



Article

# Financing the Water and Sanitation Sectors: A Hybrid Literature Review

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**Abstract:** To ensure the sustainable development of the water and wastewater (WSS) sectors, new and more investments are needed. However, private financing in these sectors has not been successfully leveraged. This study conducted a systematic literature review of peer-reviewed papers in this field, to provide an overview of how researchers have been studying the financing endeavors of the WSS sectors. A three-part framework was carried out: retrieval of papers from search engines (Scopus and ASCE Library), focused on the title, abstract, and keywords; process of elimination of papers; and analysis of the selected papers based on the hybrid method combining a systematic quantitative review, a semantic network analysis, and a narrative analysis. This research resulted in the identification of four most studied areas: sustainable development; water management and public finance; project financing; and public policy. Future research should focus on existing financing instruments and how these can specifically be applied in the WSS sectors successfully. This paper makes several contributions to the literature because it addresses and emphasizes the most important financing issues in WSS, reviews the insights found, and discusses the future research needs. In addition, it demonstrates the benefits of using a hybrid methodology that could be adopted in other literature review studies.

**Keywords:** financing; water; wastewater; sanitation; literature review; SDG



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## 1. Introduction

In 2015, all United Nations (UN) Member States adopted the 2030 Agenda for Sustainable Development, composed of 17 Sustainable Development Goals (SDGs), including a goal entirely dedicated to the clean water and sanitation sectors (SDG6), with the main objective of ensuring the availability and the sustainable management of water and sanitation for all [1]. The focal goal for these sectors is to ensure universal access to water and wastewater services that are safe, reliable, sustainable, and affordable. The UN recognizes the human right to water and sanitation, and ascertains that clean drinking water and sanitation is essential to the safety and wellbeing of individuals [1]. Data suggest that achieving universal access to basic sanitation services by 2030 would require doubling the current annual rate of progress [2] and that future investment needs will be incredibly high [3]. However, although the sustainable development of the water and wastewater sectors depends on investments, currently, there are not enough financing endeavors in these sectors [4].

The cost recovery of the water supply and sanitation/wastewater (WSS) sectors relies on finding an equilibrium between tariffs, taxes, and transfers (known as the “3Ts”) that guarantees the financial sustainability of the services provided, and, in addition, on ensuring other sources of financing that can help develop the needed infrastructure projects [5–7]. Different investment financing structures and instruments can be used to finance infrastructure projects. Some of these schemes are direct (e.g., on-balance sheet investments in corporate entities conducted without any intermediary, such as collective investment vehicles) and others are market-based (e.g., stocks and bonds) [8,9]. The funds

for water come from several types of sources that can be public or private. According to Winpenny [10], the major sources of investment are typically the governments, official development assistance (ODA) donors, and international financial institutions (IFIs), which need to be complemented by other types of funding sources to induce a larger total flow.

The private sector is a source of additional investments that is mostly unexploited and that could be leveraged to ensure the achievement of sustainable WSS services. Between 2012 and 2017, USD 2.1 billion was mobilized from the private sector by official development finance in the WSS sectors, which constitutes only 1.36% of all private finance mobilized across sectors, namely: banking and financial services (29%); energy (26%); industry, mining, construction (18%); others (26%) [4]. There are several barriers that hinder the current financing of the WSS sectors and the participation of commercial investments, for example: lack of administrative capacity of the borrower; corruption; expectations of the population; absence of analytical tools and data to assess and track water-related investments; need for high initial investment followed by a very long pay-back period; lack of understanding by external lenders and investors; short tenor of available financing; reduced financial capacity of the borrowers due to the services fragmentation; and others [3,6,11,12]. In addition, it is extremely important, for the success of the WSS sectors, to study existing financing sources and instruments, and to develop new ones tailored to the needs of infrastructure investment [13,14].

Although finding literature reviews on infrastructure financing or water irrigation financing was relatively straightforward, finding papers on the financing of WSS sectors was harder and only a small number was identified.

In fact, the only paper found that solely focused on providing a systematic review regarding costing and financing of water was published in 2017, and studied specifically the water, sanitation, and hygiene (WASH) in schools in a developing country context. This study, by McGinnis et al. [15], tried to answer the questions of “1. What are the elements, and associated costs that could apply to WASH programs in school in a developing country context? 2. How can or how is WASH in schools financed in a developing country context?” through a review methodology based on “Cochrane Handbook for Systematic Reviews of Interventions”. The literature was searched using the PubMed/MEDLINE database with the help of chosen terms in titles, abstracts, and keywords. All of the retrieved articles were scanned for the inclusion and exclusion of relevant criteria. Thus, the applied systematic review article screening process was divided into four phases—Identification, Screening, Eligibility, and Included—which helped focus the research and reduce the collected sample from 3605 articles to 48 relevant articles. In terms of financing, this literature review emphasized the importance of financial planning and management. It also defined as successful financing models the following three main groups: Government/Public Financing; Private/NGO Financing; and User/Household or School Fees. The difficulty in making financing recommendations clear, due to the financing mechanisms and models high variety, was discussed, and several key considerations for WASH budgeting and financing were elaborated: addressing inequities; community involvement and education; monitoring and evaluation; management; and lack of guidance and technical assistance.

Nonetheless, a deep analysis of relevant literature made it possible to identify papers with a chapter dedicated to a literature review regarding the sector in study, although not detailing a systematic review methodology. The following two are stated as examples:

- Ameyan and Chan [16], focused on water supply PPP (public-private partnership) projects and aimed to find influencing factors capable of skewing private sector decision to participate and invest in water supply projects, through an explorative research approach: a literature review of success factors, a survey with a group of PPP experts, and a multicriteria analysis of the collected data. Ultimately, this study identified, among other factors, the need to have an enabling policy and legal frameworks, profitable water projects, the public acceptance/support of private sector involvement in water services, and strong and competent public water authorities.

- Ditsebe et al. [17] analyzed the perceived occurrence of challenges delaying the delivery of water infrastructure assets in South Africa, which included a literature review focused on existing financing models. It identified a growing investment deficit for infrastructure development in Africa and stated that the application of innovative financing (IF) solutions (such as PPPs, loan guarantees, municipal bonds, low-interest loans, and credit options available to all spheres of governmental projects) would result in positive outcomes such as: “efficiency of financial flows, reduction of delivery time and costs, and the establishment of a direct link between financial flows and measurable performance”. In conclusion, this paper’s literature review identified the challenges facing infrastructure development in developing countries: “high transactions costs, financial sector impediments, lack of projects development capacity, lack of credit history and cost recovery constraints”.

Due to its need and relevance, the research and literature on financing the WSS sectors has slowly grown, even if traditionally financing issues within the water sector have not been emphasized, with the exception to the perspective of supply side investments [11]. Global Water Intelligence [18] highlighted the use of private finance to secure the investments needed as a noteworthy trend for the water sector. In addition, according to the latest forecasts from Global Water Intelligence (GWI), the global water market is projected to be valued at USD 914.9 billion in 2023 [19].

In view of the lack of private financing in the WSS sectors and of their challenges, the present study aims to conduct a meta-analysis on the past research carried out within this scope. Thus, a literature review on financing in the WSS sectors, aimed at identifying the main findings of the relevant literature, was carried out in this research. The objective was to provide an overview and understand how researchers have investigated the financing opportunities that could help bridge the financing gap in these sectors. Therefore, this literature review aimed to answer the following questions:

- What has been the evolution and current research trend of studies on WSS financing?
- What are the main themes studied in the past and insights offered in the literature regarding WSS financing?

The answers to these questions allowed interesting conclusions to be reached about the future prioritizations and directions on WSS financing. These questions were addressed through a methodology divided into three main phases: the retrieval of papers, through search engines, with the help of pre-defined relevant keywords and based on their title, abstract, and keywords; the screening of papers found relevant for the present study; and the organization and analysis of these papers. The last phase was accomplished using a hybrid methodology consisting of a systematic quantitative review, a semantic network analysis, and a narrative analysis [20]. As far as the authors know, this kind of literature review has not been previously developed and, consequently, the current paper can make a good contribution and provide a landmark to the literature.

This paper is organized in four sections. Following this brief introduction, Section 2 contains a description of the research methodology developed and applied. Section 3 presents and discusses the results. This section is divided into three parts: the systematic, semantic, and narrative analyses of the papers. The final section provides the concluding remarks and expectations for future research.

## 2. Materials and Methods

The literature review is a useful means of obtaining information on specific research topics and allows for an appreciation of the studies developed and the existing knowledge on the desired subjects [21]. The objective of the current paper was to identify and analyze all of the relevant papers that researched or expanded the topic of financing the WSS sectors.

The systematic review approach used in this paper was based on the framework used by Yu et al. [22], which includes 3 distinct phases: the use of a search engine to retrieve papers based on their title, abstract, and keywords; a process of elimination of

duplicate papers, of papers from non-relevant journals, and of papers not relevant to the research topic; and organization and analysis of the found papers and their information based on key characteristics (e.g., number of papers per year, countries, and methods applied). Following this approach, the research framework displayed in Figure 1 was drawn and applied.

<b>Phase 1</b>	Papers Search: Title / Abstract / Keywords Approach: Scopus and ASCE Library <i>(Result: 676 papers)</i>
	Elimination Process: Duplicated hits Approach: Visual Examination <i>(Result: 433 papers)</i>
<b>Phase 2</b>	Elimination Process: Non-relevant journals Approach: Scimago Journal & Country Rank <i>(Result: 433 papers)</i>
	Elimination Process: Non-relevant papers Approach: Visual Examination <i>(Result: 139 papers)</i>
<b>Phase 3</b>	<b><i>Systematic Quantitative Review</i></b> <b><i>Semantic Network Analysis</i></b> <b><i>Narrative Analysis</i></b>

Figure 1. Research framework.

The first phase of the present literature review consisted in the selection of an appropriate search engine and of keywords related to the research topic. Scopus was the first selected search engine because it has been successfully used in the past by other authors and is considered to be one of the best search engines for business, management, and accounting topics [23]. The keywords were chosen to enable the appreciation of the research previously developed and to ensure the selected papers were relevant and focused on the topic of financing the WSS sectors. No time restrictions were applied to guarantee a comprehensive collection of relevant papers. Therefore, 18 different searches were conducted, based on the keywords presented in Table 1, which resulted in the retrieval of a total of 603 papers. The search codes used in the 18 searches can be seen in Appendix A.

The Scopus search was complemented with a search of the ASCE Library, due to its relevancy in all infrastructure topics. Thus, based in a focused search of the financing and sustainable development goals in WSS, it was possible to retrieve 73 papers from the ASCE Library. The retrieved papers were analyzed, and duplicates were eliminated, thus reducing the sample from 676 to 433 papers. Then, the authenticity of the publishing journals was verified, with the help of the online platform Scimago Journal & Country Rank, to guarantee their recognition in the scientific community. As a result of this process, it was possible to verify that all of the journals were listed, and the sample remained unchanged, at 433 papers. Subsequently, the papers were submitted to a visual analysis, and all of the non-relevant papers were eliminated from the sample. This elimination was accomplished based on the following criteria: elimination of papers that were not specifically about, or with specified direct application to, the WSS sectors; and/or elimination of papers that were not entirely or partially about financing these sectors. Thus, this visual analysis made it possible to reduce the sample to 139 papers.

**Table 1.** Results from Scopus searches.

Search Number	Keywords		Results
1			Wastewater 5
2	Private Financ *		Water 32
3			Sanitation 5
4			Wastewater 2
5	Financ* Instruments		Water 41
6			Sanitation 0
7	Project Financ *		Wastewater 15
8			Water 85
9			Sanitation 7
10	Public Financ *	Infrastructure	Wastewater 3
11			Water 24
12			Sanitation 8
13	Financ * Tools		Wastewater 2
14			Water 17
15			Sanitation 3
16	Sustainable Development Goal	6	Wastewater 26
17			Water 209
18			Sanitation 119
<b>Total</b>			<b>603</b>

Note: the use of \* (wildcards) in Scopus allows the recovery of word variations (e.g. “finance” and “financing”).

The final sample of 139 papers was submitted to a systematic quantitative review, a semantic network analysis, and a narrative analysis [20]. This multifaceted analysis allowed for a more in-depth study. The first method used was the systematic quantitative review, which enabled the determination of key aspects of the sample, such as: the year of publication; author’s affiliations and their geographical locations; journals and institutions with more publications; author’s affiliations and productivity; and methodologies adopted in the papers.

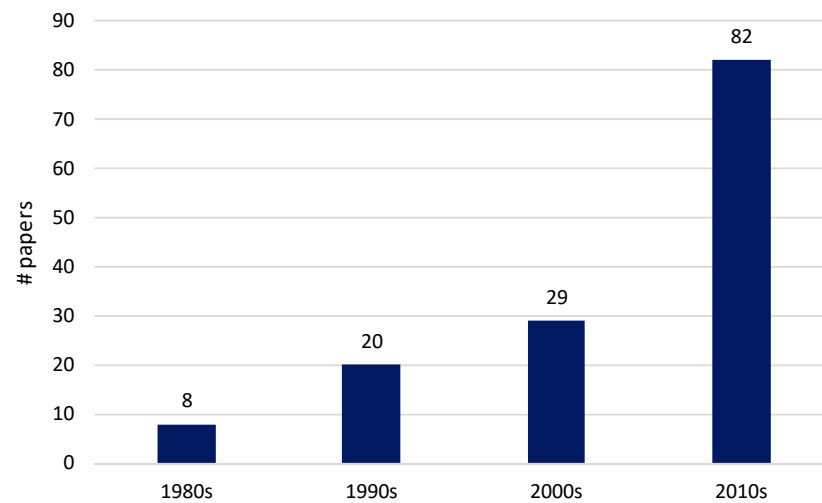
The second method applied was semantic network analysis. Using the keywords from the final sample of papers, word clouds were created using the Word Clouds online tool. The resulting word clouds allowed the identification of word frequency and, subsequently, the recurrent topics amongst the selected papers. In addition, the Leximancer machine learning software was used to conduct a quantitative content analysis of the keywords [24]. Leximancer produces a co-occurrence matrix that is based on the frequency of keywords, and identifies word connections and divides them into the main topics discussed in the papers [24].

The third and last method adopted was narrative analysis, which resulted from the combination of the information retrieved from the previous two steps. Therefore, the main three phases of the applied methodology were the following: visual observations, topic identification, and connection of concepts.

### 3. Results

#### 3.1. Systematic Quantitative Review

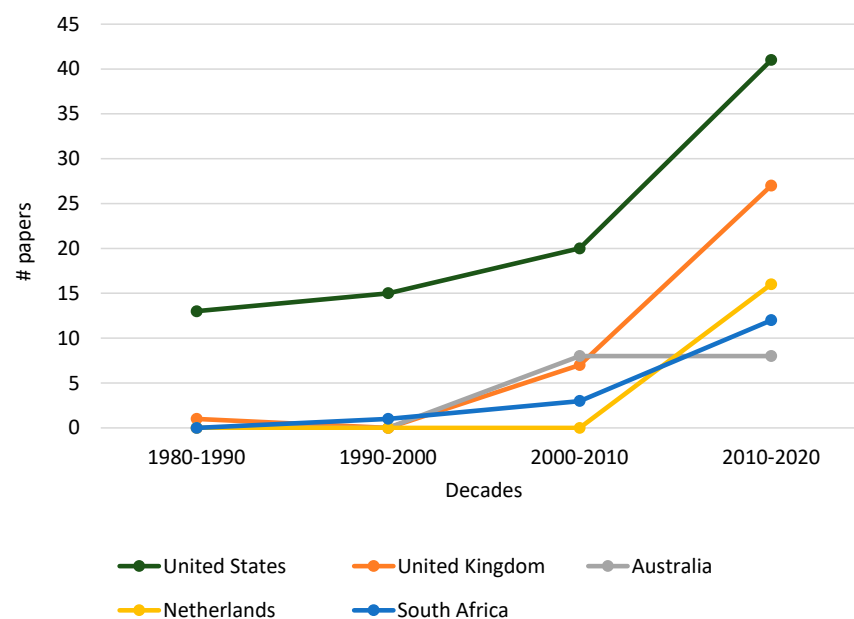
The first stage of the quantitative systematic review was the analysis of the number of papers published per decade. As Figure 2 suggests, the scientific community has shown a growing interest in the topic of investments in the WSS sectors. More than 40% of the papers were published between 2010 and 2020.



**Figure 2.** Number of papers retrieved per decade.

The papers in study were developed by many experts from all over the world, so it was important to understand their geographic distribution according to the authors’ affiliations. The graphical representation of the geographical distribution and frequency of papers can be seen in Appendix B. The countries with the most publications, according to the authors’ affiliations, were the United States (25%), the United Kingdom (10%), Australia (5%), the Netherlands (5%), and South Africa (5%). It was found that there is a lack of research on water financing by authors from several countries, such as countries in the Middle East or Asia. It should be noted that the sum of papers from the sample (139) differs from the number of studies according to the authors’ affiliations (352) because the papers have multiple authorship.

The temporal distribution and the number of papers published by authors affiliated to the United States, the United Kingdom, Australia, the Netherlands, and South Africa can be seen in Figure 3. Most papers from authors affiliated to institutions in these countries were published from 2010 onwards (around 83%). Until the year 2000, the United States was nearly the only country to contribute to the research in this field.



**Figure 3.** Number of papers published by decade in the United States, the United Kingdom, Australia, the Netherlands, and South Africa.

The 139 papers from this study's sample were published in 88 different journals. The 23 journals with the greatest number of publications can be seen in Table 2.

**Table 2.** Number of papers by journal.

Journals	Papers
Desalination	11
Science of the Total Environment	6
Journal of Water Resources Planning and Management	5
Water Policy	5
International Journal of Water Resources Development	4
Journal of the American Water Resources Association	4
World Development	4
Journal of Construction Engineering and Management	3
Sustainability (Switzerland)	3
Water (Switzerland)	3
Development Policy Review	2
Environment and Planning A	2
Environment and Planning C: Politics and Space	2
International Journal of Project Management	2
Journal of Environmental Engineering	2
Journal of Financial Management of Property and Construction	2
Journal of Urban Planning and Development	2
Proceedings of Institution of Civil Engineers: Management, Procurement and Law	2
Proceedings of the Institution of Civil Engineers: Municipal Engineer	2
Water Alternatives	2
Water Bulletin	2
Water Resources Research	2
Water Supply	2
Others	65
<b>Total Number of Papers</b>	<b>139</b>

It was found that most authors only published one paper from the sample in study. The authors with more than one published paper can be seen in Table 3 (each of whom published two papers). It should be again noted that, due to multiple authorship, the total number of studies is higher than the number of papers.

Analysis according to the authors' affiliations showed that the institutions with a higher number of publications were the Stockholm International Water Institute and The World Bank (Table 4). The universities with the most publications regarding the present research topic were the Technical University of Denmark and the University of California. The fifth most productive institution was McKenna Long & Aldridge LLP, a United States-based international law and public policy firm.

**Table 3.** Number of published studies by author.

Authors	Studies
Briscoe, J.	2
Characklis, G.W.	2
Giné-Garriga, R.	2
Humphreys, E.	2
Jiménez, A.	2
Mehta, P.	2
Mourad, K.A.	2
Pérez-Foguet, A.	2
Qadir, M.	2
Reed, P.M.	2
Schwartz, K.	2
Tan, J.	2
Others	331

**Table 4.** Publications according to authors’ affiliations and country.

Author’s Affiliation	Country	Studies
Stockholm International Water Institute	Sweden	11
The World Bank	United States	8
Technical University of Denmark	Denmark	7
University of California	United States	7
McKenna Long and Aldridge LLP	United States	6
Cornell University	United States	5
Loughborough University	United Kingdom	5
Universidad Industrial de Santander	Colombia	5
University of Oxford	United Kingdom	5
UNSW-UWS Research Centre	Australia	5
Other Affiliations	N/A	278

Analysis of the institutions according to the affiliation of the authors allowed the papers to be split into two groups, namely purely academic and not purely academic papers. The first group consists of papers written by authors affiliated with academia (i.e., universities and science foundations). The second group includes papers with at least one author affiliated with non-academic institutions. Thus, as observed in Figure 4, 47% of the papers are purely academic (66 in total), and the remainder, and also the majority, are papers developed by other types of institutions.

The final stage of the quantitative systematic review was analysis of the methodologies adopted by the studies, i.e., how many papers used qualitative, quantitative, or mixed methods. As highlighted in Table 5, most of the papers used mixed methods (34%), followed by qualitative (32%) and quantitative methods (21%).



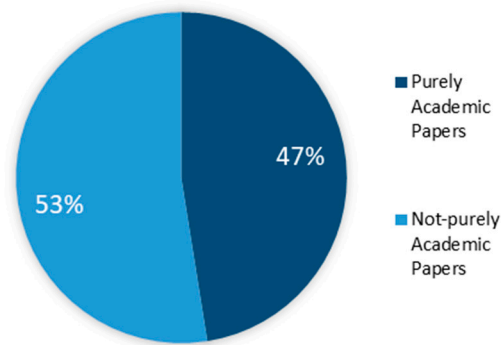


Figure 4. Purely and non-purely academic papers.

Table 5. Papers’ methodologies.

Methodology	Papers
Qualitative	44
Quantitative	29
Mixed	47
N/A	19
<b>Total Number of Papers</b>	<b>139</b>

### 3.2. Semantic Analysis

Word clouds help break down and identify the word frequency in the body of a text, enabling the identification of main research topics by highlighting high-frequency keywords. The result of the word cloud frequency analysis, of all the keywords of the sample in study, can be seen in Figure 5. The keywords inputted into the software helped identify the following seven top keywords, in order of frequency: “water” (9.21%), “development” (3.55%), “management” (2.64%), “supply” (2.30%), “sustainable” (2.15%), “project” (2.39%), and “financing” (1.70%).



Figure 5. Research topics’ word cloud.

Subsequently, four more distinct word cloud analyses were conducted. In these exercises, the papers were divided into groups according to the decade of publication: the 1980s (Appendix C); the 1990s (Appendix D); the 2000s (Appendix E); and from 2010 onwards (Appendix F). Analysis of the keyword frequency over time helped highlight the different thematic trends and the research topics explored in each decade.

In the 1980s, cost was one of the main topics discussed in WSS financing, including the sharing of costs, as highlighted by the keyword “sharing”, which was the fourth most common keyword in this decade. In addition, concerns regarding project economic feasibility and water resource development were highlighted. According to the keywords’ weights found in the following decades, it can be noted that cost stopped being an emphasized research topic. Since the end of the 1980’s, specialists started focusing on the sector’s management issues; although “management” was one the seventh most common keyword in the 1980s, during the 1990s, management was the fifth most common keyword, the second most common in the following decade, and the fourth most common since 2010.

During the 1990s there was a surge in papers focused on desalination, due to the scarcity of water resources, and the rise of competition and commercial availability of desalination technology [25]. The popularity of this research topic in the 1990s is justifiable because desalination plants are known to be costly and their viability could/would greatly depend on well-adjusted financing schemes. This research trend, regarding the financing of desalination projects, continued during the 2000s, but ceased after 2010.

Prior to the year 2000, risk was not a researched subject (with zero references in the 1980s and 1990s), but from 2000 to 2010, it became one of the main discussed topics (the fourth most frequent keyword). According to Kong et al. [13], risk management of all types of build-operate-transfer (BOT) projects, including those in the WSS sectors, has been extensively studied. Thus, this fact could help explain why, from 2010 onwards, the research community switched its focus to other key aspects, such as policy and investments. The increase in research referring to policies is noteworthy, because risks regarding the sectors’ financing needs could be mitigated through the enforcement of well-adjusted regulation frameworks and policies.

When analyzing keyword connections, with the help of the Leximancer software, seven main topics became apparent: “water” (with 94 hits); “development” (66 hits); “sustainable” (56 hits); “finance” (49 hits); “developing” (48 hits); “infrastructure” (41 hits); and “financing” (32 hits). As can be observed in Figure 6, these main themes connect to their own set of defining concepts, namely: “water”—management, treatment, countries, wastewater, analysis, economics; “development”—public, industry; “sustainable”—sanitation, planning, environmental, economic, drinking, approach, cost, social, economy; “finance”—project, system; “developing”—policy, public-private, private, urban; and “infrastructure”—investment, financial.

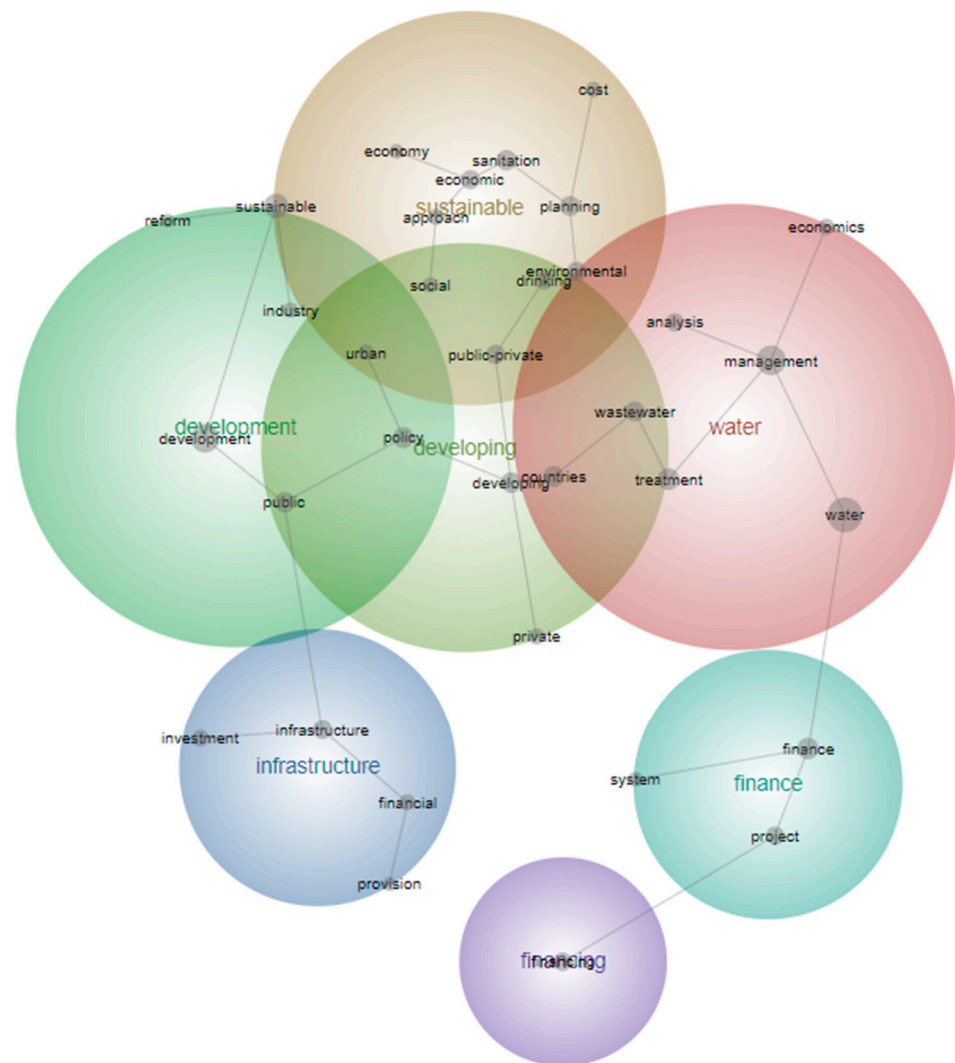


Figure 6. Leximancer’s concepts map.

#### 4. Discussion

The following narrative analysis aims to present and expose in more detail the main themes found in the 139 papers retrieved from the Scopus and ASCE Library search engines. However, the sample is not without bias, because the results obtained on the research topic were dependent on the availability of papers in the chosen research engines. Thus, it is important to introduce and briefly describe the key characteristics and challenges of the present thematic.

According to the OECD [26] and Varela [7], the effective financial modelling of the WSS sectors requires finding the correct combination between the revenues of the so-called “3Ts”—tariffs, taxes, and transfers—which means that a balance between tariff income, public funds, and external subsidies is required [27].

Customers pay service providers to access and use the WASH services, so tariffs are the revenues that come from them [28]. Tariffs can be charged through different schemes, depending on the local circumstances where the services are provided [29]. However, theoretically, WASH tariff systems are designed to enable a level of cost recovery (total or partial) that ensures balance and equity in the economy and promotes the well-being of society, while ensuring the financial sustainability of the services provided by the utility [30]. The tariff contribution to financial sustainability is usually significant.

Taxes are the transfers from the government that originate from taxpayers. These transfers can come from various levels of government (national to regional and local) and are usually provided in the form of subsidies for capital investment or operations [28].

Funds from international donors and charitable foundations are transfers. According to the OECD [26], in the WASH sector, the transfers mainly consist of official development assistance (ODA) grants, but funds can also assume the form of concessionary loans or guarantees [28].

The establishment of a balance between these three types of revenues is extremely important, since none of these 3Ts alone would be able to support the provision of WSS services. Thus, the optimal balance between these factors allows cost recovery in the sector and ensures its sustainability, which in turn attracts other forms of financing, such as, loans, bonds, and private investment. Private repayable financing opportunities differ from the 3Ts because they must be repaid or receive a return [26].

Private repayable financing is important for the accomplishment of infrastructure works by the utility, but this is only viable if the sector has the capacity to repay investors. In this way, the 3Ts represent those who, in practice, pay for WSS services, and the additional sources of financing help cover initial investment costs and new projects costs, thus allowing governments and utilities to take advantage of available sources of income and, hopefully, reduce their personal financing costs. In other words, it is very difficult to close the financing gap with the 3Ts, and repayable finance helps bridge the financing gap, as depicted in Figure 7. Repayable finance does not fully close the gap because it requires future repayment of capital and, in addition, a return in the form of interests or dividends [6].

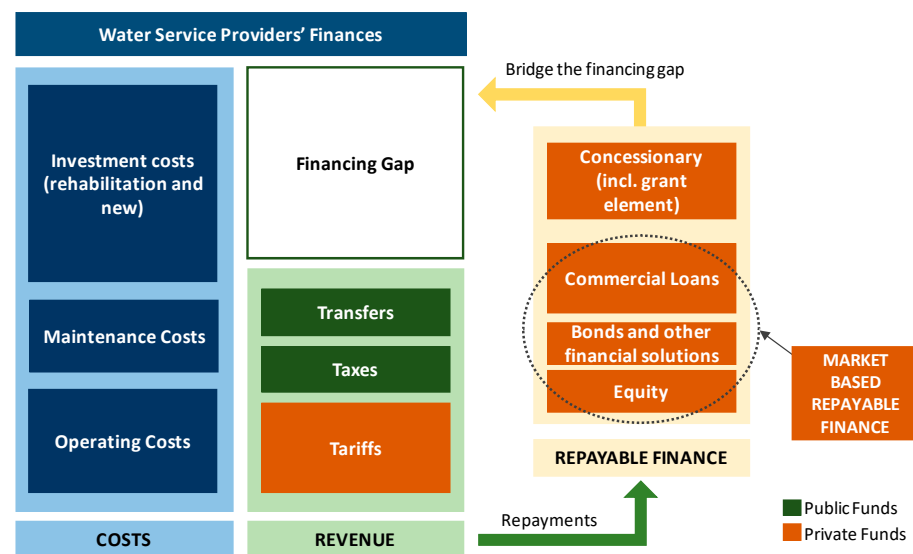


Figure 7. Water utilities' financing (adapted from [6]).

However, currently, private sector involvement is not sufficient to cover the needs of the sector, and the goal of universal access to safe and sustainable WSS services is still far from being achieved. Thus, the availability of financing is extremely important for the success of WSS projects. However, there is still a need to better understand the main available sources of financing and their characteristics, and how to leverage these for the sectors' success. This lack of studies focusing on the financing aspect, i.e., the sources of funds, has been noted by authors such as Kong et al. [13], who stated that, historically, a significant focus has been given to issues such as project evaluation and risk management of concession projects, but not to financing. The study of financing sources and instruments is particularly important because there is an inherent need for new sources and instruments of finance, to mobilize funds capable of satisfying the growing demand for infrastructure investment [14].

According to the results found with the previous analysis, it was possible to distinguish four major areas of focus, which will now be discussed, namely: sustainable development, water management and public finance, project financing, and public policy. It should be noted that some of the papers developed on one or more of these main topics, whereas others were outside this scope and only discussed other minor themes.

#### 4.1. Sustainable Development

The sustainable development subject appeared in 44 papers (i.e., 32% of the total sample of 139 papers). The sustainability of the services provided in the WSS sectors is indispensable for the safety of the population.

The challenges faced by the WSS sectors globally are sufficiently important that, in the year 2000, when the Millennium Development Goals (MDGs) were launched by 189 United Nations (UN) member states, the seventh goal was specifically designed to address environmental challenges, with the target of halving the proportion of the population without access to clean and safe drinking water and basic sanitation by 2015 [31]. The MDGs were successful in creating momentum and improving global focus on the lack of access to safe drinking water and sanitation [32]. However, the consultative processes of the Post-2015 Development Agenda highlighted the need to address the broader water challenges, including institutional deficiencies [33].

In addition, a core problem was identified: the lack of data measuring the sustainability of safe drinking water access [34]. The UN information only recorded if households had access to drinking water infrastructure (e.g., improved water sources), but not the water quality and safety or the regularity and reliability of the supply [34]. Due to the necessity to improve the various MDGs' results across sectors, and with the goal of continuing to strive for equality across the globe, the MDGs were succeeded by the Sustainable Development Goals (SDGs). The SDGs are composed of 17 goals, which call all countries to action, for the 2016–2030 period. Within the SDGs, a goal exclusively relating to the clean water and sanitation sectors was set, i.e., SDG6, with the main objective of ensuring the availability and the sustainable management of water and sanitation for all [1]. Thus, currently, there is a clear focus on the major topic of sustainability [35].

Water scarcity is one of the constraining factors that influences the WSS sectors, which can be felt due to a shortage in water resource availability, i.e., a physical shortage, or due to a lack of quality service provision through adequate infrastructure. For example, in Cape Verde, water scarcity is felt both due to the lack of physical infrastructure and an extreme lack of water resources [30]. In some developing regions, such as the Middle East and Africa, water scarcity problems are partly due to rapid urbanization and population growth [16]. Thus, the competition for water among various types of uses has grown, particularly in countries where water insecurity is prevalent, making it important to assess the economic benefits of investing in water security [36]. According to the OECD [3], the benefits from strategic investment in water security could exceed hundreds of billions of dollars per year, by correcting the economic losses related to water insecurity. It is predicted that water scarcity will continue to increase, and that water use will be more difficult to manage, and thus, water will become more valuable [37]. However, although there is a strong economic case for investing, currently financing endeavors in the WSS sectors [4] are not sufficient. In addition, future investment needs are estimated to be extremely high [3].

The current, and typical, financing approach is based on concessional finance, which means that the WSS sectors are financed by the public sector [4]. When a water utility needs additional financing (e.g., to build a new treatment plant or to repair infrastructure) it approaches a government for a grant. However, the resources generated from these sources are not enough to address the total financing needs of the sector and to achieve the SDG6 by 2030 [4]. In addition, there is a risk that the government will not award the company with a grant because of limited availability of resources. Thus, it is typical for a water utility to contact a commercial bank or other financial institution to apply for a loan. However, banks only invest after considering the attractiveness of the investment

opportunity and water projects are often labelled as unattractive. Thus, for water-related investments, banks will often not accept loan requests or impose strict conditions, such as short repayment periods and high interest rates.

This is problematic because the sustainable development of the WSS sectors depends on investments [4]. According to Hutton and Varughese [38], to achieve the SDG related to the achievement of universal and equitable access to safe and affordable drinking water for all by 2030 requires additional investments valued at USD 1.7 trillion. However, this value is considered to be only a fraction of the future water sector financing needs, because, according to the OECD [3], the “projections of global financing needs for water infrastructure range from USD 6.7 trillion by 2030 to USD 22.6 trillion by 2050”.

#### 4.2. Water Management and Public Finance

The public finance and management themes, in the WSS sectors, were prevalent in 53 papers (38%). Public finance in the WSS sectors refers to the government role in the economy of these sectors through the use of public revenues (mostly from taxes) to finance public expenditures [39]. Water and wastewater management refers to addressing several aspects of these sectors, for example, it could refer to the operation and maintenance of the water supply or wastewater systems.

Some of the weaknesses of the water sector, identified in the literature, are: high levels of non-revenue water; inappropriate cost recovery; limited use of targeted subsidies; inadequate sound investment planning; lack of integrated water resources management; lack of proper environmental impact assessments; and insufficient capacity building in water resource management and utility management [40]. Adding to the limitations of the WSS sectors, there is an ever-growing demand for clean drinking water due to several factors, such as increasing population and climate change [41,42]. Excessive water demand is a major problem in many places around the world, such as developing countries with increasing tourism or urban areas with marked population growth [30]. Water demand management could help reduce final water demand, “through improved public awareness, universal and more reliable metering, control of illegal connections, and more appropriate water tariffs” [40]. However, to solely focus on management techniques is not sufficient to address the current and significant challenge of increasing the coverage of WSS services through sustainable infrastructure systems [43].

In 1999, Rillaerts [44] predicted that private sector involvement in drinking water supply and wastewater treatment would increase globally, based on new EU legislation on water quality, which revealed the need for private financing for large-scale infrastructure projects. In line with this trend, in 2002, Grimsey and Lewis [45] found that the limitations of public funds led governments, in many countries, to invite the private sector to participate in “long-term contractual agreements for the financing, construction and/or operation of capital-intensive projects”.

Although the literature argues that the involvement of private finance is a necessity for the achievement of the SDGs, through innovative financing instruments and models, public finance continues to play a major role in the WSS sectors. For example, in Sub-Saharan Africa, most of the infrastructure was financed with the help of generated public revenue [46,47]; and, in recent decades in the United States, the federal government has introduced complex, multilevel state-operated revolving loan fund programs, that stimulated new local investment in wastewater infrastructure [48].

Small and/or rural towns constitute an additional challenge. Public finance for WSS infrastructure in these places is characterized by a skewed public fund allocation [39], due in part to the limited possibilities to generate local revenue [49,50]. Central governments appear to have an urban bias and favor the allocation of funds in large metropolitan areas [39,51] and local governments often prioritize other sectors (e.g., health, agriculture, and education) when allocating scarce local public resources [39]. Moving forward, and to successfully achieve the SDGs, Tutusaus and Schwartz [51] studied the water services in small towns in developing countries, and recommended that small towns (i.e., towns

with fewer than 100,000 inhabitants) should be addressed separately through the creation of specialized models (e.g., management and financing models). Finally, it should be mentioned that the rapidly growing peri-urban areas (which put enormous pressure on cities in the developing world) need development alternatives designed to ensure access to quality WSS because currently there is an absence of formal municipal systems and most depend on community-level forms of water supply [52].

#### 4.3. Project Financing

The theme of project financing related to the WSS appears in 25 papers (18%). It is common for privately financed infrastructure projects to use project finance structures that differ from corporate finance: in the former, the debt used to finance the project is paid back with the cash-flows generated by the project; and in the latter, the debt is sponsored by the company, “backed by its entire balance sheet”, and not only by the project [53]. Project finance could be advantageous, and Annamalai and Jain [53] recommend that, in developing countries, the project development companies should consider the application of project financing techniques to achieve financial closure of large infrastructure projects.

To ensure its success, the financing of projects should not be reactionary (e.g., to rectify market imperfections), but carefully planned through the adoption of rigorous project evaluation procedures [54]. The sources of funds and the basic elements of project financing are influencing aspects that can affect the performance of privatization exercises [55], and that need to be carefully assessed and tailored to the specific needs of a project. It is important for industries, and arguably developers, to actively participate in the “financing of infrastructure projects as a strategy for their own development” [56].

PPP arrangements, when used as a project financing method, can effectively help alleviate shortages of infrastructure construction funds [17,57], but to ensure the viability of a PPP project, a long-term revenue stream has to be established over the concession [45]. The success of project finance and PPP arrangements is dependent on the achievement of value-for-money in the provided services and on the adopted risk transfer principles [58].

It is important to evaluate the risks of WSS endeavors in which the “private sector entities enter into long-term contractual agreements for the financing, construction and/or operation of capital-intensive projects” (e.g., public-private partnership projects) [41,59]. Risk evaluation and management, including its allocation, is complex and needs to consider both the perspectives of the public and of the private sector entities, to effectively distinguish between the responsibilities of the government and private investors [41,60,61].

To negotiate the allocation of risks, it is necessary not only to understand the current risks, but also predict possible future risks that could affect the project. It is not easy for decision makers to identify and agree on the uncertainties (boundaries, importance, and probability distributions) that influence water infrastructure investment and management problems [62,63].

In addition, investments in the WSS sectors vary significantly depending on the nature of the activity. Additionally, the financing needs of a single project may vary according to its different phases (e.g., planning, construction, or operational). According to Ehlers [14], each phase “requires a different mix of financial instruments to cover different risk and return profiles—and so targets different types of investors”. Thus, it is important to understand that there are several financing instruments that can be applied and, also, different financing sources. For example, an analysis of the total private finance mobilized in the WASH sector by official development finance interventions, between 2012 and 2017, identified six types of blended finance instruments: credit lines, direct investment in companies and special purpose vehicles, guarantees, shares in collective investment vehicles, simple co-financing (standard grants and loans), and syndicated loans [4].

Historically, project finance focused research has been limited [64], and usually solely focused on project risks, contractual framework, and credit structure [65]. According to Kayser [65], there is a need to develop comparative studies in developing and emerging economies, such as India or China, analyzing the risk environment in terms of economic,

legal, and political risks. When researching studies on water project finance, the results are even more limited. Nevertheless, it has been debated that the current mechanisms for financing water infrastructure projects are not sufficient, and that these need to be complemented by newly designed financial models [17,66–68]. Thus, research focused on innovative models is a necessity. For example, in 2019, Gonzalez-Ruiz et al. [43] developed an investment valuation model that uses a debt mechanism based on bonds alluding to PPPs and project finance, and found that lenders could capture financial value by converting outstanding debt into equity shares throughout the operation and maintenance stage of the project.

#### 4.4. Public Policy

Public policies relating to the WSS sectors are discussed in 29 studies (21%). Water policies (e.g., public service obligations or privatization) need to be reevaluated and adjusted to meet the changing needs of the population, which are caused by factors such as increasing urbanization [54,69].

In privatization and PPP endeavors of the water industry, it is common to encounter structural and policy changes that allow financing of WSS projects to shift from concessional to market-based sources [55,70]. In these cases, regional water policies need to be robust enough to mitigate negative impacts from supply and financial failures. According to Trindade et al. [71], these negative impacts can be mitigated through the application of a framework that carefully considers the regional context and all of its actors, to help stakeholders discover pathway policies. These policies should be able to improve the performance levels for supply reliability and financial stability and “to guide robustness compromises that may be necessary between regional actors” [71]. Thus, in some circumstances, external pressures are capable of influencing policy direction and water reforms [71,72]. These external influencing factors sometimes positively change the existing policies, and provide a better environment for the sustainability of the WSS sectors. In other circumstances, however, they do little to help achieve the sector goals or even negatively influence their achievement [17,72].

According to Harvey and Mercusot [73], changes and awareness of public policy are key to strategies to address local water scarcity through “tariff structures, water rights management, and environmental stewardship”, while enabling transparency in the discussion of alternatives and the monetary value of water. Water scarcity is experienced by more than half of the world’s population during at least one month per year [74,75], and is expected to increase [43]. This increase in water scarcity is being influenced by factors such as urbanization, rising incomes, changing diets, climate change and growing populations [42]. Consequently, water scarcity can be a threat to socio-economic development and to the livelihood of many communities, both in developed and developing countries [76].

In addition, a better investment climate could be ensured through well-designed regulatory frameworks and policies (which include a fair judicial system, systems of checks and balances within government, promotion of independence of regulators, optimization of price-setting practices, and stakeholder participation through transparent regulatory processes) that increase cash-flow predictability and reduce some risks (e.g., political, environmental, and social risks) [77]. Winpenny [10] provides the mitigation of contracts’ vulnerability exploitation as an example of a risk that could be reduced through good regulation systems. In addition, according to Annamalai and Jain [53], the creation of a supporting institutional framework (regulatory, legal, and contractual arrangements), which supports the use of project finance, could help attract investment from foreign investors.

## 5. Conclusions

This article aimed to understand the evolution of financing research in the WSS sectors and to collect the main thematic insights from the literature. To develop the literature review, a three-part framework was used: retrieval of papers from the Scopus and ASCE Library



search engines, based on title, abstract and keywords; process of elimination of papers (non-relevant and duplicates); and analysis of the selected papers based on a hybrid method that included a systematic quantitative review, semantic network analysis, and narrative analysis. This methodology resulted in the collection and analysis of 139 papers from 88 different journals. The results from this analysis were successful in answering the proposed research questions of this paper.

There has been a gradual increase in peer-reviewed papers referring to WSS financing, with 59% of the papers collected dating from 2010 to 2020. Most papers were published by authors from institutions from the United States (64%) and the United Kingdom (25%). The universities with the most publications were the Danish Technical University of Denmark and the American University of California. In the United Kingdom, the university with the most publications was Loughborough University. Most of the collected papers were developed by authors with affiliations to both academia and non-academic institutions: 53% of the papers were not purely academic and 47% were purely academic.

The semantic analysis performed in this study enabled the identification of the main topics discussed in the collected papers: sustainable development; water management and public finance; project financing; and public policy.

The sustainable development topic appeared in 44 papers (32%). The importance and shortcomings of the MDGs were mentioned, including how they led to the creation of the SDGs (which are more focused on the issue of sustainable development). The need to ensure the WSS sectors' sustainability was highlighted, in addition to the need for a significant increase in financing to achieve this sustainability.

The public finance and management themes, in the WSS sectors, were prevalent in 53 papers (38%). The important role of public finance in the WSS sectors was highlighted, however it was also mentioned that it is not sufficient to cover all of the sector financing needs. Thus, the necessity for private financing for large-scale infrastructure projects was revealed. In addition, public fund allocation was identified as being sub-optimal due to central governments' bias towards urban areas and other sectors.

The project finance theme appeared in 25 papers (18%). It was highlighted that the application of project financing techniques could be advantageous to finance large infrastructure projects, including in developing countries, and that these should be carefully planned with the help of project evaluation procedures. In addition, it was determined that there is a need for more research focused on project finance because current mechanisms for financing water infrastructure projects are not sufficient.

Policies in the WSS sectors were discussed in 29 studies (21%). Attention was drawn to the necessity to adapt the water policies according to the needs of the WSS sectors, and that these should be designed in a way that improves the sustainability of the services provided (e.g., by supporting the use of project finance to help attract investment from foreign investors).

This paper contributes to the literature because it provides an in-depth analysis of the papers discussing finance, specifically in the WSS sectors, so that the academia and the practitioners can have a better understanding of the evolution of topics discussed, the needs of these sectors, and the directions to follow.

Although the literature claims that there is a need to design new and innovative financing instruments and models, papers focusing on the study and understanding of current financing instruments, and how these could be helpful for the WSS sectors, are lacking. To be able to innovate, it is necessary to understand the instruments used in the past and why they were successful, or not. Moving forward, it is also necessary to understand what other financing instruments exist, determine their advantages and disadvantages, and evaluate their applicability to the WSS sectors. The challenges of the WSS sectors to achieve the SDG6 are significant and financing is clearly the critical issue.

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## Appendix A

**Table A1.** Scopus search codes.

Search Number	Scopus—Search Codes
1	TITLE-ABS-KEY (“private financ*” AND “wastewater”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
2	TITLE-ABS-KEY (“private financ*” AND “water”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
3	TITLE-ABS-KEY (“private financ*” AND “sanitation”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
4	TITLE-ABS-KEY (“financ* instruments” AND “wastewater”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
5	TITLE-ABS-KEY (“financ* instruments” AND “water”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
6	TITLE-ABS-KEY (“financ* instruments” AND “sanitation”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
7	TITLE-ABS-KEY (“project financ*” AND “wastewater”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
8	TITLE-ABS-KEY (“project financ*” AND “water”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))

Table A1. Cont.

Search Number	Scopus—Search Codes
9	TITLE-ABS-KEY (“project financ*” AND “sanitation”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
10	TITLE-ABS-KEY (“public financ*” AND “wastewater” AND “infrastructure”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
11	TITLE-ABS-KEY (“public financ*” AND “water” AND “infrastructure”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
12	TITLE-ABS-KEY (“public financ*” AND “sanitation” AND “infrastructure”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
13	TITLE-ABS-KEY (“financ* tools” AND “wastewater”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
14	TITLE-ABS-KEY (“financ* tools” AND “water”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
15	TITLE-ABS-KEY (“financ* tools” AND “sanitation”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
16	TITLE-ABS-KEY (“sustainable development goal” AND “6” AND “wastewater”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
17	TITLE-ABS-KEY (“sustainable development goal” AND “6” AND “water”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))
18	TITLE-ABS-KEY (“sustainable development goal” AND “6” AND “sanitation”) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “SOCI”) OR LIMIT-TO (SUBJAREA, “DECI”) OR LIMIT-TO (SUBJAREA, “ECON”)) AND (LIMIT-TO (LANGUAGE, “English”) OR LIMIT-TO (LANGUAGE, “French”) OR LIMIT-TO (LANGUAGE, “Spanish”))

Note: the use of \* (wildcards) in Scopus allows the recovery of word variations (e.g. “finance” and “financing”).

### Appendix B

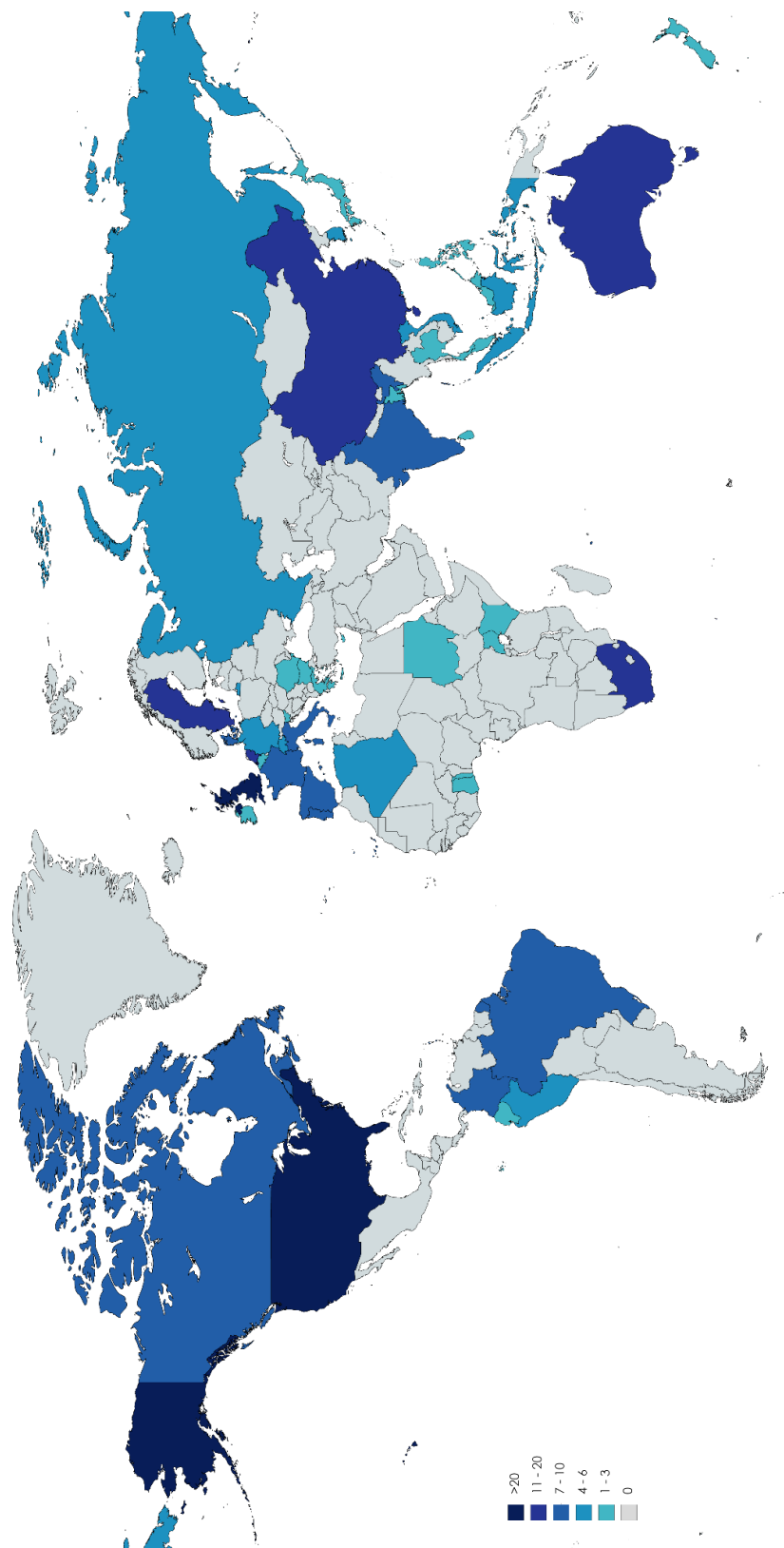


Figure A1. Geographical distribution and study frequency according to authors' affiliations.





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