Geels, F. W., Grubler, A., Hepburn, C., Hertwich, E. G., Khosla, R., Mattauch, L., Minx, J. C., Ramakrishnan, A., Rao, N. D., Steinberger, J. K., Tavoni, M., Ürge-Vorsatz, D., & Weber, E. U. (2018). Towards demand-side solutions for mitigating climate change. *Nature Climate Change*, *8*(4), 268–271. https://doi.org/10.1038/s41558-018-0121-1

Creutzig, F., Schmaus, A., Ayaragarnchanakul, E., Becker, S., Falchetta, G., Hu, J., Goletz, M., Guéret, A., Nagel, K., Schild, J., Schill, W.-P., Schlenther, T., & Molkenthin, N. (2024). Shared pooled mobility: Expert review from nine disciplines and implications for an emerging transdisciplinary research agenda. *Environmental Research Letters*, *19*(5), 053004. https://doi.org/10.1088/1748-9326/ad3cf5

Decrinis, L., Freibichler, W., Kaiser, M., Sunstein, C. R., & Reisch, L. A. (2023). Sustainable behaviour at work: How message framing encourages employees to choose electric vehicles. *Business Strategy and the Environment*, *32*(8), 5650–5668. https://doi.org/10.1002/bse.3441

DEFRA. (2008). *A framework for pro-environmental Behaviours*. Department of the environment, food and rural affairs. https://assets.publishing.service.gov.uk/media/5a789f08ed915d04220640a4/pb13574-behaviours-report-080110.pdf

DEFRA. (2011). *Sustainable lifestyle Framework*. Department for Environment, Food and Rural Affairs. https://www.sustainabilityexchange.ac.uk/files/defra_sustainable_lifestyles_framework.pdf

Dütschke, E., Engel, L., Theis, A., & Hanss, D. (2022). Car driving, air travel or more sustainable transport? socio-psychological factors in everyday mobility and long-distance leisure travel. *Travel Behaviour and Society*, *28*, 115–127. https://doi.org/10.1016/j.tbs.2022.03.002

EEA. (2022). *Decarbonising road transport: The role of vehicles, fuels and transport demand*. (No 02/2022; *EEA Report)*. Publications Office of the European Union. https://data.europa.eu/doi/10.2800/68902

Forberger, S., Reisch, L., Kampfmann, T., & Zeeb, H. (2019). Nudging to move: A scoping review of the use of choice architecture interventions to promote physical activity in the general population. *The International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 77. https://doi.org/10.1186/s12966-019-0844-z

Garcia-Sierra, M., van den Bergh, J. C. J. M., & Miralles-Guasch, C. (2015). Behavioural economics, travel behaviour and environmental-transport policy. *Transportation Research Part D: Transport & Environment*, *41*, 288–305. https://doi.org/10.1016/j.trd.2015.09.023

Gärling, T. (1998). Behavioural assumptions overlooked in Travel-Choice Modelling. In *Travel behaviour research: Updating the state of play* (pp. S. 3–18). Elsevier. https://doi.org/10.1016/B978-008043360-8/50001-7

Gärling, T., & Loukopoulos, P. (2008). Economic and psychological determinants of car ownership and use. In A. Lewis (Ed.), *The cambridge handbook of psychology and economic behaviour* (1. Aufl. S. 383–405). Cambridge University Press. https://doi.org/10.1017/CBO9780511490118.016

Geiger, S. M., Fischer, D., & Schrader, U. (2018). Measuring what matters in sustainable consumption: An integrative framework for the selection of relevant behaviors. *Sustainable Development*, *26*(1), 18–33. https://doi.org/10.1002/sd.1688

Gössling, S., & Dolnicar, S. (2023). A review of air travel behavior and climate change. *WIREs Climate Change*, *14*(1), e802. https://doi.org/10.1002/wcc.802

Graus, W., & Worrell, E. (2008). The principal–agent problem and transport energy use: Case study of company lease cars in the Netherlands. *Energy Policy*, *36*(10), 3745–3753. https://doi.org/10.1016/j.enpol.2008.07.005

Haddaway, N. R., Macura, B., Whaley, P., & Pullin, A. S. (2018). ROSES RepOrting standards for systematic evidence syntheses: Pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. *Environmental Evidence*, *7*(1), 7. https://doi.org/10.1186/s13750-018-0121-7

Hampton, S., & Whitmarsh, L. (2023). Choices for climate action: A review of the multiple roles individuals play. *One Earth*, *6*(9), 1157–1172. https://doi.org/10.1016/j.oneear.2023.08.006

Hauslbauer, A. L., Schade, J., Drexler, C. E., & Petzoldt, T. (2022). Extending the theory of planned behavior to predict and nudge toward the subscription to a public transport ticket. *European Transport Research Review*, *14*(1), 5. https://doi.org/10.1186/s12544-022-00528-3

Hensher, D. A., & Stopher, P. R. (Hrsg.). (2021). *Behavioural travel modelling* (1. Aufl. ed.). Routledge. https://doi.org/10.4324/9781003156055

Hickman, R., & Hannigan, C. (2021). Transport and climate change. In *International encyclopedia of transportation* (pp. S. 94–100). Elsevier. https://doi.org/10.1016/B978-0-08-102671-7.10620-7

Higham, J., Cohen, S. A., Peeters, P., & Gössling, S. (2013). Psychological and behavioural approaches to understanding and governing sustainable mobility. *Journal of Sustainable Tourism*, *21*(7), 949–967. https://doi.org/10.1080/09669582.2013.828733

Holden, E., Banister, D., Gössling, S., Gilpin, G., & Linnerud, K. (2020). Grand narratives for sustainable mobility: A conceptual review. *Energy Research & Social Science*, *65*, 101454. https://doi.org/10.1016/j.erss.2020.101454

Hunecke, M. (2015). *Mobilitätsverhalten verstehen und verändern*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-08825-5

Ivanova, D., Barrett, J., Wiedenhofer, D., Macura, B., Callaghan, M., & Creutzig, F. (2020). Quantifying the potential for climate change mitigation of consumption options. *Environmental Research Letters*, *15*(9), 093001. https://doi.org/10.1088/1748-9326/ab8589

Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuideke, O. E., Kajino, T., Lee, D. S., Nugroho, S. B., Ou, X., Hammer Strømman, A., & Whitehead, J. (2022). Transport. In IPCC (Hrsg.), *Climate change 2022: Mitigation of climate change. Contribution of working group III to the sixth assessment report of the intergovernmental panel on climate change* (1. Aufl. S. 1049–1160). Cambridge University Press. https://doi.org/10.1017/9781009157926.012

Javaid, A., Creutzig, F., & Bamberg, S. (2020). Determinants of low-carbon transport mode adoption: Systematic review of reviews. *Environmental Research Letters*, *15*(10), 103002. https://doi.org/10.1088/1748-9326/aba032

Jungell-Michelsson, J., & Heikkurinen, P. (2022). Sufficiency: A systematic literature review. *Ecological Economics*, *195*, 107380. https://doi.org/10.1016/j.ecolecon.2022.107380

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1991). Anomalies: The endowment effect, loss aversion, and status quo bias. *Journal of Economic Perspectives*, *5*(1), 193–206. https://doi.org/10.1257/jep.5.1.193

Kellermann, R., Biehle, T., & Fischer, L. (2020). Drones for parcel and passenger transportation: A literature review. *Transportation Research Interdisciplinary Perspectives*, *4*, 100088. https://doi.org/10.1016/j.trip.2019.100088

Klöckner, C. A., & Blöbaum, A. (2010). A comprehensive action determination model: Toward a broader understanding of ecological behaviour using the example of travel mode choice. *Journal of Environmental Psychology*, *30*(4), 574–586. https://doi.org/10.1016/j.jenvp.2010.03.001

Klöckner, C. A., & Matthies, E. (2012). Two pieces of the same puzzle? script-based car choice habits between the influence of socialization and past behavior 1. *Journal of Applied Social Psychology*, *42*(4), 793–821. https://doi.org/10.1111/j.1559-1816.2011.00817.x

Klöckner, C. A., Nayum, A., & Mehmetoglu, M. (2013). Positive and negative spillover effects from electric car purchase to car use. *Transportation Research Part D: Transport & Environment*, *21*, 32–38. https://doi.org/10.1016/j.trd.2013.02.007

Kreil, A. S. (2021). *Reducing the climate impact associated with air travel: Shifting perspectives within and beyond academia* [Doctoral dissertation]. ETH Zurich. http://hdl.handle.net/20.500.11850/519412

Lülfs, R., & Hahn, R. (2014). Sustainable behavior in the business sphere: A comprehensive overview of the explanatory power of psychological models. *Organization & Environment*, *27*(1), 43–64. https://doi.org/10.1177/1086026614522631

Martin, E. W., Chan, N. D., & Shaheen, S. A. (2012). How public education on Ecodriving Can reduce both fuel Use and greenhouse gas emissions. *Transportation Research Record: Journal of the Transportation Research Board*, *2287*(1), 163–173. https://doi.org/10.3141/2287-20

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*(1), 42. https://doi.org/10.1186/1748-5908-6-42

Müggenburg, H., Busch-Geertsema, A., & Lanzendorf, M. (2015). Mobility biographies: A review of achievements and challenges of the mobility biographies approach and a framework for further research. *Journal of Transport Geography*, *46*, 151–163. https://doi.org/10.1016/j.jtrangeo.2015.06.004

Münscher, R., Vetter, M., & Scheuerle, T. (2016). A review and taxonomy of choice architecture techniques: Choice architecture techniques. *Journal of Behavioral Decision Making*, *29*(5), 511–524. https://doi.org/10.1002/bdm.1897

Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., & Whitmarsh, L. (2021). How psychology can help limit climate change. *The American Psychologist*, *76*(1), 130–144. https://doi.org/10.1037/amp0000624

Nielsen, K. S., Cologna, V., Bauer, J. M., Berger, S., Brick, C., Dietz, T., Hahnel, U. J. J., Henn, L., Lange, F., Stern, P. C., & Wolske, K. S. (2024). Realizing the full potential of behavioural science for climate change mitigation. *Nature Climate Change*, *14*(4), 322–330. https://doi.org/10.1038/s41558-024-01951-1

Pawluk De Toledo, K., O'Hern, S., & Koppel, S. (2022). Travel behaviour change research: A scientometric review and content analysis. *Travel Behaviour and Society*, *28*, 141–154. https://doi.org/10.1016/j.tbs.2022.03.004

Pinjari, A. R., Pendyala, R. M., Bhat, C. R., & Waddell, P. A. (2011). Modeling the choice continuum: An integrated model of residential location, auto ownership, bicycle ownership, and commute tour mode choice decisions. *Transportation*, *38*(6), 933–958. https://doi.org/10.1007/s11116-011-9360-y

Princen, T. (2005). *The logic of sufficiency*. MIT Press.

Reisch, L. A., Sunstein, C. R., Andor, M. A., Doebbe, F. C., Meier, J., & Haddaway, N. R. (2021). Mitigating climate change via food consumption and food waste: A systematic map of behavioral interventions. *Journal of Cleaner Production*, *279*, 123717. https://doi.org/10.1016/j.jclepro.2020.123717

Reisch, L. A., & Thøgersen, J. (2015). *Handbook of research on sustainable consumption*. Edward Elgar Publishing. https://doi.org/10.4337/9781783471270

Riggs, W. (2022). Behavioral economics and social nudges in sustainable travel. In *Innovations in transport* (pp. S. 89–110). Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85160884323&partnerID=40&md5=65d0ea61837aa333ab22dca1067504d3

Rosenfield, A., Attanucci, J. P., & Zhao, J. (2020). A randomized controlled trial in travel demand management. *Transportation*, *47*(4), 1907–1932. https://doi.org/10.1007/s11116-019-10023-9

Ruhrort, L., & Allert, V. (2021). Conceptualizing the role of individual agency in mobility transitions: Avenues for the integration of sociological and psychological perspectives. *Frontiers in Psychology*, *12*, 623652. https://doi.org/10.3389/fpsyg.2021.623652

Rutty, M., Matthews, L., Scott, D., & Matto, T. D. (2014). Using vehicle monitoring technology and eco-driver training to reduce fuel use and emissions in tourism: A ski resort case study. *Journal of Sustainable Tourism*, *22*(5), 787–800. https://doi.org/10.1080/09669582.2013.855221

Sandberg, M. (2021). Sufficiency transitions: A review of consumption changes for environmental sustainability. *Journal of Cleaner Production*, *293*, 126097. https://doi.org/10.1016/j.jclepro.2021.126097

Schlag, B., & Schade, J. (2007). Psychologie des Mobilitätsverhaltens. *Aus Politik und Zeitgeschichte*, *29*(30), 27–32.

Schwanen, T., Banister, D., & Anable, J. (2011). Scientific research about climate change mitigation in transport: A critical review. *Transportation Research Part A: Policy and Practice*, *45*(10), 993–1006. https://doi.org/10.1016/j.tra.2011.09.005

Schwanen, T., & Lucas, K. (2011). Understanding auto motives. In K. Lucas, E. Blumenberg, & R. Weinberger (Eds.), *Auto motives* (pp. S. 3–38). Emerald Group Publishing Limited. https://doi.org/10.1108/9780857242341-001

Scott, D., Gössling, S., & Hall, C. M. (2012). International tourism and climate change. *WIREs Climate Change*, *3*(3), 213–232. https://doi.org/10.1002/wcc.165

Sheller, M., & Urry, J. (2006). The new mobilities paradigm. *Environment & Planning A: Economy & Space*, *38*(2), 207–226. https://doi.org/10.1068/a37268

Shove, E. (2010). Beyond the ABC: Climate change policy and theories of social change. *Environment & Planning A: Economy & Space*, *42*(6), 1273–1285. https://doi.org/10.1068/a42282

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Spangenberg, J. H., & Lorek, S. (2019). Sufficiency and consumer behaviour: From theory to policy. *Energy Policy*, *129*, 1070–1079. https://doi.org/10.1016/j.enpol.2019.03.013

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, *29*(3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Stern, P. C. (2011). Contributions of psychology to limiting climate change. *The American Psychologist*, *66*(4), 303–314. https://doi.org/10.1037/a0023235

Sussman, R., Tan, L. Q., & Kormos, C. E. (2020). Behavioral interventions for sustainable transportation: An overview of programs and guide for practitioners. In *Transport and energy research* (pp. S. 315–371). Elsevier. https://doi.org/10.1016/B978-0-12-815965-1.00014-4

Thorun, C., Diels, J., Vetter, M., Reisch, L., Bernauer, M., Micklitz, H.-W., Rosenow, J., Forster, D., & Sunstein, C. R. (2017). *Nudge-Ansätze beim nachhaltigen Konsum: Ermittlung und Entwicklung von Maßnahmen zum „Anstoßen“nachhaltiger Konsummuster*. Umweltbundesamt.

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review*, *4*(3), 356–367. https://doi.org/10.1177/1534484305278283

van der Voort, M. C. (2001). *Design and evaluation of a new fuel-efficiency support tool* [PhD Thesis - Research UT, graduation UT]. University of Twente.

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy & Marketing*, *25*(1), 90–103. https://doi.org/10.1509/jppm.25.1.90

World Resources Institute & WBCSD. (2013). *Technical guidance for calculating scope 3 emissions*. https://ghgprotocol.org/sites/default/files/2023-03/Scope3_Calculation_Guidance_0%5B1%5D.pdf

Zhu, Y., Diao, M., Ferreira, J., & Zegras, C. (2018). An integrated microsimulation approach to land-use and mobility modeling. *Journal of Transport and Land Use*, *11*(1). https://doi.org/10.5198/jtlu.2018.1186