water

MDPI

Review

Water Context in Latin America and the Caribbean: Distribution, Regulations and Prospects for Water Reuse and Reclamation

Carolina Rodríguez [1], Bárbara García [2], Caterin Pinto [2], Rafael Sánchez [3], Jennyfer Serrano [4] and Eduardo Leiva [1,2,*]

1 Departamento de Química Inorgánica, Facultad de Química y de Farmacia, Pontificia Universidad Católica de Chile, Avenida Vicuña Mackenna 4860, Macul, Santiago 7820436, Chile
2 Departamento de Ingeniería Hidráulica y Ambiental, Pontificia Universidad Católica de Chile, Avenida Vicuña Mackenna 4860, Macul, Santiago 7820436, Chile
3 Instituto de Geografía, Pontificia Universidad Católica de Chile, Avenida Vicuña Mackenna 4860, Santiago 7820436, Chile
4 Escuela de Biotecnología, Universidad Mayor, Camino La Pirámide 5750, Huechuraba, Santiago 8580745, Chile
* Correspondence: ealeiva@uc.cl; Tel.: +56-2-2354-7224; Fax: +56-2-2354-5876

Abstract: Water scarcity is a problem of global relevance that is affecting more and more people in the world. Latin America and the Caribbean (LAC) have around 35% of the world's renewable water resources. However, the management of water resources and inequality in access to water has made water scarcity a problem of growing interest in the region. The reuse of water could be an efficient measure to reduce the demand for water resources in the area. In particular, the reuse of greywater is a simple and decentralized method of water reuse, which would mitigate the impact of the lack of water in isolated or difficult-to-access areas. Using the Aquastat database, water consumption in the world and water availability in LAC were studied. In addition, the regulatory framework for water in LAC countries was studied, with an emphasis on water reuse and greywater legislation. Agriculture is one of the most demanding of water in the world, particularly, in LAC, which demands around 70% of renewable water resources. Furthermore, in LAC, the availability of drinking water in rural areas is lacking, with seven countries having less than 80% access to healthy drinking water. The water regulation in LAC is quite heterogeneous. The most general regulation around water is found in the political constitutions of each country. Some constitutions explicitly indicate access to water as a human right, while other constitutions do not include information in this regard. Although some countries have specific regulations on the reuse of wastewater, there is a general lack of regulations related to the reuse of greywater. In most cases, the term "greywater" is not even defined in the general water and wastewater laws. As of the date of this article, only Chile, Peru, and Brazil have bills to regulate the reuse of greywater, of which only the Chilean is approved. The reuse of greywater could help reduce water demand for non-drinking uses. However, the implementation of greywater treatment systems represents a cost that is difficult to cover, especially in the poorest countries of the region. Countries must improve their public policies to improve the management, use and reuse of water to mitigate water scarcity that severely affects human consumption in the region. The relevance of this study lies in providing a general framework of the water situation in LAC for studies and public policies focused on promoting water reuse as a measure to mitigate water scarcity.

Keywords: water reuse; water regulations; water consumption; water guidelines; greywater

Citation: Rodríguez, C.; García, B.; Pinto, C.; Sánchez, R.; Serrano, J.; Leiva, E. Water Context in Latin America and the Caribbean: Distribution, Regulations and Prospects for Water Reuse and Reclamation. *Water* **2022**, *14*, 3589. https://doi.org/10.3390/w14213589

Academic Editor: Adriana Bruggeman

Received: 2 September 2022
Accepted: 26 October 2022
Published: 7 November 2022

1. Introduction

Water scarcity is a global problem that has increased in recent years. Some 4 billion people suffer from water scarcity for at least one month a year, which occurs mainly in areas with a high population density (megacities), areas with an influential presence of agriculture, and arid areas [1–3]. Since the 1980s, the water demand has increased at an approximate rate of 1%, and it is projected that by the year 2050 the demand will increase between 20 and 30% compared to the current level [4]. The historical inequality in access to water for some sectors of the population increases social inequalities. About a third of the world's population does not have access to safe drinking water services and almost half of these people live in Sub-Saharan Africa [4,5]. These inequities in access to water, together with the growing events of water scarcity, increasingly drive the development of frameworks and actions for more efficient management of water resources.

Latin America and the Caribbean (LAC) have 8.4% of the total world population [6], while the total renewable water resources in this region represent 35.1% of the global total [7]. Compared to the rest of the world, the LAC region presents an abundance in terms of per capita water availability. However, rapid urbanization, weak governance, and poor infrastructure in some areas produce water scarcity and an uneven social and geographical distribution of water resources [8]. Additionally, LAC has been merged as an exporter of agricultural commodities to the world market, an industry that consumes around 70% of the freshwater withdrawal [9]. In this context, some hydrological models have been developed, such as SWAT, which is highly dependent on meteorological parameters and which allows the evaluation of the efficiency in the use of water, which is very relevant for the effective management of agronomic water resources [10].

In 2015, the United Nations General Assembly, in the context of the 2030 Agenda for Sustainable Development, established the aim of improving wastewater treatment and increasing water reuse, which will promote a transition towards a circular economy [11]. In recent years, water reuse has become a promising alternative to mitigate water scarcity [12]. However, water reuse policies could be limited by several factors, such as public acceptance, technical capacity, and current regulations [13].

The increase in water scarcity urges the development of technologies that facilitate and promote the maximization of the use of water resources. The reuse of water is a practice that allows for better use of the resource. In this context, agriculture is one of the main activities where treated wastewater is reused [14]. Centralized water reuse systems have several benefits, such as economies of scale [15]. However, for areas that are geographically isolated or that do not have optimal coverage of the sewage collection network, these systems may not be useful. In this context, in decentralized treatment systems that are carried out on a smaller scale, better separation and management of wastewater sources can be carried out, and they are more effective for small communities [15].

Greywater reclamation is one of the most widespread decentralized water reuse systems. This is based in part on the lower treatment complexity of greywater compared to black water, which means that less sophistication is required in treatment technologies. The reuse of greywater is an alternative that in some countries of the world has been practiced for many years due to water scarcity or the economic impossibility of accessing safe drinking water, however, in some regions, it is still an emerging technology that does not have adequate regulations for its implementation [11,16–18]. Some countries are pioneers in the reuse of greywater. In the case of Australia, the authorities have encouraged the reuse of greywater at the household level for more than a decade [19]. The National Rainwater and Greywater Initiative—Household Rebate even offers rebates of up to AUD $ 500 for the purchase of rainwater tanks and greywater reuse systems [20]. In the USA, the regulations regarding greywater depend on each state. According to Yu et al. (2013) [21], 41 states in the USA include greywater in plumbing codes or other state regulations, while 29 states allow greywater reuse. On the other hand, in Israel, the first permit for greywater reuse was granted in 1994 [22]. Since then, Israel has made great strides in its regulation, having one of the strictest water reuse standards in the world [22]. Despite this, it is one of the countries where the reuse of water is most widespread, pressured mainly by the scarcity of this resource. For its part, Japan (Tokyo) requires the installation of greywater systems in buildings with an area of over 30,000 m^2, or with the potential to reuse 100 m^3

per day [23]. These are some examples of greywater reuse practices in the world, which show their importance in the management of water resources and the need to establish effective guidelines for the reuse of greywater in the face of future events of water scarcity associated with reduced availability of the resource due to climate change.

The novelty of this study is to provide a comprehensive overview of the reuse of water, particularly greywater, a scenario with little progress in LAC compared to other regions of the world. There are many studies reviewing the literature for water reuse in EU countries [24–26], Arabic region [27,28], Africa [29,30], Asia [31–33], North America [34–36] and Oceania [19,37,38]. However, the literature on the distribution, regulation and prospects for water reuse in LAC is less extensive. Thus, this article provides an exhaustive review of the world state of water resources management, with an emphasis on water reuse in LAC. Access to drinking water throughout the region was reviewed, distinguishing between urban and rural areas, and an exhaustive review of the regulatory framework regarding the management of water resources was carried out, emphasizing the reuse of greywater as an alternative for water savings and the economics of these technologies.

The relevance of this study lies in forming a general framework of the water situation in LAC, rich in water resources and with governance problems, which face the problems of growing water scarcity. In this way, another novelty introduced by this study is given by providing a general framework of the water panorama in the LAC region, because there are no previous studies that address the entire region with this level of depth. This article can be very useful as a general context for studies and public policies focused on promoting water reuse as a measure to mitigate water scarcity.

The paper is structured as follows. Section 2 presents the methodology addressed in this review. Section 3 reviews the water resources in the world, focusing on water consumption and water uses by activity. While Section 4 shows a review of the management and uses of water resources in LAC. Section 5 delves into water reuse as an alternative to mitigate water scarcity with an emphasis on LAC countries. Section 6 extensively reviews the International guidelines for water management and reuse, with focus on the guidelines of international organizations (Food and Agriculture Organization (FAO), United Nations (UN), World Bank). Section 7 presents an in-depth discussion on water regulations in LAC, primarily addressing greywater guidelines and their practical application in LAC countries, as well as and the technical and economic aspects of greywater reuse. Section 8 provides a review of the policy and governance challenges for water management and reuse. Finally, Section 8 is left for the work's main challenges and conclusions.

2. Methodology

2.1. Relevant Literature Search

The bibliographic information on the behavior in the consumption of water and previous studies was compiled from the Google Scholar web search engine. In this step, keywords including "water reuse", "water reclamation", "water scarcity", "greywater" "Latin America and the Caribbean", "regulation", "guideline", and "greywater treatment system", among others were used. The legislation corresponding to each country was obtained from the institutional web pages of organizations related to the management of water resources and the environment. In addition, the political constitution of several LAC countries was exhaustively reviewed, particularly, water laws.

2.2. Data Collection

The data regarding the availability and consumption of water resources in the world were made from the AQUASTAT database, an information system of the Food and Agriculture Organization (FAO). The data was processed and studied according to the regional classification carried out by the United Nations in the report "Leaving no one behind" [4]. The economic indicators presented in this paper were obtained from the World Bank database. The data collected from the different databases were analyzed and correlated with each other. In addition, ArcGIS software was used for the analysis and graphing of the results.

2.3. Data Analysis

The information on water use for each area of the world was determined by weighting the data for each country by the number of inhabitants, in order to have a representative view for each defined area. The information collected for this study was ordered from the most general, beginning with a global context, to then focus on the situation of LAC and the study of its regulatory framework regarding water use. Special emphasis was placed on the reuse of greywater as a measure to mitigate the water scarcity present in the area and the regulatory framework on this matter and the scientific research carried out in LAC were studied. It concludes with a study of the economic indicators in access to water and its price, to present a general framework of the context of water in LAC and its position with respect to the rest of the world.

3. Water Resources in the World

The availability of water in the world and the consumption of this resource are quite heterogeneous. Population growth and climate change are two of the main causes of water scarcity, while the level of economic development may explain the difference in response to water stress in different regions of the world [39]. According to Distefano and Kelly (2017) [39], the economic growth projection models imply overexploitation of freshwater even in optimistic scenarios regarding improvements in the efficiency of water use. Knowing the availability and patterns of water consumption in the world, as well as the use of water according to the economic activities developed in different regions of the world, is essential to understand and project future threats of water scarcity.

Water consumption in the world was studied from the Aquastat database [7]. To determine the consumption of water for different uses in different regions of the world, the data by country were weighted by the population, to have a representative vision. The water availability in the world differs from one region to another. According to data from 2017 on the total renewable water resources per capita, 8 countries were below 100 m^3 per inhabitant per year, of which 7 correspond to countries in the Arab Region [7]. On the other hand, 15 countries in LAC present more than 20,000 m^3 per inhabitant per year of total renewable water resources [7]. Various factors, such as the level of development of the countries, the level of industrialization, urbanization, or poverty, influence water consumption and the uses that it is given [40,41]. Figure 1 shows the proportion of water destined for different uses (agricultural, industrial, and municipal) in the different regions of the world.

It is possible to observe that in Latin America, the Arab Region, and Asia and the Pacific agricultural activity uses around 70% or more of their renewable water resources. Currently, around 1.2 billion people live in areas with severe water deficits that make farming difficult, of which 43% live in Southern Asia and 38% in Eastern and South-eastern Asia [42]. Livestock demands 30% of the world’s water requirement [43]. Additionally, some crops demand exorbitant amounts of water. For example, California almonds demand around 12 L per almond kernel (or 10,240 L per kilogram) [44]. Furthermore, Chile faces a water crisis in Petorca Basin due to the intensive production of avocado, which demands around 2000 L per kilogram [45,46].

In contrast, North America and Europe use water to a lesser extent for agriculture, and more for industrial activity. Dolganova et al. (2019) [47] studied the water footprint of agricultural imports in the European Union. Its results include the identification of cotton, nuts, and rice as the main products that contribute to the water footprint, and that the greatest impact of water consumption occurs through the import of water-intensive goods produced in countries with water scarcity. On the other hand, in the industrial field, around 48% of the water consumption in the United States is used for energy generation [48].

Additionally, the textile industry is one of the high-water-use and high-water-pollution industries on the globe, whose main exporters are China and the European Union [49].

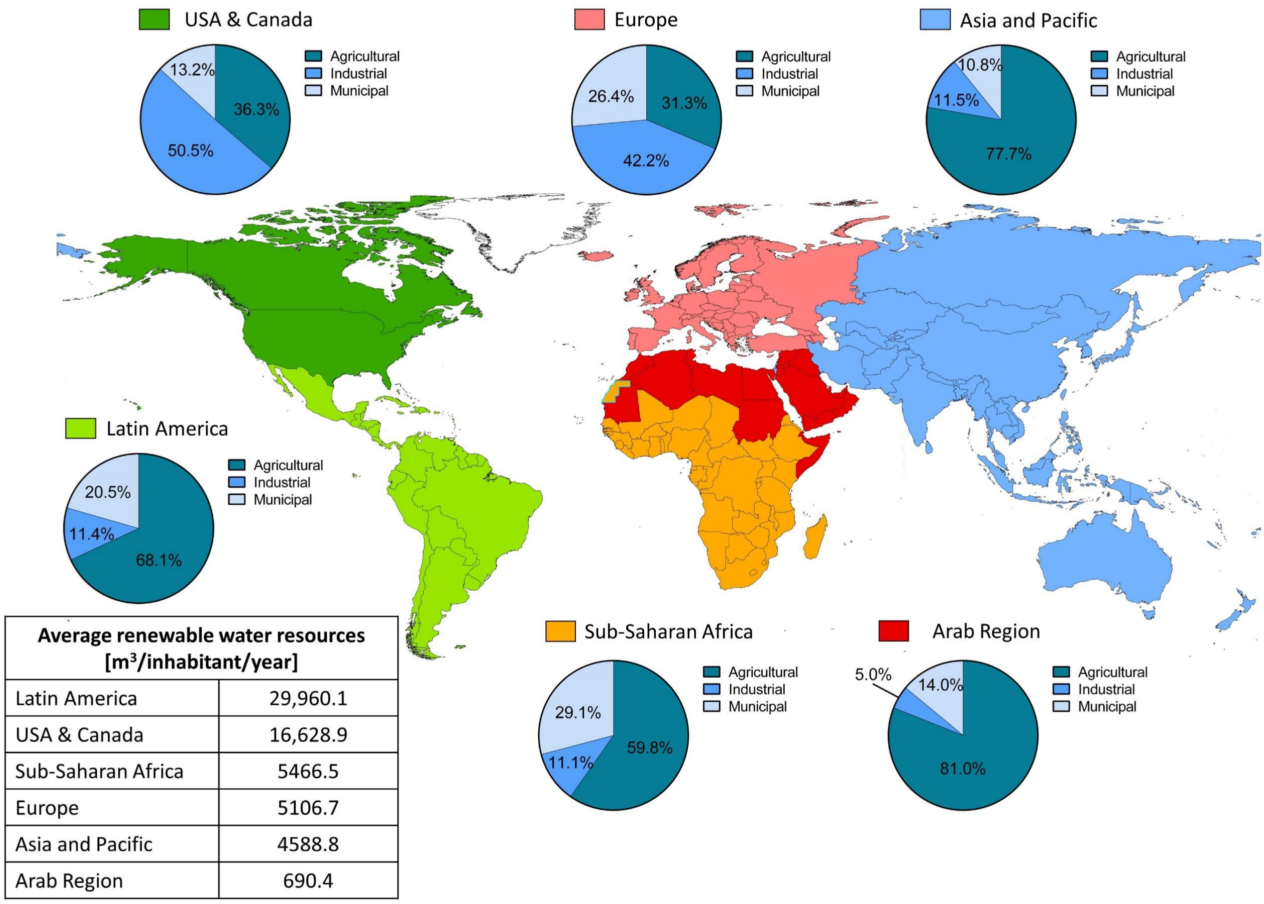

Figure 1. Water use by activity in the world. Source: Aquastat database [7].

4. Water Resources in Latin America and the Caribbean

Water consumption in LAC is mainly associated with agricultural activity, which demands approximately 68% of available freshwater, followed by municipal demand which represents approximately 21%, and industrial use 11%. (Figure 1) [7,9]. When compared to other areas of the world, LAC has a relative abundance of water. More than 14.8 million km^2 surface in LAC has renewable water resources per capita per year on average greater than 20,000 m^3 (Figure 2). However, its spatial and temporal distribution causes water scarcity in extensive areas such as Argentina, Bolivia, Brazil, Chile, Mexico, and Peru [50,51]. Besides, Latin America and the Caribbean exhibit many problems in the management and the governance of water in addition to poor infrastructure conditions and contamination of water resources [52]. The increase in agricultural activity in the region is strongly associated with water consumption. Between 1961 and 2018, the world presented an increase of 26.5% in the area used for agricultural activity, while in LAC, the increase was 25.5% [53]. LAC is a net food exporter at the expense of water availability and greenhouse gas emissions, so introducing novel agricultural practices is imperative to optimize water consumption in the region [54].

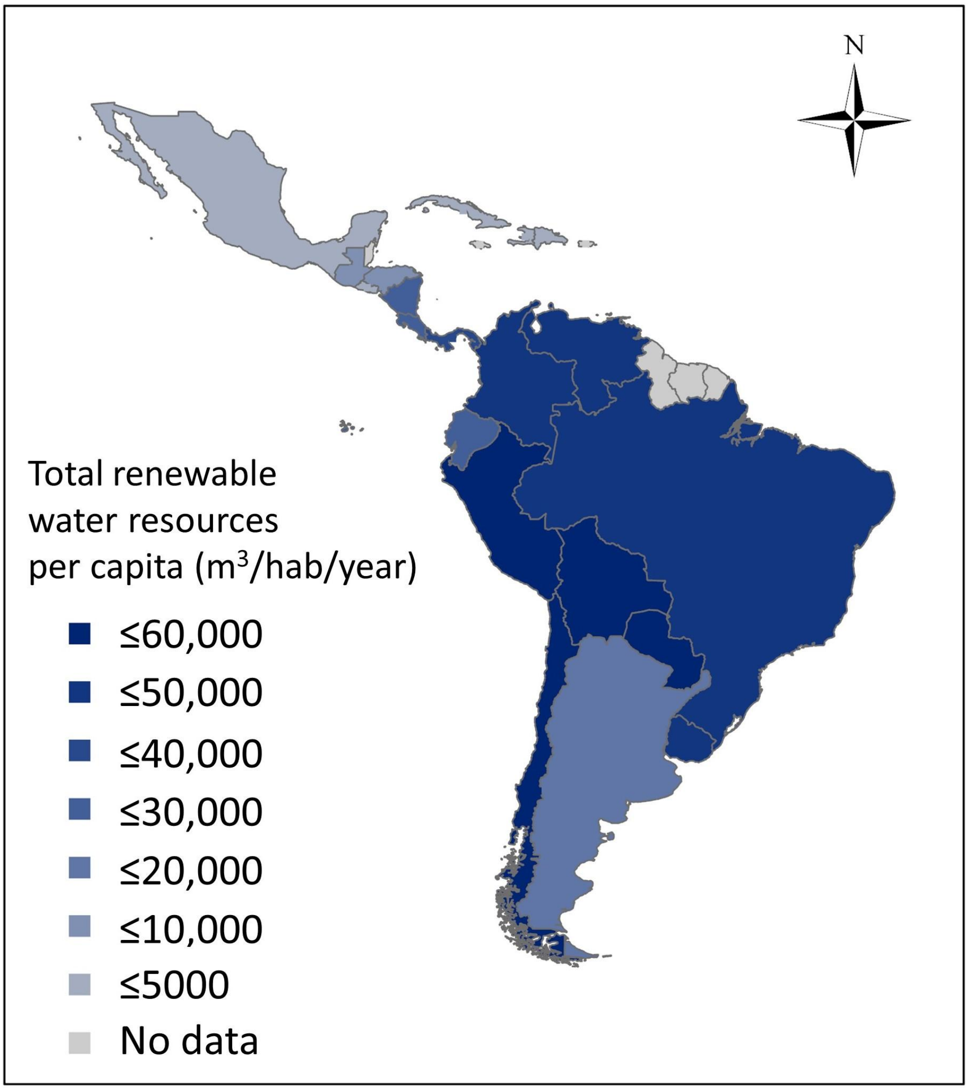

Figure 2. Total annual renewable water resources per capita by country in Latin America and the Caribbean. Source: FAO (2017) [7].

In the last 100 years, water demand has increased at a rate of 1.8% per year [55,56]. In the next two decades, the water demand is expected to increase for all uses [55]. However, industrial and domestic demand will grow more than agricultural demand [57]. By 2050, the global water demand is expected to increase between 20 and 30% [58]. According to these data, it is expected that in the next three decades the use of water in LAC increases in greater proportion for industrial and domestic use, as the population of the region increases, with projections of around 752 million inhabitants by 2056.

The countries of the Caribbean region have an average annual rainfall of over 1000 mm/year. In terms of renewable water resources, they are quite heterogeneous, with countries with a wide availability such as the case of Belize with more than 50,000 m^3/hab/year, Suriname with more than 170,000 m^3/hab/year, and Guyana with more than 347,000 m^3/hab/year according to FAO data from the year 2020 [7]. On the other hand, countries such as Antigua and Barbuda (540 m^3/hab/year) and Barbados (279.1 m^3/hab/year) present renewable water resources below the sustainable development threshold of 1700 m^3/hab/year [59,60] according to 2020 data [7]. This region is prone to intense and relatively short droughts. Between 2013 and 2016, the Pan-Caribbean drought developed, affecting more than 3 million people due to food insecurity [61].

On the other hand, greater coverage and equity in access to drinking water is an indicator of the economic and social development of a country [62]. In Latin America, as well as in other parts of the world, great inequity is observed in access to drinking water and sanitation among families of different incomes, and between urban and rural areas [62]. According to estimates made by the Pan American Health Organization (PAHO), in 2017, 28 million people lack access to an improved water source, 83 million people lack access to improved sanitation facilities, and 15.6 million practice still open defecation [63]. According to data from 2017 (Figure 3a), Argentina, Brazil, Chile, Costa Rica, Mexico and Uruguay had had coverage greater than 95% of healthy drinking water, while, Colombia, Cuba, El Salvador, Guatemala, Honduras, Panama, Paraguay, and Venezuela presented access to healthy drinking water higher than 90%. In Bolivia, Ecuador, Nicaragua, and Peru, between 85 and 90% of the population had access to safe drinking water, followed by the Dominican Republic which presented coverage of 84.7%, and Haiti with just 57.7% of safe drinking water access.

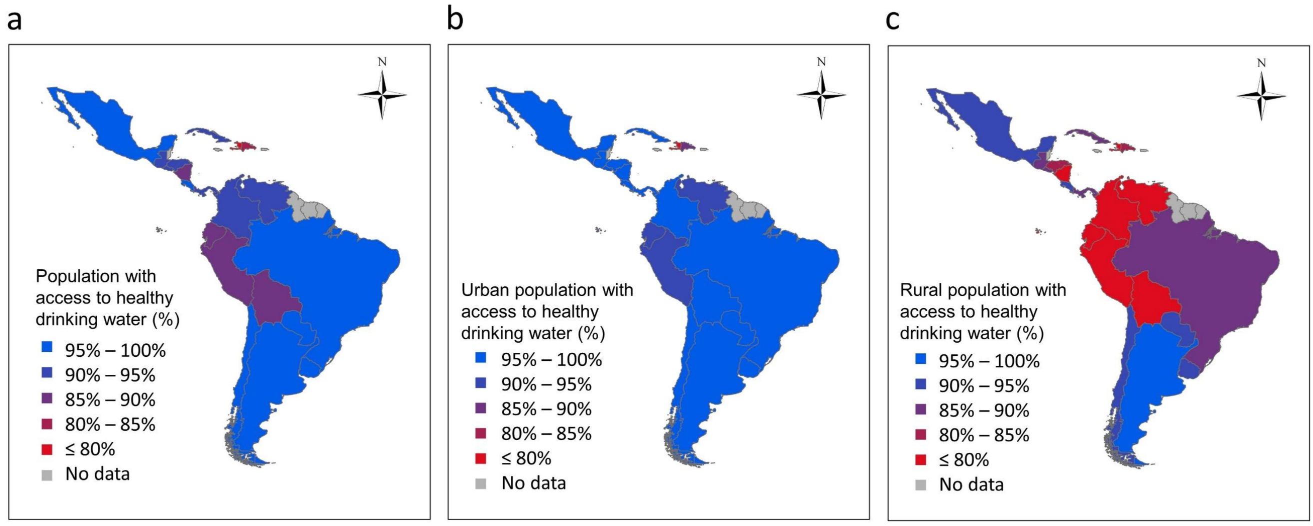

Figure 3. Access to healthy drinking water in Latin America: (**a**) Total population; (**b**) Urban population; and (**c**) Rural population. Source: FAO (2017) [7].

When looking at the general panorama of access to healthy drinking water in the urban area (Figure 3b), coverage increases considerably in most LAC countries. Here, only two of the documented countries present a safe drinking water coverage of less than 90%, which corresponds to the Dominican Republic (85.4%) and Haiti (64.9%). However, even though urban areas have better infrastructure than rural areas to guarantee safe access to drinking water, water scarcity has affected metropolitan areas. Recently, Desbureaux and Rodella (2019) [64] studied how droughts affect cities' economies. They found that during droughts, the probability that a worker is employed decreases, as does the number of hours worked, wages and earnings of informally employed workers. In fact, informal workers are more affected by droughts than formal workers. Finally, in rural areas, statistics on access to drinking water decrease considerably, with countries like Bolivia, Colombia, Ecuador, Haiti, Nicaragua, Peru, and Venezuela with less than 80% coverage of safe drinking water.

The data presented and documented in this article regarding the water context in LAC, although they are not so pessimistic compared to other less developed areas of the world, do not account for other critical aspects regarding the availability of water in the region, such as drinking water quality, infrastructure, and improved sanitation. According to ECLAC data, despite the significant progress made in the last decade, there is still a delay in the coverage of improved services, with 6% of the LAC population without access to improved water sources and 15% without access to improved sanitation facilities. In addition, access continues to be insecure and of poor quality, with intermittent service and without adequate control of water quality, to which is added a level of loss (unaccounted-for water) of around 40% [65]. Therefore, despite the abundance of water resources in the area, this will be one of the most affected by the water crisis related to climate change, because of the weaknesses and lack of public policies and governance in the efficient management of water resources.

Another factor of great relevance to understanding how water scarcity occurs in LAC is inequality in access to drinking water. Carvalho et al. determined the inequality factor for access to water and sanitation. Regarding access to water, the best results were presented by Argentina, Costa Rica, Chile, Uruguay and Mexico, with inequality indices below 3.7%. At the other extreme, the only country with inequality above 22% was Haiti. Regarding access to sanitation, the countries with less inequality are repeated than in the case of access to water, and Venezuela is also incorporated, all of them with an inequality factor of less than 8.2%, while Bolivia, Nicaragua and El Salvador showed indices of inequality greater than 24.7%.

5. Water Reuse as an Alternative to Mitigate Water Scarcity

Water reuse as an alternative to mitigate water scarcity in the world has gained relevance in various countries, although at different rates [66,67]. However, practicing water reuse as a State policy brings with it many challenges regarding regulatory, health, governance and public perception aspects [67]. Water reuse systems are classified as centralized and decentralized. The former correspond to large-scale systems, which require high investment costs but benefit from economies of scale in terms of operation and maintenance costs [15,68]. On the other hand, decentralized systems, used on a small scale such as homes or residential buildings, are often considered more sustainable and with lower infrastructure costs [15,69]. Table 1 shows a comparison between centralized and decentralized greywater treatment systems.

Table 1. Comparison between centralized and decentralized greywater treatment systems.

	Centralized	Decentralized	References
Investment Cost	Higher	Lower	[70–72]
Cost per m^3	Lower	Higher	[72,73]
Energy consumption	Higher	Lower	[74]
Water uses	Agricultural irrigation	Garden irrigation, toilet flush	[75,76]
Example	Dan Region Reclamation Project (Shafdan) in Israel	Residential buildings in Sant Cugat del Vallès (Barcelona, Spain)	[77,78]

According to Silva et al. (2008) [79], in Latin America, around 400 m^3/s of raw wastewater is delivered to surface sources and the areas are irrigated, most of the time, with untreated wastewater. Much water is reused intentionally or unintentionally, mainly associated with agriculture [54]. However, in LAC, there is not much data on the level of water reuse that is carried out effectively at the country level. FAO's Aquastat database provides information on water management in countries. Some countries contain more recent and complete information. Figure 4 shows the cases of Brazil, Chile, Mexico, and Peru regarding the amount of wastewater produced, collected and treated, and the amount of treated wastewater that is reused for irrigation purposes.

The data in Figure 4 reveal a great diversity regarding sanitation and water reuse in each country, which reflects the lack of a strong regulatory framework for the reuse of water resources, as well as the lack of policies for this purpose. The change of paradigms regarding the vision of wastewater no longer as a waste but as a resource could allow in the future to improve the indices of sustainable use of water in the region [80].

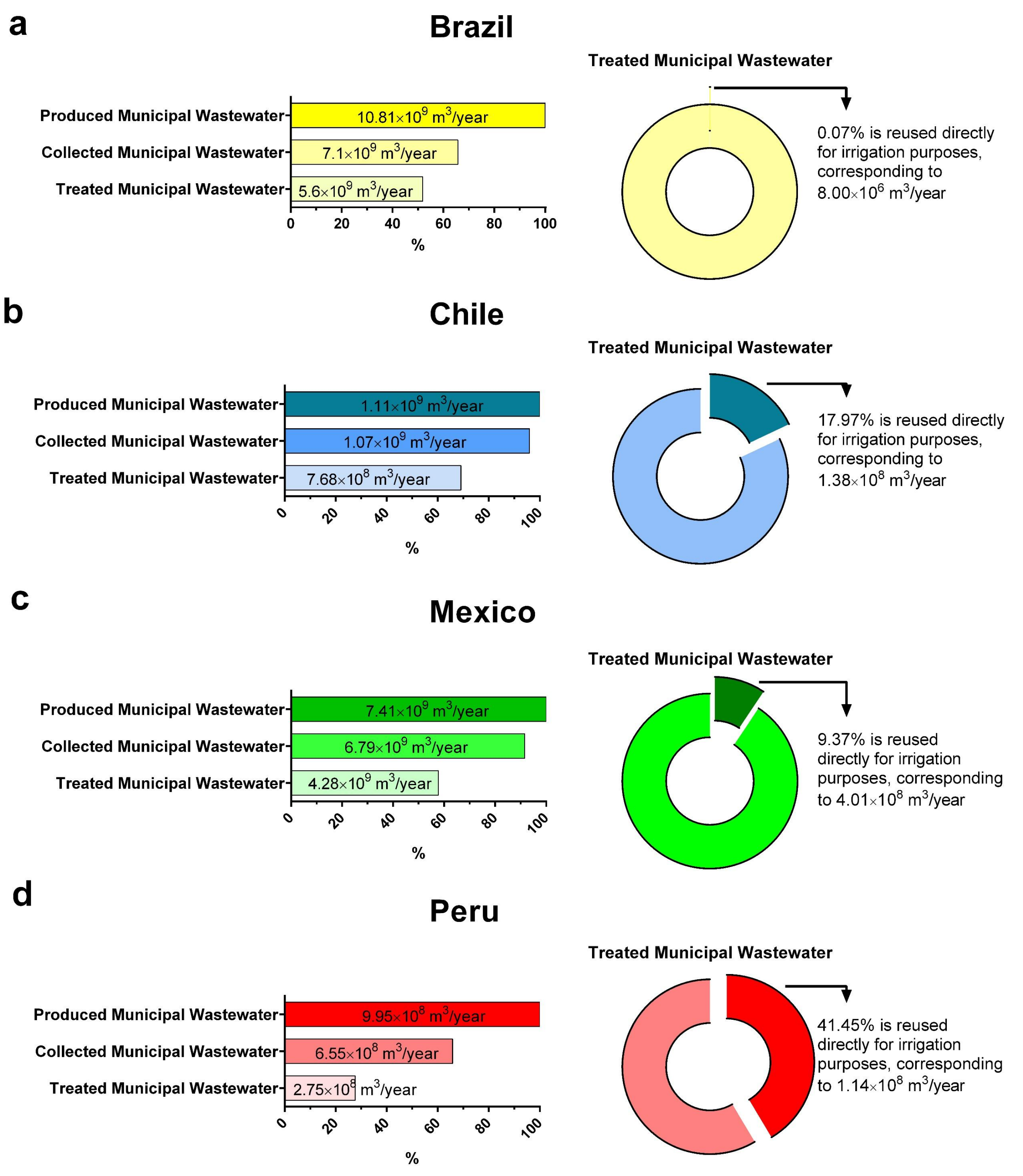

Figure 4. Amount of annual municipal wastewater produced, collected, and treated in (**a**) Brazil; (**b**) Chile; (**c**) Mexico; and (**d**) Peru. The figure also shows the amount of treated wastewater that is reused for irrigation purposes. Source: FAO (2017) [7].

The reuse of water, particularly at the household level, has gained interest in recent times. In particular, the reuse of greywater has been proposed as a measure to help mitigate water scarcity [81,82]. However, for its correct implementation, it is necessary to develop regulatory frameworks that allow greywater to be reused safely. To know the potential benefits of greywater reuse, it is necessary to know the water consumption habits at the household level. The Aquastat database does not contain all the information on municipal water produced for all LAC countries. However, when analyzing the available information on municipal wastewater produced by country based on the number of inhabitants, the three countries with the highest production correspond to Dominican Republic, Dominica, and Panama with 468×10^9 m^3/hab/year, 152×10^9 m^3/hab/year, and

130×10^9 m^3/hab/year, respectively, while the 3 countries with the lowest production are El Salvador, Bolivia, and Belize, with 20×10^9 m^3/hab/year, 18×10^9 m^3/hab/year and 10×10^9 m^3/hab/year, respectively. On average, the production of municipal wastewater is 87×10^9 m^3/hab/year. According to some studies, greywater constitutes between 50–80% of the total domestic wastewater generated [83,84], therefore, the potential greywater generated, on average, corresponds to 43 to 70×10^9 m^3/hab/year.

Globally, residential water reuse is in different stages of development and extension. Australia is one of the pioneering countries in public policies for the reuse of greywater, with numerous certified companies that offer different systems for the treatment of greywater, including aerobic treatment units, and septic tanks, among others [85,86]. In Japan as of 1991, there were 876 publicly owned treatment works in operation, discharging approximately 110×10^8 m^3 per year. Of the water recovered from these treatments, 41% was used in industrial activities, 32% was used to increase water and environmental flow, 13% for agricultural irrigation, and 8% was used for flushing toilets [87]. A widely used treatment system is the Johkasou, which is characterized by being a small-scale wastewater system and using anaerobic, aerobic and disinfectant processes which, coupled with a microfiltration process, manage to adequately comply with wastewater quality regulations reuse of the country [88]. These are successful examples and pioneers of decentralized reuse systems in the world.

6. International Guidelines for Water Management and Reuse

The concern about water resources is an issue that has taken the agenda of several international organizations. The main international organizations have set various objectives to improve conditions related to water, such as access, sanitation, and reuse.

6.1. Food and Agriculture Organization (FAO)

In 1985, the FAO published guidelines on the quality of wastewater for agricultural use, which emphasize water quality problems such as salinity, toxicity and infiltration [89]. In 1992, a guide was published with more specific water quality parameters, such as microbiological quality, and physicochemical parameters, depending on the use of irrigation water [90]. Then, in 2013, a document was published analyzing the benefits of water reuse in agriculture as a cost-effective option to mitigate the negative effects of water scarcity [91].

6.2. United Nations (UN)

UN-WATER, a specialized agency of the UN, was founded in 2003 to coordinate the efforts of UN entities and international organizations working on water and sanitation issues. In 2015, the UN established 17 Sustainable Development Goals (SDG). The SDG-6: "Ensure access to water and sanitation for all" establishes a series of goals for the year 2030, regarding universal access to water, access to sanitation and hygiene services, and international cooperation for the creation of capacities for wastewater treatment, recycling, and reuse technologies, among others [92]. The state of progress of SDG 6 in Latin America and the Caribbean reported for the year 2020 shows that LAC is the region with the lowest implementation of integrated water resources management systems worldwide. In addition, the gap is especially important in rural areas, where there is no safely managed sanitation coverage [93].

6.3. World Bank

In 2020, the World Bank published a report on wastewater as a resource in the context of a circular economy and also presents case studies [94]. In this report, guidelines are presented for the significant change from a linear approach to wastewater management to a circular approach, in which the internal policies of each country play an important role in its effectiveness. This paradigm shift is proposed as one of the main tools to achieve the goals of the SDG. These guidelines are based on planning for wastewater at the basin level, changing water treatment plants to resource recovery facilities, applying innovative financial and business models, and promoting the policies, regulations, and institutions necessary to achieve these goals.

6.4. Technical Specifications for Greywater Reuse Systems

Some countries have developed technical guides on safe practices for the reuse of greywater, with a focus on protecting people's health. The Water Supplies Department from Hong Kong presents the technical specification for new developments under government projects [95] and indicates that the system management should be performed by an appropriate contractor to operate and maintain the system in addition to regular monitoring of reclaimed water quality to ensure the public health and user safety. In this context, a non-detectable concentration of *E. coli* is recommended, a fairly restrictive parameter to protect people's health. Along these same lines, a technical guide published by the Singapore's national water agency [96] suggests that to reduce the risk of public health, it is suggested to combine a tertiary treatment process with reliable disinfection. The Department of Health of the Government of Western Australia published the Code of practice for the reuse of greywater in Western Australia [85] which provides information on the requirements for the reuse of greywater in household gardens. Additionally, its webpage contains information about approved greywater treatment systems [86]. For its part, the ANQIP association of Portugal presents technical specifications for greywater reuse and recycling building systems (ETA 0905) [97] and certification of greywater reuse and recycling building systems (ETA 0906) [98]. However, the risk of microbial and pathogen proliferation associated with the reuse of greywater remains a critical point for its safe implementation [81]. Some countries with more robust public policies regarding greywater reuse have technical guides such as those mentioned above, while LAC countries present less information or non-governmental guides. Busgang et al. (2018) [99] studied the microbial risks for various bacterial exposure scenarios involving greywater reuse for irrigation and determined maximum concentration levels for a group of pathogens for safe reuse. They also determined that the concentration of pathogens was the most important parameter in the sensitivity analysis and that a disinfection stage before the reuse of greywater is very necessary to comply with the tolerable limit of risk. The risk of microbiological contamination is even more critical in self-constructed systems and in rural settings, where the correct follow-up and monitoring of treatment systems may be less strict.

7. Water Regulations in Latin America and the Caribbean

Starting in the 1990s, the Latin American and Caribbean region began a strong restructuring in the water supply industry, strongly influenced by the neoliberal model, with a marked decentralization and an increase in private participation in the water service drinking and sanitation [100,101]. By the end of the 1990s, some countries considerably increased private participation, among which the case of Chile stands out, with 86% private financing and Argentina with 62% [101,102]. However, according to a study carried out by the OECD, public water governance in most of Latin America is fragmented, which has negative consequences on poverty reduction, in a context where water scarcity is becoming more evident [103].

On 28 July 2010, the United Nations General Assembly, through Resolution 64/292 [104], recognized the right to drinking water as a human right and urged States and organizations to intensify efforts to provide the population with economic access to drinking water and sanitation. In this context, it can be observed that some LAC countries recognize the human right to access to water in their political constitutions, which establish the values, principles, rights and basic guarantees of the people. Within the countries analyzed, 13 were identified that include in one or more articles of their Political Constitution the fundamental right of access to water and/or the State's duty to guarantee access to water resources: Bolivia [105], Colombia [106], Cuba [107], Ecuador [108], Guatemala [109], Mexico [110], Nicaragua [111], Panama [112], Paraguay [113], Peru [114], Uruguay [115], Venezuela [116]. An interesting example is Costa Rica, which in 2020 approved a constitutional reform that guarantees people's right to access water. More specifically, a paragraph was added to Article 50 of the constitution: "Every person has the human, basic and inalienable right of access to drinking water, as an essential good for life. Water is a good of the nation, essential to protect this human right. Its use, protection, sustainability, conservation and exploitation will be governed by what is established by the law that will be created for these purposes and the supply of drinking water for consumption by people and populations will have priority" [117].

On the other hand, several LAC constitutions do not explicitly mention the human right to water in any of their articles. Some examples are the Political Constitution of Argentina that in Article 41 declares that all inhabitants enjoy the right to a healthy environment, that the authorities must ensure the protection of this right and that the environmental damage caused must be repaired [118]. However, in the Political Constitution, there is no detail about water resources in particular. Another particular case corresponds to Chile, whose constitution establishes that "the rights of individuals over the waters, recognized or constituted following the law, will grant their owners ownership over them" [119]. The water code of Chile, modified in 1981, defines the types of water and establishes what refers to the domain and use of this resource. Generally speaking, water is separated from the land and becomes a tradable right. In this way, from the institutional and regulatory framework, water is not guaranteed as a human right, but rather as a right of use. In this way, Chile has the most liberal model in terms of water management.

Most of the countries in the region have a comprehensive water law, which regulates the management of water resources. However, El Salvador lacks general legislation on this matter. According to UN data, in 2012 only 2.8% of the population of El Salvador was connected to wastewater treatment [120]. These low levels of sanitation, as well as other water quality problems, are explained by the absence of a national water authority and the fact that the General Water Law, which has been under discussion since 2012, has not yet been approved, but has made progress during 2020 [121,122].

Concerning the reuse of wastewater, some countries have specific regulations. For example, Colombia, through Resolution 1207 of 2014, regulates the reuse of treated wastewater for agricultural and industrial use. In the case of Guatemala, the Governmental Agreement 236 of 2006 regulates the reuse for agricultural irrigation, irrigation of edible crops, irrigation of aquaculture, pastures and other crops, and recreational reuse. In Mexico, the Official Mexican Standard (NOM-003-ECOL) of 1997 establishes the maximum permissible limits of contaminants for the reuse of treated wastewater according to the level of interaction that the type of reuse has with people. For its part, Peru regulates the reuse of water treated by a person other than the owner of the treatment system through Supreme Decree No. 005-2011-AG. The legislative framework in LAC is summarized in Table 2.

The reuse of water from the legislative point of view is underdeveloped in the study region. The regulations adopted by the countries are based on international standards but are not adapted to the specific needs of each country, whether geographical, social and/or economic. In this way, the lack of flexibility makes reuse unattractive, which also adds to the lack of incentives in this area. From an institutional point of view, there is a lack of coordination and collaboration between different organizations (environment, energy, health, mining, among others) that must talk to each other to generate and develop a circular economy.

The reuse of water also poses other very important challenges, such as economic feasibility, which today is the main evaluation method used for decision-making, and also the reluctance generated by the consumption of reclaimed wastewater. Since the treatment of wastewater for reuse involves high investment costs, there are cheaper decentralized alternatives, on a smaller scale, that allow improving the management of water resources at the household or small community level, an example of this is the reuse of greywater. However, from a regulatory point of view, this type of treatment is poorly developed.

Table 2. Legislative framework on water matters in Latin America and the Caribbean and main authorities related to the institutional and administrative framework of water resources.

Country	Water Regulation	Water Authority or Related
Argentina	Law 25688 (2003) "Environmental water management regime"- minimum environmental budgets for the preservation of water, its use and rational use	Ministry of Public Works- Secretariat of Infrastructure and Water Policy
Bolivia	Political Constitution (2009) -Art. 16 universal right to water -Art. 20 universal and equitable right to drinking water and sewerage Law 2066 (2000) "Law of Provision of Potable Water and Sanitary Sewerage Services" Regulation Law 1333 of the Environment (1992) -Chapter V, Art. 67 water quality parameters for authorization of water reuse	Ministry of Environment and Water
Brazil	Political Constitution (1988) -Art. 21 competence of Federal Government to establish a national water resource management system and define criteria for granting rights to the use of water Federal Law 9433 (1997) establishes the Brazilian National Water Resources Policy Law 9984 (2000)	National Water Agency (ANA)
Chile	Water code (1981) -Defines the types of water and establishes what refers to the domain and use of this resource Decree 90 (2000) -Establishes the emission standard for the regulation of pollutants associated with the discharge of liquid waste to marine and continental surface waters	General Directorate of Water (DGA)
Colombia	Political Constitution (1991) -Art. 366 access to drinking water is a social purpose of the State, as well as environmental sanitation Law 99 (1993) and the Single Regulatory Decree of the Environment and Sustainable Development Sector 1073 (2015) -Establish a series of rules that govern the sustainable use and exploitation of water resources Resolution 1207 (2014) -Regulates the use of treated wastewater	Ministry of Environment and Sustainable Development
Costa Rica	Political Constitution (Constitutional reform 2020, disposed by Law 9849) -Art. 50 "Every person has the human, basic and inalienable right of access to drinking water, as an essential good for life". Law 276 (1942, modified in 2012) -Management of water resources Decree 31545-S-MINAE -Regulates the treatment and disposal of wastewater	Ministry of Environment and Energy
Cuba	Political Constitution (2019) Art. 76 establishes that everyone has the right to water and that the State creates the conditions to guarantee access to drinking water and sanitation Law 124 "Land Waters Law" (2017) orders the integrated management of terrestrial waters	National Institute of Hydraulic Resources
Ecuador	Political Constitution (2008) -Art. 3 it is a primary duty of the State to guarantee water for its inhabitants Art. 12 The human right to water is fundamental and inalienable Organic Law of water resources uses and use of water (2014) -Aims to guarantee the human right to water, and regulate the management of water resources, their uses and exploitation	Unique Water Authority
El Salvador	Decree 233 (1998) -Decrees the Environmental Law that aims at the protection, conservation and recovery of the environment General Water Law (under discussion) -Aims to regulate the comprehensive management of water, regulating its rights, use, exploitation, protection and recovery	Ministry of Environment and Natural Resources National Water Authority (ANA)

Table 2. *Cont.*

Country	Water Regulation	Water Authority or Related
Guatemala	Political Constitution (1985) Art. 127 "All water is property of the public domain, inalienable and imprescriptible Art. 128 The use of water for economic development purposes is at the service of the community and not of any private person Governmental Agreement 236 (2006) Regulation of the Discharges and Reuse of Residual Waters and the disposal of sludge -authorizes and defines the limits of water reuse for agricultural irrigation, irrigation of edible crops, irrigation of aquaculture, pastures and other crops, and recreational reuse	Ministry of Environment and Natural Resources
Honduras	General Water Law (Decree 181-2009) -Establishes the principles and regulations applicable to the adequate management of water for integrated management of water resources at the national level	Secretariat of Natural Resources and Environment (SERNA) General Directorate of Water Resources (DGRH)
Mexico	Political Constitution (1917) -Art. 4 human right to access to water -Art. 27 the waters belong to the nation, and that the State oversees regulating their use through concessions based on the laws Art. 115 municipalities are in charge of public drinking water services National Water Law (1991) General Water Law (Law proposal under discussion) -Aims to strengthen water management, and allow greater social participation of local communities, recognizing community water management NOM-003-ECOL (1997) establishes the maximum permissible limits of contaminants for treated wastewater that is reused in public services, divided into services to the public with direct contact and with indirect or occasional contact	National Water Commission (CONAGUA)
Nicaragua	Political Constitution (1987) -Art. 105 the State must promote, facilitate and regulate access to water Law 620 "General Law of National Waters" (2007) -aims to establish the institutional legal framework to manage, conserve, develop, use and sustainable use and preservation in quantity and quality of all that is water in the country, while guaranteeing the protection of other natural resources, ecosystems and the environment	National Water Authority (ANA)
Panama	Political Constitution (1972) Art. 120 The State will regulate, supervise and apply the necessary measures to guarantee the rational use and use of water. Law Decree No. 2 (1997) -the regulatory and institutional framework for the provision of drinking water and sanitary sewerage services General Law of Water Resources (under discussion) -protection, uses and use of water	National Public Services Authority (ASEP) National Environmental Authority (ANAM)
Paraguay	Political Constitution (1992) -Art. 163 establishes that it is the responsibility of the departmental government to coordinate its activities with the municipalities drinking water services Law 3239 "Water Resources Law" (2007) -regulates the management of the waters of the national territory	Ministry of the Environment and Sustainable Development Directorate General for the Protection and Conservation of Water Resources
Perú	Political Constitution (1993) -Art. 7-A declares that the State recognizes the right of everyone to access drinking water and guarantees human consumption over other uses. In addition, the State promotes sustainable water management Law 29338 "Water Resources Law" (2019) -the law and its regulations regulate the use and management of water resources Supreme Decree No. 005-2011-AG (2011) -regulates the reuse of wastewater treated by a person other than the owner of the treatment system to protect and preserve the quality of natural water sources	National Water Authority (ANA)

Table 2. *Cont.*

Country	Water Regulation	Water Authority or Related
Uruguay	Political Constitution (2004) -Art. 47 "Access to drinking water and access to sanitation are fundamental human rights . . . the sustainable management, in solidarity with future generations, of water resources and the preservation of the hydrological cycle, which are matters of general interest. Users and civil society will participate in all levels of planning, management and control of water resources" Law 18610 "National Water Policy Law" (2009) -establishes the guidelines for the management of water resources and the universalization of drinking water and sanitation services Decree 253 (1979) -standards to prevent environmental pollution by controlling water pollution.	National Directorate of Environment (DINAMA)
Venezuela	Political Constitution (1999) -Art. 178 establishes that the municipality is responsible for managing and administering the drinking water, sewerage, channeling and disposal of sewage services Water Law (2007) -establishes the provisions that govern the integral management of water	Ministry of Popular Power for the Environment

According to the analysis carried out by the World Bank [123], one of the main barriers to the reuse of wastewater is that in most LAC countries there is no regulation of treated wastewater, nor does it have a clear value or price, which discourages investment by companies in water reuse projects. Thus, the regulatory framework is a fundamental step to moving toward a circular economy of water, where water reuse projects are not just simple prototypes or research works but can be implemented on a large scale in the future.

7.1. Greywater Regulations and Its Implementation in Latin America and the Caribbean

Even though the reuse of greywater has gained relevance in some countries in Europe, Asia and Oceania as an alternative source of water to face the problems of water scarcity [22,83], in LAC it has not yet gained force in legislative matters or its implementation. Greywater corresponds to wastewater of domestic origin that includes water from the shower, washbasin, washing machine, dishwasher, and kitchen sink [80,124,125]. Sometimes a distinction is made between light and dark greywaters. The former corresponds to the fraction that comes mainly from the shower and sinks, while the dark greywaters correspond to the waters generated from the laundry and the kitchen, which due to their characteristics, have a higher content of organic matter and pollutants [80,126].

In LAC, only Chile has a legal norm on the specific matter of greywater, recognizing its separation from black water and therefore, from the general regulation of sanitation. In February 2018, Law 21,075 was approved that regulates the collection, reuse, and disposal of greywater. In Peru, Law Project 4239 is under processing since 2018, which aims to promote the care of natural water sources, the reuse of domestic wastewater, and water saving. This law does not distinguish between greywaters, but they are defined as domestic wastewater. As for Brazil, the most advanced bill on this matter is 4109 from 2012, which is pending consideration by the Federal Senate. This law institutes norms that regulate public policies for the conservation, rational use, and reuse of water. Regarding reuse, reference is made to the capture and reuse of rainwater and wastewater. Table 3 summarized greywater legislation in LAC countries.

Despite the lack of legislation regarding greywater reuse in LAC, some scientific research shows that this alternative has been studied with limited applications. In Brazil, the saving of drinking water was studied through the use of rainwater and greywater in homes and a multi-story residential building [127,128]. In both cases, three configurations of treatment systems were studied: only rainwater, only greywater, and the combination of greywater and rainwater. To treat greywater, a wetland system was used, consisting of a biological filter composed of gravel or sand and swamp plants. The conclusions suggest that for the case of the residential building, all the treatment configurations were profitable, while for the houses the systems were not profitable, however, the configuration of treating only greywater turned out to be the most attractive. Therefore, to promote water reuse at the household level, there is a need for government incentives. Additionally, greywater treatment was studied on a campus of the University of Sao Paulo in Brazil, through the use of a moving bed biofilm reactor and a sedimentation tank [85]. In this case, an economic evaluation was not performed, but the water quality studies showed stability and confidence in the treated water, ensuring the potential for safe reuse. Another study was carried out at the Tancredo Neves International Airport, where a system comprising an anaerobic filter followed by ultraviolet disinfection was evaluated for greywater treatment [129]. The results were satisfactory according to less stringent reuse standards and the economic analysis showed a payback period of five years.

Table 3. Countries in Latin America and the Caribbean that have or are processing legislation on the reuse of greywater.

Country	Greywater Regulation	Status
Chile	Law No. 21.075 regulates the collection, reuse, and disposal of greywater	Enacted on 15 February 2018
Peru	Bill No. 4239/2018-CR which promotes the care of natural water sources and the reuse and saving of domestic water	Under evaluation
Brazil	Bill No. 4109/2012, aims to institute obligatory norms for the conservation, rational use, and reuse of water	Under evaluation

In Chile, pilot treatment systems for the reuse of greywater have been studied in schools in rural areas with water scarcity [80,130]. For this, the water coming from the school sinks was collected and treated through a system of filters composed of activated carbon and zeolite. This water was used for the irrigation of green areas in the educational establishments themselves. The economic analysis of these systems revealed their infeasibility because the investment costs could not be recovered in the time range studied. However, the social benefits, mainly associated with the increase of green areas, are significant, so it is necessary to look for alternative subsidies and financing to support the implementation of these systems.

In Colombia, a study was made on the social, technical, and financial viability of rainwater and greywater collection and treatment systems (separate and combined systems) [131]. This study was conducted through surveys of low-income households in a residential complex of social housing. Although this study is based on potential treatment systems, from the results obtained it was possible to show that the surveyed population privileged water conservation over investment criteria. In addition, it showed a preference for combined treatment systems (rainwater/greywater). However, it must be evaluated whether the users would fulfill their intentions in a real scenario of implementing treatment systems. Complementary to this study, the financial analysis gave positive results, with an estimated recovery period of 23 years, a lower value than that reported in other studies, which reflects a promising scenario for implementing decentralized water reuse systems for domestic use [132].

In Costa Rica, the effectiveness of the use of low-cost reedbeds for greywater treatment was studied [133,134]. The results were positive in terms of the quality of the water obtained after the treatment, which meets the standards required for its reuse. The treatment, in this case, is not only positive to save drinking water but also due to the high amount of greywater that is channeled directly to the streets or the nearest stream [133].

The review of the state of the art in the Latin American and Caribbean Region allows us to realize that there are initiatives to study the technical and economic feasibility of treatment systems, even though in no case can widespread use of greywaters. In addition, the lack of legislation or regulatory framework can contribute to the bad practice of greywater reuse, which could have bad effects on health. In addition, some studies show the need for incentives or government subsidies for the implementation of treatment systems [124,135].

A recent study [136] analyzed the potential capture of greywater reuse using existing research on consumer preferences, taking Santiago, Chile as a case study. Their study concluded that there is a need to use advanced mathematical models that bring together economic theory and behavioral underpinnings from psychology. Similarly, Oteng-Peprah et al. (2020) [137] explored the willingness of households to adopt a greywater treatment and reuse system using the theory of planned behavior in its original form and an extended model that includes personal norms, obtaining as a result that the extended model turned out to be the best. model to predict the willingness to adopt this treatment system and domestic greywater.

7.2. Economic Aspects in the Reuse of Greywater

The economic factor is directly related to access to drinking water and sanitation. Lower-income countries have less access to safe sources of drinking water and large geographic inequalities in access to improved water and sanitation [138]. In this context, women and children are the main transporters of water to homes when the water supply is not sufficient, a complex task in the social life of people with a lack of access to drinking water [139]. However, economic inequality between countries is not only reflected in the quantity of water but also its quality. Water sources in low-income countries and rural areas are more likely to be contaminated [140]. In addition, international estimates may overestimate access to drinking water since, although improved water sources are better in quality than non-improved ones, in many cases they still present levels of contamination higher than those recommended by the WHO [140]. Figure 5 shows the relationship between Gross Domestic Product (GDP) per capita and access to healthy drinking water in some countries in Latin America. Although there is a certain variability, a relationship can be observed between GDP per capita in the coverage of access to drinking water, where Uruguay and Chile, both countries with the highest GDP per capita, have access to healthy water close to 100%, while countries such as Bolivia, Ecuador and Peru, with lower GDP per capita, have less access to drinking water, with values below 90%.

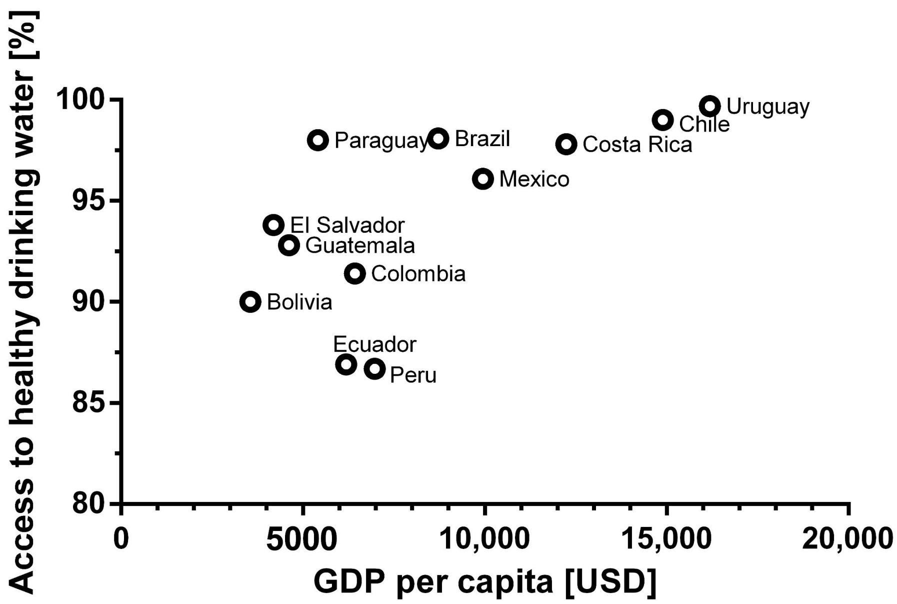

Figure 5. Access to healthy drinking water versus Gross Domestic Product (GDP) per capita in some countries of Latin America and the Caribbean. Source: GDP values were taken from The World Bank (2019) and the water access data were taken from the Aquastat database.

On the other hand, previous works have studied the Kuznets curve related to water use. Duarte et al. (2013) [141] found that the link between water withdrawal per person and GDP per capita is non-linear and shows a peculiar inverted U, i.e., water use tends to increase with lower income observations, but this trend is invested when income increases. Similarly, Von Hauff and Mistri (2015) [142] found that access to safe drinking water decreases rapidly with increasing income first, but starts to increase again with higher incomes. The reason could be in part the inability to adequately manage the effects of regional climatic and geomorphological diversity.

Although the installation of greywater recovery technologies could mean a high environmental and social benefit, it is necessary to evaluate the economic feasibility, to determine the real applicability of greywater treatment systems. Greywater treatment systems could be centralized or decentralized. A centralized treatment plant is a municipal facility or a larger facility that treats and distributes water through a pipe system, whereas a decentralized facility is at the level of individual buildings or small areas [74]. According to Ahmed and Arora (2012) [143], centralized water treatment will be easier to regulate, although it will be more costly for operation and maintenance due to complex sewerage networks. Decentralized treatment on the other hand is more likely to be more profitable if it is carried out at the individual residential or commercial level.

The profitability or money savings of greywater systems varies according to various factors, but those that generate the greatest impact at the household level are the volume of water saved, the price of the replaced network water, the costs of installation, operation, and maintenance of the chosen technology [83,144].

From different case studies of leading powers in greywater recycling, conclusions and recommendations have been obtained when installing the technologies [145]. Greywater systems are more economically viable in large buildings with multiple floors, and with a constant water need, such as gardens or a high flow of people. Additionally, it is not economically viable in small single-family homes due to how fast the use of the water generated must be. The cost of water could change the payback period, since if the water rates are subsidized or the water rate is low, the payback period of the investment will be longer and when calculating the net present value (NPV) of the project is strongly affected by water prices [146–148].

In Latin America and the Caribbean, it can be observed that the price of water for an average monthly consumption of 30 m^3 for a household is directly related to the income level of that country. Figure 6 shows the relationship between GDP per capita and the price of water. According to these results, given that lower-income countries have lower water prices, the economic feasibility of installing decentralized greywater treatment systems could be negative. However, the countries with the lowest incomes are those that also generally have the lowest drinking water coverage. In this scenario, the active participation of the State in the incentive and subsidy of systems that allow saving and recovering water is essential.

The economic reality of LAC, as well as its inequality, make evident the need for state policies for the implementation and development of water reuse systems at a decentralized level. Likewise, an improvement in the general sanitary infrastructure is urgently needed, to optimize water resources, avoid losses due to poor management, and increase the level of wastewater treatment. In this context, according to the analysis and data presented in this study, it is possible to conclude that countries with fewer economic resources face greater problems with access to drinking water and sanitation. In addition, it is to be expected that these countries will have fewer resources available for the delivery of subsidies or other aid or economic incentives that allow an expansion of decentralized water systems. On the other hand, most LAC still lacks adequate regulations to regulate and allow the reuse of water at the household level. Therefore, future efforts should be aimed at encouraging, from the political, social, and scientific spheres, resources that allow overcoming these barriers to improve water management in this context of water scarcity.

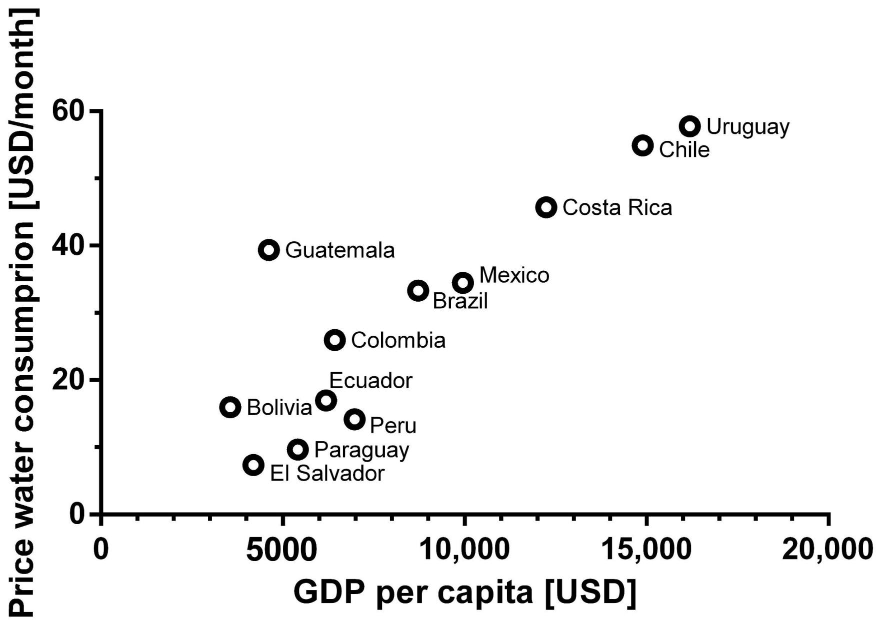

Figure 6. Price of the average water consumption of a household (30 m^3/month) versus Gross Domestic Product (GDP) per capita in some countries of Latin America and the Caribbean. Source: GDP values were taken from The World Bank (2019) [140] and the water rates were taken from [149–160].

8. Policy and Governance Challenges for Water Management and Water Reuse

In general, there are three ways to manage water use: privatization, government management, and community management. In LAC, the management of water resources is mainly based on privatization systems. This is largely explained by the lack of technological development. In rural areas, on the other hand, community management is the majority, which presents a series of problems associated with the lack of resources for its correct operation, as well as the use of low-tech processes. The privatization of water management has had good temporary results in some cases, as happened in Argentina, which in 1993 changed to this type of management to promote the universalization and improvement of drinking water and sanitation services. Privatization initially made it possible to improve the government management service, which was on the verge of collapse due to mismanagement. However, the rise in prices and the lack of social sense resulted in the system not being able to meet the objectives set at the beginning. [161]. From the previous example, it is possible to observe that the pure state and private management present problems in their operation due to the lack of efficiency, in the first case, and of social role in the second, which increases inequality in access to services drinking water and sanitation in the region. Therefore, water governance must be viewed and planned from a social and environmental perspective, continually seeking efficiency and technological development. In this context, the decentralization of water management can provide opportunities to adapt policies to local realities.

Decentralization is also relevant in the handling and management of reused water, being particularly important in rural areas and far from large cities. However, the reuse of water, such as greywater, in a decentralized manner presents significant challenges. On the one hand, general water reuse laws may be impracticable in some areas, since local realities are very diverse. Similarly, the scale of reuse can make the use of very sophisticated technologies unfeasible, as well as very expensive. The economic and technical support of the authorities is essential for a better implementation of decentralized reuse systems. Finally, the reuse of water must be considered a social problem and not only an environmental, health or economic problem. The main objective of public policies should focus on seeking an improvement in present living conditions, without harming resources for future generations, and socio-spatial justice to overcome the inequitable distribution of water resources.

9. Challenges and Conclusions

This study shows a global review of water reuse in LAC. The review clearly shows that the regulatory framework on water reuse in LAC is varied and has different emphases, approaches, and objectives depending on the country. The contribution of this work is that it presented a general overview of the management of water resources in the region, emphasizing the potential of greywater reuse and including a review of technological and economic aspects. These results are essential to evaluate potential public policies in the region that focus on promoting the application of water reuse systems as a necessary response to address scenarios of water scarcity and greater pressure on the scarce water resources available in the region. Thus, the review presented in this paper will be a great input for stakeholders and/or other studies on water reuse, water management, and water security in the LAC.

Despite the high availability of renewable water resources per capita in LAC, governance problems and the excessive use of this resource in certain agricultural or industrial activities may cause that sometimes human access to water is not guaranteed in some areas of the region. When analyzing the data on access to drinking water by country, in a general way and also distinguishing between urban and rural populations, a relationship can be seen between the income of each country (GDP per capita) and access to drinking water, being the countries with fewer resources, those with a lower coverage rate of access to drinking water.

From a regulatory point of view, most LAC countries refer to water resources in their political constitution, and more extensively, in some general water laws of each country. Similarly, each country has competent water authorities, related to a ministry or other organism. Regarding the management and reuse of wastewater, some countries have specific regulations, setting permissible water quality limits for the use of treated wastewater in activities such as agricultural irrigation.

Regarding the reuse, treatment, and use of greywater, there is a general lack of legislation and regulation. Only some countries in the region have a law or bill that refers to the use of greywater, while the vast majority do not even make a semantic distinction between greywater and wastewater in general. This positions LAC below other countries such as Australia, Israel, the USA, and Japan, among others, which have legislation and policy that promotes the reuse of greywater. LAC must move towards a circular economy of water, by strengthening the institutions and legislation of each country, according to its own needs and characteristics, in order to generate incentives for investment and development of wastewater treatment systems that allow revaluing this residue and allow to generate a decrease in hydric pressures for intensive uses of water, such as agriculture.

The management and regulation of greywater reuse in a decentralized manner must be carefully evaluated from an economic point of view since treatment systems could have unaffordable costs for people with the potential for reuse. A good implementation of public policies focused on the decentralized treatment of greywater would be very beneficial for rural and isolated communities that face problems of scarcity and shortage of water. Therefore, the regulatory framework must be accompanied by incentive and subsidy policies to promote the reuse of greywater in the region.

LAC countries should move forward in improving the legislation that allows and regulates decentralized water reuse, and at the household level or in small communities. For this, successful cases from other regions of the world, such as Australia, USA, Japan and Israel, with positive experiences in the urban and rural world, should be taken as a reference.

Author Contributions: The manuscript was written by C.R., B.G., C.P. and E.L., but all the authors contributed to its preparation and review. Conceptualization and data analyses were carried out by C.R., B.G. and C.P. in discussion with E.L.; formal analysis was performed by C.R. and E.L.; the manuscript was edited and reviewed by C.R., R.S., J.S. and E.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research has received funding by Proyecto Corfo "Consorcio Tecnológico del Agua 20CTECGH-145896", Proyecto de Políticas Públicas UC 2020 "Política de reutilización de aguas grises en Chile: una propuesta para la implementación en comunidades rurales de la ley que regula la recolección, reutilización y disposición de aguas grises" and Fondecyt Iniciación 11191154 (2019–2022) grants.

Acknowledgments: Thanks are also extended to the reviewers for their corrections and suggestions, who contributed significantly to improving the quality of this manuscript. This research was developed within the framework of Concurso de Políticas Públicas organized by Centro de Políticas Públicas UC.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Mekonnen, M.M.; Hoekstra, A.Y. Four billion people facing severe water scarcity. *Sci. Adv.* **2016**, *2*, e1500323. [CrossRef] [PubMed]
2. Mehrazar, A.; Massah Bavani, A.R.; Gohari, A.; Mashal, M.; Rahimikhoob, H. Adaptation of Water Resources System to Water Scarcity and Climate Change in the Suburb Area of Megacities. *Water Resour. Manag.* **2020**, *34*, 3855–3877. [CrossRef]
3. Pereira, L.S. Water, Agriculture and Food: Challenges and Issues. *Water Resour. Manag.* **2017**, *31*, 2985–2999. [CrossRef]
4. WWAP (UNESCO World Water Assessment Programme)/UN-Water. *The United Nations World Water Development Report 2019: Leaving No One behind 2019*; UNESCO: Paris, France, 2019; ISBN 978-92-3-100309-7.
5. Hasan, M.M.; Alam, K. Inequality in access to improved drinking water sources and childhood diarrhoea in low- and middle-income countries. *Int. J. Hyg. Environ. Health* **2020**, *226*, 113493. [CrossRef]
6. The World Bank World Databank—World Development Indicators. Available online: https://data.worldbank.org/indicator/SP.POP.TOTL (accessed on 14 October 2020).
7. FAO. AQUASTAT Main Database—Food and Agriculture Organization of the United Nations (FAO). Available online: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en (accessed on 14 October 2020).
8. Garrido, A.; Shechter, M. *Water for the Americas: Challenges and Opportunities*; Routledge: London, UK, 2014; ISBN 1317685652.
9. Mekonnen, M.; Pahlow, M.; Aldaya, M.; Zarate, E.; Hoekstra, A. Sustainability, Efficiency and Equitability of Water Consumption and Pollution in Latin America and the Caribbean. *Sustainability* **2015**, *7*, 2086–2112. [CrossRef]
10. Ostad-Ali-As, K. Investigation of meteorological variables on runoff archetypal using SWAT: Basic concepts and fundamentals. *Appl. Water Sci.* **2022**, *12*, 177. [CrossRef]
11. Connor, R.; Renata, A.; Ortigara, C.; Koncagül, E.; Uhlenbrook, S.; Lamizana-Diallo, B.M.; Zadeh, S.M.; Qadir, M.; Kjellén, M.; Sjödin, J. *The United Nations World Water Development Report 2017*; Wastewater: The Untapped Resource; United Nations World Water Developement Report; The United Nations World: New York, NY, USA, 2017.
12. Grant, S.B.; Saphores, J.-D.; Feldman, D.L.; Hamilton, A.J.; Fletcher, T.D.; Cook, P.L.M.; Stewardson, M.; Sanders, B.F.; Levin, L.A.; Ambrose, R.F.; et al. Taking the "Waste" Out of "Wastewater" for Human Water Security and Ecosystem Sustainability. *Science* **2012**, *337*, 681–686. [CrossRef]
13. Mukherjee, M.; Jensen, O. Making water reuse safe: A comparative analysis of the development of regulation and technology uptake in the US and Australia. *Saf. Sci.* **2020**, *121*, 5–14. [CrossRef]
14. Shoushtarian, F.; Negahban-Azar, M. Worldwide Regulations and Guidelines for Agricultural Water Reuse: A Critical Review. *Water* **2020**, *12*, 971. [CrossRef]
15. Sgroi, M.; Vagliasindi, F.G.A.; Roccaro, P. Feasibility, sustainability and circular economy concepts in water reuse. *Curr. Opin. Environ. Sci. Health* **2018**, *2*, 20–25. [CrossRef]
16. Gross, A.; Maimon, A.; Alfiya, Y.; Friedler, E. *Greywater Reuse*; CRC Press: Boca Raton, FL, USA, 2015; ISBN 1482255057.
17. Cook, C. Regulating the risks of domestic greywater reuse: A comparison of England and California. *Built Environ.* **2016**, *42*, 230–242. [CrossRef]
18. Maimon, A.; Gross, A. Greywater: Limitations and perspective. *Curr. Opin. Environ. Sci. Health* **2018**, *2*, 1–6. [CrossRef]
19. Pinto, U.; Maheshwari, B.L. Reuse of greywater for irrigation around homes in Australia: Understanding community views, issues and practices. *Urban Water J.* **2010**, *7*, 141–153. [CrossRef]
20. *EMRC Reuse of Greywater in Western Australia*; Discussion Paper; EMRC: Perth, Australia, 2011.
21. Yu, Z.L.T.; Rahardianto, A.; DeShazo, J.R.; Stenstrom, M.K.; Cohen, Y. Critical Review: Regulatory Incentives and Impediments for Onsite Graywater Reuse in the United States. *Water Environ. Res.* **2013**, *85*, 650–662. [CrossRef]
22. Oron, G.; Adel, M.; Agmon, V.; Friedler, E.; Halperin, R.; Leshem, E.; Weinberg, D. Greywater use in Israel and worldwide: Standards and prospects. *Water Res.* **2014**, *58*, 92–101. [CrossRef]

23. Yamagata, H.; Ogoshi, M.; Suzuki, Y.; Ozaki, M.; Asano, T. On-site water recycling systems in Japan. *Water Sci. Technol. Water Supply* **2003**, *3*, 149–154. [CrossRef]
24. Angelakis, A.N.; Bontoux, L.; Lazarova, V. Challenges and prospectives for water recycling and reuse in EU countries. *Water Supply* **2003**, *3*, 59–68. [CrossRef]
25. Paranychianakis, N.V.; Salgot, M.; Snyder, S.A.; Angelakis, A.N. Water Reuse in EU States: Necessity for Uniform Criteria to Mitigate Human and Environmental Risks. *Crit. Rev. Environ. Sci. Technol.* **2015**, *45*, 1409–1468. [CrossRef]
26. Nolde, E. Greywater reuse systems for toilet flushing in multi-storey buildings—Over ten years experience in Berlin. *Urban Water* **2000**, *1*, 275–284. [CrossRef]
27. Al-Mashaqbeh, O.A.; Ghrair, A.M.; Megdal, S.B. Grey Water Reuse for Agricultural Purposes in the Jordan Valley: Household Survey Results in Deir Alla. *Water* **2012**, *4*, 580–596. [CrossRef]
28. Shanableh, A.; Khalil, M.A.; Mustafa, A.; Abdallah, M.; Idris, A.E.; Yilmaz, A.; Merabtene, T.; Siddique, M.; Al-Ruzouq, R.; Imteaz, M.A.; et al. Greywater reuse experience in Sharjah, United Arab Emirates: Feasibility, challenges and opportunities. *Desalin. Water Treat.* **2020**, *179*, 211–222.
29. Nhapi, I.; Hoko, Z. A cleaner production approach to urban water management: Potential for application in Harare, Zimbabwe. *Phys. Chem. Earth Parts A/B/C* **2004**, *29*, 1281–1289. [CrossRef]
30. Kulabako, R.; Greywater, N. Characteristics and Reuse in Tower Gardens in Peri-Urban Areas—Experiences of Kawaala, Kampala, Uganda. *Open Environ. Eng. J.* **2011**, *4*, 147–154. [CrossRef]
31. Zhu, J.; Wagner, M.; Cornel, P.; Chen, H.; Dai, X. Feasibility of on-site grey-water reuse for toilet flushing in China. *J. Water Reuse Desalin.* **2018**, *8*, 1–13. [CrossRef]
32. Godfrey, S.; Labhasetwar, P.; Wate, S. Greywater reuse in residential schools in Madhya Pradesh, India-A case study of cost-benefit analysis. *Resour. Conserv. Recycl.* **2009**, *53*, 287–293. [CrossRef]
33. Sushmitha, M.B.; Chanakya, H.N.; Khuntia, H.K. Efficient Grey Water Treatment and Reuse Options for India—A Review. *Waste Water Recycl. Manag.* **2019**, *2019*, 143–149.
34. Exall, K. A Review of Water Reuse and Recycling, with Reference to Canadian Practice and Potential: 2. Applications. *Water Qual. Res. J.* **2004**, *39*, 13–28. [CrossRef]
35. Van Rossum, T. Water reuse and recycling in Canada—History, current situation and future perspectives. *Water Cycle* **2020**, *1*, 98–103. [CrossRef]
36. Sheikh, B.; Nelson, K.L.; Haddad, B.; Thebo, A. Grey Water: Agricultural Use of Reclaimed Water in California. *J. Contemp. Water Res. Educ.* **2018**, *165*, 28–41. [CrossRef]
37. Jeppesen, B. Domestic greywater re-use: Australia's challenge for the future. *Desalination* **1996**, *106*, 311–315. [CrossRef]
38. Weaver, L. A Comparison of Regulatory Guidance of Greywater Reuse in New Zealand and Australia. 2022. Available online: https://www.esr.cri.nz/assets/HEALTH-CONTENT/MoH-reports/A-comparison-of-regulatory-guidance-of-greywater-reuse-in-New-Zealand-and-Australia.pdf (accessed on 20 September 2022).
39. Distefano, T.; Kelly, S. Are we in deep water? Water scarcity and its limits to economic growth. *Ecol. Econ.* **2017**, *142*, 130–147. [CrossRef]
40. Arfanuzzaman, M.; Atiq Rahman, A. Sustainable water demand management in the face of rapid urbanization and ground water depletion for social–ecological resilience building. *Glob. Ecol. Conserv.* **2017**, *10*, 9–22. [CrossRef]
41. Fercovic, J.; Foster, W.; Melo, O. Economic development and residential water consumption in Chile. *Environ. Dev. Econ.* **2019**, *24*, 23–46. [CrossRef]
42. FAO. The State of Food and Agriculture 2020. In *Overcoming Water Challenges in Agriculture*; FAO: Rome, Italy, 2020.
43. Ran, Y.; Lannerstad, M.; Herrero, M.; Van Middelaar, C.E.; De Boer, I.J.M. Assessing water resource use in livestock production: A review of methods. *Livest. Sci.* **2016**, *187*, 68–79. [CrossRef]
44. Fulton, J.; Norton, M.; Shilling, F. Water-indexed benefits and impacts of California almonds. *Ecol. Indic.* **2019**, *96*, 711–717. [CrossRef]
45. Muñoz, A.A.; Klock-Barría, K.; Alvarez-Garreton, C.; Aguilera-Betti, I.; González-Reyes, Á.; Lastra, J.A.; Chávez, R.O.; Barría, P.; Christie, D.; Rojas-Badilla, M.; et al. Water Crisis in Petorca Basin, Chile: The Combined Effects of a Mega-Drought and Water Management. *Water* **2020**, *12*, 648. [CrossRef]
46. Water Footprint Network Product Water Footprint. Available online: https://waterfootprint.org/en/water-footprint/product-water-footprint/ (accessed on 15 April 2022).
47. Dolganova, I.; Mikosch, N.; Berger, M.; Núñez, M.; Müller-Frank, A.; Finkbeiner, M. The Water Footprint of European Agricultural Imports: Hotspots in the Context of Water Scarcity. *Resources* **2019**, *8*, 141. [CrossRef]
48. Blackhurst, M.; Hendrickson, C.; Vidal, J.S.I. Direct and indirect water withdrawals for U.S. industrial sectors. *Environ. Sci. Technol.* **2010**, *44*, 2126–2130. [CrossRef]
49. Rather, L.J.; Jameel, S.; Dar, O.A.; Ganie, S.A.; Bhat, K.A.; Mohammad, F. Advances in the sustainable technologies for water conservation in textile industries. In *Water in Textiles and Fashion*; Elsevier: Amsterdam, The Netherlands, 2019; pp. 175–194.
50. Guzmán-Arias, I.; Calvo-Alvarado, J. Planificación del recurso hídrico en América Latina y el Caribe. *Rev. Tecnol. Marcha* **2013**, *26*, 3. [CrossRef]
51. Martínez-Arce, A.; Chargoy, J.; Puerto, M.; Rojas, D.; Suppen, N. Water Footprint (ISO 14046) in Latin America, State of the Art and Recommendations for Assessment and Communication. *Environments* **2018**, *5*, 114. [CrossRef]

52. Canales, C.; Jouravlev, A.; Water and a green economy in Latin America and the Caribbean (LAC). Water Green Econ. *Latin Am. Caribb.* 2012. Available online: https://www.cabdirect.org/cabdirect/abstract/20123298133 (accessed on 22 April 2022).
53. The World Bank Agricultural Land (sq. km) | Data. Available online: https://data.worldbank.org/indicator/AG.LND.AGRI.K2 (accessed on 19 April 2021).
54. Mahlknecht, J.; González-Bravo, R.; Loge, F.J. Water-energy-food security: A Nexus perspective of the current situation in Latin America and the Caribbean. *Energy* **2020**, *194*, 116824. [CrossRef]
55. Boretti, A.; Rosa, L. Reassessing the projections of the World Water Development Report. *Npj Clean Water* **2019**, *2*, 15. [CrossRef]
56. Wada, Y.; Flörke, M.; Hanasaki, N.; Eisner, S.; Fischer, G.; Tramberend, S.; Satoh, Y.; Van Vliet, M.T.H.; Yillia, P.; Ringler, C. Modeling global water use for the 21st century: The Water Futures and Solutions (WFaS) initiative and its approaches. *Geosci. Model Dev.* **2016**, *9*, 175–222. [CrossRef]
57. Rosegrant, M.W.; Cai, X.; Cline, S.A. *World Water and Food to 2025: Dealing with Scarcity*; International Food Policy Research Institute: Washington, DC, USA, 2002; ISBN 0896296466.
58. Burek, P.; Satoh, Y.; Fischer, G.; Kahil, M.T.; Scherzer, A.; Tramberend, S.; Nava, L.F.; Wada, Y.; Eisner, S.; Flörke, M. *Water Futures and Solution: Fast Track Initiative (Final Report)*; IIASA: Laxenburg, Austria, 2016.
59. Damkjaer, S.; Taylor, R. The measurement of water scarcity: Defining a meaningful indicator. *Ambio* **2017**, *46*, 513–531. [CrossRef] [PubMed]
60. Liu, J.; Yang, H.; Gosling, S.N.; Kummu, M.; Flörke, M.; Pfister, S.; Hanasaki, N.; Wada, Y.; Zhang, X.; Zheng, C.; et al. Water scarcity assessments in the past, present, and future. *Earth's Future* **2017**, *5*, 545–559. [CrossRef] [PubMed]
61. Herrera, D.; Ault, T. Insights from a New High-Resolution Drought Atlas for the Caribbean Spanning 1950–2016. *J. Clim.* **2017**, *30*, 7801–7825. [CrossRef]
62. PAHO. *Informe Regional Sobre la Evaluación 2000 en la Región de las Américas: Agua Potable y Saneamiento, Estado Actual y Perspectivas*; OPS: Washington, DC, USA, 2001.
63. PAHO. Water and Sanitation—PAHO/WHO | Pan American Health Organization. Available online: https://www.paho.org/en/topics/water-and-sanitation (accessed on 19 April 2021).
64. Desbureaux, S.; Rodella, A.S. Drought in the city: The economic impact of water scarcity in Latin American metropolitan areas. *World Dev.* **2019**, *114*, 13–27. [CrossRef]
65. Jaimurzina, A.; Sánchez, R. Gobernanza de la infraestructura para el desarrollo sostenible en América Latina y el Caribe: Una apuesta inicial. *Boletín FAL CEPAL* **2017**, *354*, 1–14.
66. Wade Miller, G. Integrated concepts in water reuse: Managing global water needs. *Desalination* **2006**, *187*, 65–75. [CrossRef]
67. Gude, V.G. Desalination and water reuse to address global water scarcity. *Rev. Environ. Sci. Biotechnol.* **2017**, *16*, 591–609. [CrossRef]
68. Hering, J.G.; Waite, T.D.; Luthy, R.G.; Drewes, J.E.; Sedlak, D.L. A changing framework for urban water systems. *Environ. Sci. Technol.* **2013**, *47*, 10721–10726. [CrossRef] [PubMed]
69. Makropoulos, C.K.; Butler, D. Distributed water infrastructure for sustainable communities. *Water Resour. Manag.* **2010**, *24*, 2795–2816. [CrossRef]
70. Prihandrijanti, M.; Malisie, A.; Otterpohl, R. Cost–Benefit Analysis for Centralized and Decentralized Wastewater Treatment System (Case Study in Surabaya-Indonesia). *Effic. Manag. Wastewater* **2008**, *2008*, 259–268.
71. Wilderer, P.A.; Schreff, D. Decentralized and centralized wastewater management: A challenge for technology developers. *Water Sci. Technol.* **2000**, *41*, 1–8. [CrossRef]
72. Zhang, D.; Gersberg, R.M.; Wilhelm, C.; Voigt, M. Decentralized water management: Rainwater harvesting and greywater reuse in an urban area of Beijing, China. *Urban Water J.* **2009**, *6*, 375–385. [CrossRef]
73. Roefs, I.; Meulman, B.; Vreeburg, J.H.G.; Spiller, M. Centralised, decentralised or hybrid sanitation systems? Economic evaluation under urban development uncertainty and phased expansion. *Water Res.* **2017**, *109*, 274–286. [CrossRef] [PubMed]
74. Matos, C.; Pereira, S.; Amorim, E.V.; Bentes, I.; Briga-Sá, A. Wastewater and greywater reuse on irrigation in centralized and decentralized systems - An integrated approach on water quality, energy consumption and CO2 emissions. *Sci. Total Environ.* **2014**, *493*, 463–471. [CrossRef] [PubMed]
75. Arlosoroff, S. Wastewater management, treatment, and reuse in Israel. In *Wastewater Reuse–Risk Assessment, Decision-Making and Environmental Security*; Springer: Dordrecht, The Netherlands, 2007; pp. 55–64.
76. De Gisi, S.; Casella, P.; Notarnicola, M.; Farina, R. Grey water in buildings: A mini-review of guidelines, technologies and case studies. *Civil Eng. Environ. Syst.* **2015**, *33*, 35–54. [CrossRef]
77. Icekson-Tal, N.; Avraham, O.; Sack, J.; Cikurel, H. Water reuse in Israel—The Dan Region Project: Evaluation of water quality and reliability of plant's operation. *Water Supply* **2003**, *3*, 231–237. [CrossRef]
78. Vallès-Casas, M.; March, H.; Saurí, D. Decentralized and user-led approaches to rainwater harvesting and greywater recycling: The case of Sant Cugat del Vallès, Barcelona, Spain. *Built Environ.* **2016**, *42*, 243–257. [CrossRef]
79. Silva, J.; Torres, P.; Madera, C. Reuso de aguas residuales domésticas en agricultura. Una revisión. *Agron. Colomb.* **2008**, *26*, 347–359.
80. Rodríguez, C.; Sánchez, R.; Lozano-Parra, J.; Rebolledo, N.; Schneider, N.; Serrano, J.; Leiva, E. Water Balance Assessment in Schools and Households of Rural Areas of Coquimbo Region, North-Central Chile: Potential for Greywater Reuse. *Water* **2020**, *12*, 2915. [CrossRef]

81. Vuppaladadiyam, A.K.; Merayo, N.; Prinsen, P.; Luque, R.; Blanco, A.; Zhao, M. A review on greywater reuse: Quality, risks, barriers and global scenarios. *Rev. Environ. Sci. Biotechnol.* **2019**, *18*, 77–99. [CrossRef]
82. Radingoana, M.P.; Dube, T.; Mazvimavi, D. Progress in greywater reuse for home gardening: Opportunities, perceptions and challenges. *Phys. Chem. Earth Parts A/B/C* **2020**, *116*, 102853. [CrossRef]
83. Boyjoo, Y.; Pareek, V.K.; Ang, M. A review of greywater characteristics and treatment processes. *Water Sci. Technol.* **2013**, *67*, 1403–1424. [CrossRef]
84. Chrispim, M.C.; Nolasco, M.A. Greywater treatment using a moving bed biofilm reactor at a university campus in Brazil. *J. Clean. Prod.* **2017**, *142*, 290–296. [CrossRef]
85. Government of Western Australia, Department of Health. *Code of Practice for the Reuse of Greywater in Western Australia 2010*; Department of health Western Australia: Perth, Australia, 2010. Available online: https://ww2.health.wa.gov.au/~{}/media/Files/Corporate/general-documents/water/PDF/Code_of_practice_for_the_reuse_of_greywater_in_WA_010_v2_130103.pdf (accessed on 29 March 2022).
86. Department of Health—Government of Western Australia Approved Greywater Systems. Available online: https://ww2.health.wa.gov.au/Articles/A_E/Approved-greywater-systems (accessed on 3 August 2022).
87. Asano, T.; Maeda, M.; Takaki, M. Wastewater reclamation and reuse in Japan: Overview and implementation examples. In Proceedings of the Water Science and Technology; Elsevier Science Ltd.: Amsterdam, The Netherlands, 1996; Volume 34, pp. 219–226.
88. Yoshikawa, N.; Shimizu, T.; Amano, K.; Nakajima, J. Evaluation of Greywater Reclamation and Reuse System in a Japanese University Building. *J. Asia-Japan Res. Inst. Ritsumeikan Univ.* **2019**, *1*, 44–55.
89. Ayers, R.S.; Westcot, D.W. *Water Quality for Agriculture*; Food and Agriculture Organization of the United Nations Rome: Rome, Italy, 1985; Volume 29, ISBN 9251022631.
90. Pescod, M.B. *Wastewater Treatment and Use in Agriculture-FAO Irrigation and Drainage Paper 47*; Food and Agriculture Organization of the United Nations: Rome, Italy, 1992.
91. Winpenny, J.; Heinz, I.; Koo-Oshima, S. *Reutilización del Agua en la Agricultura*; Organización de las Naciones Unidas para la Alimentación y la Agricultura. Informe Sobre Temas Hidricos (FAO): Roma, Italy, 2013.
92. UN. Water and Sanitation—United Nations Sustainable Development. Available online: https://www.un.org/sustainabledevelopment/water-and-sanitation/ (accessed on 20 January 2022).
93. CEPAL. *Estado de Avance de los Indicadores del ODS 6: Situación de América Latina y el Caribe*; CEPAL: San José, Costa Rica, 2020.
94. Rodriguez, D.; Serrano, H.; Delgado, A.; Nolasco, D.; Saltiel, G. *From Waste to Resource—Shifting Paradigms for Smarter Wastewater Interventions in Latin America and the Caribbean*; World Bank: Washington DC, USA, 2020.
95. Water Supplies Department. *Technical Specifications on Grey Water Reuse and Rainwater Harvesting*; Water Supplies Department: Hong Kong, China, 2015.
96. Singapore's National Water Agency. *Technical Guide for Greywater Recycling System*; Singapore's National Water Agency: Singapore, 2014.
97. Associação Nacional para a Qualidade das Instalações Prediais (ANQIP). ETA 0905 Sistemas Prediais de Reutilização e Reciclagem de Águas Cinzentas (SPRAC); Lisboa, Portugal: 2011. Available online: https://repositorio.ipl.pt/bitstream/10400.21/2166/7/ETA_0905.pdf (accessed on 5 May 2022).
98. Associação Nacional para a Qualidade das Instalações Prediais (ANQIP). *ETA 0906 Certificação de Sistemas Prediais de Reutilização e Reciclagem de Águas Cinzentas; Lisboa, Portugal*. 2015. Available online: https://www.yumpu.com/pt/document/read/18231577/eta-0906 (accessed on 5 May 2022).
99. Busgang, A.; Friedler, E.; Gilboa, Y.; Gross, A. Quantitative Microbial Risk Analysis for Various Bacterial Exposure Scenarios Involving Greywater Reuse for Irrigation. *Water* **2018**, *10*, 413. [CrossRef]
100. Harris, L.M.; Roa-García, M.C. Recent waves of water governance: Constitutional reform and resistance to neoliberalization in Latin America (1990–2012). *Geoforum* **2013**, *50*, 20–30. [CrossRef]
101. Foster, V. *Ten Years of Water Service Reform in Latin America: Toward an Anglo-French Model*; World Bank: Washington, DC, USA, 2005.
102. Porcher, S.; Saussier, S. *Facing the Challenges of Water Governance*; Palgrave Macmillan: London, UK, 2019; ISBN 3319985140.
103. Akhmouch, A. *Water Governance in Latin America and the Caribbean: A multi-Level Approach*; OECD Regional Development Working Papers; OECD: Paris, France, 2012.
104. UN. General Assembly Resolution 64/292—The Human Right to Water and Sanitation. Available online: https://www.un.org/waterforlifedecade/human_right_to_water.shtml (accessed on 4 May 2021).
105. Constitución Política del Estado plurinacional de Bolivia. La Paz, Bolivia: Gaceta Oficial del Estado Plurinacional de Bolivia. 2009. Available online: http://www.gacetaoficialdebolivia.gob.bo/edicions/view/NCPE (accessed on 25 May 2022).
106. Constitución Política de la República de Colombia. Bogotá, Colombia: Congreso de la República de Colombia. 1991. Available online: http://www.secretariasenado.gov.co/index.php/constitucion-politica (accessed on 25 May 2022).
107. Constitución de la República de Cuba. La Habana, Cuba: Asamblea Nacional Poder Popular. 2019. Available online: https://www.gacetaoficial.gob.cu/es/constitucion-de-la-republica-de-cuba-proclamada-el-10-de-abril-de-2019 (accessed on 25 May 2021).

108. Constitución de la República del Ecuador. Ecuador: Asamblea Nacional. 2008. Available online: https://www.asambleanacional.gob.ec/sites/default/files/documents/old/constitucion_de_bolsillo.pdf (accessed on 25 May 2022).
109. Constitución Política de la República de Guatemala. Guatemala: Congreso de la República. 1993. Available online: https://www.congreso.gob.gt/marco_legal#gsc.tab=0 (accessed on 25 May 2022).
110. Constitución Política de los Estados Unidos Mexicanos. Ciudad de México, México: Cámara de diputados. 1917. Available online: http://www.diputados.gob.mx/LeyesBiblio/ref/cpeum.htm (accessed on 25 May 2022).
111. Constitución Política de Nicaragua. Managua, Nicaragua: La Gacetea Diario Oficial. 1948. Available online: http://legislacion.asamblea.gob.ni/Normaweb.nsf/9e314815a08d4a6206257265005d21f9/06c0db3b7bcfc75706257307006f6c6d (accessed on 25 May 2022).
112. Constitución Política de la República de Panamá. 1972. Available online: https://ministeriopublico.gob.pa/wp-content/uploads/2016/09/constitucion-politica-con-indice-analitico.pdf (accessed on 25 May 2022).
113. Constitución Nacional de la República del Paraguay. Paraguay; Biblioteca y Archivo central del Congreso de la Nación. 1992. Available online: https://www.bacn.gov.py/constitucion-nacional-de-la-republica-del-paraguay (accessed on 25 May 2022).
114. Constitución Política del Perú. Perú: Congreso de la República. 1993. Available online: https://www.congreso.gob.pe/constitucionyreglamento/ (accessed on 25 May 2022).
115. Constitución de la República Oriental del Uruguay. Uruguay: Parlamento del Uruguay. 1967. Available online: https://parlamento.gub.uy/documentosyleyes/constitucion (accessed on 25 May 2022).
116. Constitución de la República Bolivariana de Venezuela. 1999. Available online: http://www.cne.gob.ve/web/normativa_electoral/constitucion/indice.php (accessed on 25 May 2022).
117. Constitución Política de la República de Costa Rica. Costa Rica: Sistema Costarricense de Información Jurídica. 2020. Available online: https://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=871&nValor3=928&strTipM=TC (accessed on 25 May 2022).
118. Constitución de la Nación Argentina. Argentina: Presidencia de la Nación. 1853. Available online: http://servicios.infoleg.gob.ar/infolegInternet/anexos/0-4999/804/norma.htm (accessed on 25 May 2022).
119. Constitución Política de la República de Chile. Santiago, Chile: Ministerio Secretaría General de la Presidencia. 1980. Available online: https://www.bcn.cl/leychile/navegar?idNorma=242302&idParte= (accessed on 25 May 2022).
120. UNdata UNdata | Record View | Population Connected to Wastewater Treatment. Available online: http://data.un.org/Data.aspx?d=ENV&f=variableID:164 (accessed on 5 May 2021).
121. Basagoitia, J.C.Q. Water Quality in the Americas: El Salvador. *Water Qual. Am.* **2019**, *2019*, 325–624.
122. Portillo, A. Definen Estructura y Facultades de la Autoridad Nacional de Aguas | Asamblea Legislativa de El Salvador. Available online: https://www.asamblea.gob.sv/node/10738 (accessed on 5 May 2021).
123. Rodriguez, D.J.; Serrano, H.A.; Delgado, A.; Nolasco, D.; Saltiel, G. *From Waste to Resource*; World Bank: Washington, DC, USA, 2020.
124. Rodríguez, C.; Sánchez, R.; Rebolledo, N.; Schneider, N.; Serrano, J.; Leiva, E. Cost–Benefit Evaluation of Decentralized Greywater Reuse Systems in Rural Public Schools in Chile. *Water* **2020**, *12*, 3468. [CrossRef]
125. Allen, L.; Christian-Smith, J.; Palaniappan, M. Overview of greywater reuse: The potential of greywater systems to aid sustainable water management. *Pacific Inst.* **2010**, *654*, 19–21.
126. Albalawneh, A.; Chang, T.-K. Review of the greywater and proposed greywater recycling scheme for agricultural irrigation reuses. *Int. J. Res.* **2015**, *3*, 16–35. [CrossRef]
127. Ghisi, E.; Mengotti de Oliveira, S. Potential for potable water savings by combining the use of rainwater and greywater in houses in southern Brazil. *Build. Environ.* **2007**, *42*, 1731–1742. [CrossRef]
128. Ghisi, E.; Ferreira, D.F. Potential for potable water savings by using rainwater and greywater in a multi-storey residential building in southern Brazil. *Build. Environ.* **2007**, *42*, 2512–2522. [CrossRef]
129. Do Couto, E.D.A.; Calijuri, M.L.; Assemany, P.P.; Santiago, A.D.F.; Carvalho, I.D.C. Greywater production in airports: Qualitative and quantitative assessment. *Resour. Conserv. Recycl.* **2013**, *77*, 44–51. [CrossRef]
130. Rodríguez, C.; Carrasco, F.; Sánchez, R.; Rebolledo, N.; Schneider, N.; Serrano, J.; Leiva, E. Performance and treatment assessment of a pilot-scale decentralized greywater reuse system in rural schools of north-central Chile. *Ecol. Eng.* **2022**, *174*, 106460. [CrossRef]
131. Domínguez, I.; Ward, S.; Mendoza, J.G.; Rincón, C.I.; Oviedo-Ocaña, E.R. End-user cost-benefit prioritization for selecting rainwater harvesting and greywater reuse in social housing. *Water (Switzerland)* **2017**, *9*, 516. [CrossRef]
132. Oviedo-Ocaña, E.R.; Dominguez, I.; Ward, S.; Rivera-Sanchez, M.L.; Zaraza-Peña, J.M. Financial feasibility of end-user designed rainwater harvesting and greywater reuse systems for high water use households. *Environ. Sci. Pollut. Res.* **2018**, *25*, 19200–19216. [CrossRef]
133. Dallas, S.; Scheffe, B.; Ho, G. Reedbeds for greywater treatment—Case study in Santa Elena-Monteverde, Costa Rica, Central America. *Ecol. Eng.* **2004**, *23*, 55–61. [CrossRef]
134. Dallas, S.; Ho, G. Subsurface flow reedbeds using alternative media for the treatment of domestic greywater in Monteverde, Costa Rica, Central America. *Water Sci. Technol.* **2005**, *51*, 119–128. [CrossRef] [PubMed]
135. Leiva, E.; Rodríguez, C.; Sánchez, R.; Serrano, J. Light or Dark Greywater for Water Reuse? Economic Assessment of On-Site Greywater Treatment Systems in Rural Areas. *Water* **2021**, *13*, 3637. [CrossRef]

136. Amaris, G.; Dawson, R.; Gironás, J.; Hess, S.; de Ortúzar, J.D. From mathematical models to policy design: Predicting greywater reuse scheme effectiveness and water reclamation benefits based on individuals' preferences. *Sustain. Cities Soc.* **2021**, *74*, 103132. [CrossRef]
137. Oteng-Peprah, M.; de Vries, N.; Acheampong, M.A. Households' willingness to adopt greywater treatment technologies in a developing country—Exploring a modified theory of planned behaviour (TPB) model including personal norm. *J. Environ. Manag.* **2020**, *254*, 109807. [CrossRef] [PubMed]
138. Deshpande, A.; Miller-Petrie, M.K.; Lindstedt, P.A.; Baumann, M.M.; Johnson, K.B.; Blacker, B.F.; Abbastabar, H.; Abd-Allah, F.; Abdelalim, A.; Abdollahpour, I.; et al. Mapping geographical inequalities in access to drinking water and sanitation facilities in low-income and middle-income countries, 2000–2017. *Lancet Glob. Health* **2020**, *8*, e1162–e1185. [CrossRef]
139. Sorenson, S.B.; Morssink, C.; Campos, P.A. Safe access to safe water in low income countries: Water fetching in current times. *Soc. Sci. Med.* **2011**, *72*, 1522–1526. [CrossRef] [PubMed]
140. The World Bank GDP per Capita (Current US$) | Data. Available online: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD (accessed on 6 May 2021).
141. Duarte, R.; Pinilla, V.; Serrano, A. Is there an environmental Kuznets curve for water use? A panel smooth transition regression approach. *Econ. Model.* **2013**, *31*, 518–527. [CrossRef]
142. Von Hauff, M.; Mistri, M.A. Environmental Kuznets curve (EKC): Implications on economic growth, access to safe drinking water and ground water utilisation in India. *Glob. J. Hum. Soc. Sci.* **2015**, *15*, 1–15.
143. Ahmed, M.; Arora, M. Suitability of Grey Water Recycling as decentralized alternative water supply option for Integrated Urban Water Management. *IOSR J. Eng.* **2012**, *2*, 31–35. [CrossRef]
144. Mohamed, N.M.; Ali, S.S. Economic study for greywater reuse to achieve the sustainability in Egypt. *Aust. J. Basic Appl. Sci.* **2012**, *6*, 655–665.
145. Munoz, N.J. What Is The Economic Feasibility Of Implementing Grey Water Infrastructure At The Citywide Level? Master of Science in Environmental Management (MSEM). 2016, Volume 353. Available online: https://repository.usfca.edu/capstone/353/ (accessed on 7 August 2022).
146. Friedler, E. The water saving potential and the socio-economic feasibility of greywater reuse within the urban sector—Israel as a case study. *Int. J. Environ. Stud.* **2008**, *65*, 57–69. [CrossRef]
147. Friedler, E.; Hadari, M. Economic feasibility of on-site greywater reuse in multi-storey buildings. *Desalination* **2006**, *190*, 221–234. [CrossRef]
148. Jabornig, S. Overview and feasibility of advanced grey water treatment systems for single households. *Urban Water J.* **2014**, *11*, 361–369. [CrossRef]
149. OSE Decreto Tarifario 2019. Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente, Ministerio de Economía Y Finanzas. Available online: http://www.ose.com.uy/descargas/clientes/tarifas/ose_decreto_tarifario_2019.pdf (accessed on 19 November 2021).
150. Acueducto Tarifas 2020. Available online: https://www.acueducto.com.co/wps/portal/EAB2/Home/atencion-al-usuario/tarifas/tarifas_2020/!ut/p/z1/nZFNa4NAEIZ_Sw8e64yTrSy9rZJqG4jZFImdS9BgN4Jxg7GV_vtKCqUWSUPnNsPzzsc7wJABN_l7ZfKusk1eD_kL-9uF9CmOJC0lLQRqT83jYK4oiQk2Z8DXIXoSaYmCQtTPq2CdpKG38gTwNXochcJgTcE (accessed on 8 November 2021).
151. Aresep Tabla de costos en ¢ del agua potable en Costa Rica para 2020. Available online: https://datawrapper.dwcdn.net/ORDcO/1/ (accessed on 8 November 2021).
152. Asp Tarifas Por Rango De Consumo Del Servicio De Agua Potable Medido Y No Medido. Available online: http://www.asp.com.hn/asp/tarifas_vigentes.pdf (accessed on 8 November 2021).
153. Aguas Andinas Tarifas—Aguas Andinas. Available online: https://www.aguasandinas.cl/web/aguasandinas/tarifas (accessed on 8 November 2021).
154. SEMAPA. Estructura Tarifaria. Available online: http://www.semapa.gob.bo/estructura-tarifaria (accessed on 8 November 2021).
155. EPMAPS Pliego Tarifario. Available online: https://www.aguaquito.gob.ec/wp-content/uploads/2019/06/Pliego-Tarifario-EPMAPS-05.2019.pdf (accessed on 8 November 2021).
156. SABESP. Agência Virtual Tarifas. Available online: https://www9.sabesp.com.br/tarifas (accessed on 8 November 2021).
157. Zolic Tarifas Servicios Básicos. Available online: https://zolicguate.com/tarifas-servicios-basicos/ (accessed on 8 November 2021).
158. AySA. Conocé tu Factura. Available online: https://www.aysa.com.ar/usuarios/Conoce-tu-factura (accessed on 8 November 2021).
159. ESSAP. Tarifa de los Servicios. Available online: http://www.essap.com.py/consultas/tarifa-de-los-servicios/ (accessed on 8 November 2021).
160. SACMEX. Código Fiscal Artículo 172 Ciudad de México. Available online: https://www.sacmex.cdmx.gob.mx/storage/app/media/tarifas/Tarifas_Agua_Art_172_2020.pdf (accessed on 8 November 2021).
161. Azpiazu, D.; Schorr, M.; Crenzel, E.; Forte, G.; Marín, J.C. Agua potable y saneamiento en Argentina. Privatizaciones, crisis, inequidades e incertidumbre futura. *Cuad. CENDES* **2005**, *22*, 45–67.