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Article

# Water Valuation in Urban Settings for Sustainable Water Management

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**Abstract:** This study examines water scarcity and quality deterioration in various components of the urban setting, including agriculture, manufacturing, construction, residential buildings, and the recreational industries. This paper also analyzes various measures that can be used as valuation matrices to assess the quality and quantity of water consumption, as well as conservation practices and sustainable management strategies. The aim of this work is to enhance and encourage an increase in the value of consumed water through economistic, efficient, and sustainable approaches. The analysis includes the evaluation of measures such as price reform, adoption of efficient appliances, implementation of effective utilization techniques, reduction in water waste, treatment of wastewater, and employment of reuse and reclamation techniques. This article further discusses the multifaceted costs associated with the acquisition of water, emphasizing the need to consider not only economic factors but also environmental and social implications. This study examines the potential adverse effects of introducing value-added measures, specifically focusing on the impact of water pricing reforms on farmers and industrial manufacturers. The analysis highlights the potential increase in costs that these stakeholders may face as a result of such reforms. This study suggests that the implementation of subsidies can be an effective measure to mitigate the negative effects discussed. This article highlights the urgent global need for governments and international organizations to implement strict policies and regulations in order to preserve water resources and protect their inherent value and, also, emphasizes the importance of consumers understanding the true value of water in order to grasp its significance and scarcity.

**Keywords:** water valuation; freshwater; water conservation; water price reforming

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## 1. Introduction

Rapid urbanization around the globe is escalating concerns over water scarcity. Increasing population growth [1], nonviable water administration [2], deficient regulatory frameworks [3], inadequate infrastructure, suboptimal water utilization, and heightened competition for water resources across diverse domains [4] are all playing crucial roles in water scarcity. As, currently, half of the global population is residing in urban areas, by 2050, it may rise to 70% [5]. Therefore, the reduction in the quantity of water allocated to each person and the consequent deterioration in its quality are interrelated. The World Bank has projected a 50–70% rise in the demand for water in urban regions over the next three decades [6].

Due to built environments and modified ecosystems and to anthropogenic activities, there has been a reduction in the ground's ability to absorb water and an escalation in the quantity of water flowing off the surface. In addition to that, improper urbanization leads to climate changes and global warming and influences precipitation and the water cycle. This will result in water-related issues in availability and quality. The depletion of surface- and groundwater reservoirs has led water utility providers to acknowledge that historical water replenishment patterns may not be reliable in the future.

Water is utilized in urban areas as an input for various production processes or as a commodity in utility practices [7]. Consequently, water demand and its value become essential issues in these regions, particularly when confronted with managing or mitigating water-related risk to supply the growing demand. These water-related risks may result from an unreliable water supply. Thus, it is now essential to have a proper mechanism for understanding the significance of water, increasing its value, and regulating its efficient and effective use. However, in some countries where there is an adequate supply of water, the value of water and its scarcity are not recognized [8]. Some countries have set extremely low water-usage standards, which has led to inefficient water usage on the part of consumers. As with other commodities, the price paid for water in many countries does not adequately reflect its value to the consumer. Therefore, this undervalued resource, the uninterrupted supply of which is essential to numerous needs, is not optimally utilized, resulting in significant operational inefficiency. To advance the state of water efficiency management and achieve sustainability goals, the value of water must be accounted for to incorporate it more effectively.

Urban water services must exhibit resilience and sustainability to alleviate water scarcity in urban areas. Therefore, this study focuses on specific ways to examine the possible strategies to incorporate sustainable solutions, particularly in urban areas, for increasing the value of water in identified major water-demanding components. Even though some previous relevant studies have been conducted [1,2,6,9,10], this study has the novel concept of including all the components in a study. Urban water services must exhibit resilience and sustainability to alleviate water scarcity in urban areas. The sustainability of services encompasses not only the tangible infrastructure but also the approach to the execution and administration of the systems [9], in addition to the enabling environment for the sector and other overarching considerations, such as the evaluation of water resources. One potential approach to addressing the issue of water scarcity is the emerging concept of incorporating water valuation within urban areas as a sustainable solution over time. The assessment process takes into account various factors such as the quantity, quality, spatial distribution, and temporal availability of water [11]. These factors are contingent upon the techniques employed to govern water resources.

In this context, improving the value of water will concentrate on the primary facets, encompassing the impacted water resources, the potential remedies to address the emergent water-related challenges, the geographical locations and timeline for executing novel approaches to surmount the issues, and the anticipated results of the proposed interventions. The feasibility of any value-addition methods are contingent upon the availability of relevant information, including quantitative or physical data pertaining to alterations in the provision of interest, such as the quantity of water, biochemical quality, and the size of the affected user population. The optimal selection of a suitable valuation approach is contingent upon determining the valuation approach that is most congruent with the decision issue and the requisite level of substantiation. This study aims to comprehensively analyze the various techniques used for enhancing the value of water for different sectors in urban areas, with a focus on relevant aspects.

Consequently, the scopes of the study are:

- Identifying the high water-demanding components in the urban settings;
- Examining the water scarcity status of the identified high water-demanding components of the urban region;
- Analysis of strategies to improve the quality and quantity of water sources;

- Examining the valuation and value-addition techniques in the identified components.

Section 2 delineates the methodology employed in this study. Section 3 provides an overview of the various global methodologies employed for the purpose of valuing water. Section 4 investigates the various methods used to determine the value of water in urban areas. Section 5 examines the issue of water scarcity in urban areas and explores potential strategies for improving water resource management in these settings. Section 6 encompasses the discussion, culminating in a comprehensive summary of the study and the subsequent formulation of conclusions in the final Section 7.

## 2. Materials and Methods

This study focuses on the assessment of water valuation and the optimization of water utilization in urban areas. In this study, high water-demanding components of urban components as agricultural industries, manufacturing industries, construction industries, residential buildings, and recreational industries have been identified and taken into consideration. Figure 1 shows the graphical illustration. The present investigation analyzes the scholarly articles and examines the methods of valuation and effective optimization of water consumption in the primary urban applications. The articles were published between 2000 and 2022 and were selected according to the preferred reporting items for systematic analysis and meta-analyses (PRISMA) guidelines. The present study was carried out by employing the Web of Science, Scopus, Springer, and Science Direct databases. The search was conducted using specific keywords, including water valuation, reforming water pricing, improving water efficiency, and urban water usage.

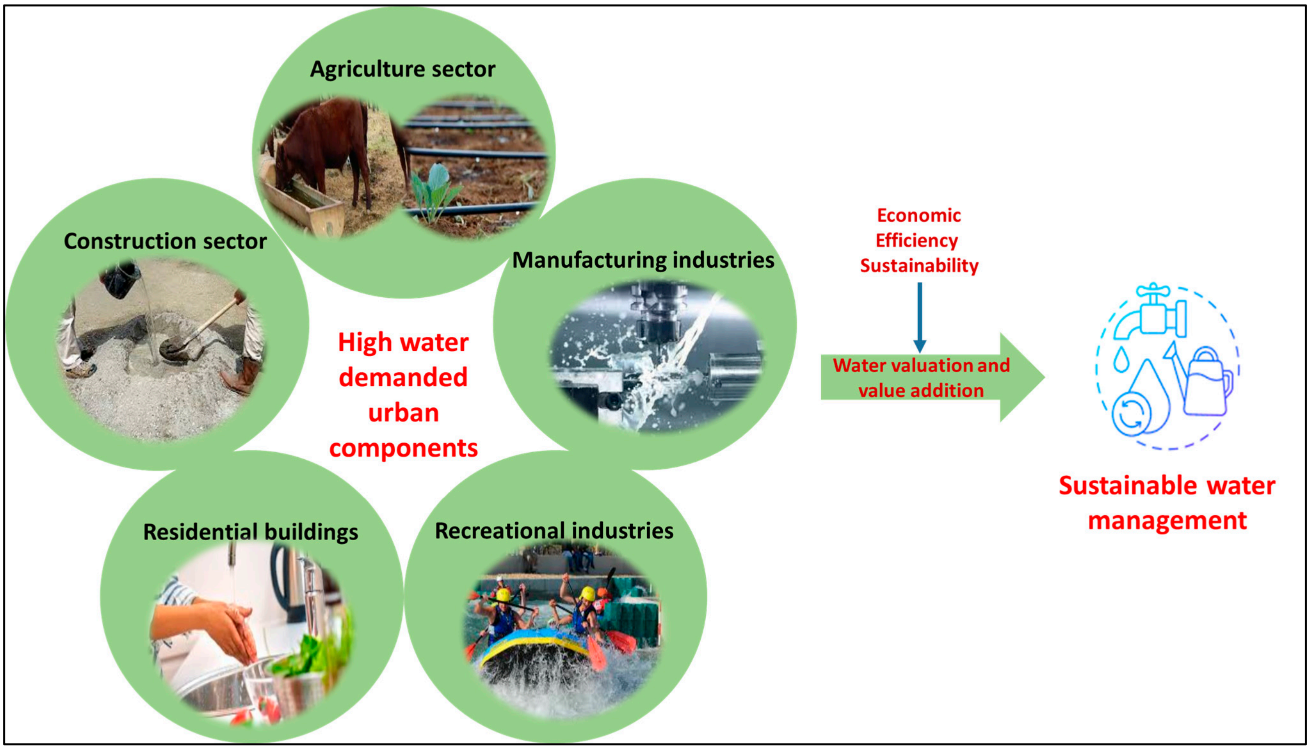


**Figure 1.** Graphical illustration of the study.

Figure 2 illustrates the method undertaken to conduct this study. The analysis encompassed a total of 250 pertinent articles comprising original research articles, analysis papers, and scientific reports. The studies included both measurement- and simulation-based approaches. The study was delimited to five specific sectors, namely, agriculture, manufacturing industries, construction processes, residential needs, and recreational activities. Additionally, duplicated papers extracted from different databases were excluded from the analysis. Consequently, following meticulous screening and filtering procedures, a total of 59 articles were deemed eligible out of the initial pool. In the subsequent stage of filtration, a total of 37 articles were eliminated because of their lack of relevance to the scope of this study. The scope of our analysis was limited to articles that specifically addressed the topics of water valuation, value addition strategies, and efficiency enhancement approaches within the aforementioned sectors. Following a screening and filtering process, a total of 107 research articles were selected and subsequently classified according to the specific urban areas they examined.

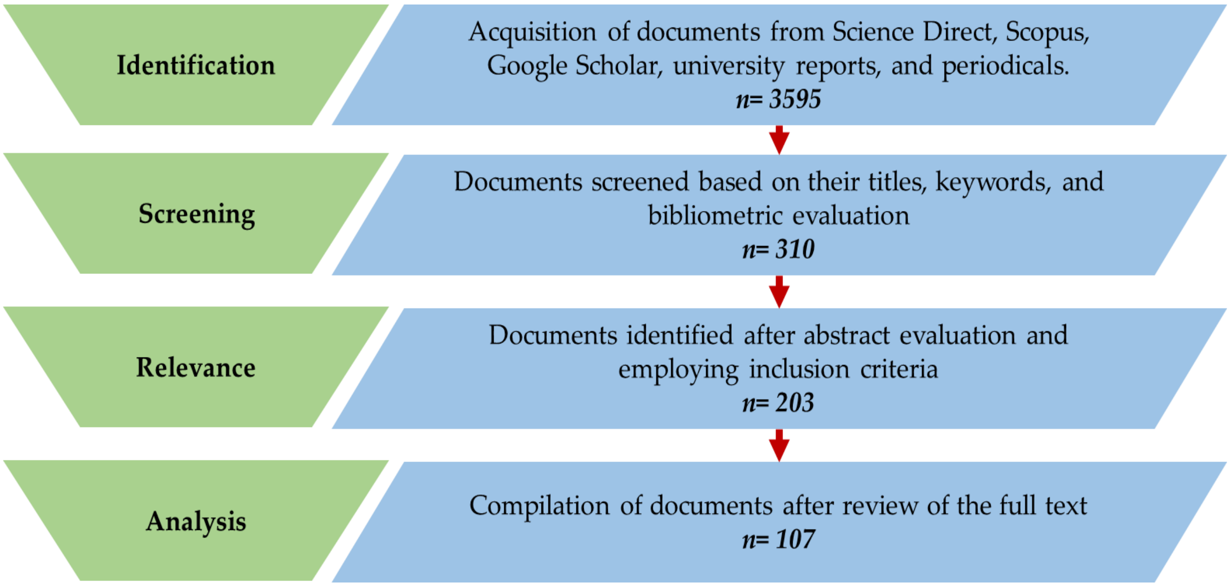


**Figure 2.** Method followed for conducting this study.

## 3. Global Approaches to Valuing Water

The strategies used for valuing water resources on a global scale may be broadly classified into two categories: revealed preference techniques and stated preference techniques. Revealed preference approaches rely on empirical market data, whereas stated preference techniques rely on survey responses on individuals' willingness to pay. Residual values, such as the marginal contribution of water to production, may be quantified by removing all other expenses from income [10]. The production function approach is a method of measurement that quantifies the change in output resulting from a unit increase in water intake within a specific sector. The impact of reallocating water resources throughout the whole economy may be assessed via the use of optimization models and programming techniques, which enable the measurement of changes in sectoral production. Hedonic pricing is applied in the valuation of land with water resources. The concept of opportunity cost refers to the potential benefits or opportunities that are forgone while choosing one choice over another. The stated preference approach encompasses the contingent valuation method, which involves conducting surveys among consumers, particularly those pertaining to domestic water use and recreational activities [12].

Promotion of public awareness and fostering an understanding of the inherent value of water are important aspects in water valuation. This can be implemented in two different ways to educate individuals about the significance of water resources and their role in sustaining various aspects of life and the environment and the dissemination of research findings and survey results conducted by both national and international agencies. These organizations conduct comprehensive studies to assess the economic, social, and environmental aspects related to water. By sharing their findings, these agencies contribute to a broader understanding of the value of water and its implications for various stakeholders. This knowledge can inform decision-making processes and policy development, ultimately leading to more sustainable and equitable water management practices. The implementation of methods and communication strategies regarding water values within the public sphere should be tailored to the unique social and cultural context of each community.

### *3.1. Cultural Approaches*

Throughout history, religious texts and the political and development spheres have acknowledged the significance of various water values. The Quran contains approximately 48 references pertaining to the significance of water in sustaining life. Incorporating religious perspectives into water conservation efforts can serve as a powerful means of engaging individuals and fostering a sense of responsibility toward the effective utilization of this vital resource. Armstrong (2022) posits that religious teachings across societies commonly emphasize the importance of preserving the integrity and sustainability of natural systems, including water, during human interactions with nature [13].

The significance of nature and water in the cultures of various regions is highlighted in a recent publication on sustainable natural resources. The book presents a compilation of various social and cultural thoughts around the globe such as in Europe, the Middle East, India, and China. Its aim is to assist adherents in formulating ethical frameworks that can direct human conduct and cognition toward the natural world, with a specific focus on water.

### *3.2. Involvement of National and Global Entities in Water Valuation*

Valuing water depends on the efficiency of linkages among various water agencies and the growing engagement of the private sector, which invests in water as a commercial opportunity. The global approaches value water as an essential public good beyond the retail value. The High Panel for Water (HLPW) helped determine the current state of water valuation practices, with water management, equitable, and sustainable results. In addition to that, it offered suggestions for following up the global actions within the Sustainable Development Goals framework [14].

The government of the Netherlands hosted the Valuing Water Initiative Secretariat, which produced the valuing water conceptual framework for making better decisions impacting water in 2020, and it states that the productive value of water is often expressed in monetary terms. This aspect generally receives the most political interest because economic development is considered the most important and may occur at the expense of environmental and social values. The risk is that water will be allocated to uses with the highest production values, bypassing other vital criteria. The challenge is to foster equity in access and ensure that nonmonetary and noneconomic water values are considered in addition to productive values. An inclusive valuation framework should be comprehensive and encompass problems of economy, ecology, and society at different geographical scales [15].

In addition to that, as valuation frameworks are seldom comprehensive, and multi-objective decision-making is often needed for understanding the diverse values of water benefits and leads to sustainable management of water, including water resources, water services, and water treatment and reuse. The UN Water Development report of 2021, entitled Valuing Water, presents the multidimensional values of water and recommendations in order to enhance social and economic development [16]. A recently published report by the Global Commission on the Economics of Water represents the culmination of extensive research and analysis conducted over years, and it presents a bleak outlook for the future if proactive measures are not promptly implemented [17].

The Water Framework Directive (WFD) has served as the primary legislation governing water conservation in Europe, namely pertaining to rivers and lakes, groundwater, and bathing waters. The primary objective is to prioritize the maintenance of both qualitative and quantitative aspects of health, encompassing efforts to mitigate and eliminate pollution, while concurrently maintaining adequate water resources to sustain both wildlife and human populations. This regulation is applicable to surface waters found in inland, transitional, and coastal areas, as well as groundwater. The integrated approach to water management ensures the preservation of an increase in the values of water in a complete ecosystem by limiting individual contaminants and establishing associated regulatory criteria [18].

The global report published by the Global Commission on the what, why, and how of the world water crisis recommends ensuring sustainable development for all resilient economies. This requires a new framework beyond conventional economic practices. According to the 17 Sustainable Development Goals (SDGs), it is deeply interconnected with biodiversity and the climate while providing a stable foundation for human well-being and ecosystem health and, hence, is necessary for socioeconomic and ecological development [19].

Water prices rarely reflect the economic value of the water resources or the costs of treatment and distribution. Low prices have resulted in inefficient use and reduced the provision and expansion of services, particularly to the poor, making the sector less attractive to investors and inflicting high costs upon the economy, society, and environment. The incorporation of data on hydrological cycles, water quality, the water supply and drainage industries, water fees and charges, public expenditures and investments financing, and consumptive sectors into the national accounts framework enables the estimation of aggregate value-added, productivity, and market-oriented prices of water. The use of these sources of information is innovative and has a tendency to estimate the contributions of water to GDP, the main users and efficiency rates of water, and the impact of exogenous shocks of water in the economy [20].

The UN report presents detailed options and methodologies for valuing water, including the environment, hydraulic infrastructure, water supply, sanitation and hygiene services, water for food and agriculture, energy, industry, and business, and cultural values of water [16]. However, consolidating the different approaches and methods for valuing water across multiple dimensions and perspectives will likely remain challenging. Various approaches can lead to strikingly different valuations, even within a specific water-use sector.

Effective strategies employed by national and international agencies to achieve sustainable water valuation can be incorporated with various approaches, such as acknowledging and embracing the diverse values associated with water across different stakeholder groups to reconcile values and build trust; conduct all processes to reconcile values in equitable, transparent, and inclusive ways; protect the sources, including watersheds, rivers, aquifers, associated ecosystems, and used water flows for current and future generations; educate to empower by promoting education and awareness among all stakeholders about the intrinsic value of water and its essential role in all aspects of life; and invest and innovate to ensure adequate investment in institutions, infrastructure, information, and innovation to realize the many benefits derived from water and to reduce risks.

## 4. Importance of Water Valuation Approaches on a Global Scale

Scarcity of water is measured as the insufficiency of water supply, both in terms of quantity and quality [21,22]. The impacts of climate change, such as irregular precipitation, significantly lead to the high demand for water, particularly in the highly urbanized areas [23]. The challenges posed by escalating water scarcity and finite water supplies may impede further urban expansion from either an increase in population or the expansion of urban areas. Numerous studies have been conducted to examine the effects of climate change and population expansion on the scarcity of urban water availability [21,24], and many findings have been demonstrated through the literature, such as that the configuration of urban development can significantly influence the hydrological cycles of a region by altering the geology of river basins, including slope and permeability.

A thorough understanding of the importance of urban development patterns in exacerbating water scarcity can provide a basis for policymakers to address the issues [25]. The escalation of urban water demand is primarily attributed to the urban development patterns [26]. However, this factor has received less attention in research than the consequences of population expansion and climate change. High-density development patterns have been linked to lower rates of outdoor water use per capita, whereas sprawling patterns have been linked to greater rates of outdoor water use per capita [27]. Therefore, better and more environmentally friendly urban development methods will assist to manage the water scarcity challenges associated with urbanization.

Inside the urban structures, water requirements are either met through the provision of market goods or services that are directly consumed by the public, such as drinking water, transportation, electricity generation, pollution disposal, and irrigation, or the provision of nonmarket goods and services that include biodiversity, support for terrestrial and estuarine ecosystems, habitat for plant and animal life, and the psychological benefits that individuals derive from the existence of a lake or river. The significance of water in contemporary urban settings necessitates that consumers have a thorough comprehension of its actual worth.

Therefore, it is essential to consider all the possible factors in water valuation processes in terms of the economic and environmental bases [28]. The pricing mechanism plays a crucial role in determining water use patterns and influencing customer behavior with regards to water consumption. The prevailing cost per unit of water in numerous countries is relatively low, which implies that water is undervalued in comparison to other commodities. Figure 3 illustrates the price of a water bottle (0.33l) in different parts of the globe. Despite being among the countries with the lowest water prices globally, China and India emerge as the primary consumers, collectively accounting for half of the total water consumption out of highest water-consuming countries globally [29]. Table 1 shows the detailed list of the highest water-consuming countries [29]. The provision of water at lower prices by densely populated and water-intensive countries may provide evidence for a probable cause of increased global water wastage.

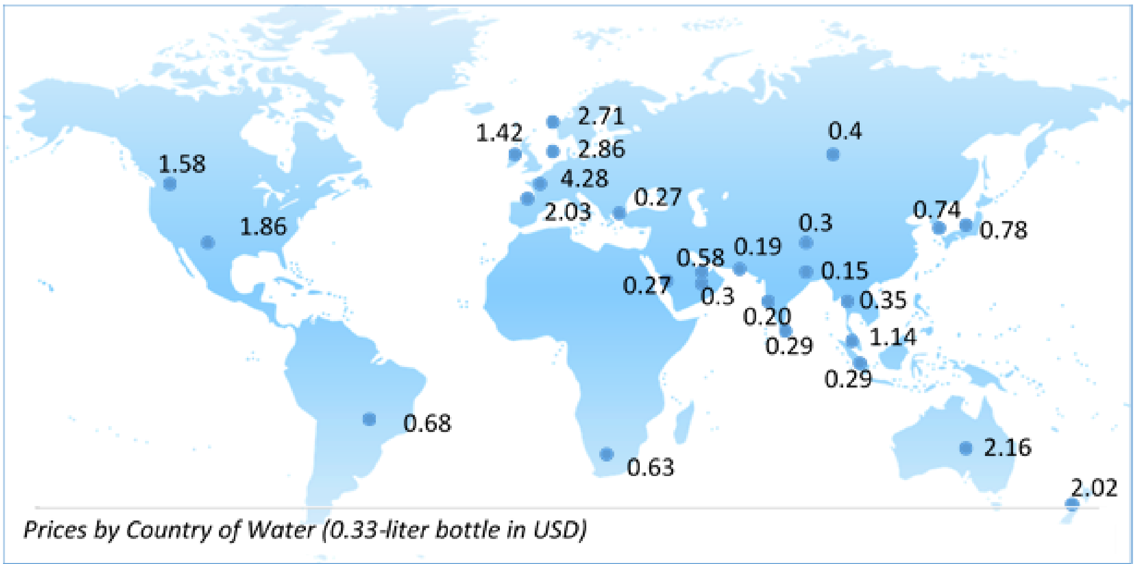


**Figure 3.** Prices of a 0.33 L water bottle on the globe in USD.

The implementation of a pricing mechanism on its intended purpose is imperative for the sustainable management of water resources and the optimization of economic benefits [30]. The government authorities largely regulate the price and distribution of water because of its significant social functions. The pricing structure shall be contingent upon the prevalent utility rates within the respective region. Efficient price structures, from a utility standpoint, would facilitate the promotion of water conservation, rationalize investments in water-saving technologies, and generate adequate revenue for daily operations, maintenance, and future infrastructure development [31].

**Table 1.** Major water consumers on the globe.

| Country | Water Consumption (Billion $m^3$) |
|---|---|
| Canada | 36.23 |
| Argentina | 37.78 |
| Peru | 38.55 |
| Iraq | 56.62 |
| Thailand | 57.31 |
| Uzbekistan | 58.9 |
| Türkiye | 62.21 |
| Russia | 64.82 |
| Brazil | 67.2 |
| Egypt | 77.5 |
| Japan | 78.4 |
| Vietnam | 82.03 |
| Philippines | 85.87 |
| Mexico | 89.55 |
| Iran | 93.3 |
| Pakistan | 183.45 |
| Indonesia | 222.64 |
| USA | 444.29 |
| China | 581.29 |
| India | 761 |

In the manufacturing industry, water cost and price are often regarded as interchangeable terms, referring to the expenses incurred by the company for the consumption of this resource. This is akin to the cost of procuring or utilizing any other product or resource in the production process. The expenses and pricing of manufacturing processes are subject to fluctuations based on the source of water, whether from an in-house water supply or an external purchase. Figure 4 depicts the various categories of costs that are considered in water management. However, it is important to note that these costs do not encompass all expenses associated with water utilization. Apart from the initial cost, the comprehensive cost encompasses additional expenses incurred by the user including energy consumption, maintenance, permits, and treatments [32]. Additional expenses incurred internally pertain to ensuring an adequate water supply to fulfil production requirements.

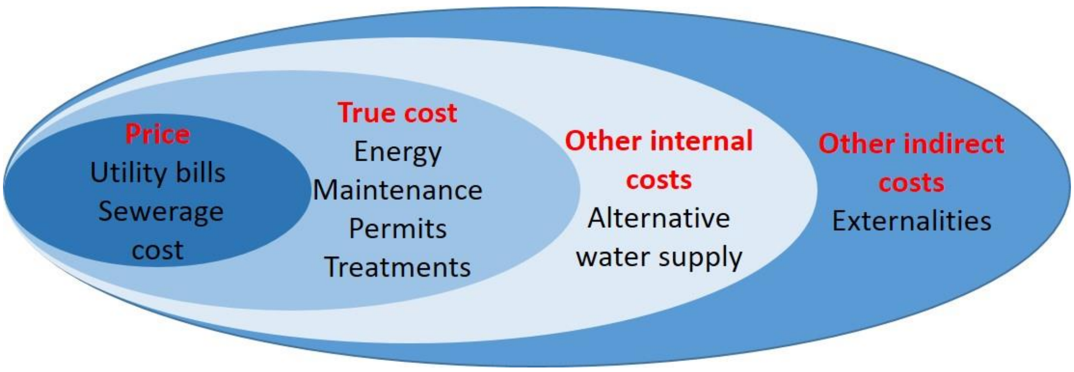


**Figure 4.** The value of water encompasses different costs.

The actual expenses incurred in the production or consumption of a good or service are called its true cost, and the societal expenses associated with limited availability and environmental impacts are indirect costs. Externalities refer to the costs, either economic or environmental, that are imposed on third parties because of an activity that is beyond their control [32]. The expansion of water infrastructure and water scarcity may result in social costs associated with industrial water use, including conflicts such as loss of income or employment opportunities caused by insufficient water resources. The current state of the global climate is experiencing substantial transformations that may result in both acute occurrences such as floods and droughts, as well as chronic changes in agricultural growing seasons and populations, necessitating access to uncontaminated water [33].

These occurrences possess the capacity to adversely affect the availability of water resources. Episodic occurrences can give rise to hazards and disruptions throughout the annual cycle, leading to phases of water insufficiency. The persistence of events over time may exacerbate the competition for water resources among various sectors. This underscores the importance of efficiently monetizing the potential impacts of forthcoming water hazards on diverse urban requirements [34]. This will facilitate a deeper comprehension of the actual value of water beyond its present monetary valuation and harmonize it with the suitable conceptual structure. Water-related hazards can be classified into physical, regulatory, and reputational risks [35]. The limitation of access to a dependable and sufficient water supply presents tangible hazards that can influence the cost of water, irrespective of any ambiguities associated with the potential impacts on water supply. The limitation of a water supply can be attributed to a range of factors, such as droughts or floods that result in the impairment of the water-supply infrastructure.

Furthermore, a reduction in water system capacity may arise as a result of deteriorating infrastructure and delayed maintenance. Regulatory risks pertain to the possible consequences of sudden changes in legislation or regulations that may impede the capacity of a facility to obtain water resources or services and dispose of waste. This particular risk has the potential to affect the expenses associated with water discharge. The perceived risks associated with detrimental production activities on water are predominantly negative. However, industries are failing to consider the diverse categories of risks associated with the ecological value of water.

The growing apprehension regarding water scarcity in diverse domains necessitates a heightened inclination to acknowledge the intrinsic worth of water. This measure is expected to mitigate superfluous depletion and excessive consumption and to foster efficient utilization of this invaluable resource. The process of evaluating the value of water involves the utilization of either inductive or deductive methodologies, which are selected based on the nature and extent of data employed in approximating the industrial worth of water. The aforementioned technique is predominantly employed at the facility level and is reliant on empirical data to establish overarching correlations. The accomplishment of this task is facilitated by employing diverse methodologies, including econometric, contingent valuation, and damage cost analyses.

## 5. Initiation of Water Valuation Approaches within Urban Regions

Despite numerous studies indicating the likelihood of impending water scarcity, many countries have yet to implement significant measures to address this issue. As per the recent report on water scarcity by UNICEF, a significant proportion of the global population, approximately two-thirds, accounting for four billion individuals, undergo acute water scarcity for a minimum of one month annually [36]. It is projected that, by 2030, approximately 700 million individuals may experience displacement caused by severe water scarcity [37]. The issue of water scarcity in agriculture is frequently classified as physical scarcity, which arises because of insufficient water supply as a result of local ecological factors, and economic scarcity, which is caused by inadequate water infrastructure [38]. As an illustration, a region experiencing high levels of stress may exhibit a deficit in precipitation, coupled with insufficient provisions for water retention and hygienic infrastructure.

Hence, the issue of water scarcity in a given area is frequently attributed to human factors, particularly in terms of the availability of potable water and hygienic sanitation, despite the presence of notable natural causes. In many cases, the issue of inadequate drinking water supply is not primarily attributed to physical water scarcity but rather to the limited availability of the financial and political resources required to establish the necessary infrastructure for the provision of clean water to the consumers [39]. Simultaneously, certain regions experiencing a state of physical water scarcity possess the necessary infrastructure that has facilitated the flourishing of life in those areas.

Water supply is subject to governance and influence from various authorities, ranging from national entities to regional and local jurisdictions. The region of the Middle East and North Africa (MENA) exhibits the highest degree of physical water stress [40]. The MENA region experiences comparatively lower levels of precipitation in comparison to other regions, and as a result, its constituent nations often feature rapidly expanding, heavily populated urban areas that necessitate increased water resources. However, inadequate infrastructure and high levels of mismanagement are still challenging factors [41]. Consequently, enhancing the value of water across multiple domains and optimizing its utilization by minimizing superfluous wastage and consumption are imperative. The present investigation aims to analyze various methods for enhancing the value of water within key facets of urban environments.

### 5.1. Enhancing the Value of Water in the Agriculture Sector

The augmentation of food production is a crucial factor because of the high concentration of the human population. Crop cultivation and livestock husbandry are the two categories of agricultural industries, and their water requirements are depicted in Figure 5 along with their water sources. The agriculture sector generates more than 75 percent of the world's water demand, and water scarcity issues are more severe in this sector than in others. The majority of suburban and rural agricultural industries rely on natural water sources such as surface water, groundwater, and rainwater, with the availability of water and scarcity having little impact on water needs. In contrast, urban areas rely primarily on artificially treated water, with scarcity having a significant effect.

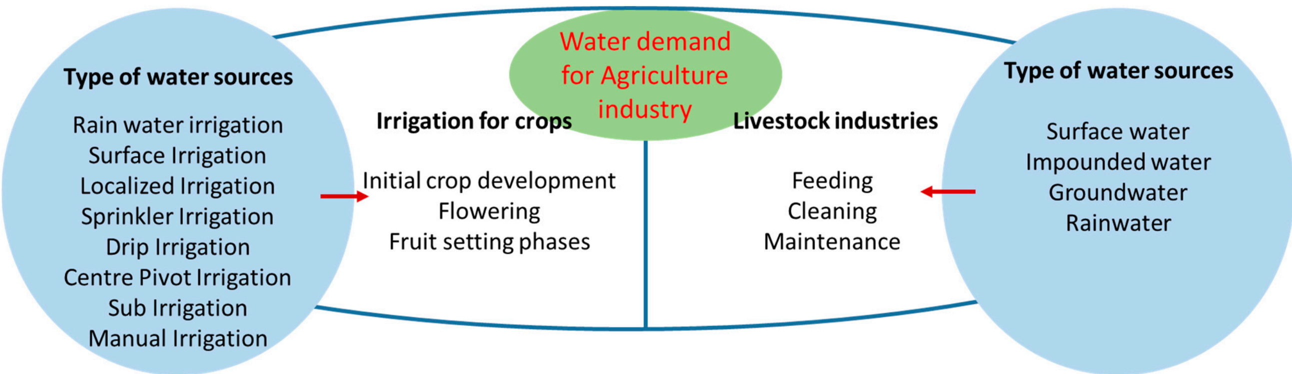


**Figure 5.** Water requirements for agricultural industries.

Transformation of natural water bodies and wetlands into built environments and urban structures is escalating the water-scarcity-related issues within the urban region. In addition to that, sustainable green building constructions are promoting greenery spaces such as home gardening including backyard gardens, tactical gardens, street landscaping, forest gardening, greenhouses, green walls, rooftop gardens, vertical farms, and aquaponics [42], and the irrigation for those initiations also increases the demand of water.

However, water wastage, improper water management practices, and alterations of water catchment and storage areas continue to demonstrate that water in urban areas is undervalued. Therefore, to tackle the obstacles encountered by the agricultural industry on water scarcity, it is imperative to reassess proper water management protocols with the aim of enhancing the efficacy of water consumption. But those strategies can be employed to achieve accountability, efficiency, and sustainability. These may include improving current equipment, identifying areas of water leakage and wastage, installing sub-meters and meters to monitor water consumption, conducting water audits, setting sustainability goals, recycling and upgrading water, and promoting consumer awareness. The aforementioned phenomenon can be attributed to the notable progress in agricultural water efficiency, which has resulted in premature encounters with intricate dilemmas concerning water disputes among diverse domains, dwindling water levels, and predicaments of water contamination [43,44].

Various legal frameworks have been established by various countries to safeguard their water resources, including the implementation of water pricing concepts to assign value to water. The determination of prices entails the allocation of distinct responsibilities to each sector, the facilitation of pricing transparency, and the involvement of various stakeholders in water pricing. Countries such as the United States, Spain, Italy, the Republic of Korea, and South Africa apply full water-supply cost pricing for their water supplies, while Israel, Pakistan, Mexico, and China also add the operational and maintenance charges to the water pricing. Japan has its own technique to calculate area-based water pricing. However, rapidly developing countries like Vietnam and Thailand offer free-of-charge water supplies [45]. Hence, insufficient institutional frameworks, conflicting responsibilities, challenges in quantifying the consumption, inadequate infrastructures, and absence of a foundation for pricing hinder the development of a rational mechanism for water price formation [45]. Several recent research studies have indicated that the adoption of pricing reform can be a viable strategy for enhancing water-use productivity and environmental responsibility in the agricultural industry [46].

The unique attributes that differentiate water from typical goods require the utilization of economic principles in the management of water resources, in conjunction with a comprehensive social and institutional outlook. Although some countries have taken on the responsibility of covering the expenses associated with agricultural irrigation to ensure food security, the rate of cost recuperation is notably sluggish, thereby exacerbating the pressure on the fiscal resources [46,47]. Thus, endeavoring to tackle the environmental and resource costs (ERC) linked with water represents a viable approach [48]. The determination of water prices for agricultural use in developing countries is marked by a heightened level of practicality, which can be traced back to their economic advancement and focus on guaranteeing food sovereignty.

The implementation of agricultural water pricing reform in developing nations is significantly challenged by practical hindrances. The efficacy of increasing agricultural water prices as a means of reducing water consumption may be limited by the implementation of relevant infrastructure. The lack of appropriate water metering systems has impeded the adoption of volumetric pricing mechanisms in certain developing nations. The increased water tariffs have caused significant strain on farmers in developing countries [45]. Hence, water price hikes may have a significant impact on farmers with lower incomes, resulting in a reduction in the profitability of their agricultural pursuits. Insufficient subsidies may result in challenges in executing water pricing reforms. The implementation of modest subsidies holds promise in terms of fostering the willingness of farmers to embrace increased water tariffs and reinforcing the dependable functioning of irrigation facilities [49].

The sustainability of water in the agricultural sector may be jeopardized by excessive subsidization, despite the potential economic benefits it may offer to farmers. In another way, disproportionate subsidies lead to the nonviable depletion of water resources and inadequate water provision. The utilization of price leveraging is a frequently employed mechanism for regulating the efficiency of water usage [50]. The increase in water prices presents a formidable obstacle in emerging economies where farmers have grown accustomed to obtaining water at minimal or no expense. Globally, diverse water pricing strategies are practiced such as uniform pricing, negotiated pricing, differential pricing, quota pricing, classified pricing, and block pricing, which are all rational mechanisms for pricing [51]. Differences in the income of farmers, improvements in infrastructure, and fluctuations in global economic conditions can lead to varied pricing approaches within a particular geographical area. While regional variations in agricultural water pricing may exist, it is noteworthy that the revised pricing structure has appropriately considered the expenses linked to operation and maintenance.

The implementation of a water quota system, coupled with a block water pricing structure, has been introduced with the objective of incentivizing water conservation practices within the agricultural industry [51]. Moreover, particular regions have initiated adaptable pricing strategies, such as the transformation of energy usage for well irrigation [52]. Diverse incentive and subsidy measures have been enforced to promote water conservation and alleviate the financial strain on agricultural producers. Simultaneously, the implementation of elevated tariffs on water usage in crops that necessitate substantial amounts of water and reduced tariffs on crops that entail minimal water consumption incentivizes alterations in planting methodologies [53]. In areas where irrigation is highly dependent on water resources, the distribution of water is subjected to meticulous examination and approval. The consumption of water that falls within the authorized quota is not subject to fees; however, any utilization that exceeds the assigned limit will incur a significant rise in tariffs.

In response to the reform mandates, regional governmental entities have taken a proactive approach to formulating regulations and standards related to water that enable the efficient implementation of subsidies and incentives while maintaining strict compliance [54]. Within the domain of water conservation, incentives are commonly classified based on either the percentage of water conservation attained or the volume of water conserved by end-users [55]. In certain regions, incentive policies have been instituted to facilitate the exchange of water rights. Significant regional disparities exist in the regulations and criteria governing subsidies and incentives. The principles of precision and rationality are fundamental in advancing water efficiency and guaranteeing the durability of policies.

### 5.2. Enhancing the Value of Water in Manufacturing Industries

Water is employed for diverse purposes in the manufacturing sector, including for cooling, power generation, sanitation, and fire protection [56]. Water sources can be utilized in the manufacturing process either as an input or facility management component. As with input, facilities management is also essential in such a situation where water is unavailable for cooling and an alternate heat sink is not present and the process equipment is vulnerable to overheating, malfunction, and consequent plant shutdown. Industries that rely on water as a fundamental input, such as the food and beverage manufacturing and chemical manufacturing sectors, demonstrate a comparatively less responsive demand in contrast to industries that employ water as a process input, which exhibit a relatively more responsive demand [57].

As a result, the issue of water demand and its associated value assumes significance in the context of managing or mitigating water-related risks such as those pertaining to price, availability, and quality. The occurrence of water scarcity may be attributed to an unreliable water supply, leading to a transient escalation in regional water prices. In contrast to other goods and services in the market, the monetary compensation for water does not comprehensively account for the benefits it offers to the end user. Consequently, due to its undervaluation, this resource, which is crucial for numerous manufacturing processes, is not utilized to its full potential, leading to significant operational inefficiencies [25]. The incongruity between the cost and value of water-conserving technologies hinders their advancement and implementation, as the assessment of return on investment is based on cost rather than value [45].

In addition, the financial burden associated with water often leads manufacturers to give precedence to capital improvements that focus on enhancing the utilization efficiency of other resources that incur greater operational costs, such as electricity [58]. To promote the advancement of water conservation technologies and attain sustainability objectives, it is imperative to revamp the water pricing system to better incorporate its value [59]. The evaluation of the economic impacts of industrial self-supply water withdrawals or utility water use is commonly conducted by employing fundamental measures such as water cost and water price [60].

Various water valuation matrices have been used in the manufacturing sector. While profit is the main orientation of manufacturing industries, these valuations will be more toward profit. Therefore, water is either an input or component in facility management, and utilization of the required quantity of water is also included in their main expenses. The concept of willingness-to-pay (WTP) pertains to the extent to which factories are willing to pay an amount that exceeds the current cost or price they pay for their water requirements. The WTP measure evaluates several categories of water risk by assessing the highest price at or below which a customer would certainly purchase a single unit of a commodity. This matric will be followed as an inductive or deductive procedure [61]. WTP is mostly relevant at the level of individual facilities or industries and analyzes the econometric, contingent value and damage cost assessment. In contrast, deductive methodologies, like value-added analysis, computable general equilibrium (CGE) modeling, and alternative cost models, use less data but provide greater logical and analytical suitability for estimating macro-level regional or national phenomena [62].

Additional metrics often used to estimate the value of water include the value of marginal product (VMP), average water productivity, shadow pricing, and elasticity coefficients. The concept of the shadow price of water pertains to the potential intangible societal cost associated with water. This cost reflects the value of a product that may be manufactured by using an additional unit of water, taking into consideration the amount of other inputs, such as labor and raw materials. Elasticity is a commonly used measure for valuating water, which is utilized to comprehend the level of responsiveness of industrial water demand and production to changes in different factors [63].

The availability of water is contingent upon its geographical location, thereby rendering localized water scarcity a potential hazard for manufacturing activities in close proximity. In cases where utilities are unable to meet their financial obligations, deferred maintenance and capital expenditures have led to deteriorating water infrastructure, which has had adverse impacts on both the quality of water and the dependability of its supply [64]. The inadequate incorporation of the economic significance of water to various stakeholders and businesses in existing water risk assessment tools may lead to a misinterpretation or underestimation of water risks by manufacturers, particularly in extensively developed river basins [65]. Projected increases in industrialization, environmental water discharge regulations, and climate change impacts such as drought and extreme weather are expected to result in more frequent water supply disruptions.

The comprehensive valuation of worth to manufacturers should take into account the potential hazards associated with water scarcity or inadequate water purity, which may result in the interruption of manufacturing processes [66]. The precise evaluation of the worth of water is of utmost importance in measuring the external and indirect consequences of interruptions in water supply. It is also a critical factor in determining the viability of economical industrial water conservation technology alternatives such as in countries like Germany that utilize vast volumes of water that have long since adopted practices that recycle or reuse. Reusing water for different purposes has been a secondary concern for German facilities. The relevance of water reuse for the industrial sector is shown by a financial measure pursued by the German government called future-oriented technologies and concepts to increase water availability by water reuse and desalination (WavE) [67].

Furthermore, the practice of assigning a monetary value to water resources would facilitate manufacturers' comprehension of the tradeoffs associated with water consumption, particularly when financial metrics are used to quantify inputs and outputs [68]. The implementation of water valuation could prove advantageous for local utilities in terms of optimizing the allocation of water resources. The development of specialized economic evaluation methodologies that are specific to the manufacturing region is crucial to facilitate the progress and adoption of water conservation technologies in the industrial domain.

The cost of a typical commodity is dependent on its quantity. Water is regarded as an unconventional commodity owing to its distinctive attributes that surpass its volume and are not mirrored in market valuation. Water exhibits distinctive properties, including its fluidity, which induces it to move instead of remain still. However, the transportation of water over long distances and elevations is a challenging and costly endeavor, leading to difficulties in establishing ownership rights and distributing it to areas in need [69]. The availability of freshwater is subject to spatial and temporal variations influenced by weather and climate. The quality of water is a crucial factor in determining its suitability for specific applications, and its multifaceted social functions necessitate regulated pricing.

The expenses and prices associated with the manufacturing process are dependent on the method of water procurement, which can either be through self-supply or purchase. This results in unique cost and price structures for each approach. Manufacturing establishments that obtain water from public utilities are subjected to a particular tariff that is contingent on the amount of water procured. These establishments frequently associate the aforementioned cost with the genuine expenditure of water usage on their premises. On the contrary, it is noteworthy that self-supplied industrial facilities typically do not incur any costs for the acquisition of raw water. In the event that there are any expenses, the total cost may comprise various incidental expenses, including but not limited to abstraction licenses, infrastructure, and technology expenses [70]. In both scenarios, there are supplementary expenses associated with utilizing the water. The direct costs pertain to the expenses that are specifically linked to the creation and sustenance of the water supply infrastructure of the manufacturing facility, including the procurement of circulating pumps and chemicals for treatment [71]. In more technical language, these pertain to expenses linked to capital investment, operation and maintenance, and the acquisition of water-saving technologies.

### *5.3. Enhancing the Value of Water in Construction Industries*

The trend of modern urbanization is characterized by a swift proliferation of constructed structures and built environments. A projected increase of 35% in global building growth is anticipated by the year 2030 [72]. The increase in building construction has resulted in a heightened demand for water, as it is a crucial raw material in the construction process. In the context of water management, it is imperative to identify processes and activities that consume significant amounts of water, quantify the corresponding water demands, and implement effective conservation strategies during construction. As with various other sectors, the preservation of the environment is widely acknowledged as an essential imperative within the domain of construction. Water management in the construction industry is often overlooked by construction stakeholders and government authorities.

According to the World Bank, the industrial sector withdraws approximately 19% of the total water, with the construction industry ranking among the highest consumers of water [73]. The global built environment is responsible for a significant 20% of water consumption; however, it has been suggested that the implementation of green buildings may potentially reduce this usage by nearly 40% [74,75]. The water consumption profiles of various materials exhibit significant variations across the value chains, encompassing raw material extraction, processing, manufacturing, transportation, and construction. In addition, it is imperative to consider both direct and indirect water consumption throughout their respective supply chains to identify key areas of interest for water efficiency.

Hence, it is imperative to establish metrics that follow systematic protocols to measure the volume of water usage and potential environmental consequences associated with water usage. The water footprint network (WFN) and the life-cycle assessment (LCA) are the prevalent methodologies globally practiced for valuating water footprints [73]. The

WFN adopts a volumetric methodology when assessing water footprints, which takes into account the total volume of freshwater utilized by an individual, community, or business activity.

The evaluation of material, technology, and structural design alternatives in the building industry involves the consideration of the process boundary of the water footprint analysis. The evaluation of the water usage efficiency of a building should consider various factors such as its durability, maintenance requirements, disposal methods, post-construction water usage, transportation of materials, and compatibility of materials [76,77]. Additionally, the assessment should also account for the grey water footprints associated with effluents. The purpose for using a particular water-efficient option can alone be validated by a comprehensive cradle-to-grave water footprint analysis.

It is imperative to conduct a thorough investigation of the water footprints of raw-material extraction and processing, energy sources utilized, labor practices, and the soil attributes of construction sites that impact the load-bearing structures of buildings. Despite water being a substantial component of building costs, serving as both a raw material and for various utility uses, several stakeholders exhibit a lack of awareness about the true worth of water. Numerous construction enterprises often consider water as an inexhaustible resource and engage in excessive consumption beyond their actual requirements. This will negatively affect them as additional costs and causes water scarcity.

During the construction phase, water plays a variety of roles such as facilitating the blending of mortar and concrete, aiding in the solidification of work, managing dust levels, saturating materials, promoting vegetation growth, conducting geotechnical borings, conducting pipe flushing and pressure testing, and facilitating washing and cleaning activities [78]. The primary activities that contribute to water wastage in the construction industry have been recognized as dust suppression, cleaning, commissioning, and testing [79]. Typical water sources utilized in construction activities comprise naturally occurring water bodies, pipelines supplying potable water, nonpotable water from storm water, and recycled water from wastewater treatment facilities.

Despite the widespread use of a substantial amount of potable water in road construction, there is a dearth of research on the quantification of water usage in this domain. Additionally, water extraction from the aforementioned establishments could be subject to government regulations. Furthermore, it is crucial that the water undergoes a comprehensive purification procedure to eradicate any deleterious concentrations of alkalis, acids, oils, salt, sugar, organic matter, plant growth, or other substances that could potentially have an adverse impact on bricks, stone, concrete, or steel [51]. In addition to that, a comprehensive analysis of the various aspects such as source types, consumption patterns, handling procedures, storage methods, transport protocols, disposal techniques, policies, and alternative water sources at the project site is imperative to ensure sustainable water utilization. Moreover, it is imperative to establish benchmarks that are customized to the construction phase. The preceding data emphasize the importance of water as a vital resource within construction. Recognizing the intrinsic value of sustainable practices is imperative for their safeguarding and adoption.

### *5.4. Enhancing the Value of Water in Residential Houses*

The consumption of water in residential structures primarily encompasses domestic water and irrigation water. A significant observation is that the water utilization efficiency in residence-type buildings is suboptimal, leading to substantial wastage of water resources. The valuation of water in residential buildings is a crucial phenomenon for the effective management of water resources. This approach can help to minimize water wastage and enhance water conservation strategies.

The amount of water consumption in various types of residential structures is contingent upon factors such as the occupants' preferences and requirements, the social status of the inhabitants, and the facilities and practices implemented within the buildings [80,81]. The valuation of water consumption for individual practices can aid in the identification of areas where water efficiency can be improved and reduction measures can be implemented. Daily per capita is one of the water valuation matrices in residential houses and hotels that aims to estimate the overall water demand. This approach provides insights into consumption patterns, total water requirements, and wastage levels for households and hotels. By identifying areas of wastage, this technique facilitates the implementation of strategies to minimize water wastage, promote efficient water usage practices, and offer recommendations for future effective water utilization.

Incorporating uncomplicated and inventive strategies that prioritize the reduction in water consumption, the utilization of alternative water sources such as recycled wastewater and rainwater, and the implementation of green infrastructure can be seamlessly integrated into newly constructed buildings, as well as retrofitted onto pre-existing structures, to establish residential communities that are efficient in their water usage.

Facilities ought to prioritize the reduction in their water consumption by enhancing their efficiency and minimizing the overall volume of water utilized whenever feasible. The implementation of water-efficient fixtures and appliances, irrigation equipment, sustainable landscape design solutions, and improved operation and maintenance of water systems can significantly decrease water consumption [82]. After achieving optimal efficiency, it is recommended that facilities maximize their utilization of on-site or building-collected, used, purified, and reused water. Two prominent options include the collection of rainwater and the treatment of wastewater for reuse. The implementation of the collect-and-treat approach results in a reduction in treatment and transport losses, while also decreasing the total energy consumption associated with processing and conveyance. It also serves to mitigate reliance on freshwater supplies, thereby alleviating pressure on water resources. Minimizing stormwater runoff is a significant factor in mitigating water loss from a facility.

As urbanization continues to encroach upon natural landscapes, the conversion of forests and green fields into buildings results in the accumulation of pollutants in rainwater runoff. This runoff, which originates from surfaces such as roofs and pavements, carries a variety of contaminants including trash, bacteria, fertilizer, oil, pesticides, and dirt [83,84]. The untreated runoff is then directed toward stormwater drains and ultimately discharged into bodies of water such as streams, rivers, lakes, and oceans. Stormwater runoff is a significant contributor to water pollution and urban flooding. To mitigate the adverse effects, it is recommended to incorporate tailored green infrastructure measures on the premises, such as rain gardens, permeable pavements, green roofs, infiltration planters, and rainwater harvesting systems, among others [85,86]. These solutions can facilitate the infiltration of stormwater into the primary water source.

This measure not only significantly mitigates the occurrence of flooding but also effectively inhibits the infiltration of contaminated runoff into sewer systems or surface waters. From an ecological standpoint, the utilization of alternative water sources that are not obtained from fresh surface- or groundwater sources can potentially mitigate the demand for freshwater resources. This approach can also enhance the dependability of access to the resource, diversify its usage, and decrease the amount of wastewater that is released into the environment [87]. Water-efficient appliances constitute a crucial component of the water supply and drainage infrastructure in buildings, and those efficient techniques represent a significant aspect of the water conservation assessment framework.

Domestic water-saving appliances can result in a reduction in water consumption while maintaining the same level of functionality. This can be observed in activities such as drinking, flushing, bathing, and irrigating. Water-conserving appliances primarily comprise water-efficient faucets, water-efficient toilet-flushing mechanisms, and water-efficient showerheads. Water-saving flushing mechanisms for toilets represent a new approach to mitigating water consumption in restroom facilities. When aiming to maintain the proper functioning of the drainage system, the utilization of a selected stool equipped with a graded flushing mechanism has the potential to conserve a significant quantity of water [84].

Currently, hydraulic tanks and hydraulic flushing valves are commonly utilized in restroom facilities. These devices exhibit consistent performance and can be easily operated. The adjustability of their water output is noteworthy. They ought to be our primary option. It is recommended that self-closing flushing valves, automatic inductive flushing appliances, and other water-saving flushing equipment be encouraged for use in public areas [82]. The utilization of water during showering constitutes a significant proportion, ranging from 20 to 35%, of overall water consumption. During the process of showering, failure to promptly adjust the water output may result in excessive water wastage. Currently, a novel type of shower that conserves water and includes a thermostat is accessible.

The wrench can be operated at a predetermined temperature, while the shower facilitates rapid adjustment of water temperature, thereby reducing water consumption [88]. In communal restrooms, replacing the double-pipe water supply with a single-pipe water supply equipped with a thermostat can result in water savings. The implementation of shower systems equipped with pedal valves is another type of efficient technique and results in a reduction in water, and the utilization of an intelligent IC card control mechanism also has the potential to conserve water. The utilization of the aforementioned three mechanisms primarily results in a reduction in indoor water usage. Simultaneously, conserving outdoor water usage holds equal significance. In outdoor settings, water is primarily utilized for the purpose of landscape irrigation. Currently, micro-spray irrigation is widely utilized. Compared to conventional irrigation methods, utilizing this technique can result in water conservation to a considerable proportion [89].

The primary origin of reclaimed water is the effluent generated from washing and showering activities. Recycled water is commonly utilized for the purposes of toilet flushing, landscape irrigation, and road spraying. The utilization of recycled water for treatment and reuse purposes is a viable approach to enhance the efficacy of wastewater utilization. Various methods for treating wastewater exist, including bio-contact oxidation, BAF, and SBR, alongside emerging techniques like up-flow anaerobic sludge blankets (UASBs) and suspended carrier bioreactors [90]. Undoubtedly, these methodologies possess inherent constraints. Rainwater has the potential to serve as a resource for both irrigation and road flushing purposes. To conduct a thorough assessment of water-saving retrofitting for pre-existing residential structures, it is imperative to adhere to established principles when selecting evaluation criteria.

Initially, it is imperative that the index system has the capacity to comprehensively depict the water conservation status of edifices. The inclusion of both the external environment and internal characteristics of projects is imperative for a comprehensive system. The system ought to comprise both quantitative and qualitative indexes. It is imperative that the indexes accurately and impartially represent the actuality. The development of comprehensive evaluation indexes is crucial in providing a theoretical foundation for the optimization of the design of water-saving retrofitting of residential buildings.

### *5.5. Enhancing the Value of Water in Recreational Activities*

Freshwater ecosystems offer a multitude of benefits to human society and are often associated with elevated property values for locations that offer access to or views of these environments. In this way, recreational activities are more popular in modern society in urban areas. Engaging in aquatic activities such as boating, swimming, or fishing has especially been found to provide various psychosocial benefits and contribute significantly to the economy. Notwithstanding, leisure pursuits such as angling, aquatic recreation, or navigation could potentially exert adverse effects on biodiversity or disrupt ecosystem processes as well. Proper strategies to protect the aquatic ecosystem and the value of water are very essential elements in freshwater conservation.

The assessment of a water balance in recreational activities, such as artificial swimming pools and boating ponds, involves estimating the quantity of recharge water and waste water. The occurrence of water wastage, such as through leaks, spills, and evaporation, necessitates the constant addition of extra water. High-quality water that is safe for customers to engage with is necessary for swimming activities. Hence, it is important to assess many quality indicators, including chlorine levels, pH levels, alkalinity levels, stabilizer levels, and hardness levels. Otherwise, the preference of customers may decrease because of increasing health concerns, resulting in a decline in profitability. In this sector, water auditing, leakage tests, and WTP metrics can be employed as methods to assess the valuing of water resources.

Aquatic leisure pursuits are predominantly conducted in the superficial regions of water bodies such as rivers, lakes, and oceans. Despite the high quantity of surface water bodies, there is a significant level of contamination and quality degradation. Regrettably, public awareness and concern regarding this issue are insufficient. The salinity of these aquatic ecosystems supports a diverse array of organisms, and their degradation and pollution can have significant impacts on both the ecosystems and humans, either through the food chain or via consumption of drinking water [91]. Hence, it is imperative to subject potential water bodies to be utilized for recreational purposes to stringent measures to avert any degradation of their quality. The operation of motorized vehicles, particularly boats, can result in the introduction of various pollutants into surface water bodies [92]. Contaminants may be introduced into the environment by maintenance activities, such as the application of new paint, removal of old paint, use of antifungal solvents, oil and grease, fuels, and cleaning agents [51].

Coastal urban regions have large numbers of marine-related activities such as moored boats, but those have been found to have increased levels of contaminants. These contaminants can come from various sources such as engine exhausts, antifouling paints, and activities related to boating such as washing, sanding, painting, bilge water drainage, and refueling. With regard to the discharge of fuel from boats, it is worth noting that outboard motors release their exhausts directly into the water, whereas inboard motors release their exhausts either at or below the water line [93]. The velocity of the boats in those activities will be the factor of the magnitude of the abovementioned contaminations. Hence, implementing a speed limit and revising regulations to enforce penalties on individuals who breach these regulations would be a viable approach to safeguarding the integrity of water resources in the recreational domain [94].

Furthermore, it is noteworthy that uncombusted fuel impurities have the potential to be present in the aqueous phase and may also amass within sedimentary deposits as hydrocarbons of varying chain lengths [95]. The aforementioned phenomenon has the potential to elevate turbidity levels, induce alterations in coloration, and impact the biota. It is imperative to establish discharge regulations pertaining to navigation activities within recreational settings. Boat traffic within freshwater rivers has the potential to negatively affect water quality through the resuspension of polluted sediment located at the bottom [96]. The notion that public access to reservoirs and catchment areas can lead to the presence of pathogens in said reservoirs is widely acknowledged. The majority of waterborne pathogens are introduced into drinking water sources through the presence of human or animal excrement. The most significant threat to human health arises from the release of human fecal matter [97].

The causative factor behind the observed increase in bacterial concentration remains undetermined, as it is unclear whether it resulted from the introduction of bacteria via physical contact with swimmers or from the resuspension of bacteria present in the streambed sediments [98]. The presence of soil particles that are suspended because of erosional activities can have detrimental effects on the quality of water. These particles can enter a reservoir that is meant for drinking water, leading to an increase in turbidity levels. This, in turn, can negatively impact the aesthetic quality of the water and result in higher costs associated with water treatment. Additionally, the presence of these particles can potentially shield pathogens from disinfection treatment, thereby posing a risk to public health. Hence, it is imperative to identify the origins of said contaminations and establish effective measures to mitigate their discharge from recreational watercraft and similar sources.

The presence of boats along a shoreline has been observed to result in bank erosion. Additionally, the movement of boats through water has the potential to cause disturbance to the bed of the water body [99,100]. This disturbance can occur through direct contact or through the turbulence generated by the vessel's passage. Such disturbances have been found to adversely impact the quality of water. The sediments found in urban catchments frequently exhibit significant levels of contamination from a diverse range of pollutants that pose a threat to both human health and the aquatic ecosystem. Consequently, the aforementioned sediments will give rise to numerous challenges and ultimately exert an influence on the quality of water. Improper anchoring techniques may result in anchor drag, which can lead to disturbance of the upper sediment layers and subsequent localized particle suspension [101]. The engagement in recreational activities within the adjacent catchment area may also serve as a source of water pollution, as the erosion resulting from the movement of vehicles or animals can lead to turbidity in water storage.

Increased nutrient concentrations in aquatic environments can stimulate the proliferation of algal blooms and hazardous cyanobacteria, resulting in malodorous conditions [102]. The potential impact of increased treatment times and costs on the health of water consumers is a matter of concern. The act of recreation, akin to any alteration of a natural habitat, can potentially yield a multitude of effects on the ecology of a given system. Therefore, safeguarding crucial infrastructure, such as treatment plants, dam walls, and raw water storage, from potential security threats should be undertaken by the entities to protect the water quality. Water supply entities must exercise appropriate care and attention in complying with both legal requirements and customary practices when deciding whether to authorize or restrict recreational entry to catchment areas and reservoirs.

## 6. Discussion

The significance of water value in the perception of consumers is a crucial factor that can enhance the optimal utilization of water resources and mitigate the prevalence of water wastage and inefficient practices [103]. The present study undertook an analysis of the economic and environmental ways of adding the value of water utilized in key sectors that are major consumers of water in urban areas, including agriculture, manufacturing industries, construction, residential, and recreational activities. Despite that agriculture counts as a major contributor of water consumption on the globe, there exists a significant degree of inefficiency and wastage in water usage, particularly in instances where agricultural lands rely on self-sourced well water.

Hence, the cost of the water consumed is relatively low. The precise worth of water remains ambiguous. Similar to other resources, the cost of water is often not factored into the pricing of agricultural commodities. Thus, despite the water being sourced from a self-sourced well, it is imperative to safeguard its value. The current abundance of water reserves may not pose an immediate concern; however, the eventual depletion and degradation of water quality and quantity will inevitably lead to significant challenges in the future [8]. The implementation of appropriate treatment methods prior to water utilization can significantly enhance the quality of both water and agricultural produce. The proper treatment of effluent and its discharge with minimal or negligible environmental impact can potentially contribute to the replenishment of water reserves.

In recent years, significant progress has been made in the exploration of comprehensive water price reform, building upon previous studies. This has created new opportunities for the sustainable utilization of water resources. The implementation of a comprehensive reform of water prices has yielded favorable outcomes in enhancing the efficacy of water management, refining the mechanism for determining water prices, and fostering various water-demanding practices that prioritize high efficiency and water conservation [104]. Notwithstanding, certain academics have highlighted that a surge in water costs would curtail not just the utilization of water but also the revenue of water-based sectors such as agriculture and manufacturing industries.

In the case of agriculture, farmers residing in regions with differential water pricing tend to decrease the proportion of crops that require high water consumption and encourage farmers to cultivate low-water-consuming crops that can lead to increased revenue per hectare but, in another way, results in food security issues [105]. This may result in farmers abandoning their agricultural pursuits and seeking employment in alternative sectors, ultimately leading to a decline in their motivation to cultivate crops. The manufacturing sector serves as a crucial pillar for the economies of various nations worldwide. In the upcoming decade, the water scarcity issue has the potential to jeopardize numerous industries. Managing these challenges is a crucial undertaking in the realm of integrated water management, particularly for the industrial sector, given the paramount importance of public water supply and food security.

The industrial sector faces particular obstacles in this regard, namely, the need to enhance water resource efficiency while simultaneously disassociating it from production growth, as well as the imperative to establish wastewater management systems that align with the principles of circular economy [106]. The industrial sector typically prioritizes the optimization of production and cost reduction, often at the expense of water conservation efforts. This is largely due to the relatively low economic value placed on water resources. In addition, the availability of water flow data and comprehensive information on the indirect and concealed expenses associated with water usage in individual companies is restricted or absent, thereby posing a challenge in the determination of precise water valuations. An illustrative instance of this scenario could be a situation where a business entity is compelled to curtail its manufacturing activities owing to a scarcity of water resources, thereby resulting in a substantial financial shortfall.

As there is currently no standardized methodology or framework, the estimation of the value of water must be based on an integrated approach. Certain obstacles may serve as catalysts for the implementation of a comprehensive approach to water resource management. Water scarcity is the primary factor driving water security. Water stress is a result of competition for usage among various entities, including municipalities, agriculture, and industry, each with their own water-related functions such as supply, transport, and ecosystem services. Various types of risks, including physical risks related to water quality and quantity, regulatory risks, such as limitations on water withdrawal or discharge, increasing water prices, and strategic risks such as ensuring production capacity and managing negative media perception, are significant factors to consider [107].

Reusing water is another way of enhancing the value of water that is becoming increasingly important, especially in view of the concepts of circular economy. The current trend in wastewater management involves a transition from the conventional approach of treating and disposing of wastewater to a more sustainable approach that emphasizes reuse, recycling, and the recovery of valuable resources. The practice of utilizing wastewater for multiple purposes can prove to be economically advantageous, and the retrieval of secondary products has the potential to create novel avenues for commercial enterprise, including but not limited to nutrients, metals, and other valuable resources. Within the production-related sectors, there is a growing trend to view wastewater as a viable resource. Through appropriate treatment, its reuse or recycling can offer economic advantages, alleviate strain on water resources, and serve as a supplement to corporate social responsibility initiatives.

The recognition of potential outcomes will lead to individual accountability, thereby eliciting personal standards that mandate the worker to act judiciously in order to avoid water wastage in such works like construction operations while also endorsing broader water conservation initiatives. The assessment of water value in the construction industry is accomplished by means of techniques such as leak detection, auditing, and sub-metering [78]. This particular disposition elicits several implications with regard to the planning and management of construction activities on site. Certain techniques that are popularly employed in green buildings, such as rainwater harvesting, may not be deemed as noteworthy water conservation measures in conventional construction endeavors. The implementation of a water action plan during the initiation phases of construction projects is imperative to address the issue of the inadequate prioritization of water management. The justification for advocating waste reduction can be supported by various perspectives, including the cost of water and its source. The evidence indicates that builders exhibit a lack of willingness to incur expenses associated with both the wastage of treated water and the squandering of water resources. The utilization of treated water for activities such as construction has been subject to criticism by previous researchers for its wastefulness.

## 7. Conclusions

In summary, water scarcity has become an increasingly pressing issue in contemporary life, particularly in urban areas. In contrast to suburban and rural regions, urban areas experience significant issues related to water supplies and availability because of their dense population concentration and rapid urban growth. The implementation of water valuation holds promise as a viable approach for comprehending the intrinsic worth of water and facilitating its sustainable management. This study has identified key urban components, including agriculture, manufacturing, construction, residential, and recreational industries, that contribute to increased water demand and various valuation matrices that can be carried. The value matrices will be predicated around the principles of accountability, efficiency, and sustainability. The assessment criteria for water management in various sectors can include water auditing, sub-metering, tariff comparison, leakage testing, and flow rate calculations. In the context of manufacturing industries, additional valuation matrices such as WTP, VMP, average water productivity, shadow pricing, and elasticity coefficients can be employed. The construction industry has the capacity to implement WFN and LCA methodologies as water valuation matrices. On the other hand, residential buildings can adopt the daily per capita metric for the purpose of valuation. The recreational industries require a significant amount of water because of the building of artificial water bodies. To preserve the value of water and maintain profitability, it is imperative to adhere to practices such as water auditing, leakage testing, and the monitoring of water treatment plant metrics. This study investigated the significance of conducting value assessments and addressed the water quality concerns in metropolitan areas that contribute to water scarcity. The adoption of revised utility water pricing has been widely acknowledged in diverse sectors as a strategy to augment the value of water, while concurrently incorporating suitable measures to mitigate any potential adverse consequences on affected individuals. The implementation of pricing reform has brought to light a number of noteworthy concerns, particularly in relation to the matter of food security. The use of tactics such as the reutilization, recycling, and improvement of wastewater has been recognized as a prospective method to augment the value of water. The premises also took into account the use of water-efficient equipment, rainwater harvesting systems, and wastewater reduction measures. Therefore, the effective management of impending water scarcity and its associated challenges can be facilitated.

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