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*An Integrated Review*

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# Determinants of Long-Term Water and Energy Conservation Behavior: An Integrated Review

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**Abstract:** Over the last decades, drinking water and energy use have increased exponentially. To preserve ecosystems in the long term, a change in behavior is necessary on all levels of society including on the household level. This paper presents an integrated review of the determinants of long-term drinking water and energy conservation behavior of households. We identified forty-nine relevant studies discussing long-term conservation behavior in the context of drinking water and energy use. Long-term conservation behavior was measured as either persistent behavior, maintaining behavioral change, or intentions to maintain behavior, each with specific determinants. We found four key factors for long-term conservation behavior: consumption feedback, household characteristics, effort, and motives for conservation behavior. For future studies, we suggest follow-up questionnaires or interviews to measure the persistence of behavior and differentiate between curtailment and efficiency behavior. Worthwhile avenues for future research on long-term conservation behavior are household-tailored feedback mechanisms and the interaction between contextual factors and effort-based choices.

**Keywords:** water; energy; conservation behavior; review; long-term behavior



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## 1. Introduction

Water and energy are two of the world's most critical resources [1] and preserving these resources plays a significant role in climate mitigation strategies [2–4]. Yet, the use of fresh water has increased exponentially since the 1980s and is still growing globally [5]. Also, energy usage has continued to rise despite mitigation agreements [2]. Change is required on all levels of society to adequately preserve ecosystems. This change includes household energy and drinking water behavior [2,6–10]. Numerous studies have investigated how to encourage drinking water and energy conservation behavior in households [6,8,11,12]. The evidence in these studies is partially conflicting. Many studies find that even if households become more conservative in their use of these primary utilities, these behavioral changes tend to be modest and short-lived [11–13]. Yet, there are also numerous studies that did find significant factors that contribute to long-term conservation behavior. To address the conflicting evidence, we systematically study the factors that contribute to long-term water and energy conservation behavior.

In this literature review, we aim to synthesize the evidence found by previous studies on determinants of long-term drinking water and energy conservation behavior of households. We focus on the following research question: *what determinants explain long-term drinking water and energy conservation behavior of households?* We review the available evidence of previous studies on long-term drinking water and energy conservation behavior by households. We consider drinking water as tap water that is used for drinking,

showering, toilet flushing, bathing, washing, and hosing the garden. In the remainder of the paper, we use "water" to refer to drinking water. Compared to the area of water conservation behavior, many more studies have been conducted into energy conservation behavior (e.g., [14,15]). Such simultaneous investigation of energy and water behaviors is quite common, as illustrated by various reviews that consider multiple types of resource conservation (e.g., [16,17]), spillover effects between water and energy behavior (e.g., [18]), or the water–energy nexus [19]. Being the primary utilities used in a household, a quick comparison of previous reviews shows that the determinants of water and energy conservation behavior are quite similar (see for comparison [6–8,11,12]). Hence, this review takes both water and energy conservation behavior into account, which we refer to as "conservation behavior" in the remainder of the paper.

Two types of conservation behavior are generally distinguished in the literature: curtailment and efficiency behaviors [20,21]. Curtailment behavior refers to the adjustment of frequent, repetitive, and low-cost behaviors like shortening shower time or turning off lights [20,22]. The second type is efficiency behavior. Efficiency refers to "infrequent structural changes and/or those requiring investments or purchases" [20] (p. 428). Using rain barrels to harvest water and switching to more energy-efficient light bulbs are examples of efficiency behavior [20,22]. While efficiency tends to save more energy than curtailment [21], people think they are more likely to exhibit curtailment behavior than efficiency behavior [22]. Both types of behavior influence water and energy consumption, but the determinants might differ due to differences in perception and impact [21].

## 2. Materials and Methods

### *2.1. Prisma Protocol and Study Selection*

The review aims to provide insight into the factors that have been identified to have an influence on long-term conservation behavior. We followed the Prisma protocol for systematic reviews [23]. The protocol provides clear guidelines to conduct a review and consists of three stages: identification, screening, and inclusion. In the identification stage, we used two queries to identify the relevant studies. One query was set up to identify the relevant studies on long-term water conservation behavior, the other was focused on long-term energy conservation behavior. The search was conducted in Scopus and PsycINFO. Scopus covers more than 240 disciplines and the search engine covers most key publications [24]. PsycINFO is a specific search engine for studies in the realm of behavior and psychology. The query consists of three elements. First, the title must contain energy, electricity, or water, and the title must refer to conservation behavior or a synonym. Secondly, in the abstract, title, or keywords, there should be a reference to conservation or a synonym in combination with a reference to household or a synonym. Third, the abstract, title, or keywords must contain a reference to persistent or maintained behavior, or a reference to the length of the study (Table 1).

We applied five selection criteria to select relevant papers for our research. First, the study must be concerned with the water or energy conservation behavior of households. Secondly, it must be an empirical study. Third, it must contain an element of a long-term perspective. This could be, for example, a longitudinal experiment, a repeated survey, or a long-term case study. Fourth, to include only high-quality studies, the paper must be published in a peer-reviewed journal or submitted as a conference paper. Lastly, the paper must be written in English. The screening stage consisted of two steps. The first step was to screen the titles and abstracts of the studies retrieved from the search string for the criteria. From the 297 studies found using the query, 105 remained after screening for duplicates and relevancy based on the title, abstract, and keywords. The second step was to read these papers in more detail and apply the selection criteria listed in Table 2. After the second stage, 43 studies remained and are included in the review. Through snowballing, we identified 6 additional relevant studies, bringing the total to 49. Table 2 provides an overview of the selection process.

**Table 1.** Queries used for literature search.

| | Query | Results |
|---|---|---|
| Energy | TITLE ((“energy” OR “electricity”) AND (“conservation” OR “reduc*” OR “save*” OR “saving*” OR “demand*” OR “consumption*” OR “habit*” OR “use*” OR “using*” OR “usag*” OR “behavio*”)) AND TITLE-ABS-KEY ((“household*” OR “resident*” OR “domestic”) AND (“conservation” OR “reduc*” OR “saving*” OR “save*” OR “demand*” OR “consumption*” OR “habit*” OR “use*” OR “usag*” OR “using*” OR “behavio*”)) AND TITLE-ABS-KEY ((((“persisten*” OR “maint*”) W/5 (“behavio*” OR “change*” OR “changing”)) OR ((“longitudinal” OR “long term” OR “long-term” OR “longterm”) W/5 (“study” OR “studie*” OR “data” OR “research”))) | 184 |
| Water | TITLE ((“water”) AND (“conservation” OR “reduc*” OR “save*” OR “saving*” OR “demand*” OR “consumption*” OR “habit*” OR “use*” OR “using*” OR “usag*” OR “behavio*”)) AND TITLE-ABS-KEY ((“household*” OR “resident*” OR “domestic”) AND (“conservation” OR “reduc*” OR “saving*” OR “save*” OR “demand*” OR “consumption*” OR “habit*” OR “use*” OR “usag*” OR “using*” OR “behavio*”)) AND TITLE-ABS-KEY ((((“persisten*” OR “maint*”) W/5 (“behavio*” OR “change*” OR “changing”)) OR ((“longitudinal” OR “long term” OR “long-term” OR “longterm”) W/5 (“study” OR “studie*” OR “data” OR “research”))) | 113 |
| Total | | 297 |

Note. Queries were used on 17 April 2024. The asterisk “*” functions to replace multiple characters in a word, allowing to search easily for variations of the searched concepts.

**Table 2.** PRISMA protocol, selection procedure.

| Selection Process | Scopus | PsycINFO |
|---|---|---|
| Articles identified | 281 | 16 |
| Articles remaining after removing duplicates | 263 | 6 |
| Articles remaining after screening of title and abstract | 105 | 2 |
| Full-text assessment | 105 | 2 |
| Non-English | 2 | 0 |
| Irretrievable | 13 | 0 |
| No empirical results | 6 | 0 |
| No focus on conservation behavior | 21 | 0 |
| No determinants of behavior discussed | 16 | 0 |
| No focus on household behavior | 6 | 0 |
| Not peer-reviewed | 0 | 0 |
| Remaining articles for analysis | 41 | 2 |
| Relevant articles identified through snowballing | 6 | |
| Total | 41 + 2 + 6 = 49 | |

### *2.2. Analysis and Synthesis*

This synthesis is a qualitative synthesis. A qualitative synthesis relies on expert judgment to draw meaning of the collected studies into a narrative of the field of study [25,26]. This is especially helpful when the research context is multidisciplinary and many different methods and conceptualizations were used to study the phenomenon [25]. To study the diverse field of long-term energy and water conservation behavior, we used a three-step process to analyze the studies as described by [26]. First, we organized the studies into categories based on their approach to long-term conservation behavior. The second step consisted of a coding process in which we attributed a label of the factors in an extended version of the theory of planned behavior (TPB) [27] to all determinants used in the papers. We used the TPB to code the papers in order to increase the reliability of our assessment of the variables. Within each sub-category of the TPB, we identified and grouped similar determinants. To finish step two, we analyzed these determinants within the approaches to studying long-term conservation behavior. The third step was to synthesize all the evidence across the approaches to long-term conservation behavior and the TPB into key factors in studying long-term conservation behavior.

We use an extended version of Ajzen's [27] TPB as our theoretical lens to analyze and categorize the determinants of long-term conservation behavior. In the original TPB, behavior is determined by three factors, (1) attitude towards behavior, (2) subjective norms, and (3) perceived behavioral control, and it is preceded by an intention to perform the behavior [28]. This extension explicitly includes context and habits in the theoretical model [8,29,30]. Context is an important factor as it provides the opportunity to perform particular behaviors [8]. In addition, while the TPB considers behavior as reasoned action, water and energy behavior to a considerable extent rely on habits and routines [8]. These five categories (attitude, subjective norms, behavioral control, context, and habit) were used as an initial categorization for the determinants. Within these five categories, we examined what factors emerge for the review sample as determinants for long-term conservation behavior.

For the inclusion of a determinant in a particular category, we used the following working definitions of the categories. Attitude towards behavior is defined as the degree to which an individual values specific behavior positively or negatively and is based on experiences and expected outcomes, also known as behavioral beliefs [27]. Subjective norms are the social pressures felt to perform or not perform behavior. Subjective norms are fueled by normative beliefs: the expectancy of important others to approve or disapprove of certain behavior [27]. Behavioral control is the extent to which an individual considers the behavior as easy or difficult to perform based on their perceived capabilities, abilities, and agency [28]. Context refers to a wide variety of external features. These external features are present at both the macro level like the climate, natural resources, incidents, or events but also at the micro and meso level like the physical infrastructure and technical facilities in a household [31–33]. Habits are "a tendency to act automatically that reflects a mental association between a situation and a response" [34] (p. 3).

## 3. Results

### *3.1. Long-Term Conservation Behavior*

In the reviewed studies, we identified three different approaches to studying long-term conservation behavior. The first approach is to identify the determinants of persistent behavior. Sixteen papers used a longitudinal study design to gain insight into the continuance of household behavior over a prolonged period of time. These studies do not necessarily explain how to encourage conservation behavior but do show us why drinking water and energy usage are at a certain level and remain there. The second approach consists of studies that research the maintenance of behavioral change. The central question in these studies is the following: what determinants explain why households maintain conservation behavior after an intervention? The third approach focuses on the intention to maintain behavior. The papers with this study design explore the variety of factors that make households more willing to maintain conservation behavior or break old habits. Figure 1 shows how many studies focused on persistent behavior, maintained behavioral change, or the intention to maintain behavior.

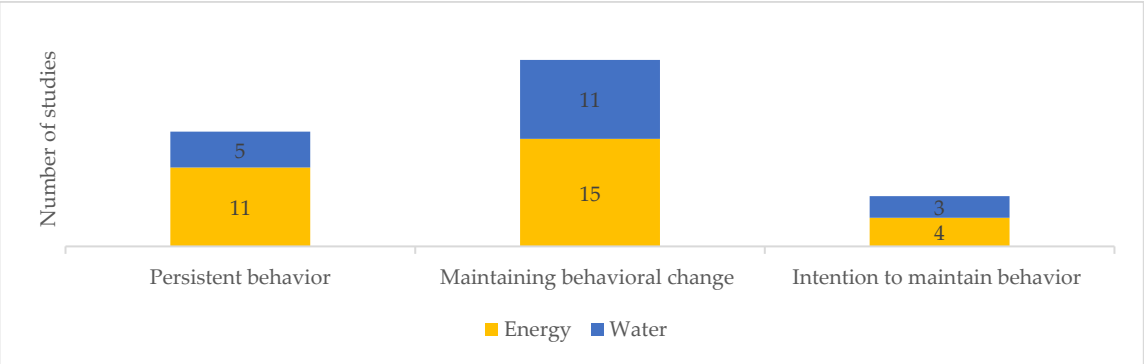


**Figure 1.** Three approaches in studies on long-term conservation behavior by households.

We used the extended TPB as a tool to categorize all determinants used in the 49 studies of this review. The extended TPB proved to be a sufficient tool to analyze the papers as all used determinants fit into one of the categories of the extended TPB. We identified nineteen distinctive determinants for long-term conservation behavior in this review. Figure 2 provides a summary of the determinants. The figure shows the number of studies that examined a particular determinant and which approach to long-term conservation behavior they aimed to explain. It displays how many studies found long-term significant effects.

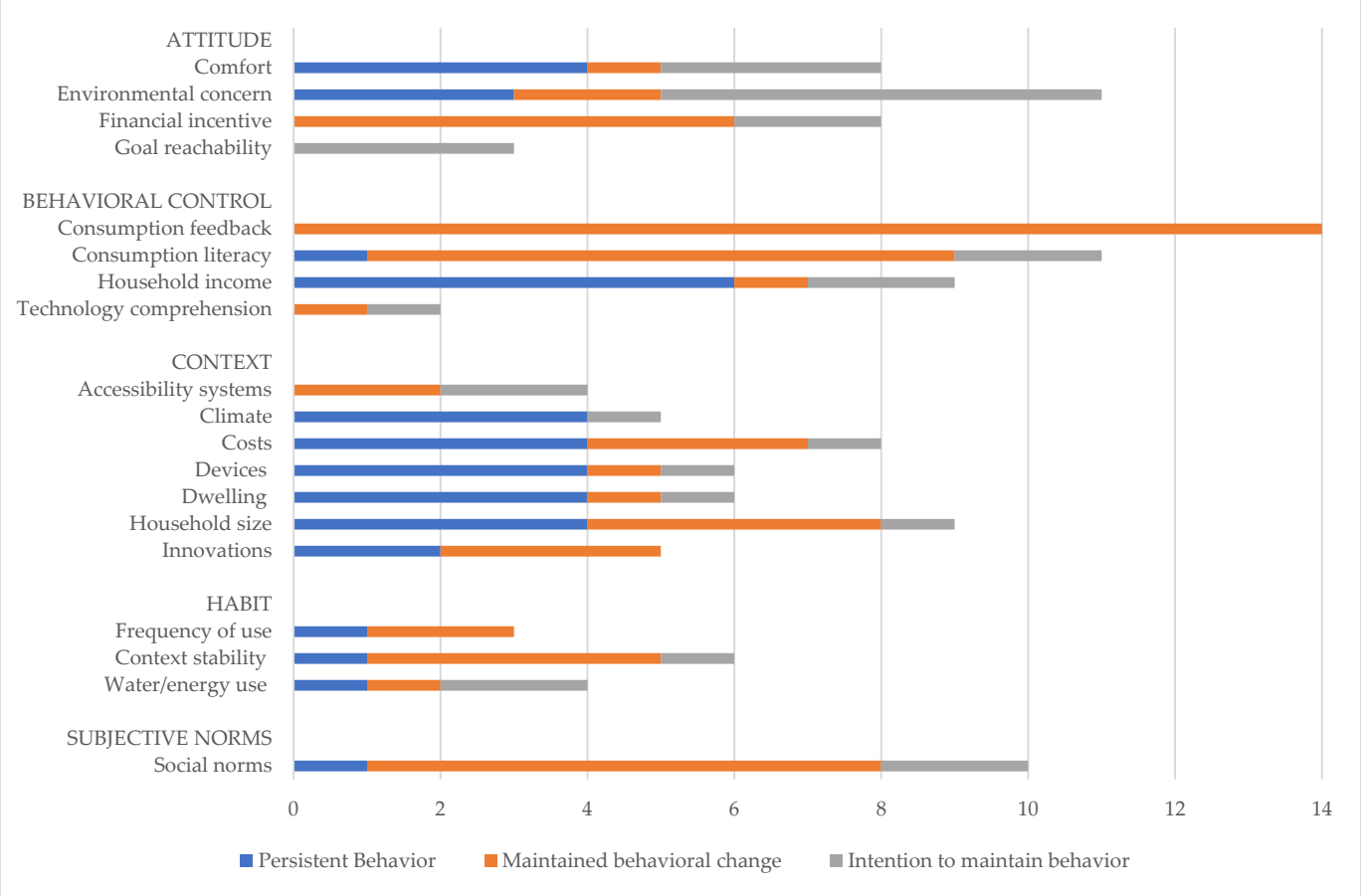


**Figure 2.** Overview of determinants for explaining long-term conservation behavior.

The Supplementary Materials contain two additional tables, Tables S1 and S2. Table S1 is a more elaborate version of Figure 2. Aside from the significant effects, Table S1 also shows how many studies did not reveal significant effects, differentiates between curtailment and efficiency studies, and shows at what level this determinant plays a role. Table S2 provides the details of all studies included in this review.

#### 3.1.1. Persistent Behavior

Sixteen papers used a longitudinal study design to investigate persistent conservation behavior (>6 months of data collection) (Figure 1). The most frequently used determinants of persistent consumption are behavioral control and contextual determinants. Even though the price elasticity of drinking water and energy usage is debated [35–38], the behavioral control that comes with household income is found to be significantly correlated with higher usage in the long term in several studies [39–45]. This might also be due to little efficiency behavior by occupying bigger dwellings [43,45–47] and owning and using more energy-using devices [39,45,46,48]. Moreover, household size also contributes to higher water and energy usage [41,43,46,47,49]. In addition to these factors, there are also more external factors that increase water and energy usage. The climate has an influence on

persistent behavior, for example through temperature [14,50,51]. With higher temperatures, people tend to use space-cooling appliances more often [51]. However, for rainfall [36,42], no significant correlation was found. These studies show that drinking water and energy usage levels persist or increase if any of these contextual determinants increase.

While household income is correlated with higher consumption, these effects are counterbalanced in the long term by more energy-efficient devices [39,40] and environmental concern [36,49,52]. If a household has more energy-efficient devices or is more concerned with the environment, it is more likely that conservation behavior persists. However, rebound effects might be noticeable in the long term [39,52]. Households with a higher income that do want to reduce their energy and water consumption by adopting more energy-efficient devices out of pro-environmental values can also compensate for this reduction via other routes, for example, by buying more energy-using devices than necessary [39]. Hence, the overall decrease in water or energy usage remains limited. Habits and accustomed lifestyles might explain the rebound effect [52]. For example, households that spend much time at home obviously use more energy than households that spend less time inside their homes [51], even if they have more environmental concerns. Moreover, an accustomed level of comfort also serves as a barrier to conservation behavior [14,45,47,49].

In the long term, conservation behavior is mainly influenced by contextual and behavioral control factors. Over time, a behavioral pattern is based on these factors, and it becomes difficult to increase conservation levels as rebound effects might come into play. This research shows primarily the barriers to conservation behavior.

#### 3.1.2. Maintained Behavioral Change

Twenty-six papers used a study design that shows why households maintain a behavioral change (Figure 1) and what factors contribute to such maintenance. In these studies, participants were subjected to an intervention, and their water or energy use was monitored over time to see whether a change in behavior occurred and was maintained. We observed two ways to test whether participants maintain behavioral change. One is to have a relatively long intervention period and the other is to have a follow-up questionnaire or interview after the intervention. With the first one, researchers can better track behavioral change for a longer time, and the follow-up shows how well households have adopted new behavior. This study design distinguishes itself from the other designs by a focus on behavioral control mechanisms, habit formation, and the role of subjective norms in long-term conservation behavior.

The studies that do not use a follow-up often use consumption feedback [15,53–57] and increasing consumption literacy [9,56,58,59] as means through which to encourage conservation behavior. The mechanisms behind consumption feedback and consumption literacy are similar. Facilitating behavioral control by learning about one's own consumption history and how one could change their consumption should stimulate an intrinsic motivation to improve conservation behavior [54–56]. In addition, social norms [54,60] and financial incentives [53,57,58] can be provided via a feedback system and encourage conservation behavior. The nature of the feedback does matter. For instance, quantitative feedback is found to be more effective than normative feedback [9], and a health-based energy-saving tip has a longer-lasting effect than a cost-saving message [53]. Furthermore, it was found that households that were bigger in size or had a higher income were less likely to adopt conservation behavior even if they did participate in an education program [59].

While the above-mentioned studies do report significant decreases in water or energy consumption, it seems that if a study uses more data points, it can reveal how the effect of the intervention diminishes over time [15,53,56,61]. Ref. [55] explained that at the beginning of an experiment, there is a sense of innovativeness that stimulates the participants to show more effort and usage of the system at hand. After a while, it is not a new system anymore and if a habit has not been established yet, the participants tend to display a lower level

of conservation behavior. This might be similar to the Hawthorne effect: at first, the participants are well aware that they are researched and want to display "good" behavior. However, when the research continues, the participants return to their natural behavior and the effect of the intervention seems less radical [62].

The second strand of studies combines an intervention with a follow-up at a subsequent time after the intervention has taken place. The idea behind this study design is that the researcher can measure to what extent the effects were maintained and behavioral change can lead to habit and structural changes. Fourteen papers in this review used this study design. The evidence from the studies using this design is mixed. Five studies found that after the treatment period, consumption feedback led to maintained conservation behavior [63–66], while three other studies found a significant decrease in energy or water consumption because of consumption feedback during the treatment period but the participants were not able to maintain their conservation behavior [67–71]. There was, however, a difference in the type of feedback that might have caused the difference in outcomes. Refs. [68,69] just used insight into the consumption, whereas [65] taught the participant to self-monitor their electricity consumption and [64,66] used a combination of usage information and a suggested objective. The feedback in the latter two studies was thus more extensive and suggests that the combination of different mechanisms into one feedback system might be most effective [66]. There was also mixed evidence for consumption literacy as the determinant of maintained behavioral change. Ref. [64] found that conservation behavior was maintained after the intervention period, while [69] found the participants returning to their previous behaviors. The differences in outcomes stress the importance of a follow-up on the intervention, especially when considering that the experiments without a follow-up study all pinpointed toward consumption feedback and literacy as determinants for maintained conservation behavior.

Similarly, there is mixed evidence on the effect of financial incentives on conservation behavior. While [66,72] found that it does maintain the motivation to conserve energy, refs. [68,71,73] found that the effect of a financial incentive diminishes over time. Also, dynamic pricing seems to have a persistent effect [74] while a one-time price increase does not [37]. In the same vein, strong social norms can lead to a maintained decrease in drinking water consumption per household [63,75], while a weaker social norm message or social comparison does not always lead to a maintained change in behavior [68,75].

The only undisputed determinants in these experiments were contextual determinants. For instance, the removal of cues increases the chance that households return to their old behavior [67,69,73,74]. The stability of the context is thus an important factor in maintaining behavior. Maintaining conservation behavior is related to creating habits which are often defined as "a tendency to act automatically that reflects a mental association between a situation and a response" [34] (p. 76). Context stability is a way of maintaining that association. Also, physical changes to the contextual environment such as installing a feedback system that is accessible to frequent use create the opportunity to establish maintainable habits of conservation behavior [37,72,74].

From these intervention-based studies, we learn that conservation behavior can be encouraged by increasing the understanding of energy and water consumption and through normative messages and social comparison. However, the achieved conservation levels often diminish over time and conservation behavior is unlikely to be maintained at the desired level. Having a stable context seems to be a key influence in maintaining the changed behavior.

#### 3.1.3. Intention to Maintain Behavior

The last group of studies identifies the determinants for an intention to maintain conservation behavior. Nine papers used the intention to maintain conservation behavior as their variable of interest (Figure 1). As opposed to the previous groups of studies, these studies seek determinants that break with maintained behavior, in this case a high usage of energy or drinking water. Only [13] conducted a survey on the intentions to maintain

drinking water conservation behavior. Other studies looked into the willingness to change to a more efficient system [76–78] and setting goals [79] to increase conservation behavior. The study designs are predominantly surveys, with [79]'s experimental study design as the exception.

When looking at the intention to maintain conservation behavior, the researchers mostly look at attitudinal factors. This is different from the other types of research about long-term conservation behavior. The attitude toward comfort and the opinion on the environment are positive determinants of the intention to conserve water and energy [80]. Currently experienced levels of comfort are barriers to start conserving water and energy [13,78,79]. Without an intervention, if the household is satisfied and experiences comfort from the current levels of water and energy use, there is a decreased intention to change the behavior. Also, the thought of having to exert effort is a barrier to change toward conservation behavior [13]. Moreover, current habits also correlate with a decreased likeliness of saving energy [44]. Attitudes like environmental concern can trigger an intention to maintain conservation behavior. The more concerned a household is about the environment, the more likely it is to display intentions to maintain efficiency conservation behavior like using renewable energy or signing up for an energy-saving program [76–79]. The idea of contributing to the environment [78] or financial incentives [77] increases the willingness to adopt new efficient appliances. Other stimuli for intending to maintain conservation behavior are consumption literacy [13,79] and social norms [13,76]. Understanding what the effects of water and energy use are and wanting to conform to social norms increases the will to maintain water or energy conservation behavior.

To summarize, the intention to maintain conservation behavior or break with currently maintained behaviors often starts with an attitude that the household wishes to contribute to the environment and is supported by social norms and consumption literacy. Comfort and habits are barriers to breaking from current behavior.

### *3.2. Maintaining Curtailment and Efficiency Behavior*

In total, 18 of the 49 studies distinguished between curtailment and efficiency, either explicitly or implicitly. Curtailment behaviors were relatively more popular in follow-up studies regarding the maintenance of conservation behavior; ten of the twenty curtailment relations were identified in study designs using a follow-up after the intervention. The studies reveal three main determinants for maintaining conservation behavior. First, consumption feedback encourages maintaining curtailment behaviors. For example, households that were informed that their consumption was relatively high quickly adjusted their behavior [53]. In the papers where consumption feedback was linked to curtailment behaviors, the feedback was continuous and frequent [15,53,65]. The constant reminder about one's behavior might have worked as a stimulus for changing frequent low-cost behavior. This relates to the second determinant: habit. Habit is related to curtailment conservation behavior. Both curtailment behavior and habitual behavior are concerned with repetitive behavior [20,30]. The creation of habit by frequently using a feedback system increases the chance that the curtailment behavior persists. A stable context helps in this regard as the association between cues and behavior remains [14,74]. The third determinant for maintaining curtailment behaviors is the level of comfort. According to [14], behavioral changes that have a low level of discomfort are more likely to persist than behaviors with high discomfort. Satisfaction as a result of highly frequent behaviors can be a barrier to limiting the frequency [37,78]. For example, if one enjoys a long shower every morning, it would take effort to adjust this behavior because one would be tempted to defer back to the satisfying behavior. Hence, discomfort and effort seem to be barriers to maintaining those behaviors.

Efficiency conservation behaviors were mostly linked to longitudinal and intention study designs. Contextual factors were the most frequently investigated determinants for efficiency behavior. This connection is not surprising, as efficiency behavior relates to investments and infrequent behavior, and many of the finance and device-related determinants

were typified as efficiency behavior [20]. Within the category of efficiency behaviors, there is a distinction between efficiency behavior as a determinant for conservation behavior and efficiency behavior as an intention. Efficiency behavior as a determinant refers to factors such as the characteristics of a dwelling or the number of energy-efficient devices. These previous investments (efficiency behavior) in the size of the dwelling [43,45,56] or the number of energy-efficient devices [39,46,48] influence the amount of energy or water consumed. This provides evidence that efficiency behavior does lead to water or energy conservation yet does not explain why households made these investments. In the small number of efficiency intentions that were identified in the studies, the costs of the investment seem to play a significant role [14,77]. A decrease in the costs of energy-efficient devices increases the likeliness of the investment. Another determinant of efficiency behavior is the will to or feeling of contributing to the environment [77,78].

### *3.3. Key Factors*

We cross-examined all determinants for long-term conservation behavior at once to transcend the TPB and came to four key factors. These factors span across both the different approaches to long-term conservation behavior and across the categories of the TPB: consumption feedback, household characteristics, motives for conservation behavior, and effort.

Consumption feedback is used in various studies as a tool to assess drinking water and energy behavior. These measurements and information provision are often conducted via smart meter experiments (e.g., [56,64,66,68]). As such, these feedback devices provide the opportunity for households to learn about their consumption and better control their behavior [54,56,58,68]. Aside from feedback as a contextual and behavioral control factor, it also works as a normative and attitudinal mechanism. Consumption feedback presented as a ranking among neighbors provides the social norm that households want to adhere to [9,54,75]. Ref. [64] argued that consumption feedback contributes to more effective water-saving tips that, in turn, should contribute to achieving the target water consumption. Refs. [73,79] showed that a feeling of more achievable goals motivates conservation behavior. While the provision of consumption data and information might seem like a superior intervention for stimulating conservation behavior, the effect of feedback devices is dependent on the frequency of use [55,66,72,74]. If considering that the feedback does not become a habit, it might lose its effect. Moreover, the type and extensiveness of the feedback seem to influence the effect. More extensive feedback [64–66] and quantitative or health-based feedback [9,53] yield the best results. Consumption feedback is a driving force for maintaining conservation behavior. It can encourage conservation behavior via various mechanisms; however, the extensiveness of the feedback and frequency of use seem to be crucial in maintaining the conservation behavior.

Household characteristics form the second key factor in this review. Maintaining conservation behavior, or rather long-term water and energy use, depends on a variety of characteristics of a household. Obviously, if a household consists of more individuals [41,43,46,49] or if the dwelling is larger [43,45–47], the household uses more energy and water in the long term. There are, however, deeper-lying mechanisms. First, larger households, especially those with children, are less susceptible to interventions as they wish to remain flexible [56] and place the needs of the family above other values [58]. Moreover, families with children use more appliances in the first place [46]. Secondly, bigger dwellings are often accompanied by a higher income which is correlated with higher long-term water usage [39–45]. In addition, they seem to be accustomed to a particular high-usage lifestyle as attempts to increase the conservation behavior often result in compensation behavior through rebound effects [52]. Yet, household income could be rather important for interventions as financial incentives (e.g., [53,68,73]) and water or energy prices (e.g., [35,37]) are debated determinants of long-term conservation behavior. Stimulating households that have the means to adopt resource-efficient devices might be a crucial intervention as

multiple studies showed that the presence of these devices helps households to maintain conservation behavior [13,39,45,46,48].

The third key factor is the motives for conservation behavior. There are two types of motives; those formed by a household's attitude towards the environment and social norms they want to adhere to. While these attitudes reflect one's intrinsic motivation, the social norms act as external motivation to maintain conservation behavior. A household's attitude towards the environment consists of various elements that (among other things) may include environmental concern, pro-environmental values, and emotions associated with contributing to the environment. Environmentally concerned households worry about the negative impact of their water usage on the environment [49,79] and hence want to maintain a lower water usage. Environmental concern can lead to a green self-identity which results in the persistent intention to perform conservation behavior [13,77]. Also, satisfaction with previous conservation behavior can stimulate further savings as households feel like they contribute to the environment [55]. Aside from these intrinsic motives, the social environment can also stimulate the maintenance of conservation behavior. Social norms can be either induced via normative messages [9,60], by social comparison [54,75], or by a household's own perception of what is socially acceptable [13,52,76]. The experienced social pressure and personal desire to behave within the norms create a motive to change toward conservation behavior and maintain this new behavior.

The last key factor is effort. The role of effort can manifest itself in different ways: in a lack of comfort, physical effort, or time that needs to be invested. Regardless, the mechanism is the same: if conservation behavior requires too much effort, it is less likely to be maintained. Ref. [13] found that the perception of physical effort is a barrier to conservation behavior (besides a lack of comfort as mentioned before) [14,45]. It depends on how much a household values comfort [37,47,49]. Moreover, if households have low access to energy- or water-efficient systems and they require much effort to understand and maintain, it is less likely that households continue to use these systems [72,76,77]. While the effort to learn is a behavioral control factor, the accessibility of a system is more related to context. For example, a smart meter must be present for a household to be able to use it, but if the program is too complicated or the meter is in an inconvenient place, it would not be used often. Hence, both determinants impose a certain effort to master the system. Lastly, while most studies did find persistent effects of their interventions or stimuli, refs. [73,74] found that once a cue is removed and the context is destabilized, it might take too much effort for some households to maintain conservation behavior. This made them fall back to their original routines. Hence, effort is also related to habitual factors.

Table 3 provides an overview of the four key factors. It contains a brief explanation of which determinants fall into this category and in which studies this factor is present.

**Table 3.** Key factors of long-term conservation behavior.

| Factor | Brief Explanation | Determinants | Studies |
| --- | --- | --- | --- |
| Consumption feedback | Households tend to change towards conservation behavior and maintain this behavior if they are provided with information about their consumption. Provided with the right information and if used frequently, consumption feedback can be an effective mechanism to maintain conservation behavior. | Consumption feedback, consumption literacy, goal reachability | [9,13,15,53–57,59,63–70,74,79] |
| Household characteristics | More affluent households and bigger households tend to have a higher water and energy usage in the long term. They have more opportunities and control to invest in efficiency measures but are also accustomed to a high-usage lifestyle. | Dwelling, household income, household size, devices | [13,37,39–43,45–49,56,58,59,76,77,79] |

**Table 3.** *Cont.*

| Factor | Brief Explanation | Determinants | Studies |
| --- | --- | --- | --- |
| Effort | Households tend to maintain old behavior if conservation behavior requires too much effort. | Comfort, context stability, frequency of use, technology comprehension, accessibility systems | [13,15,45,47,49,51,55,58,67,72,73,76–79] |
| Motives for conservation behavior | Households could be intrinsically motivated because of environmental concerns or extrinsically motivated by social norms to display long-term conservation behavior. | Environmental concerns, social norms, climate | [9,13,14,36,49–52,54,55,60,63,68,70,73,75–80] |

## 4. Discussion

This literature review aimed to synthesize the existing evidence on determinants for long-term conservation behavior. From the reviewed studies, four key factors were drawn that play a notable role in long-term conservation behavior in households: consumption feedback, household characteristics, effort, and motives for conservation behavior. Maintaining conservation behavior can be encouraged through specific and continuous feedback on the household's consumption pattern. The feedback can have various forms that preferably should be related to the household characteristics. This is relevant because household characteristics play a significant role in the maintained level of consumption in the long term. Enforcing conservation behavior is thus dependent on these household characteristics, and consequently, interventions should be tailored toward these characteristics. Moreover, conservation behavior ideally should require little effort and the cues that trigger the behavior change should remain in place over time for it to be maintained in the long term. In addition, internal motivations like environmental concern and external motivations like social norms and the climate can increase the likelihood of long-term conservation behavior.

As to studying long-term conservation behavior by households, we found that there are three approaches, each with their own specific determinants and purpose (summarized in Figure 2 and Table 3). First, studies that consider persistent behavior identify household characteristics such as household income and the composition and size of the household as the main barriers to long-term conservation behavior. Over time, a behavioral pattern is based on these factors, and it becomes difficult to increase conservation levels as rebound effects might come into play. Second, studies that focus on maintaining behavioral change point mainly towards consumption feedback and literacy, yet there is mixed evidence on what type of feedback stimulates maintained change. Third, studies that investigate the intention to maintain behavior reveal that intentions are largely the product of attitudes, with environmental concern as a stimulus and the fear of discomfort as a barrier to long-term conservation behavior. It turned out that context plays a crucial role in long-term conservation behavior in all three approaches. The stability of the context is necessary to maintain appropriate habits or for behavioral patterns to persist. The presence and accessibility of resource-efficient devices also form a context in which long-term conservation behavior is more achievable.

If we compare the three approaches, we notice that each of the study designs has its own strengths and limitations (see Table 4). The longitudinal study design helps to explain what determinants are responsible for the level of water or energy usage in the long term. It reveals behavioral patterns and the contributing contexts that correlate with a particular water or energy consumption level. In addition, the effect of efficiency measures on conservation levels can be identified by means of a longitudinal study design. On the downside, there tends to be little focus on the role and determinants of long-term curtailment behavior. Future longitudinal studies of conservation behavior could pay more attention to curtailment behavior. This way, stimuli to change the accustomed lifestyle that [52] referred to might be revealed. A more fundamental shortcoming of this

study design is that the patterns found might be correlations instead of causality. We recommend using an intervention to get a better grasp of causality or choose a specific setting where the long-term conservation behavior can only (or mainly) be attributed to the measured determinants.

**Table 4.** Differences between long-term study designs.

| | **Persistent Behavior** | **Maintained Behavioral Change** | **Intention to Maintain Behavior** |
|---|---|---|---|
| Primary method | Survey | Experiment | Survey |
| Strengths | Identification of behavioral patterns<br>Connection of efficiency measures to household consumption | Ideal to find causal mechanisms<br>Usage of follow-up studies<br>Directions for stimulating conservation behavior | Inclusion of many possible determinants<br>Inclusion of attitudinal explanations |
| Limitations | Correlation instead of causal mechanism<br>Little focus on lifestyle/particular water or energy practices | Sometimes self-reported behavior<br>Possible Hawthorne effect | No focus on actual behavior<br>Correlation instead of causal mechanisms |
| Recommendations | Add curtailment behavior<br>Connect study to an intervention | Pre-intervention measurement<br>Usage of water and energy meters | Multiple surveys for the maintained intention<br>Connecting intention to behavior |

The studies that investigate maintaining behavioral change tend to use an experimental study design, which is well-suited to find causal mechanisms that initiate conservation behavior. By either tracking the subjects for a longer period of time or by using a follow-up study, the researchers can measure the extent to which the new behaviors are maintained. These studies provide a clear direction for stimulating long-term conservation behavior. While this study design does seem ideal for identifying the determinants of long-term conservation behavior, there are some potential pitfalls. For instance, some studies rely on self-reported data (e.g., [65,68]), but it is known that self-reported conservation behavior has reliability issues [9]. In recent research, the use of smart meters has become common practice and we recommend using these instead of relying on self-reported data. Other studies have a relatively small sample size (e.g., [37,58]) or do not have a follow-up on their intervention. In addition, the participants in experiments might be subjected to the Hawthorne effect [62]. The participants could display the desired behavior because they know their behavior is tracked. To tackle this issue, future studies could use a pre-intervention survey to estimate baseline behavior. Refs. [64,74] already used a pre-intervention measurement as part of their study design. Lastly, these studies exclusively look at curtailment changes, while an efficiency intervention is more effective [22] and the reasons for rebound effects could be explored.

The studies that look at the intention to maintain long-term conservation behavior stand out by the number of variables they include in their surveys. For example, ref. [13] considered eleven distinctive water-saving behaviors and could include seventeen explanatory variables. This type of research could thus explore what type of explanations might be most viable to consider more in-depth. An in-depth follow-up might be necessary as research into intention does not explain actual long-term conservation behavior. Also, some studies use just one single questionnaire (e.g., [13,78]). Even though it provides a direction to consider the determinants of long-term conservation behavior, it does not show whether these intentions are maintained over time. In addition, it is much more likely to find correlations rather than causal mechanisms with this type of research.

Aside from the recommendations for each specific study design, there are also more general avenues for future research, mostly concerned with unresearched or promising determinants. First, in all three study designs, context turned out to be an important factor in long-term conservation behavior. These contextual factors could vary from the presence of devices to the stability of context and to the social environment. While we have covered

some contextual factors, there are probably more factors of influence. Future studies could consider which different contexts could be a pathway to long-term conservation behavior. What combinations of contextual factors could serve as necessary conditions for long-term conservation behavior?

Second, one of the most promising avenues for both policymakers and researchers is tailored feedback. Both household characteristics and consumption feedback appeared to be an important factor in the studies of this review. A total of 14 of the 49 studies used feedback as an intervention, and one of the findings was that elaborate feedback was most effective [64,65]. Future research could concentrate on identifying more tailored approaches for specific household characteristics to encourage long-term conservation behavior.

Third, effort was identified as one of the key factors in maintaining conservation behavior. Effort is a barrier to changing toward conservation behavior and too much effort is a stimulus to abandon conservation behavior. Future research could consider how effort constrains maintaining conservation behavior and how different levels of effort (e.g., lack of comfort, habit development, and accessibility) interact with one another. While research has been conducted into effort-based choice models [81], this could be connected to long-term conservation behavior.

Fourth, this synthesis has mainly focused on the effects of individual determinants. However, these determinants do not exist in isolation from each other. For example, studies involving smart meters often use multiple mechanisms to encourage long-term conservation behavior (e.g., [54,73]). Also, many different determinants were found to have an effect on long-term conservation behavior. Long-term conservation behavior might be subjected to causal complexity: the idea that different combinations of determinants can all lead to the desired outcome [82]. Future research could focus on identifying the different configurations of determinants that cause long-term conservation behavior.

## 5. Limitations

One of the main limitations of this study is the inherent bias towards countries in the Northern Hemisphere. The USA and European countries are overrepresented in the studies. One could thus question whether the identified key factors and determinants would also apply in countries with rather different climates and cultures like South American and African countries. Even though there is little evidence on whether rainfall has an impact on long-term water demand (e.g., [36,42]), there is a representation of countries that are more susceptible to droughts like Australia (see [13,36,60,69]) or Kuwait [43] and, for example, Indonesia, that is more vulnerable to heavy rainfall [39]. The sample size of these countries is small, and we suggest remaining careful when applying the identified determinants to countries with less moderate climates. In the Supplementary Materials, there is an overview of the countries in which the studies included in this review were conducted. Another reason for this bias might be because we considered only English papers.

The second limitation of this review is in study selection. It is possible that there are more studies that qualify for the selection criteria of the review yet did not come up by searching on the query. Through snowballing, we identified six extra studies to enhance the sample of this review, yet it remains possible that some studies that would have been relevant were not found. Consequently, the list of determinants might not be exhaustive, because the scholarship on long-term conservation behavior might have overlooked relevant determinants. However, with regard to the available evidence, the snowballing method added only six studies to the review which fitted with the factors found in the other studies. Moreover, a comparison with other reviews on energy and water conservation behavior [6–8,11,12] and the maintenance of behavioral change [83] let us believe that the four key factors we identified do provide a comprehensive overview of the main mechanisms that apply to long-term conservation behavior.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16114399/s1, Table S1. Elaborate table summary determinants to long-term conservation behavior; Table S2. Included studies in review. References [9,13–15,35–61,63–80] are cited in Supplementary Materials.

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