

## Review

# Residential Sustainable Water Usage and Water Management: Systematic Review and Future Research

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**Abstract:** Sustainable water management has vital ramifications for people's societal, economic and environmental future. To advance research in this domain, this article synthesizes the current state of knowledge regarding water resource management in the residential context. The aim of this paper is to identify research gaps and future research directions for residential water management in order to recommend solutions against water scarcity. To that end, this article applies bibliometric analysis and the Antecedents, Decisions and Outcomes (ADO) framework to the literature on residential sustainable water management. We reviewed the most impactful journals, most frequently cited articles, keyword trends and density-centrality maps. The in-depth analysis on 114 articles underscored three orientations for residential water usage and management: urban, household and consumer. Based on this analysis, we were able to identify the significant topics that structure this research field, as well as research gaps and future directions.

**Keywords:** water usage; water consumption; water management; sustainability; residential; systematic review



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## 1. Introduction

The availability and management of freshwater is foundational to human civilization. However, water is a largely irreversible resource: At present, humans have no way of expanding their water allowance, but excess activity can diminish our supply [1]. While societies have invented valuable technologies for manipulating and distributing freshwater to sustain their populations [2]—dams, irrigation systems, hydropower, and so on—the demand created by human activity is outpacing our available water. People's broadening awareness of this fact is reshaping their water consumption habits.

Against this backdrop, the three most notable sectors for water consumption are agricultural, industrial and domestic. Agricultural irrigation uses approximately 70% of total water consumption [3] due to its foundational role in food production and economies [3]. Industrial water use, accounting for approximately 19% of the total, is the result of accelerated economic growth, which merits finding ways to balance economic development with sustainable water resources [4]. Domestic water consumption accounts for approximately 11% of total water consumption [5]. Based on WRI's Aqueduct [6], domestic water demand increased by 600% from 1960 to 2014. Some of the main domestic water usage activities are showering, washing-machine usage, toilet flushing and outdoor activities such as swimming pools [7]. The primary drivers of domestic water consumption seem to be urbanization, brisk population growth and higher living standards, which result in excessive domestic water consumption, but there are other relevant factors such as price, monetary incentives [8], socioeconomic factors, the size of housing and outdoor space, as well as house typology, which are some of the most commonly found determinants of water consumption in literature on the subject [9]. Despite this breadth of knowledge, there are relatively fewer articles regarding sustainable water usage and management in the

domestic sector. Sustainability in water usage can be explained based on the Brundtland report, which defines sustainability as ‘the way to ensure that development meets the needs of the present without compromising the ability of future generations to meet their own needs’ [10]. Thus, sustainability on water usage is finding ways to use and manage water in a way that development will be assured while future generations will not have to face critical issues of water scarcity. In addition, as this paper will also focus on water management, it is crucial to mention that sustainable water management concerns the proper allocation of water resources, management optimization of resources, analysis of the climate change and its effect on water and management of natural disasters and their effects on water resources in order to assure that present and future generations will have water supplies [11].

In order to synthesize existing knowledge on this topic and narrow the research gap regarding finding solutions to excessive residential water usage, we followed the suggestion of many authors and performed a bibliometric review [1]. This technique uses quantitative analysis and statistical methods to construe patterns and trends among research articles on a specific topic. Here, we conducted an in-depth bibliometric analysis of articles in the Web of Science database that concern water management. Additionally, we conducted a content analysis based on the ADO framework [12], which examines the antecedents (A), decisions (D) and outcomes (O) of the collected articles. The ‘antecedents’ of a study are defined as the motives behind the research, ‘decisions’ are defined as the characteristics of a study and ‘outcomes’ are the results. The main aim of this content analysis is to examine the anatomy of our research area and identify any kind of research patterns [13]. Combined, our analytical methods may serve to illuminate the breadth and depth of research on residential water usage, as well as existing research gaps and future research directions. The need for this kind of research lies in the fact that research regarding residential water usage should be broader and cover similar research topics that have not been analysed up till now. However, in order to do so, we need a clear picture of what has already been researched and what has not; this can be achieved by a systematic analysis of the specific research area. By doing so, we hope this research will inspire new solutions for sustainable water management. In addition, past reviews regarding water were mostly focussed on the agricultural industry, water resources and sustainable water usage [14–16], but none of them has focussed on residential water usage and water management. The uniqueness of our study also relies on the combination of two different systematic review methods, bibliometric and content analysis; in previous reviews it is more common that only one method was used.

Given the above, our study seeks to answer the following questions: What are the existing studies in residential water usage and water management? How much research on water usage and management specifically addresses sustainability? Who are the most influential authors in this domain? Which is the most influential journal? What are the most popular research topics in this field? Do existing studies present any solutions and/or future implications for sustainable water consumption? What are the antecedents, decisions and outcomes of the selected articles? By systematizing the available knowledge regarding water consumption in the context of sustainability, we aim to reveal trends and directions that can be utilized by future research.

The present article is divided into five main sections. Following this introduction, the second section details the conceptual framework that underpins our analyses. The third section describes our research methodology, search criteria and data collection. The fourth section details the results, while the fifth section presents the conclusions of the findings from our analysis to establish the theoretical framework of our study.

## 2. Conceptual Framework

With many nations facing water scarcity issues for the foreseeable future, proper water usage and management are crucial topics for academics, policymakers, water system managers and administrators [17]. While water management is integral to sustaining a

good quality of economic, environmental and societal life, the term itself is broad and complex, taking on different meanings in various contexts. In agriculture, for instance, water management concerns the usage and conservation of water for crops, but in the context of irrigation systems, the term is related more to addressing industrial, domestic and recreational needs [18]. Given this dynamic, research has generally defined water management as the control of water resources for the sake of increasing efficiency. This encompasses activities such as fresh water supply, water treatment systems, waste water management, irrigation and drainage [19]. Here, we take water management and water usage as correlated terms because they both reflect how water is controlled.

As mentioned in the introduction, there are three sectors that consume the majority of water: agricultural (70%), industrial (19%) and domestic (11%) [5]. Obviously, water is essential to agriculture; it is necessary for increasing crop production, and by extension, maximizing food productivity, lowering food insecurity and strengthening the economy [20]. Without proper water usage and management, the agriculture sector cannot sustain itself [21]. Because of the sector's high total water use, scholars have already performed extensive studies on sustainable water management in agriculture. Case in point: previous bibliometric research identified and examined 436 articles related to agricultural water use, management and sustainability issues [15]. For example, previous research has examined how to improve sustainability in irrigation systems [15,22] and has presented the agricultural poverty index in order to showcase vital issues regarding sustainable agriculture management [23]. In addition, a recent study by [24] summarized the water-saving techniques utilized by farmers.

The second-largest water consumer is the industrial sector, which encompasses manufacturing firms, mines and other energy generating facilities. The advance of industrialization has led to constant increases in water usage, and there is little reason to think this trend will abate in the near future [25]. This sector uses water primarily for goods production and cooling purposes, but also for activities such as plant cleaning and sanitation [5]. In this domain, authors have explored the factors that influence industrial water use [24], investigated policies that can lead to better utilization [26] and examined tools for better water management [27], particularly in relation to sustainability [28].

The third sector, domestic, represents a smaller amount of total water consumption, but is nonetheless a critical domain due to the rapid increase in domestic water use. Data from WRI's Aqueduct platform [6] indicate that domestic water use increased by nearly 600% from 1960 to 2014. Population growth, climate change and urban development may explain the bulk of this trend, but certain consumer actions—such as showering—are also notable. In the Netherlands, 40% of domestic water was used in the shower, 28% in the toilet and 12% from washing machines [29]. Previous research in this domain has adopted a similar focal point: the determinants of consumer water demand in terms of water end behaviours, socio-demographics and psychological constructs [30]; the determinants of home water consumption [31]; the causes of domestic water consumption in terms of housing infrastructure [32] and urban sustainability policies [33]. However, it is clear that few articles have examined sustainable solutions to water consumption in the residential sector.

Sustainability addresses the relationships between economic and ecological systems—in other words, how humans can develop while simultaneously protecting and developing ecological life. Water is a foundational consideration in this regard. Previous systematic reviews have focused on sustainable irrigation systems [33], water use [16,33] and agricultural efficiency [16]. Other systematic reviews have examined water management and sustainability in terms of managing storm water [34] and roof-harvested water [35], as well as addressing water allocation problems [36]. There have also been some efforts to map humanity's water footprint [37] and manage sustainable resources [1]. We synthesized these reviews in the table below, which makes it apparent that few articles have concentrated on water management and sustainability in the residential sector. Notably, even the consumer-oriented articles—such as the study on household water conservation behaviours [38] and the systematic review of public perceptions surrounding decentralized

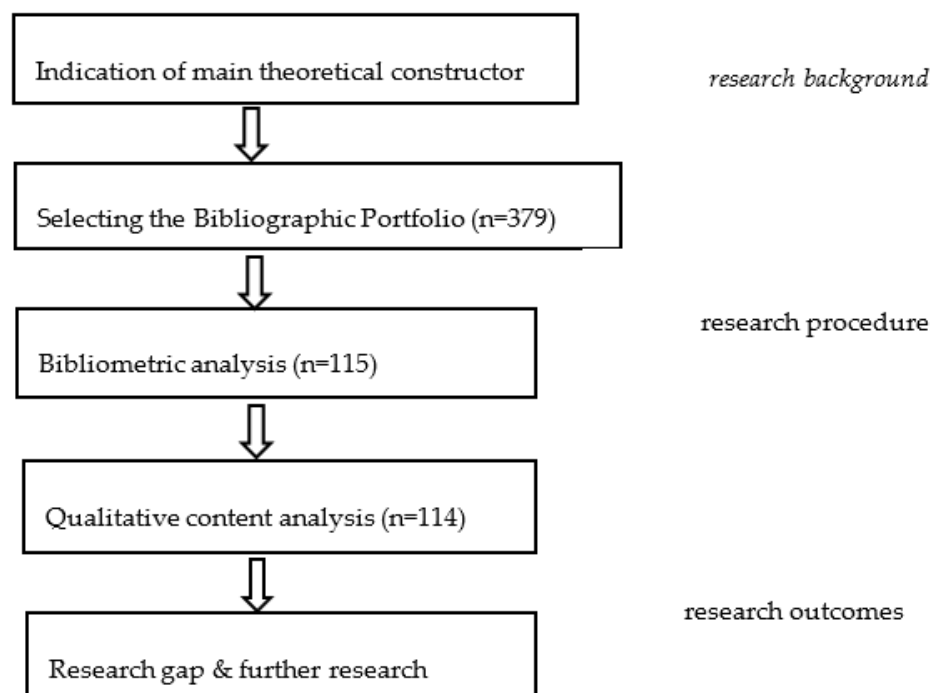
wastewater systems—do not adopt a specific framework for their analyses [39]. Thus, Table 1 illuminates a considerable research gap regarding water use in the residential sector. To fill this gap, we will perform bibliometric and ADO framework analyses on the three pillars of residential water use: urban, household, and consumers.

**Table 1.** Overview of systematic reviews on water usage.

	Main Area(s) of Interest	Limitation(s)	Articles Reviewed	Method(s)
Ricart et al. (2021) [40]	Reclaimed and desalinated water returned and rainwater	Focused on south-eastern Spain	81	Bibliometric and literature review
Nkosi et al. (2021) [14]	Land Management on Water Resources	Focused on the South African context	39	Literature review with thematic analysis
Gebre et al. (2021) [36]	Water Allocation Problems		49	Systematic literature review
Gómez-Román et al. (2020) [39]	Public perceptions of the acceptance of decentralised wastewater treatment systems		46	Systematic literature review
Ochoa-Noriega et al. (2020) [15]	Water in Agriculture	Focused on Mexico	436	Bibliometric
McCarroll & Hamann (2020) [41]	Water literacy		55	Thematic Literature review
Ehret et al. (2019) [38]	Interventions based on content and water conservation effectiveness		66	Systematic literature review
Velasco-Muñoz et al. (2019) [33]	Sustainable Irrigation in Agriculture		713	Bibliometric
Wu et al. (2019) [34]	Stormwater Management		3080	Bibliometric
Aleixandre-Tudó et al. (2019) [42]	Global water-use efficiency focusing on Agricultural Science		2077	Bibliometric
Harmanny & Malek (2019) [43]	Irrigated agriculture	Focused on the Mediterranean area	85	Systematic literature review of case studies
Jeuland et al. (2019) [44]	Water information systems		764	Systematic literature review
Boeuf & Fritsch (2016) [45]	Water Framework Directive in Europe		89	Meta- and bibliometric analysis
Amos et al. (2018) [35]	Roof Harvested Rainwater Usage in Urban Agriculture	Focused on Australia and Kenya Scopus Subject areas of: “Economics, Econometrics and Finance”, and “Business, Management and Accounting”	160	Scopus review
Aznar-Sánchez et al. (2018) [46]	Sustainable water use		1022	Bibliometric
Durán-Sánchez et al. (2018) [1]	Sustainable Water Resources Management	Query string limited to article title	370	Bibliometric
Velasco-Muñoz et al. (2018) [16]	Sustainable Water Use in Agriculture		2084	Bibliometric
Zhang et al. (2017) [37]	Water footprint research		636	Bibliometric

### 3. Methods

We conducted a structured review of the literature in order to accomplish our objectives. Figure 1 depicts the research scheme we followed.



**Figure 1.** Structured review procedure.

We specifically focused on scientific articles published in journals that are listed in the Web of Science database. Web of Science was chosen based on previous research as it provides high standard literature with many available and updated scientific papers and publications from many disciplines since 1945 that can be used for our review [1,40].

We refrained from specifying a time frame in order to capture all research to date; thus, the study considered all articles indexed in the analysed database as of 23 January 2021. We limited the search to three domains: water management, residential usage and sustainability. We also reviewed the articles' abstracts and keywords in order to derive a list of synonymous terms. The final version of the query in the search engine was:

- (1) water management—"water management" OR "water consumption" OR "water-use" OR "use of water" OR "water use" OR "water usage";
- (2) resident—resident\* OR household\* OR house OR home;
- (3) sustainability—sustainable OR sustainability.

Where the OR separator indicates the need for at least one of the indicated terms, and the symbol "\*" captures all words that start with the preceding prefix. The search was limited to research articles published in English. Given these parameters, we arrived at 379 items before manual selection. This database resulted from the limitation of articles related to water management (7689 articles), the residential area (1409 articles, which constituted 18.23% of all articles) and, additionally, the field of sustainable water management. Next, all authors reviewed the abstracts, titles and keywords in order to exclude articles whose research subject was non-compliant with our focal issues. Specifically, each author reviewed each paper in order to identify whether it related to sustainable residential water management or usage and elected to exclude it otherwise. After individually reviewing the articles, we compared our results. In the case of discrepancies, we read the full texts and reached a consensus through discussion. There were 42 cases that merited this extra step. Of these 42 cases, we reached a total agreement rate of 94%. This process left us with 114 articles for the full review.

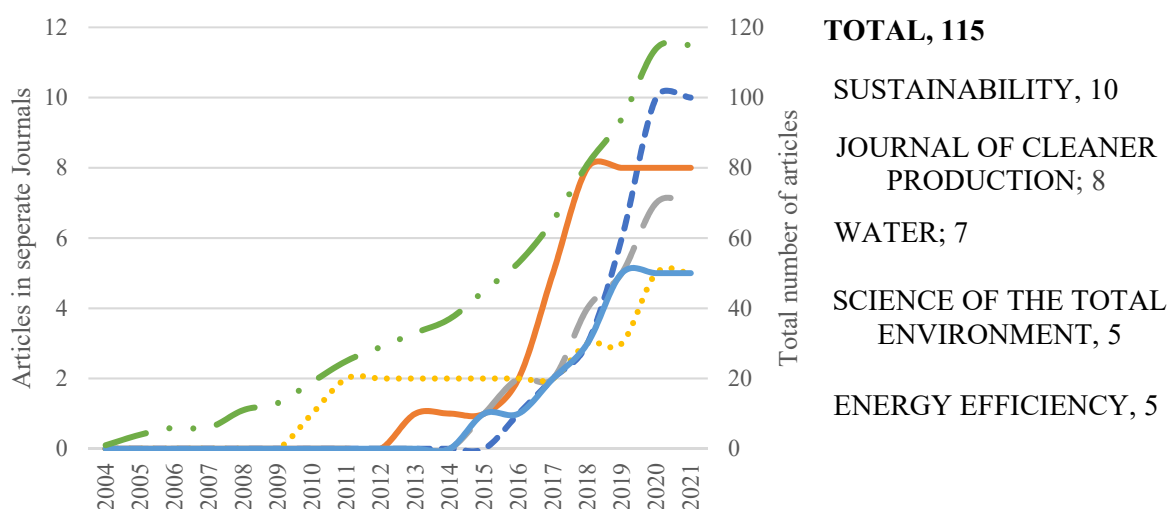
First, we conducted a bibliometric analysis in order to discern patterns in the articles that could be used to inform future research avenues. This type of analysis is statistical in nature and is often accompanied by author analysis, conceptual maps, citation analysis and

other tools. We downloaded the data from WOS and uploaded them into R software, which is a powerful analytical tool that can visualize the results. We also incorporated keywords and their frequency, alongside the articles' time stamps, in order to detect trends. In the second part of the analysis, we examined the full texts. There was one case where we could not obtain the full text, and thus we focused our analysis on the remaining 114 articles. The analysis used the Antecedents-Decisions-Outcomes (ADO) framework to synthesize all studies and uncover new research directions. Prior to analysis, we separated the collected articles into three main categories: the first concerning articles related to consumers and their behaviour toward water; the second concerning articles about households and their water consumption, and the third concerning articles about urban water consumption. Following this step, we examined the antecedents for each category (i.e., the motives behind analysing water consumption), the decisions (which includes what the articles decide to focus on) and the outcomes (i.e., the results as they relate to water consumption and sustainability). It is crucial to mention that ADO dimensions are inter-related: For instance, droughts (A) may influence the characteristics of decisions such as location (D), which will further have an impact on the outcomes (O). The ADO framework analysis has not been applied to this research area yet, and thus can work in tandem with the bibliometric analysis to generate novel insights and future research directions.

## 4. Results

### 4.1. Bibliometric Analysis

The first step in the bibliometric analysis was to determine the total number of articles, the places of publication, and any relevant trends. The articles covered the time period 2004–2021. The number of publications increased by an average of 22.11% per year, with the largest volume [20] being published in 2020. All 115 of the analysed articles were published across 68 journals. Figure 2 presents the cumulative change in the number of articles over the years. Additionally, in this graph, the number of articles in the 5 journals that most often published results in this area is shown.



**Figure 2.** Article trends.

In the second step of the analysis, we considered the source's local impact. The h-index value—encompassing the number of citations, the number of articles and the publication time range—was the highest (h-index = 6) for the Journal of Cleaner Production. Table 2 presents a list of the 10 journals with the highest h-index, taking both the productivity and impact of the published articles into account. When examining the m-index, which is a variant of the h-index (considering the year of the first publication), we found that Science of the Total Environment achieved the highest ratio.



**Table 2.** Source's local impact.

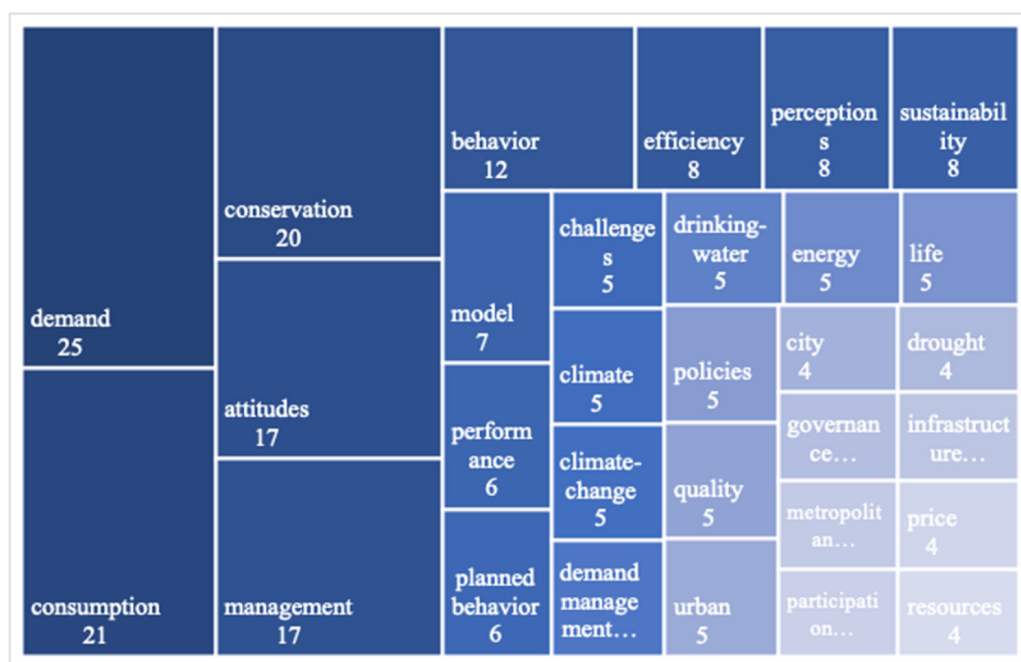
Source	h-Index	M-Index	Total Citations	Articles	First Article
Journal of Cleaner Production	6	0.67	183	8	2013
Science of the Total Environment	5	0.71	58	5	2015
Resources Conservation and Recycling	4	0.31	44	4	2009
Sustainability	3	0.50	28	10	2016
Water	3	0.43	25	7	2015
International Journal of Consumer Studies	3	0.27	56	4	2011
Energy Efficiency	2	0.17	113	5	2010
Journal of Environmental Management	2	0.14	77	3	2008
Ecological Economics	2	0.14	58	2	2008
Journal of Industrial Ecology	2	0.17	36	2	2010

At the next stage, we analysed individual articles. The most cited article in global terms was by Gill [47], which was referenced 196 times in total or 16.3 times per year. Table 3 presents the 20 papers with the highest number of citations. In total, all 115 articles were cited 2007 times. The articles represented 371 authors in total, with each document having an average of 3.23 authors. Nine cases were single-author works. The author with the most publications was Stamminger R., who published five articles.

**Table 3.** The most influential publications.

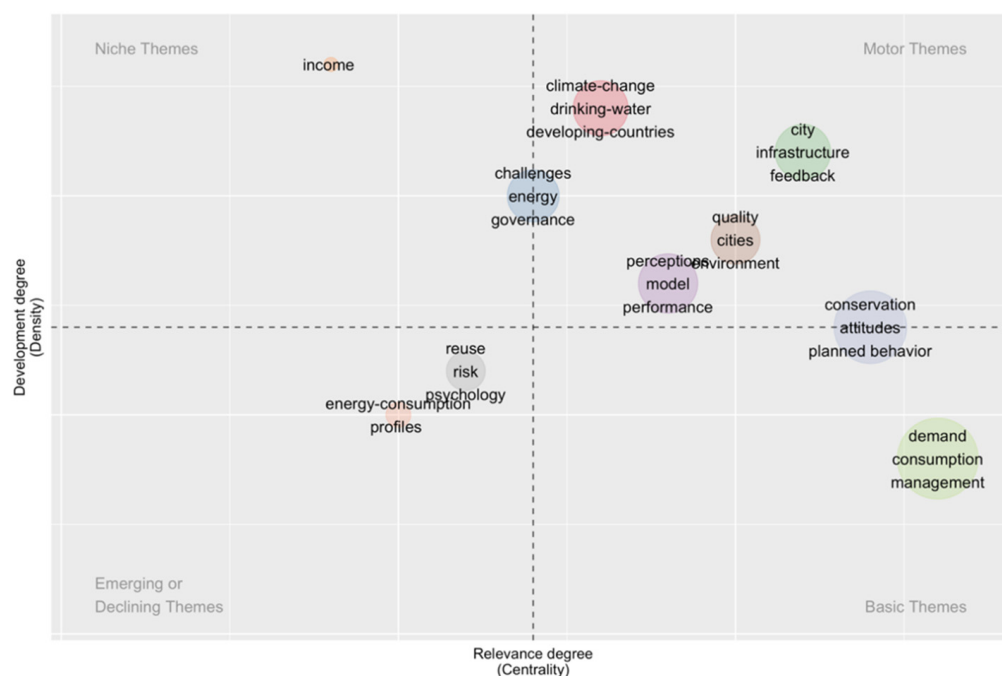
Paper	Total Citations	TC per Year
GILL ZM, 2010 [47]	196	16.3
GUHATHAKURTA S, 2007 [48]	135	9.0
SYME GJ, 2004 [49]	126	7.0
HARLAN SL, 2009 [50]	99	7.6
BEAL CD, 2013 [51]	89	9.9
PAKULA C, 2010 [52]	88	7.3
HOUSE-PETERS L, 2010 [53]	88	7.3
DOMENE E, 2005 [54]	72	4.2
KURZ T, 2005 [55]	70	4.1
HURLIMANN A, 2008 [56]	61	4.4
HEAD L, 2007 [57]	60	4.0
MALLER C, 2012 [58]	57	5.7
MILLER E, 2008 [59]	53	3.8
BITHAS K, 2008 [60]	45	3.2
BROWNE AL, 2014 [61]	32	4.0
LOWE B, 2015 [62]	29	4.1
DEAN AJ, 2016 [63]	26	4.3
DEUTSCH M, 2010 [64]	26	2.2
STAMMINGER R, 2011 [65]	25	2.3
LIU A, 2015 [66]	23	3.3

In order to obtain the main keywords that were used to the collected articles, we used Keywords Plus, which is the proprietary algorithm of Clarivat, a database of WOS articles for assigning keywords. Based on Keyword Plus, 344 keywords were obtained. Differently from the authors' keywords, the Keywords Plus field is normalized. Figure 3 presents a list of the 30 most common keywords.



**Figure 3.** Most common keywords.

In order to detect, quantify and visualize the evolution of a research field, we created a strategic diagram using co-word network analysis and clustering [67]. All clusters are visualized on two axes, development and relevance, while accounting for the number of publications, their citations in local and global terms and the strength of the relationship with other clusters into account (Figure 4).



**Figure 4.** Strategic diagram.

The axes naturally gave rise to quadrants in the graph above. Centrality is the degree and the strength of interaction between clusters and research themes; the more links a research theme has with others, the more central that theme becomes. Density is the strength of the internal ties that comprise a theme. In our case, the research themes were



represented by the keywords used in the articles and their links. Topics that appear in the upper-left quadrant are considered niche topics with marginal importance in the research area. The one niche topic is the area of “income”, which is well-researched but has little external relevance. One example is a study which mainly examined the influence of consumers’ economic status on their behaviour, including water demand [68]. Themes placed in the lower-left quadrant are not well developed and have marginal importance to the topic. This quadrant features two clusters: the first using the keywords “reuse, risk and psychology” and the second using “energy consumption and profiles”. Examples of these clusters include the studies that investigated the adoption of water reuse by applying the Social Amplification of risk framework [69] and studies that examined the societal and personal practices of showering [70]. The lower-right quadrant covers basic themes that are important for the field, but not yet developed. In that quadrant, there are usually articles that also appear in other research fields. Our analysis revealed one cluster in this quadrant built around the terms “demand, consumption and management”. As an example, there was one study that investigated smart meters in the context of water demand, consumption and management [71]. Finally, the upper-right corner presents “motor themes”. These articles have high density and centrality and are thus considered well-developed and important for the research field. One cluster in this quadrant contains the terms “city, infrastructure and feedback”, which exemplified research on the influence of smart meters on a city’s water consumption [72]. Another theme from this quadrant is “climate change, drinking water and developing countries”, which is reflected in a paper dealing with water resource adaptations in the face of climate change [73]. A third cluster includes keywords such as “quality, cities and environment”. As an example, a paper described how different water quality targets for the water purification process can actually save energy and help the environment in cities [74]. A fourth cluster, featuring the keywords “perception, model and performance”, is embodied by studies that use an empirical agent-based model to analyse the risk perception of water reuse [69]. A fifth cluster, built on the keywords “challenges and energy governance”, is exemplified by a study which analysed the challenges of user perceptions toward decentralized water [75]. Notably, the cluster referring to “conservation, attitudes and planned behaviour” is highly significant, but less developed than the rest of the motor themes. Thus, this thematic map illustrates a research gap and provides directions for future research, specifically in relation to consumers’ water attitudes and conservation behaviour in connection with planned behaviour theory.

#### 4.2. ADO Framework Analysis

After conducting the bibliometric analysis, we proceeded to analyse the antecedents, decisions and outcomes (ADO) of articles related to residential water use. In order to more finely analyse the antecedents, we separated the articles into three themes: urban, household and consumer. For the urban theme, we separated articles’ antecedents into four main categories. The first category, sustainable water use, covers articles focused on sustainable water use in cities [60] and buildings [76], as well as outdoors [77]. In all these cases, the specific motive for analysis is unsustainable urban water consumption. The second category is water scarcity and droughts, specifically in countries such as Australia [78,79] and Jordan [80]. The third category, water supply systems [74], is motivated by a desire to improve these systems. For instance, previous research focused on how to improve such systems in urban settings [81], while other studies analysed a local community’s supply systems [82] or semiarid regional supply systems [83]. The fourth category of urban antecedents is underpinned by the motive to generally improve and provide water to everyone. These studies grapple with the prices of drinking water [84], water and sanitation services [85,86], securing long-term water availability [87] and water access [75,88] in the context of urban environments.

The second theme for which we identified antecedents is household water consumption. The first category of antecedents is related to ways of making household appliances more environmentally efficient [52,89,90] in order to counteract relatively high household

water and energy consumption. The second category of antecedents involves ways to make housing more sustainable [90] and perform green renovations [58]. The third category of antecedents is connected to water use [91], management [49,71], conservation [92] and sustainable practices [93] in households.

The third theme, consumers, concentrates on their regular and sustainable water consumption [66,72,94,95], sustainable water management [72,96], the use of resources, water consumption reduction [68,73], consumption conservation [62,97] and eco-friendly behaviours [98]. The majority of these studies highlight the importance of finding ways to reduce excessive water consumption and thereby mitigate water scarcity. In relation to this, much of the consumer-oriented research emphasizes the importance of sustainability; a number of studies regard water shortage [99,100], short-term supply constraints [101] and drought [102] as problems that should be examined and addressed from the consumer perspective. In almost all the categories of antecedents, authors highlighted climate change [73,103] and environmental problems [104], and protection of water resources [105] were also discussed in order to find adequate solutions.

After uncovering the antecedents for these themes, we proceeded to analyse the decisions within each article. Studies focused on households were largely concerned with analysing home appliances. Past researches examined how dishwashers can be energy-efficient and waste less water [89,90,106], while others did the same with washing machines [52]. Similarly, Brunzell [107] investigated technological household improvements that can reduce water consumption, while Retamal and Schandl [93] investigated the most efficient methods for doing laundry. Other studies in this realm considered factors that affect household water consumption. For example, March [71] examined how metering systems could be effective in water conservation, while Beal [51] analysed how smart metering can be used to find the socio-demographic factors that affect water consumption. Other researchers analysed how demographics, lifestyle, social desirability, conservation attitudes, garden interest and garden recreation could play an important part in household water consumption [91]. Notably, the decisions in this category did not refer to the location or size of the study, but rather to other dimensions such as the factors and tools used.

Regarding the urban theme, a major dimensional focus was on local communities. Moshtagh and Mohsenpour [83] examined the community's view on water issues, while other researchers analysed the community's perception of water supply [88] or its satisfaction with recycled water [56]. Another dimension of this category is the influence of social and economic forces on water conservation [81,84], as well as social inequality [59]. Many researchers in this category used economic dimensions to examine water consumption; for instance, "water management pricing" [60], "low income population" [68], "pricing policies" [80] and "forms of capital on consumption" [82]. In summary, this category focuses on society and how it is interrelated with not only the aforementioned antecedents, but also the outcomes that will be highlighted below.

Regarding the consumer theme, these articles largely focus on how providing information can help to reduce consumers' water consumption. For instance, many scientists have analysed how providing feedback can contribute to water conservation, while others have focused on the marketing dimension (e.g., advertisements, social and water marketing campaigns, eco-visuals, leaflets and labels), but also more personal and direct information for the consumer, such as information provided by water metering systems. Additional research in this category was focused on the factors that influence water use [59,96] and water habits [108].

The third part of the ADO analysis, the outcomes, reflects the results of the collected studies. It is important to emphasize here that outcomes are interrelated to both antecedents and the decision. Thus, because the urban theme was largely related to the community, the outcomes naturally concerned the impact of the community's water behaviour. For instance, the study by Moshtagh and Mohsenpour [83] found that public knowledge and clarification would help enhance social trust and positive attitudes, as well as encourage the adoption of more responsible behaviours toward water resources. Moreover, Brown and Pena [85]

came to the conclusion that people's awareness of their environmental impact is predicated on their knowledge regarding their own consumption. As seen in the antecedents and decisions of urban category, societal outcomes were also examined. For example, the study by Satur and Lindsay [76] focused on low income and how it influences water consumption. The outcome of the study was that low-income societies consume water just to meet their needs, without consuming excessively.

For the household theme, the outcomes mainly referred to home equipment. For example, studies examining the effectiveness of household appliances reached the conclusion that dishwashers [89,90,106] and washing machines [52,93] can actually reduce household water consumption. However, other studies suggested that consumers should be educated and technology should be improved [109] in order to make household appliances more efficient. Moreover, some researchers in this domain examined the factors that may produce more sustainable water consumption behaviours in households. For instance, one paper found out that one's feeling of responsibility toward climate change can affect household water consumption [109], while Cvetković [110] found that households increased their water consumption in response to COVID-19 and the increased amount of time spent indoors. Lastly, Pearce [92] noted that location, household size and annual household income affect households' water consumption.

As with the above themes, the outcomes of research focused on consumer water use were connected to their antecedents and decisions. Specifically, these studies focused on methods for encouraging consumers to behave in a sustainable way (e.g., through marketing materials, educational materials, consumption feedback, etc.), and the outcomes were related to the most successful techniques. For example, studies focused on providing information to consumers [66,94,111,112] concluded that information can indeed impact water consumption. Likewise, studies found that feedback [66,104] and marketing campaigns [55,62,95,99,100] can influence consumer behaviour. Ultimately, these studies signal that having more knowledge [63]—whether in the form of feedback or marketing—can incline consumers to change their behaviour and consume less water [113].

## 5. Discussion

Although scholars have made progress in the domain of water management, there are still important questions that need to be answered. Thus, this section outlines the research gaps and some future research directions.

The first gap, arising from the literature review (see Table 1), is the lack of systematic analyses in the field of residential water use. While our use of bibliometric and framework analysis may help narrow this gap, there is still a gap regarding systematic analysis in the field of residential water consumption, while focusing on a different scope, for instance, concentrating specifically on urban, household or consumer aspects. In addition, our keyword analysis suggests an opening to more deeply explore the keywords “price” and “resources”, which only appeared in the studies by de Lira Azevêdo [114] and Okello et al. [115], respectively. The reason for the above research gap could be that researchers may not have access to reliable pricing information in order to examine this strand of literature. Future studies could, for instance, adopt a more economic orientation in order to more equitably address the three pillars of sustainability (economic, social, environmental). Another gap revealed by the keyword analysis is the exclusion of consumer characteristics. While “attitude”, “perception” and “behaviour” were present in some studies [102,116], there were no keywords relating to consumers' environmental behaviours, demographics or subjective norms. We could justify this research gap based on the fact that it is impossible to define a behaviour in a way that is comparable in many different contexts. The field would benefit from more research regarding how consumer characteristics influence water demand, as well as people's attitudes, perceptions or conservation efforts.

Our ADO framework analysis, a novelty in this field, revealed other meaningful research gaps and future research directions in relation to our three themes: urban, household and consumer. Most of the analysed articles on household water consumption concen-

trated on home appliances or green renovations as part of efforts to increase sustainability. For instance, studies examining how dishwashers and laundry techniques can affect water resource consumption, and these studies also uncovered more sustainable alternatives [93,106]. However, the excessive focus on this aspect of household consumption has created some research gaps. For instance, it would be beneficial to examine how household consumption is shaped by countries' differing levels of technology. Do countries without access to efficient household appliances consume more or less water? Another research gap concerns residential behaviour; for instance, why do residents use home appliances the way they do? This topic represents an exciting opportunity for the field to make progress in understanding and improving water management.

With regard to the urban aspect of residential water consumption, the analysis uncovered a heavy emphasis on societal issues, for instance, scholars focusing on topics such as community satisfaction, community perception, cities' water usage and water accessibility [56,83]. However, these articles tended to focus on communities embedded in countries or cities that are facing water scarcity, such as Australia or Jordan. While finding a solution for such communities is undoubtedly important, water scarcity is quickly becoming a global issue. Thus, future research might focus on finding proactive urban solutions for communities that are not currently facing water scarcity, but may in the future. In relation to this, researchers could look for ways to not only address water scarcity, but also prevent it. Moreover, as the ADO analysis uncovered, there is a need for more research examining communities' characteristics, for instance, their political situation, technological development, economic background, environmental sensitivity, and how these factors jointly affect a community's water consumption. As with the household theme, the urban theme needs more investigations into the characteristics that drive behaviour.

Lastly, with regard to the consumer theme, the ADO framework analysis revealed that previous research has mostly focused on how to prompt consumers to adopt more sustainable behaviours. For instance, studies focusing on educating consumers—whether via information or feedback regarding water usage, or through marketing materials [50,66]. In this vein, future research could explore other ways of encouraging consumers to behave more sustainably, for instance, with advertisements, water meters, social groups, visuals, information, educational materials, authorities, etc. On this point, there is a lack of research on the consumer characteristics that may shape their willingness to behave more sustainably. For example, “Is water consumption feedback internalized differently by older or younger consumers?”, “Are environmentally-friendly consumers keener on reading educational materials?”, “Does a consumer's geographical location affect their perception of green advertisements?”, “Are consumers facing water scarcity more sensitive toward water conservation information?” Understanding these characteristics will be crucial to determining the effectiveness of any given rhetorical method and promoting more sustainability.

## 6. Conclusions

Research on sustainable water use is becoming increasingly popular—a point evidenced by our bibliometric analysis. By collecting and analysing a significant number of studies regarding sustainable residential water consumption, we make a twofold contribution to the literature. First, we used thematic mapping to illustrate the topic's evolution, and second, we identified research gaps and future research directions.

With the bibliometric analysis, we depicted an annual increase in the number of publications that reflects the significance of the discussed topic. There were 68 journals with relevant publications, with the Journal of Cleaner Production being the most influential based on the local impact analysis. Moreover, we found that journals are publishing more and more articles on this specific field, and these articles are being broadly cited. Thus, our subject of interest—residential water consumption—could be considered as important but developing.

Based on the keyword analysis, we gleaned that demand, consumption and conservation are the most prominent themes for this research field. Meanwhile, the keywords “resources” and “prices” are related to more specific studies: For instance, “prices” would be more applicable in a study with a socio-economic interest. Moreover, the centrality and density map indicated that the research direction of this research field is expected to be about “conservation, attitudes and planned behaviour”.

The ADO framework analysis was useful for uncovering key patterns in the research field. Most of the articles adhere to a similar motive (antecedent): namely, sustainable water uses in cities and households and personal use in order to stop existing environmental issues or prevent new ones. Considering the decisions, it can be observed that previous research was dedicated to specific scopes without trying to extend their aims. In terms of analysed outcomes, research largely found that home appliances, feedback on individual water consumption, information campaigns and societal factors have an impact on residential water consumption. That said, we want to reiterate that antecedents, decisions and outcomes are interrelated. For instance, the antecedent of household water consumption was sustainable water use, its decision was the use of home appliances and its outcome was that home appliances can affect water consumption; thus, changing one part of the ADO may change the others. Interestingly, all three aspects—urban, household and consumer—had the same antecedent of sustainable water use. Consequently, we can say that the majority of studies in the field are being conducted for sustainable and environmental reasons such as reducing the water consumption in households in order to prevent water scarcity issues and not for economic or societal ones, such as to analyse the ways the household water consumption is affecting or is being affected by economic factors nor by the society.

The main achievement of this research is the fact that we managed to collect and analyse a broad number of articles in this research field, which gave us the opportunity to find the research gaps and the future directions regarding domestic water usage and management. Based on this analysis and by knowing the research gaps, we are able to continue with future researches in order to narrow them down. The main research gaps we identified are related to extending the research field of residential water consumption and its relation with pricing, resources, attitude, perception, behaviour, technology and water appliances, community behaviour and consumer characteristics and its influence on water consumption based on knowledge. Thus, future research in this area could focus on the relation between water consumption and the above keywords in order to minimize the research gaps and extend our knowledge on residential water consumption.

Lastly, we recognize that this study is limited by the specific nature of bibliometric analysis. Future research may also include network or world maps in order to present the collaborations between institutions and researchers, as well as to show the importance of the subject based on geographical locations.

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