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Review

Urban Wetlands: A Review on Ecological and Cultural Values

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Abstract: Wetlands are a critical part of natural environments that offer a wide range of ecosystem services. In urban areas, wetlands contribute to the livability of cities through improving the water quality, carbon sequestration, providing habitats for wildlife species, reducing the effects of urban heat islands, and creating recreation opportunities. However, maintaining wetlands in urban areas faces many challenges, such as the reduction of hydrological functions, changed water regimes due to barriers, contamination by wastewater, habitat loss due to land-use change, and loss of biodiversity due to the entry of alien species. In this article, we review the theoretical background of wetlands in urban areas through the existing studies in the literature. We provide knowledge on urban wetlands and highlight the benefits of these wetlands in urban areas. These benefits include *sustainability*, *biodiversity*, *urban heat islands*, *social perception*, and *recreation* values. We also summarize the objectives, methodologies, and findings of the reviewed articles in five tables. In addition, we summarize the critical research gaps addressed in the reviewed articles. Our review study addresses the research gaps by performing a rigorous analysis to identify significant open research challenges, showing the path toward future research in the field. We further discuss and highlight the role of policymakers and stakeholders in preserving wetlands and finally present our conclusions.

Keywords: wetland; urban wetland; green-blue infrastructure; sustainability; ecosystem services

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Citation: Alikhani, S.; Nummi, P.; Ojala, A. Urban Wetlands: A Review on Ecological and Cultural Values. *Water* **2021**, *13*, 3301. https://doi.org/10.3390/w13223301

Academic Editors: Anne W. M. Ng and Nitin Muttil

Received: 15 October 2021
Accepted: 17 November 2021
Published: 22 November 2021

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1. Introduction

According to the United Nations, 55% of the world's population currently lives in urban areas. This number is also projected to grow to 68% by 2050 [1]. This growing tendency of urbanization, both in terms of area and density, is affecting the natural infrastructure and disrupting its natural process of sustainability [2]. It also severely affects the health and ecological functions of the urban environment, leading to vegetation degradation, water pollution, and biodiversity loss [3]. Moreover, urban areas, in most cases, have less vegetation and water compared with the surrounding areas, and existing green and blue infrastructure is often threatened by increased population density [4].

Preserving and creating these infrastructures in the urban context can also be used to control the adverse effects of climate change. Therefore, there is a need to study the impact of urban natural infrastructures, such as green-blue infrastructure (GBI), on the climate of urban areas. Using GBI, this impact of climate change can be adopted in urban areas. In cities, GBI enables water treatment, reduction of urban runoff, and the provision of psychological and social ecosystem services. For example, water ecosystems, such as ponds and other urban wetlands, which are two elements from GBI, contribute to hydrological cycles in the cities [5].

Wetlands are considered as one of the excellent natural resources in urban areas. Wetlands are one of the most important green-blue infrastructure components with their wide range of services. The optimal use of wetlands increases the social and environmental sustainability of urban areas [6]. In particular, wetlands situated in urban areas are a fundamental element of urban ecosystems. Urban wetlands provide various ecosystem services and vital suppliers to the human communities [7]. These include coastal area conservation [8], water quality rectification [9,10], reducing air pollution, carbon sequestration [11], and recreation and leisure [12].

The other positive effects of blue infrastructure, such as wetlands and ponds in the urban area include controlling the effect of urban heat islands (UHI). This effect is mainly due to changes in the surface properties that lead to a greater absorption of solar radiation, reduced convection cooling, and reduced water evaporation [2]. In addition, it is known that urban wetlands show their own microclimate and are usually cooler than the surrounding areas [4,13]. Thus, they help to improve the quality of life and the environment, which leads to sustainable urban development [14].

Wetlands also play an essential role in the protection of global biodiversity. Accordingly, wetlands are known as hot spots of biodiversity [15]. However, they are the most endangered ecosystems on the globe [16] since they are ecologically sensitive yet compatible systems [17]. This characteristic has caused wetlands to offer great diversity due to their origin, geographical location, water and chemical regime, dominant species, and soil and sediment features [18].

Many cities consider the conservation and restoration of urban wetlands as a strategy in urban planning that can make cities more resistant to climate change [19]. However, while wetlands play an essential role in cities and offer various services, these services are drastically under pressure due to rapid urban expansion [20]. In fact, the urbanization and the development of cities have presented wetlands with many challenges, such as (i) direct habitat loss due to land reclamation and dredging, (ii) changed water regime by barriers, (iii) contamination by wastewater, garbage, and pesticides, and (iv) biodiversity loss due to the introduction of alien species [6].

Therefore, wetland preservation has been seriously threatened by the surrounding urban development and expansion processes. It is necessary to preserve wetlands in cities to helps reduce climate change impacts. Therefore, the need to study wetlands and their effects on urban areas and their inhabitants is required.

This article aims to investigate the role of wetlands in urban areas by answering how urban wetlands contribute to the values in urban environments. The considered values in this article include *sustainability*, *biodiversity*, *urban heat islands*, *social perception*, and *recreation*. Each of these values benefits urban environments by reducing the impacts of climate change, enhancing the sustainability and livability of the cities, and easing accessibility of nature and water resources in urban environments, which offers diverse recreational benefits.

1.1. Motivation and Contributions

Recently, wetlands as part of the GBI, are mostly considered as nature-based solutions. They can provide many services of significant social, economic, and environmental value to human well-being [21]. At the same time, wetlands are known as ecologically sensitive systems. This knowledge clarifies why much attention has been paid in recent years to formulating and implementing sustainable management strategies for wetlands [22]. Concern about wetlands could connect ecology and society through science, partnerships, and ethics. This important step helps to realize a more integrated and interdisciplinary approach to environmental research [23].

Due to the increasing growth of cities, aquatic environments, such as lakes, wetlands, and ponds have been drawn from the outskirts of cities into the urban texture [24]. Fortunately, using this opportunity helps us meet the needs of fast-growing urban areas and adapt to climate change. Urban wetlands interact (Figure 1) with various parameters, including adverse effects of climate change, population growth and density, urban development, urbanization, social perception, sustainability, and help by improving health and well-being, bringing biodiversity to the city, and controlling the urban heat island effect.

This article reviews and analyzes the current research perspective on wetlands and their role in the urban environment. We focus specifically on how wetlands affect the urban environment by controlling the impact of the urban heat island, providing biodiversity, recreational opportunities, increasing urban sustainability, and investigating public perception. Previous studies on wetlands have focused on the benefits, economic value calculation, and ecosystem services. However, to the best of our knowledge, few review articles focus on urban wetlands to highlight their role as a solution in adapting to climate change.

In this article, we first contribute by providing a background on constructed wetlands and compare them with natural wetlands. Then, we explore the literature on urban wetlands and conduct a review about the relation between the urban wetlands and the fundamental values offered by these wetlands, including *sustainability*, *biodiversity*, *urban heat islands*, *social perception*, and *recreation* values. We also summarize the objectives, applied methodologies, and findings of the reviewed articles in five tables.

In addition, we summarize the critical research gaps addressed in the reviewed articles. Indeed, our review study addresses the gaps by performing a rigorous gap analysis to identify significant open research challenges and, hence, show the path toward future research directions in the field. Finally, we discuss and highlight the role of policymakers and stakeholders and conclude our article.

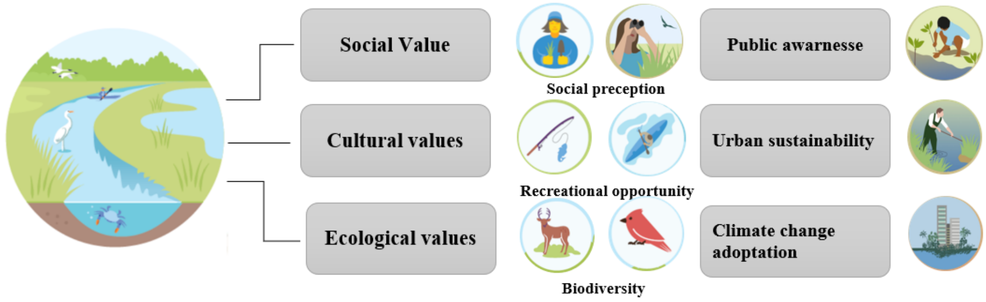

Figure 1. Ecological and cultural values offered by urban wetlands.

1.2. Methodology

We conducted a comprehensive interdisciplinary scientific literature review on the impact of wetlands on urban climate and human comfort. The databases of: ISI WEB OF KNOWLEDGE (ISI), SCIENCE DIRECT (SCD), WILEY, SPRINGER (SPR), and MDPI were searched. A search by title and abstract was performed with the following keywords: "Urban wetland", "nature-based solutions in urban areas", "Wetland as climate resilience", "Wetland as green-blue infrastructure", "Wetland ecosystem services", and "Wetland and urban sustainability". We limited the search to articles published between 2000 and 2021 to discover challenges. Table 1 shows the summary of our search from different databases.

Table 1. The keywords, numbers of articles, and the names of journal databases.

Keyword	ISI	SCD	WILEY	SPR	MDPI
Urban wetland	5	9	2	9	4
Nature-based solutions in urban areas	2	3	1	0	1
Wetland as climate resilience	4	6	3	1	1
Wetland as green-blue infrastructure	6	3	0	0	1
Wetland ecosystem services	8	6	5	4	3
Wetland and urban sustainability	8	8	1	2	4
Urban development and wetland	8	7	2	2	2
Urban wetlands and recreational use	4	6	0	2	1
Social perception of wetland	5	4	1	3	2
Total number	50	52	15	21	19

It is worth mentioning that, when searching the databases as presented in Table 1, we chose articles that studied urban wetlands from different cities in different countries. To this end, in our paper, we review a total of 48 urban wetlands located in 23 countries covering all of the continents. The locations of these urban wetlands are shown on the world google map (https://www.google.com/maps/, accessed on 15 September 2021) in Figure 2. The legend of the figure presents the name of the countries and the number of wetlands. The selection of these wetlands, each having exclusive characteristics providing valuable services in urban environments, provides a deep understanding of these wetlands' ecological and cultural values. As a result, these selections help to achieve the objectives of our review article to make a rigorous analysis and form solid conclusions.

Figure 2. The locations and number of reviewed urban wetlands in different countries.

The remainder of this paper is constructed as follows. Section 2 provides a background on urban wetland definition and types of wetlands. Section 3 explains the concept of biodiversity. Section 4 presents the effect of urban wetlands on urban heat islands. Section 5 defines the wetland and urban sustainability concept. Section 6 describes the recreational values provided by wetlands in the urban environment. Section 7 discusses the social perceptions about urban wetlands and how citizens contribute to conserving urban wetlands. Section 8 is a summary of the discussion and the research gaps in the urban wetlands studies. Finally, Section 9 concludes the paper.

2. Background on Urban Wetlands

According to the Ramsar Convention on Wetlands [6], urban and peri-urban wetlands are located inside and around urban areas and their suburbs. Wetlands can be either natural or artificial, i.e., constructed and can also be permanent or temporary, containing a low water depth of not more than 6 m of water. In principle, urban wetlands are classified as natural and constructed [25,26]. Natural wetlands (NWs) include rivers, lakes and their flood plains, swamps, estuaries, peatlands, tidal flats, coral reefs, and mangroves, while constructed wetlands (CWs) include artificially constructed canals, drains, reservoirs, artificial lakes, fish and shrimp farming ponds, ponds, rice fields, and stormwater treatment sites [27,28].

It is expected that, by 2050, the global population will increase to around 9.8 billion most of whom will live in cities [1]. Therefore, if urbanization is not planned and controlled, the increased population growth in urban areas will be a threat to urban wetlands. The effects will include draining, contaminating, and destroying wetlands by land construction for housing, agriculture, and industry [29]. Unfortunately, due to the impact of urbanization, urban wetlands have become unconnected/fragmented. They have become patchy and distributed in different areas, and they have lost connectivity with each other. This habitat fragmentation in urban wetlands has led to a decrease in biodiversity in urban areas.

Urban wetlands possess a variety of ecological functions that cannot be replaced by other urban ecosystems. Urban wetlands are natural GBI in cities that host a wide range of biodiversity. Urban wetlands, due to their special role in urban ecological infrastructure, are known as a "city's kidneys" and "biodiversity library" [27]. In addition, the interaction with these valuable ecosystems in cities improves citizens' physical and mental health [30]. Urban wetlands offer a wide range of socio-cultural services, such as creating a space for recreation and leisure for the city inhabitants [31].

Urban wetlands not only provide ecological and recreational services in cities but also improve water quality by natural water purification and perform climate regulation. In terms of climatic regulation, urban wetlands create their own unique microclimate and reduce the overheating of urban environments [32]. As a result, the protection of urban wetlands is essential for obtaining sustainable living environments [12].

2.1. Urban Wetlands as Part of Green-Blue Infrastructure

Green-blue infrastructures (GBI) is presented as a strategy to deal with climate change in urban areas [33]. In urban developments, the GBI helps to optimize the use of lands in urban areas and meet the needs of people and nature in a sustainable way. In fact, GBI complements urban areas by combining hydrological networks with green areas and the built environments [34]. Among the diverse functions and advantages, in cities, the GBI enriches biodiversity, reduces global warming effects, enhances connectivity among ecological networks, and improves people's health and well-being [35,36].

In the urban context, the presence of GBI, such as trees, rivers, and ponds can increase thermal acceptability and establish climate-resilient urban systems [37], by obtaining higher cooling effects from blue infrastructures than the green infrastructures [38]. Moreover, if the area of GBI is larger than one hectare, there is a higher cooling effect (especially in summer) [39]. In cities, the GBIs have a significant therapeutic effect on human health and enhance the positive psychological reaction of humans [2,40]. Accessible GBI encourages physical activities and social cohesion and facilitates healthier living environments [41].

Within the GBI, the blue infrastructure can be either natural or constructed. Blue infrastructures, such as wetlands, contain waters that are easily accessible to humans in cities [42]. Wetlands are infrastructures that are composed of different elements, such as shore vegetation, soil, and water. This leads to a complex structure between land and water, harboring great biodiversity. Wetlands are transition zones that are caused by surface flooding or soil water saturation [27]. In principle, wetlands provide mechanisms to restore some of the natural processes that are needed to manage and create vital urban environments [43].

With proper planning and management, the ecosystem services of wetlands can benefit a growing urban population. Sustainable development and well-planned cities can generate higher levels of social welfare and drive economic growth and prosperity [44]. In sustainable cities, wetlands provide a range of ecosystem services, for example, by increasing water efficiencies, improving biodiversity, managing stormwater and flood regulation, regulating the regional climate, and mitigating climate change [45–47]. Wetlands also enable water quality protection, coastal protection, groundwater level and soil moisture regulation, and carbon sequestration [21].

Wetlands provide a large number of ecosystem services and the potential to be used as nature-based solutions to meet a variety of environmental, social, and economic challenges [48]. Unfortunately, during past decades, urbanization has changed the types or land use of wetland [49]. As a result, the reduction of wetlands has become one of the main threats to the sustainable development of urban areas [50]. It is mandatory to improve wetlands by sustainable developments and by applying and adopting appropriate methods for maintaining and protecting the existing wetlands or by constructing artificial wetlands in cities [46].

2.2. Urban Wetlands and Stormwater Management

Increased urbanization and subsequent human activities, such as uncontrolled construction are changing the watershed landscape. These changes increase runoff in urban areas, which has adverse effects on runoff quality and quantity, such as increased stormwater runoff pollutants [51]. Wetlands, whether natural or constructed, play an important role in cities for managing stormwater runoff including reducing the impacts of floods, absorbing pollutants, erosion control, groundwater recharge/discharge, and improving water quality.

In fact, urban wetlands can be an effective system for improving water quality. The complex hydrological, biological, physical, and chemical interactions that occur in a wetland lead to the natural reduction and effective purification of pollutants [52,53]. In addition, wetlands have an effective role in receiving storm runoff due to the inherent water storage and subsequently create a process to improve stormwater runoff quality. The most important wetland processes that improve stormwater runoff quality are sedimentation, filtration, adsorption and retention, ion exchange, precipitation, and biodegradation [51].

When water enters a wetland/pond through a stream or surface runoff, the water flows and passes through dense vegetation. The water flow velocity drops, and the suspended material in the water gradually settles to the surface of the wetland. Wetland plant roots can bind and remove up to 90% of the accumulated sediment from runoff or stream flow [52]. In addition, wetlands with dense vegetation, by reducing the velocity of the water flow through them, improve sedimentation and promote the removal of more contaminants.

The removal of contaminants by filtration through soils is effective in removing organic matter, phosphorus, bacteria, and suspended material. As runoff passes through the wetland, excess nutrients are absorbed by the wetland plants and accumulate in less harmful chemical forms [54]. When wetland plants die and decay, nutrients are recycled within the wetland. Wetlands are so effective in remove excess nutrients from stormwater runoff that it has led to the construction of wetlands specifically to treat effluent wastewater treatment in cities. It should be noted that natural wetlands are not suitable for this purpose, since there is a limitation for each wetland to how much can be added before the natural plant and chemical processes are overloaded and break down [55].

2.3. Natural and Constructed Wetlands

This subsection presents the definitions of natural wetlands (NWs) and constructed wetlands (CWs) and compares them. According to the United Nations Environment Program-Centre on Water and Environment (UNEP-DHI) (https://www.unepdhi.org/, accessed on 15 September 2021), "Natural wetlands are ecosystems that are permanently or seasonally saturated in water and create habitats for aquatic plants and provide conditions that lead to the development of hydric soils" [28,56,57].

NWs are GBI systems that can be found in diverse geo-environmental settings around the world [46]. NWs consist of rivers, lakes, saltwater lake, estuaries, swamps, tidal flats, coral reefs, peatlands, and mangroves [27]. In all environmental settings, NWs refine and enhance the quality of water passing through the system, because they operate as ecosystem filters [35]. In the other word, NWs are understood as high-efficiency disinfecting ecosystems. In particular, in local environments, NWs provide ecological flood protection and clean water [58]. They also offer shelters for birds during breeding and feeding [59], and preserve more native plant species [55].

In contrast to NWs, the constructed wetlands (CWs) are defined as "man-made complexes of the saturated substrate, emergent and submerged vegetation, animal life and water that simulate natural wetlands for human use and benefits" [60]. CWs contain stormwater basins, constructed canals, drains, reservoirs, artificial lakes, fish, and shrimp farming ponds, constructed ponds, rice fields, and sewage treatment sites [27,57]. CWs are ecologically engineered systems that have similar functions to NWs. CWs are used as an alternative cost-effective approach to conventional wastewater treatment [61,62].

CWs are affordable and sturdy systems that are low cost, easy to maintain, and easy to operate systems that only need periodic on-site labor [35]. In general, CWs are the repetition of the natural process of NWs that pursue a beneficial purpose. This means that CWs are constructed to emulate and improve the function of NWs [63]. Sometimes CWs can be constructed for specific purposes (such as flood control and surface water management) to support a specific environmental concern and provide sustainable environments [64,65].

In living environments, CWs are accepted as a practical and effectual approaches to improve the environmental quality of cities by having a key role in revitalizing urban ecology [66]. For example, CWs utilize natural processes that are suitable to remove pollutants from contaminated water within a more controlled environment [67]. Moreover, CWs provide habitat and biodiversity, support recreational activities (such as bird watching), storing water during periods of drought and saturation, and adding aesthetic value in urban areas [68].

Both NWs and CWs can be considered as an alternative to conventional systems for wastewater treatment. Both systems contain vegetation, substrates, soils, microorganisms, and water. They use multiple processes, including physical, chemical, and biological mechanisms, to eliminate different contaminants and subsequently enhance the quality of the outlet water. Indeed, comparative studies considering the ecological operations of natural and constructed wetlands indicate that both accomplish relatively similar ecological functions [35,69].

Despite containing similar constructing elements, NWs and CWs have significant differences in their intended use and functions. For example, while CWs are used for the purifying of contaminated wastewater in urban areas [70]. NWs are normally not used for wastewater treatment purposes as this can yield irreparable detriment to the ecosystem of these wetlands [71].

A study by Rooney et al. [55] introduced three structural and biophysical differences between NWs and CWs. First, while CWs are usually steep-sided, the shores of NWs have much gentler slopes. Second, NWs are usually more strongly connected to both surface and groundwater streams compared with CWs. This is due to the fact that CWs are often covered with clay to prevent any connection to the groundwater, and their water levels are often maintained at constant depths. The third difference is related to the difference in landscape positions of NWs and CWs. While NWs are naturally created in different environments, CWs are constructed in peri-urban areas with higher population density, locations with higher exposure to roads and contaminants, and locations with impervious beds.

Another difference between CWs and NWs refers to the hosting biodiversity, as NWs have considerably more habitat types than CWs [72]. Indeed, while NWs are commonly a habitat for native species, CWs often host non-native species and have the potential to increase the number of undesirable species [55]. Still, due to the diverse benefits offered by natural and constructed wetlands, both need to be preserved and have their functionality improved. This could be done by preserving natural wetlands and stopping their loss as well as constructing new wetlands in urban areas.

Along with urbanization, the number of CWs have increased by 233% from the year 1970 to 2014 [73]. However, due to diverse human activities, including the expansion of urbanization, agriculture, and aquaculture which has taken place over the last decades, the majority of NWs have been significantly manipulated, destroyed, fragmented, or totally lost [74]. A research report that more than half of the world's NWs have disappeared during the last century [75]. Another study supported this finding by considering more than 2000 wetlands around the world and reported that the number of NWs decreased by an average of 35% from the year 1970 to 2015 [73].

3. Urban Wetlands and Biodiversity

Wetlands are biologically diverse systems that improve water quality and sequester carbon [76]. As significant biodiversity sources, wetlands provide habitats for groups of species from micro-organisms to mammals [77]. Examples of these species include amphibians, insects, reptiles, birds, and mammals (e.g., beavers) that are uniquely adapted to aquatic environments [78,79]. Indeed, wetlands increase the biodiversity in urban areas by acting as networks of fragmented habitat to facilitate the movement of species in the environments [80,81].

Unfortunately, due to the urbanization and the development of urban areas, wetlands as habitats have been fragmented. Fragmentation of wetlands indeed damages the habitat and has become a major challenge in urban environments [82]. Although the fragmentation of wetlands is a major threat to their existence, they remain important and are highly functional for wildlife species [83]. Therefore, identifying the importance of wetlands, preserving them, and possibly increasing the connectivity between them would considerably support the protection of biodiversity in urban areas [84].

Even preserving wetlands that are considered of lower quality (in terms of reduced biodiversity) and polluted (in terms of water quality) has numerous advantages compared to the situation of totally lacking wetlands or having fewer of them [85]. This is because, when fragmentation of urban wetlands occurs, low-quality habitats can play an important role by supporting connectivity between good patches. In this way, a sub-optimal habitat network structure can support a higher level of biodiversity on a landscape level [82].

Due to the significance of wetlands for providing habitats and supporting biodiversity in urban areas, in the following, we provide a review on this topic and summarize the objectives, methodologies, and findings of the reviewed articles in Table 2.

Table 2. Urban wetlands and biodiversity.

Reference	Objective	Methodology	Findings
Melbourne, Australia (Hale et al., 2019) [82]	Highlighting the potential ecological effects of stormwater wetlands to manage the unintended consequences for urban biodiversity	Investigated 67 urban wetlands with pollutant concentrations to specify storm wetlands could be ecological traps for native amphibian and fish in the studied areas	The stormwater wetlands often become habitats for animals, which is beneficial for the persistence of species in cities
Vihti, Finland (Wahlroos et al., 2015) [69]	Designing two wetlands with slightly different and monitored them for 5 years	Studied the vegetation establishment, water quality improvement, animal settlement, as well as people's recreation	In the second year, vegetation was self-established and wetlands became successful breeding grounds for amphibians and birds and offered recreation values to people
Netherlands and New Zealand (van Roon, 2012) [86]	Investigating the role of wetlands in carbon sequestration and evaluating biodiversity loss in the urbanization process	Used the literature review and case study investigation in a period from 2002 to 2010	There are problems in creating suitable conditions for a variety of rare and vulnerable wetlands near urban use
Melendugno, Italy (Semeraro et al., 2015) [87]	Assessing the role of multifunctional CTW in terms of biodiversity and enhance ecosystem services	Monitored fauna and flora, preparing habitat map by GIS	CTW's ability to provide side benefits beyond the main purpose of water treatment, conservation of wildlife habitats and biodiversity

Table 2. *Cont.*

Reference	Objective	Methodology	Findings
Helsinki, Finland (Liao et al., 2020) [88]	Examining how urbanization influences the diversity of diving beetles	Sampled diving beetles in 25 urban ponds using the GLMM model	The model revealed that urbanization reduced the richness of diving beetle species but had little effect on their abundance
Catalonia, Spain (Gascon et al., 2009) [89]	Conducting conservation biology by prioritizing sites based on high biodiversity	Regression tree models were used to identify key factors affecting biodiversity, including water, wetland, and landscape features as explanatory variables	The biodiversity criteria used in this study were significantly related to some explanatory variables. Significant positive relationships were found between some biodiversity criteria and wetland habitat conditions
Guapore, Brazil (da Silva et al., 2015) [90]	Investigating development targets and planning tasks for the area between the Pantanal and the Amazon as an important ecotone or transition zone	Used the (DPSIR) framework to evaluate cause-and-effect relationships	Planning and management in this wetland in three ways: (1) Business as usual (2) Conservation actions (3) Integrating biodiversity objectives into other policies and planning strategies
Meli et al., (2014) [91]	Presenting a meta-analysis to evaluate the effectiveness of ecological restoration and identify what factors influence	A literature review was conducted to identify quantitative studies on the effects of ecological restoration	The meta-analysis study showed that ecological restoration increases biodiversity and ES supply
Lombardy, Italy (Morganti et al., 2019) [92]	Studying the bird communities of inland wetland	Environmental variables were collected at the two different spatial scales of Natura 2000 sites and point counts respectively	The extent of the reedbeds/mires was positively associated with the occurrence of all species of conservation concern at the site scale
Andalusia, Spain (Guareschi et al. 2015) [93]	Exploring the relationships between community composition and species richness of waterbirds and aquatic macroinvertebrates in 36 Ramsar wetlands	Waterbird data surveys, as part of an official monitoring program, were performed by the Regional Government	The collection of waterfowl was more affected by climatic variables and water levels, while conductivity was the most important factor affecting large vertebrate communities

A study by Hale et al. [82] highlighted the potential ecological effects of stormwater wetlands to manage the unintended consequences for urban biodiversity. The study investigated 67 urban wetlands with pollutant concentrations to specify whether storm wetlands could be ecological traps for native amphibians and fishes in the studied areas. The findings of this study stated that the stormwater wetlands often become habitats for animals, which is beneficial for the persistence of species in cities. Another important finding is that the animals that colonise the stormwater wetlands suffer from the accumulated pollutants.

Based on these findings, this study highlighted the following key considerations for stormwater wetland management to reduce its negative effects on biodiversity. The accumulation of pollutants and adverse effects on amphibians and other animals is one of the main aspects of habitat quality in relation to storm wetlands. Therefore, it is suggested that inspection and maintenance programs be considered to ensure the function of storm wetlands. Another consideration pertains to the ecological consequences of changes in wetland quality.

Changes in the quality of wetlands can cause ecological traps, which are recognized as an unintended consequence of management activities. Ecological traps are usually a serious situation, but they remain hidden and unknown.

Wahlroos et al. [69] evaluated the design of two urban wetlands with slightly different designs in urban parks. The two wetlands were designed to adapt open water areas for habitat and recreation at the cost of densely vegetated areas. The two wetland parks were designed to have sufficient wetland space for amphibian habitats. Larger open water areas, as well as islands, were designed as habitats for both wetland parks to provide waterfowl habitats and attract people. The study showed that, in the second year, the vegetation was self-established.

The vegetation establishment reached 102 species with 97% native plants after 5 years. Furthermore, the results of wildlife observation showed that breeding of amphibians and water birds was successful after constructing the wetlands. These wetlands also became successful breeding grounds for spawning amphibians and nesting birds. Thus, the wetlands succeeded in creating high biodiversity at the habitat scale in the center of a residential community. Moreover, the study reported the recreation values of peoples' everyday visits due to the increase of biodiversity and vegetation in these parks in the city of Vihti.

Van Roon [86] investigated the role of wetlands, such as bogs, fens, and swamps in carbon sequestration and evaluated the biodiversity loss in the urbanization process. This study reviewed the literature related to historical degradation, current maintenance, and management of wetlands, including bogs, fens, and swamps. Additionally, Van Roon investigated these sites in the period from 2002 to 2010, analyzed the documents related to the site, and interviewed staff from the site information centers as well as municipal planners.

Based on the literature review, this study concluded that creating suitable conditions for the reconstruction and maintenance of vulnerable wetlands is very difficult for swamps to fens to bogs near urban areas. Creating these conditions requires minimizing air emissions and manipulating groundwater flows, protecting springs, and minimizing nutrient depletion through the surface or groundwater. For instance, bogs survive in the lowest-density urban development areas.

Ecological corridors that contain fen wetland remnants can survive in development areas only with high biodiversity. In fact, fens survive throughout the ecological corridors near high-density urban areas, but the results showed that they are chemically and hydrologically degraded, and their contribution to stopping biodiversity loss is limited. Furthermore, achieving these conditions helps water-centric development and corridor reservations and is beneficial to all stakeholders.

Semeraro et al. [87] aimed to assess the role of constructed treatment wetlands (CTW) in terms of biodiversity and enhanced ecosystem services. This study used annual monitoring of fauna and flora to identify national and international species strongly related to available new habitats. In the first stage, to identify the CTW wetland habitat, a habitat map was prepared by taking photos and orthophotos and then classifying the habitat using the Commission of the European Communities, 1991 (CORINE) habitat classification.

The habitat map was validated and updated through inspections and field surveys at GIS. The second stage was done by describing the vegetation to identify different types of plant communities in the basins and canals, along the beaches, in artificial soils, and in the garrigue. The outcomes of the study confirmed CTW's ability to provide side benefits beyond the main purpose of water treatment, such as the conservation of wildlife habitats and biodiversity at local and international scales, as well as its ability to create recreational and educational value.

Liao et al. 2020., [88] examined how urbanization influences the diversity of diving beetles (Dytiscidae) and the effect of pond margin steepness, as well as the presence/absence of fish in the pond on urban diving beetles. In this study, diving beetles were sampled using activity traps in 25 urban ponds (14 ponds without fish and 11 ponds with fish). In the study, various characteristics were considered, such as the pond water depth, pond size, shoreline length, and proportion of impermeable surface in a buffer zone.

The results reveal that urbanization reduced the richness of diving beetle species but had little effect on their abundance. This indicates that urbanization does not diminish the capacity of ponds to support diving beetle species, as their numbers are unchanged; however, some species react negatively to urbanization. The presence of fish in the ponds compared to the absence of fish has a very significant and negative effect on species richness.

The presence of fish had a stronger effect on the richness of diving beetle species compared with urbanization and the pond margin steepness. Furthermore, the pond margin steepness had no statistically meaningful effect on the richness of diving beetles in ponds without fish. However, the interaction between the pond margin steepness and the presence of fish had a very notable and negative effect on diving beetles.

A study by Gascon et al. [89] aimed to identify the key factors affecting the biodiversity in wetlands to find a relationship between biodiversity metrics, conservation status, and habitat conditions. The objectives of the study were:

(*i*) comparing the reactions of different biodiversity metrics,
(*ii*) recognizing key environmental factors for different biodiversities, and
(*iii*) investigating whether wetlands with high biodiversity also have good habitat conditions and high protection status.

In this study, 91 wetlands (such as ponds, lagoons, and marshes) were sampled at the assemblage level (crustaceans and insects). The study used regression tree models to identify key factors affecting biodiversity. Thus, the study used variable factors, including the dissolved inorganic nitrogen, soluble reactive phosphorus, total nitrogen, total phosphorus, chlorophyll-a, conductivity, water permanence (temporary vs. permanent), water body size, wetland isolation, and water body density. The study calculated eleven biodiversity metrics, such as the assemblage structure, rarity, and taxonomic distinctness for each (crustacean and insect) sample. Among the eleven metrics, three metrics were related to the structure of the assemblage, including:

(*i*) the number of species in each sample,
(*ii*) the species diversity obtained using the Shannon–Wiener diversity, and
(*iii*) Pielou's evenness (species evenness) based on Shannon's index.

Analyzing the key factors determining the biodiversity of wetland aquatic invertebrates, the results showed that five of the eleven biodiversity metrics used in this study were significantly related to some explanatory variables. Moreover, the results obtained from the comparison of the two sampled seasons (winter vs. spring) showed that conductivity was the main factor influencing biodiversity metrics. Significant positive relationships were found between certain biodiversity metrics and wetland habitat conditions, while there was no case for conservation status, indicating the inadequacy of conservation policies to protect aquatic invertebrate biodiversity.

A study by da Silva et al,. [90] investigated the development targets and planning tasks for the Guaporé–Paraguay wetland, which is an area between the Pantanal and the Amazon as an ecotone with high biodiversity importance. It is worth noting that an ecotone indicates a transitional area of vegetation between two different plant communities, such as forests and wetlands. The study used a framework named the driver pressure state impact response (DPSIR) to evaluate cause and effect relationships between the interrelated components of social, economic, and environmental systems.

These interrelated components include the driving forces of environmental change; pressures on the environment; state of the environment; impacts on population, economy, ecosystems; and the response of the society, e.g., policy response. Note that the DPSIR approach was originally derived from the social sciences and later became extensively accepted as a general framework for organizing information about the state of the environment.

This research utilized a database of plant and animal species including the presence/absence information, abundance, and diversity index for different scales. Then, they analyzed the existence and distribution of plants, mammals, birds, fish species, macrophytes, peri-phytons, and zooplankton in order to assess the biodiversity status of the region. As a result, the research proposed the following three strategies for planning and management of the Guaporé–Paraguay ecotone:

(*i*) Business as usual, which refers to a further decrease of natural areas. The court of justice decided that Guaporé–Paraguay does not require special protection in the state planning system. Thus, this strategy will result in ongoing forest and river fragmentation.

(*ii*) Conservation actions that calls for the restoration of riparian deforested or degraded areas and protecting wetlands in both basins. The development of conservation actions can lead to the expansion of current protected areas and management plans in the region; therefore, regional protected areas can be identified to preserve a large area of river forests to survive the priority species of the Guaporé–Paraguay ecotone.

(*iii*) Integrating biodiversity objectives into other policies and planning strategies, which refers to the restoration of riparian deforested or degraded areas and the protection of wetlands in the basin. This strategy integrates biodiversity goals in the planning and implementation of hydroelectric dams and agricultural management.

A study by Meli et al. [91] reviewed 70 experimental studies to identify quantitative studies on the effects of ecological restoration on the biodiversity and ecosystem services of degraded aquatic and semi-aquatic wetlands. A meta-analysis identified the factors influencing restoration. The study compared the performance factors of the selected ecosystems between (1) the destroyed and restored wetlands; and (2) between the restored and natural wetlands using response ratios and stratified modeling of random effects.

The meta-analysis showed that ecological restoration increases biodiversity and ecosystem services supply in degraded wetlands and, thus, benefits the human communities that interact with them. The exact effects of wetland restoration strongly depend on the underlying factors, thus, emphasizing the need for specific habitat planning and evaluation of restorations. Furthermore, biodiversity demonstrates good recovery, although the exact recovery strongly depends on the species.

Restoration wetlands showed 36% of ES supply, regulation, and support levels compared to degraded wetlands. The biodiversity recovery and ecosystem services also positively showed a correlation, which represents an effective restoration result. Moreover, the restored wetlands showed a level of ecosystem services similar to natural wetlands.

Morganti et al. [92] studied the bird communities of an inland wetland. This study aimed to:

(*i*) understand the landscape-scale variables affecting the biotope level occurrence of conservation birds,

(*ii*) identify the habitat variables related to the occurrence of a set of target reedbed-dwelling species, and

(*iii*) achieve practical management recommendations for the protection of bird communities and populations in the inland wetlands.

The results showed that the extent of the reed beds/mires was positively associated with the occurrence of all species of conservation concern at the site scale. At the field scale, the reed bed extent positively predicted the species' occurrence but only in the presence of patches of clear shallow water. Species-specific MARS models qualitatively demonstrated similar results for some species but were generally outperformed by multi-species.

Guareschi et al. [93] explored the relationships between the community composition and species richness of waterbirds and aquatic macroinvertebrates in 36 wetlands. As core objectives, this research aimed to:

(*i*) test the congruence of the patterns of species composition and richness among waterbirds and aquatic macroinvertebrates, and (*ii*) investigate which environmental variables were associated with the biodiversity patterns of waterbirds and macroinvertebrates in order to identify the key factors explaining potential discordance in these patterns.

The study demonstrated that climatic variables and water levels mostly affected the collection of waterbirds; while conductivity was the most important factor affecting large vertebrate communities. The results depict a slightly inverse relationship in the richness patterns, where wetlands that are rich in waterbird species are less rich in Hemipetra families and macroinvertebrates. The results of the linear models also demonstrate that, in general, different environmental variables were related to the richness patterns of different classification groups. In addition, the analysis of different biological communities revealed that using datasets of different classification groups is an essential prerequisite for successful policies and monitoring of wetland conservation. The research concluded that there is a need for creating a diverse and complete network of protected sites, which can maintain multiple biodiversity components in wetlands.

To conclude the section, wetland biodiversity has been severely disrupted as a result of urbanization, as urban development is a primary factor in reducing the biodiversity of wetlands. In the literature, the studies explain that, when natural or human factors destroy wetlands, ecological restoration is often performed to preserve biodiversity and ecosystem services. Consequently, the preserved wetlands become a breeding ground for wildlife and strengthen the biodiversity in wetlands.

Wetlands create a network of fragmented habitats and provide feeding, spawning and nursing areas for many species, such as invertebrates, amphibians, birds, and fish. Preserving biodiversity in wetlands is essential to maintaining the vital functions of wetland ecosystems and preserving the values they provide to their environment. The maintenance of biodiversity in wetlands also can be achieved by raising public awareness, which requires continuous guidance and learning at the public level.

4. Urban Wetlands and Urban Heat Islands

In recent decades, urbanization associated with the increase in human activities has changed the land use, land cover, and hydrological cycles. The increase in human activities has impacted the microclimate of urban areas through the increase in urban temperature, known as the Urban Heat Island (UHI) effect [94–96]. This effect is one of the well-known effects directly related to the current climate change [97,98]. The UHI effect appears when an urban area is significantly warmer than the surrounding areas [94,99]. The reason for the UHI effect is the change in the type of the land surface use [100]. When human-made surfaces replace natural landscapes, the latter surface can store additional heat that is slowly released at night [101–103].

UHIs influence the energy consumption, environmental quality, and human health in urban areas [101]. Hence, the relationship between land use and urban climate has increasingly attracted the attention of urban planners and policymakers to coordinate development strategies to boost the well-being of people [4]. In this vein, the natural and eco-friendly cooling effect of GBI has been realized as a solution among research communities, strategists, and urban planners [104].

However, regardless of the cooling effect of water bodies, e.g., urban wetlands, in practice, they have been less investigated compared to green spaces, such as forests and parks [39]. This is one of the motivations behind our study. Indeed, urban wetlands are areas located inside or at the borders of cities where they offer a variety of benefits and ecosystem services, such as their potential for providing a significant cooling effect (CE) to surrounding areas and mitigating the UHI effects on urban areas [101].

To study the impacts of UHIs on the microclimate of urban areas and understand the methodologies and approaches for mitigating UHI impacts through the cooling effects of urban wetlands, we conducted a review on the topic. We summarize the objectives, methods, and findings of the reviewed articles in Table 3.

Chun-ye and Wei-ping [65] aimed to analyze the effect of urban wetlands on city temperature by using remote sensing technology. This study used Landsat TM remote sensing images from the city of Hangzhou and applied an algorithm to analyze the distribution of the heat island effect qualitatively. They demonstrated that urban wetlands well mitigate the urban temperature. This temperature regulation was more significant near urban wetlands.

In addition, the heat island intensity gradually decreased from the periphery to the urban area of Xixi Wetland. The higher distance from the wetland indicates a greater average surface temperature and weaker wetland regulation. Furthermore, the range of temperature regulations and the extent of urban wetlands on UHIs can change due to the types of wetlands. This change can include the ratio and pattern of water distribution in urban wetlands, vegetation and other types of landscapes.

Table 3. Urban wetlands and urban heat islands.

Reference	Objective	Methodology	Findings
Beijing, China (Sun et al., 2012) [105]	Evaluating the cooling effects of wetland in urban areas	15 urban wetlands were assessed using the ASTER images technique	The Landscape Shape Index and the location of wetlands are remarkable indicators that impact the intensity of UCI in an urban area
Changchun and Jilin, China (Xue et al., 2019) [101]	Quantitatively evaluating the cooling effect of wetlands	Used remote sensing data in the form of Landsat-8 TIRS with two thermal infrared spectral bands to regain LST	The CE of urban wetlands is considerably associated with the wetland area, shape, and hydrological connection
London, UK (O'Malley et al., 2014) [106]	Investigating minimizing UHI effects in London, UK.	Simulations used ENVI-met software, using the Urban Futures Assessment Method	Constructions and buildings forms orientation and layout are highly effective UHI mitigation strategies
Shenzhen and Hong Kong, China (Lin et al., 2020) [107]	Measuring the amount of surface urban heat island (SUHI) reduction, that induced by water bodies in the urban environment	Used the Google Earth engine to map the severity of SUHI and water bodies	A 10% increase in water body surface was accompanied by a 11.33% reduction in SUHI severity
Sivas, Turkey (Kuscu simsek and Odul, 2018) [13]	Determining the distance at which wetlands exhibit a cooling effect as well as revealing the impact of land use change	Used remote sensing techniques and collected four consecutive satellite images	The regular temperature increases up to a maximum of 1000 m around the wetland
City model (Gunawardena et al., 2017) [4]	Reviewing the effectiveness of green and blue spaces in decreasing the risks of heat-related illness from high temperatures of the cities	Used two city models, including "compaction" and "dispersal"	The compaction model increased the strength of UHI, the dispersal model decreased the UHI impact
City model (Theeuwes et al., 2013) [108]	Investigating the effect of blue spaces on the urban temperature and human thermal comfort	Used the WRF model to consider the surface water coverage, size, spatial configuration, and temperature variations	A large lake has a great impact on its surrounding temperature and thermal comfort, while several smaller lakes affect a higher percentage of the city and offer better human thermal comfort

Table 3. *Cont.*

Reference	Objective	Methodology	Findings
Sheffield, UK (Hathway and Sharples, 2012) [109]	Investigating the effectiveness of small urban rivers in reducing the impact of UHI.	The temperature and humidity were measured in 12 places near the river by Ibuttons (Maxim, San Jose, CA, USA) measurement devices using 12 plate Gill solar radiations screens	Significant cooling over the river with an average cooling of nearly 1 °C when the ambient temperature was higher than 20 °C
Hangzhou, China (Chun-ye and Wei-ping., 2011) [65]	Analyzing the effect of urban wetland on city temperature	Used Landsat TM remote sensing images	Urban wetlands have good regulation on urban temperatures
Rotterdam, Netherlands (Steeneveld et al., 2014) [110]	Investigating the relation between UHI and open water fraction (OWF)	Used googlemaps™ to map the relation between the UHI and OWF	Blue spaces have a relatively high heat capacity compared to their surroundings

Sun et al. [105] evaluated the cooling effects of wetlands in urban areas. This research used ten reservoirs and lakes and five rivers as wetlands to assess the severity of the UCI. This research aimed to:

(*i*) develop a method for estimating the UCI severity of wetlands,
(*ii*) evaluate the effects of the area, forms, and sites of wetlands on the UCI severity, and
(*iii*) discuss the importance of evaluating ecosystem services and landscape design in urban areas.

The selected wetlands were evaluated using the ASTER (advanced spaceborne thermal emission and reflection radiometer) imaging technique to obtain cooling effects. This technique was used because air temperature is highly associated with the land surface temperature. The findings of this research stated that the Landscape Shape Index (LSI) and the location of wetlands are remarkable indicators that impact the intensity of UCI in an urban area. It is also essential to evaluate the quantification of a wetland microclimate regulation and urban landscape design to reduce the effects of UHI.

A study by Xue et al. [101] evaluated the cooling effect of 21 urban wetlands and three green spaces in cities. This study used remote sensing data in Landsat-8 TIRS with two thermal infrared spectral bands to obtain the LST and measure the selected areas' UHI reduction abilities. Then, the study performed correlation analysis to examine the relationships between the characteristics of wetlands and surrounding buildings and two cooling-effect indices: the normalized cooling capability index (NCCI) and normalized cooling efficiency index (NCEI).

The results showed that the cooling effect of urban wetlands was considerably associated with the wetland area, shape, and hydrological connection. The cooling effect was better in wetlands with more complex shapes. The average NCCI of wetlands connected to other surface waters was six-times higher than separated wetlands. Notably, there was an inverse relationship between the cooling capacity of urban wetlands and the height and density of surrounding buildings. The size of wetlands was the most important element to reduce the air temperature. More extensive wetlands had a more significant cooling effect compared with smaller wetlands. As a result, to increase the cooling effect of urban wetlands, wetlands should be designed more naturally while considering the surrounding built areas.

O'Malley et al. [106] investigated minimizing urban heat island (UHI) effects. UHI is a significant problem in the UK that requires reduction. They evaluated effective and resilient UHI mitigation strategies to guide architects, urban designers, urban planners, and city authorities. First, the research defined four possible future scenarios for 2050 to conducted the UHI mitigation strategy. Then, they performed simulations using ENVI-met software and input the parameters from the surrounding area, such as tall trees with dense crowns and dense hedges.

The research also utilized the Urban Futures Assessment Method (UFAM) to assess the resilience of the mitigation strategies. The study stated that the construction and building forms, orientation, and layouts were highly effective UHI mitigation strategies. These layouts may include the use of trees, shrubs, grass, and high albedo materials in external building surfaces. The assessment also showed that the use of these layouts had a similar level of resilience.

A study by Lin et al. [107] measured the amount of surface urban heat island (SUHI) reduction induced by water bodies in the urban environment. The study area was in the middle of the Pearl River Delta (PRD) metropolitan area. This research aimed to:

(*i*) quantify the cooling effect of water bodies,
(*ii*) compare water bodies regarding the thermal context, and
(*iii*) identify the impact of water body overflow in reducing the SUHI phenomenon.

In this study, Google Earth was used to map the severity of SUHI and water bodies to investigate water bodies' cooling effect and efficiency in a metropolitan area. The study determined that water bodies with different features had a considerable cooling impact on the local thermal environment. In addition, a 10% increase in water body surface was accompanied by a 11.33% reduction in SUHI severity.

A study by Kuşçu Şimşek and Ödül [13] investigated the distance at which wetlands exhibit a cooling effect and revealed the impact of land-use change. As a methodology, they selected five wetlands. Then, they used remote sensing techniques and collected four consecutive satellite images in the summer. The temperature values were taken from Landsat TM-5 images on 18 June, 4 July, 20 July, and 5 August in 2007. Then, they analyzed their images utilizing GIS software. In the analysis phase, they investigated the correlation between surface temperature information and land use information as well as the distance from shoreline information.

This research used the following three phenomena: permanently irrigated land, which means forest areas that include wetlands; non-irrigated arable land; and pastures, which refers to open spaces with little or no vegetation with water bodies. The research used one "permanently irrigated land", one "non-irrigated arable land", and one "pasture"; and studied the cooling effects of their wetlands at 1000, 900, and 900 m distances, respectively.

As a result, they found that the regular temperature increased up to a maximum of 1000 m around the wetland. The maximum temperature difference concerning the distance was 16.29 °C in 400 m of "non-irrigated arable land". Another important observation was the temperature change in different areas with different land uses. The type of land cover is expected to have a significant impact on the different land uses. The study also emphasized the necessity of climate-sensitive land use planning. This research suggested that the land use around wetlands must be decided with awareness. This is to enhance the climate regulatory effects of wetlands. The efficient use of natural resources is important to identify the strategies to adapt to climate change.

Gunawardena et al. [95] conducted a literature review on the effectiveness of green and blue spaces in decreasing the risks of heat-related illness from high temperatures in cities. In this research, green space referred to areas covered with vegetation, and blue space indicated water bodies or watercourses in the cities. This research provides critical notes useful for urban planning and urban development. The study used two city models, including "compaction" and "dispersal". To this end, the research used these models to discuss the impact of UHI on cities. This literature review showed that the compaction and dispersal urban models change the mesoscale UHI in different ways.

While the compaction model increases the strength of UHI, the dispersal model decreases the UHI impact. Nevertheless, due to the lack of enough evidence, it is difficult to conclude that one urban model is superior to another in terms of heat balance optimization. Another result explains that different parameters, such as scale, geometry, extent, and distance of interventions, surface roughness, fetch length, the morphology and material of the context, and the prevailing climate impact the thermal effects in blue and green spaces in urban areas.

Greenspace extends the micro-scale cooling effect, while blue spaces may provide a warming effect when the UHI intensity and the risk of heat stress are higher (especially at night in late summer). When green and blue operate together, they create a mutually dependent environment and offer synergistic cooling.

A study by Steeneveld et al. [110] investigated the relation between UHIs and the open water fraction (OWF). The study used the data collected from weather observations and a weather monitoring station. Then, they investigated the relation between UHI and open water fraction (OWF) utilizing the collected dataset. To map the connection between the UHI and OWF, they used Google Maps™ images for a range of possible buffer sizes. The results showed that the UHI was significantly related to the OWF.

Physically, blue spaces have a relatively high heat capacity compared to their surroundings. In late summer and autumn, the blue spaces gained a relatively high temperature compared to rural areas. The results also showed a considerable increase of the 95 percentiles of the UHI with open water surface availability.

Theeuwes et al. [108] conducted a quantitative study regarding the effect of blue spaces on urban temperature and human thermal comfort. This research studied how the spatial distribution of blue spaces and water fractions in the city impacts the urban temperature. It also quantified the impact of the lake water temperature in urban areas and thermal comfort. The research used a weather research and forecasting (WRF) model to evaluate the influence of surface water on urban temperature. This model utilized the impact of geometry of the street canyons and shadowing from built environments.

The model computes the energy exchange between the atmosphere and urban facades, such as roofs, walls, and roads. Using the WRF model, the research takes into account the surface water coverage, size, spatial configuration, and temperature variations. The results showed that the cooling effect of water depends nonlinearly on the fractional water cover, size, and distribution of individual lakes within the city. The air temperature change due to lakes depends on the size, the number of lakes, the distance from the lake, and the water temperature. In general, the cooling effect of water decreases with distance from the lake.

However, the impact of the lake is still measurable several kilometres downwind of the lake. A large lake has a significant effect on its surroundings temperature and thermal comfort, while several smaller lakes affect a higher percentage of the city and offer a better human thermal comfort. As a result, proper weighing of the sizes and locations of the blue spaces is helpful for urban planning.

Hathway and Sharples [109] investigated the effectiveness of small urban rivers in reducing the impact of UHI. They also explored the role of urban riverbanks in reducing the cooling effect. Hence, they perform a study along the River Don. They measured the temperature and humidity in 12 places near the river or vertical to the riverbank. Therefore, they mounted Ibuttons (Maxim, San Jose, CA, USA) measurement devices in 12 plate Gill solar radiations screens in those places.

The measurement results showed significant cooling over the river with an average cooling of nearly one °C when the ambient temperature was higher than 20 °C. The results also demonstrated substantial cooling by almost two °C and 1.5 °C cooling on the riverbank on hot days in May. The banks, which included engineering materials had a higher temperature than the banks having vegetation. In addition, open street intersections with rivers had more cooling effects than streets shut off from the river.

To summarize this section, urban wetlands play an important role in reducing the effects of urban heat islands through their cooling effects. The reviewed articles explain that the effect of urban wetlands regulating the urban temperature is very high. While, closer to wetlands, the higher the regulation effect. Indeed, the cooling effect of urban wetlands brings positive benefits, especially for improving environmental health. However, the cooling effect also is significantly affected by the shape and size of the wetland, the hydrological connections of wetlands, the surrounding built areas, and the combination of wetlands with vegetation.

Therefore, it is necessary to consider these factors in urban wetland construction, maintenance, and rehabilitation. The proper and optimal wetland design to increase the cooling effects is of vital value in urban development. Considering the cooling effect of wetlands in urban design and development is critical when guaranteeing urban sustainability in the era of climate change.

5. Urban Wetlands and Urban Sustainability

With the increase in urbanization, proper planning and management of natural resources can contribute to urban sustainability. Sustainable cities contribute to economic growth and prosperity and are examples of sustainable development [44]. In sustainable urban areas, wetlands as natural resources provide various ecosystem services, such as increasing the biodiversity, improving water quality, and mitigating climate change [45]. Furthermore, wetlands can preserve human safety by stormwater management in these cities and provide a comfortable living environment by regulating regional climate [46].

However, in past decades, urbanization has threatened wetlands by destroying and changing the land use from GBI to residential or industrial buildings. As a result, the decline in natural wetlands has become one of the central warnings to preserving these valuable natural resources and contribute to urban sustainability [50]. Thus, appropriate approaches should be adopted to evaluate and analyze the sustainable development of wetlands [46].

Wetlands are known for providing ecosystem services and, therefore, have excellent potential to be used as nature-based solutions to meet various environmental, social, and economic challenges [21]. To study the impacts of wetlands on urban sustainability and learn the practices of preserving wetlands in urban areas, in the following, we present a literature review on this topic and summarize the objectives, methodologies, and findings of the reviewed studies in Table 4.

Roy-Basu [111] reviewed the East Kolkata Wetlands (EKW) and suggested a sustainable model. The EKW is one of the largest aquaculture systems where municipal wastewater is recycled for aquaculture and agriculture. The wetlands are also used for flood mitigation in the city of Kolkata. Indeed, in recent decades, rapid encroachment on the wetlands has had various environmental, social, and economic impacts due to unplanned development.

Table 4. Urban wetlands and urban sustainability.

Reference	Objective	Methodology	Findings
Panjin, China (Su et al., 2020) [112]	Identifying the ecosystem value and sustainability of wetland	Used Emergy analysis	Human activities, developments, and investments in the area play critical roles in protecting wetland ecosystems
Jecheon, Korea (Byeon and Nam. 2020) [113]	Investigating the treatment of non-point source (NPS) pollution and biodiversity increase in a constructed wetland	Used an SSB system as a treatment wetland for NPS pollution with short retention time and high biodiversity	SSB wetlands indicated a treatment impact on NPS pollution at the initial rainfall events within the moderately short retention time
Shanghai, China (Wu et al., 2018) [114]	Addressing the effects of wetland rehabilitation on the coastal environment	Used an object-oriented classification method, and digital shoreline analysis system	Considering the resilience of wetland ecosystem, a balance should be established between land use and wetland rehabilitation

Table 4. *Cont.*

Reference	Objective	Methodology	Findings
Chongqing, China (Zhou et al., 2020) [115]	Recognizing the cultural ecosystem services of two wetland parks	Used the social values for the ecosystem services (SolVES) model and preferential survey data	The high value of cultural ecosystem services of Xiuhu Wetland Park was transferred to enhance Guanyintang Wetland Park
Taipei, Taiwan (Chen et al., 2019) [58]	Investigating how to use quantitative and qualitative measure of wetlands to develop plans for the protection of the wetland's environmental resources.	Conducted an experimental study by using DEMATEL and DANP models	DEMATEL can be used with DANP to construct a new measurement model for the effects of wetlands environment plan
CMA, Chile (Rojas et al., 2019) [116]	Assessing the impacts of urban planning and development between 2004-2014 on wetland conservation	Used SEA as a framework and under a MUPC urban growth around the wetland planned and implemented	The inefficiency of wetland conservation under MUPC and this plan is not sustainable enough
Review paper (Roy-Basu et al., 2020) [111]	Suggesting a sustainable model	Adaptive co-management to prevent further wetland degradation	Contact relevant actors, build capacity, and implement protection measures
Ria Formosa, Portugal (Sousa et al., 2020) [117]	Evaluating the impact of economic activities on the process of wetland rehabilitation	A temporal and spatial perspective of land use change in wetland areas	The rehabilitation of the wetland in Ria Formosa since the late 19th century was a process dependent on the success of economic activities
Hunan, China (Luo et al., 2019) [118]	Evaluating the sustainability of an artificial wetland	Used a model of probabilistic linguistic preference relations	The sustainability of artificial wetlands plays an important role in the local environment, society, and economics development
Quebec, Canada (Varin et al., 2019) [119]	Developing a spatial analysis tool to quantify ecosystem services to help wetlands sustainable management	Used object-based and photo-interpretation approaches	The expansion or accumulation of many wetlands may decrease the biodiversity in wetlands

Thus, this paper examined the trends, reasons, extent, and effects of landscape conversion over the past few decades. The paper introduced a model called adaptive co-management to prevent further wetland degradation. The adaptive co-management model refers to the convergence of two independent concepts of adaptive management and co-management. For the long-term sustainability of the wetlands, adaptive co-management is integrated with five environmental, political, physical, economic, and institutional aspects.

In summary, this paper provided the following key recommendations for regulatory, institutional, development, and management authorities. The government should contact relevant actors to raise funds for research, capacity building, and implementation of conservation measures. Participation of the locals in decision-making and planning committees is necessary to ensure the inclusion of their invaluable knowledge in conservation action.

For strong awareness, acknowledgments are needed, and educational programs should be planned. In addition, civic institutions must work with the government to implement adaptive co-management and sustainability plans. The media should also use prominent programs with corporations to promote the cause of wetland protection.

Su et al. [112] identified the ecosystem value and sustainability of the Liaohe Estuary wetland (LEW). This study aimed to (i) define the wetland flows based on the sustainability analysis, (ii) assess the relationship between the input and output of the LEW, and (iii) investigate the sustainability of the wetland ecosystem and suggest a sustainable future for the LEW through the sustainability analysis.

For sustainability evaluation, this study used Emergy analysis. Emergy assessment is a method to estimate the capacity for sustainable development of regional eco-economic systems at different scales. For example, "Emergy converts energy or currency that cannot be directly compared in the natural environment and economic systems into the same magnitude index".

An ecosystem service function was used to value the area to the humans. The results showed that human activities, developments, and investments in the LEW area play a critical role in protecting the wetland ecosystem. Due to diverse human activities, the environmental loading ratio indicated high environmental pressure, and the LEW area became unsustainable. In summary, the study illustrated that the services offered by LEW have great ecosystem potentials. Wetlands not only facilitate environmental benefits for the societies but also provide urban sustainability.

Byeon and Nam [113] investigated the treatment of non-point source (NPS) pollution and biodiversity increases in a constructed wetland. NSP stands for the diffusion of pollutants from a wide area, compared to point source pollution. They used the sustainable structured wetland biotope (SSB) system with a short retention time and high biodiversity as a treatment wetland for non-point source pollution.

The SSB system is used to investigate site-specific environmental conditions and maximize water treatment efficiency. In this research, the SSB system included a Forebay area (primary retention basin), a micro pool area (secondary retention basin), and multi-cell structures of marshes and ponds. For evaluation, a wetland and a rainwater detention tank were constructed with the SSB system to treat NPS pollution downstream from Jecheon city, located in the upper river basin of the Han River in the Republic of Korea.

In addition, the filter media and the retention basin were partially compensated for the seasonal change of the treatment. The overall flow of water was also maintained at a low level. As a result, the SSB wetlands indicated a treatment impact on NPS pollution at the initial rainfall events within a moderately short retention time. The research also suggested that this methodology can control urban NPS pollution while providing access to an area with high biodiversity for residents in urban areas with drastic land use.

A study by Wu et al. [114] addressed the effects of wetland rehabilitation on a coastal environment. The research considered two objectives. First, they aimed to identify detailed land use and vegetation changes due to wetland rehabilitation. Second, they sought to determine how to balance land rehabilitation and ecological protection in coastal areas. Time-series analysis of images illustrates that from 1989 to 2013, ca. 9793.4 ha of coastal wetlands were separated from the sea and enclosed to inland wetlands.

The separation interrupted the exchange of sediment and water flux between wetlands and the coastal ocean. The results indicate that the coastal wetland ecosystem structure was destroyed or replaced with a drained and impervious surface with increased human activities. This means that the main elements of the wetlands, including water, soil, and vegetation, were destroyed. In summary, considering the resilience of the wetland ecosystem, a balance should be established between land use and wetland rehabilitation to reduce the conflict between economic growth and coastal ecological security.

A study by Zhou et al. [115] aimed to recognize the cultural ecosystem services of two wetland parks. These parks were the Xiuhu Wetland National Park and Guanyintang Urban Wetland National Park. The study used the social values for ecosystem services (SolVES) model and preferential survey data. The SolVES model (http://solves.cr.usgs.gov, accessed on 15 September 2021) a GIS application, was developed to assess, map, and quantify the social values of ecosystem services. The SolVES application is suitable for evaluating small-scale waterbodies (e.g., wetlands and ponds). In Xiuhu Wetland National Park, the cultural ecosystem services were graded.

The services included the perceived biodiversity, future and historical value, the value of beauty and recreation, and the value of culture and learning, as well as spiritual and therapeutic values. From the gender perspective, while men preferred aesthetic, cultural, recreational, spiritual, and therapeutic values, women were primarily interested in historical values. From these analyses, the value of cultural ecosystem services of Xiuhu Wetland National Park was transferred to Guanyintang Urban Wetland National Park. As a result, the Guanyintang park has performed well from the cultural ecosystem services point of view.

Chen et al. [58] investigated how to use quantitative and qualitative measurements of wetlands to develop plans for the protection of a wetland's environmental resources. The research also presented a model to solve real problems and an experimental study to achieve sustainable development at the desired level. As a methodology, the research utilized a hybrid Multiple Attribute Decision-Making (MADM) model and a decision-making trial and evaluation laboratory (DEMATEL) technique. The technique was used to identify complex relationships to create an effective network relation map.

The method was an experimental test to assess and measure the actual conditions for improving the environmental problems of the wetland. The technique also enhances the effectiveness of wetland resource plans and improves the strategic target plans. The aim is to achieve the interest levels for human welfare and sustainable development.

Regarding the findings, the research presented a combined model using DEMATEL and DANP models. DEMATEL can be used with DANP to construct a new measurement model for the effects of wetland environmental planning. It is suitable for complicated decision-making problems involving environmental planning, psychology, and human resources management. In short, the model is seen as relevant and suggested for use, for instance, in areas of soil and water conservation, ecosystems, environmental development, and landscape and rural development.

A study by Sousa et al. [117] evaluated the impact of economic activities on the process of wetland rehabilitation. This study considered a temporal and spatial perspective of land-use change in wetland areas. They examined the feasibility of productive activities, such as aquaculture activities, without compromising the natural system while creating long-term sustainable economic development. The study applied a combination of mapping and documentary data to assess the wetland change in the Ria Formosa as a function of economic activity dynamics. They also integrated various datasets into a GIS and tracked the wetland land-use change over the past 130 years at intervals of a decade.

The results indicated that the rehabilitation of the wetland in Ria Formosa since the late 19th century was a process dependent on the success of economic activities. The historical analysis of wetland land-use changes also proves the importance of sustainable economic management for the study area. The recession periods led to the abandonment of wetland's revitalized areas. As a solution for developing new productive units, the research proposed adopting an ecosystem approach to aquaculture as a management strategy by creating an aquaculture management area. The management strategy can be used to stimulate small-scale aquaculture through the networking of more profitable production systems with reduced environmental impacts.

Furthermore, small-scale aquaculture units can improve market development and supply chain sustainability in sensitive environmental areas, such as coastal wetlands. Aquaculture ponds can help create wildlife migration, food supply, and natural corridors used by waterbirds. Bird watching areas can also have many benefits and ultimately contribute to the growth of ecotourism in the area.

Research by Luo et al. [118] evaluated the sustainability of an artificial wetland using a model of probabilistic linguistic preference relations (PLPRs). Since the decision-making process involves uncertainty and fuzziness, the decision-makers (DMs) often have difficulty expressing their opinions. Thus, this research aimed to study the impact of decision-makers' decisions on the sustainability of artificial wetlands. The study used the group decision-making (GDM) approach to assess the sustainability of constructed wetlands under PLPRs.

Hence, the research adopted linguistic preferences information, a straightforward procedure using information directly from the DMs. Therefore, linguistic preferences can reduce the cost of inaccuracy to some extent. The research formulated a mathematical model based on the trust degree for determining the weight of DMs in the GDM. The trust degree defines the trust relationship among DMs. The research proposed a cosine similarity measure called probabilistic linguistic term sets (PLTSs), which is known to be a good choice for information expression.

In most cases, PLTSs accurately and clearly describe the DM preferences. Thus, the mathematical model enables selecting the best-constructed wetland in Hunan province. In summary, the results showed that the sustainability of artificial wetlands plays a vital role in the coordinated development of the local environment, society, and economics.

Rojas et al. [116] evaluated the impacts of urban planning and development on wetland conservation between the years 2004 and 2014. They assessed the urban development and its impacts on pre-preserved areas, reducing flood risks, and projected under the Metropolitan Urban Plan of Concepción (MUPC). They also discuss the consequences of land zoning in coastal regions to provisioning ecosystem services and flood controlling against frequent tsunamis on the central coast of Chile. This study used a remote sensing method to detect the wetland area and the remaining Land Use and Land Cover (LULC) categories for 2004 and 2014.

Remote sensing was used to select the most abundant wetland vegetation to improve its detection in contrast to the surrounding LULC categories. The study considered the whole area of the wetland and its surroundings with a distance of approximately 300 m. Then, the study used two Landsat images and one Landsat 5 TM (Thematic Mapper) for 2004. A Landsat 8 OLI/TIRS (Operational Land Imager/Thermal Infrared Sensor) was also used for 2014.

The study also used maximum likelihood classification (ML) for images—a supervised classification widely used for Landsat satellite imagery. Then, 25 training areas, i.e., control points, were selected for each classification category, a total of 200 categories, to evaluate the images. These categories included the built-up, water bodies, mixed forest, planted forest, scrublands, grasslands, beaches and dunes, and wetlands.

In the methodology, first, the relevant GIS layers were combined with the geographical form map of the wetland. Then, the impact of both new and planned urban development was investigated on the geographical form of the wetland. The effect of both new and planned urban development was investigated on wetland loss. In addition, the effect of the tsunami was examined on these urban areas.

As a result, this study showed the unsustainability and inefficiency of wetland conservation under MUPC. This is because the wetland areas of MUPC were significantly decreased to about 60% of their current size. It also appeared that both new and planned urban development areas under the MUPC are in danger of flooding caused by a tsunami. In addition, strategic environmental assessment is needed to reduce the adverse effects of urban development and contribute to the sustainability of the study area.

Varin et al. [119] developed a spatial analysis tool to quantify ecosystem services (ES) to help wetlands sustainable management decisions at the watershed scale. This research aimed to:

(*i*) recognize and design spatial indexes to represent the functions of ecosystem services;
(*ii*) extend an approach with two spatial scales, one for strategic planning and the other for local interventions;
(*iii*) map a complete watershed using the past, present, and future wetland ecosystem services; and
(*iv*) ensure that the approach is usable for other watersheds in the same area and other ecosystem services.

The research used several methods for preparing spatial data, i.e., maps. For instance, the object-based and photo-interpretation approaches generated recent and historical land-use data for 2011 and 1984, respectively. Therefore, Landsat TM satellite imagery with a spatial resolution of 30 m was used to prepare the maps. Then, these maps were used to simulate future land use for the year 2050. The study also considered two wetland management scenarios for comparison between 1984, 2011, and 2050. The scenarios were an optimistic scenario between 1984 and 2050 and a pessimistic scenario between 2011 and 2050.

These were used to evaluate ecosystem services over a historical period of 27 years (1984–2011) and a forecast period of 39 years (2011–2050). Furthermore, the ecosystem services quantification method was used to describe the functions of the wetlands. To prepare the ecosystem services indicator (ESI), the technique summarizes the weight and standardized function indicators (FI). The ESI describes the benefits to the community and consists of three types of FI, including ecological, socio-cultural, and economic indicators.

Based on sustainable development, these indicators are utilized to measure the conserving habitat support services' efficacy spatially. Six function indicators were selected to evaluate ecosystem services, four of which are the ecological FIs, and the other two are the socio-cultural FIs. These FIs include wetland connectivity, habitat fragmentation, water connectivity degree, anthropogenic barrier, natural heterogeneity, and natural aesthetics.

The results of the two wetland management scenarios, i.e., the optimistic and the pessimistic scenarios, showed that, in 2011, there were more critical areas than in 1984. This was due to the significant loss of wetlands in the territory between these two times. In the pessimistic scenario between 2011 and 2050, many sub-watersheds are destroyed; however, these sub-watersheds can be improved in some cases. The improvement can be made by fragmenting some large wetlands into several smaller wetlands.

This can be potentially beneficial for wetland connectivity and natural heterogeneity. In the optimistic scenario between 1984 and 2050, some sub-watersheds are worse than in 2011. The expansion or accumulation of many wetlands may decrease the diversity of the wetlands by reducing the connectivity. This illustrates the significance of the choice of FIs and how a wetland can develop.

To conclude the section, urban wetlands contribute to urban sustainability by providing ecosystem services to human societies. However, human activities, urban developments, and the changes in land use in urban areas affect the sustainability of wetlands, leading to challenges in urban sustainability. The studies showed that where human activities increase, the ecosystem structure of wetlands is destroyed. This results in the decrease of wetland efficiency and, thus, reduces urban sustainability. Therefore, to reduce the conflict between increasing human activities and reducing the ecological efficiency of the wetlands, studies suggest a balance between land use and wetland restoration. Indeed, the development of urban areas without considering protecting natural resources, such as wetlands will emasculate urban sustainability.

Unfortunately, the ecosystem services provided by wetlands are often undervalued and even ignored during the planning and design stages of urban development. Therefore, it is essential to inform governments and increase public awareness and stakeholders about the importance of urban wetlands to consider them as a nature-based solution in urban and peri-urban areas. This information is indeed mandatory to plan future sustainable cities.

6. Urban Wetlands and Recreational Values

Wetlands provide significant opportunities for nature-based recreation [16]. The economic benefits of wetland recreational services can be used as a basis for the protection of wetlands. The extensive recreational opportunities created by the wetlands include fishing, swimming, wildlife viewing, and hiking [120]. People who visit wetlands for recreational benefits perceive and highly value these nature-based resources, especially since other kinds of recreation cannot easily replace these activities. [31,121,122]. Consequently, recreational benefits can provide a stronger motivation for people to maintain wetlands ecosystems [123,124].

To highlight the recreational values of the urban wetlands and understand the methodologies and approaches for calculating these values, in the following, we review some existing studies in the literature and summarize the objectives, methods, and findings of the reviewed literature articles in Table 5.

Table 5. Urban wetlands and recreational values.

Reference	Objective	Methodology	Findings
Valencia, Spain (Vidal Gimenez and Ruiz Mas, 2020) [125]	Analyzing the economic values of the recreational services for wetlands	Used the travel cost method (TCM) and the contingent valuation methods (CVM).	The economic crisis had "no direct impacts" on the economic valuation of the recreational aspects of these wetlands
Muzuma, Tanzania (Musamba et al., 2012) [126]	Evaluating the recreational value of Lake Victoria in Musoma Municipality	Used a questionnaire to a sample of 120 recreationists	A limited number of recreational activities around the Lake Victoria
Kerala, India (Sinclair et al., 2018) [127]	Mapping nature-based recreation patterns, and investigating how recreational benefits are affected by changes in ecosystem quality	Used an economic valuation tool for recreational ES. Used a crowd sourced travel cost method and geotagged photographs	The results of the CTCM are consistent with economic theory for both the travel cost and income variables
Costa Brava, Spain (Pueyo-Ros et al., 2018) [128]	Evaluating the socioeconomic value of the ecological restoration of a coastal wetland on Costa Brava (Spain)	Developed a model combination of travel costs and contingent behavior to assess restoration on the recreational value	The results of the TC + CB model indicated that wetland recreational value was not significantly affected by restoration
Finland (Lankia et al., 2019) [129]	Investigating the impact of water quality changes on swimming behavior and recreation benefits.	Conducted a survey include two types of questions (1) general information, such as age and gender; (2) water quality perceptions of water clarity	Reduction in water quality to a level where water visibility is less than 1 m was associated with the recreation value being reduced
Finland (Vesterinen et al., 2010) [130]	Investigating the association between recreational participation for water activities and the water quality	Used the national recreation inventory data combined with water quality data to model recreation participation	Water quality had no effect on boating. Improving the water clarity increased the frequency of swimming and fishing
Finland (Lankia et al., 2020) [131]	Conducting a national-level accounting study for nature-based recreation in Finland	Recreation ecosystem services was defined as the number of recreational day visits to nature areas	The location of recreational areas is one of the main elements of recreational opportunities
Zarivar, Iran (Aazami and Shanazi, 2020) [132]	Exploring livelihood effects of wetlands on people's livelihood	Used a quantity–quality approach conducting library and field studies along with questionnaire and a focus group discussion	The wetland had a great effect on residence's life in five dimensions of livelihood capitals, i.e., financial, natural, human, physical, and social
Iowa, US (Park et al., 2017) [133]	Exploring visitors' perceived benefits of wetlands and examining residents and non-residents differ	Developed an extended model of goal-directed behavior to examine the impact of perceived benefits of wetlands	Residents showed that a positive attitude toward wetlands played a significant role in forming a strong desire to visit wetlands
Denmark (Odgaard et al., 2017) [45]	Analyzing which ecosystem services indicators defined the placement of wetlands and what are the recommendations for future selection for potential wetland reconstruction	Used the multi ecosystem service value-driven method to drive the optimal placement of wetlands in terms of maximizing selected ecosystem services that wetlands can provide	35 identified catchments with potentially high suitability, recreation potential, high biodiversity, and low land rent have not been prioritized

Vidal Gimenez and Ruiz Mas [125] investigated the impact of the economic crisis on the economic valuation given by visitors to three natural parks with wetlands. The research compared the results of a questionnaire collected in 2004–2005 as favorable years of economic conditions and a survey conducted in 2013–2014 as unfavorable conditions. Therefore, the research applied the travel cost and the contingent valuation methods to offer an approach to the economic values of the recreational services for the three wetlands.

The results based on a comparison did not show a clear impact with different behaviors among natural areas between the values of the two time periods, which had a decade difference. The research stated that it can also not be concluded that the economic crisis directly impacted the economic valuation of the recreational aspects of the wetlands. In some parks, the situation led to a lower valuation, but the crisis led to higher valuation in others. In all cases, visitors evaluated the recreational aspects of the parks positively. However, this evaluation was not related to the economic factors but the social awareness of the environment.

Musamba et al. [126] addressed the recreational value of Lake by applying the travel cost method. Lake Victoria offers a wide range of recreational activities, including fishing, bird watching, a lake view site, boating, and camping activities. This study used primary and secondary data. The primary data included the background of wetlands, land uses, participants' socio-economic characteristics, and recreational activities of Lake Victoria. In contrast, the secondary data were collected by interviewing 120 local people and visitors. Attention was paid to the number of visits, visit seasons, expenditures, and visited sites in the collected information.

People were also asked to indicate their willingness to pay for goods and services provided by Lake Victoria to improve its quality. The willingness to pay was considered a good reflection of the value of the wetland. Then, the collected data was investigated using the Statistical Package for Social Sciences (SPSS) software. The quantification of wetland benefits was also performed using Microsoft Excel. The study showed that Lake Victoria has a high capacity to support the livelihood of local people. However, there was a limited range of recreational opportunities, but the recreational value of Lake Victoria contributes significantly to the income of local people.

Sinclair et al. [127] introduced an economic valuation tool for recreational ecosystem services that is suitable for large spatial scales. This tool was based on crowdsourced metadata, i.e., geotagged photos collected from social media sources in Vembanad Lake. This study used the metadata of 47,246 geotagged images from the Flickr website, retrieved using Flickr's Application Programming Interface (API) between 1 January 2005 and 31 December 2016. The geotagged metadata is used as a proxy for human behavior. The metadata includes the user identification number, location, and timestamp of the time of the shooting. Therefore, the study used the retrieved metadata to:

(*i*) map nature-based recreational patterns,
(*ii*) identify the value of recreational ecosystem services, and
(*iii*) examine how recreational benefits are affected by changes in ecosystem quality.

This study mapped the geotagged photos on the Vembanad Lake and used GIS to identify the recreational hotspots. Then, the Flickr images were analyzed to predict the home locations of the users who did not share their information in their public profile. Next, geotagged photos wre used to make a single site "crowdsourced" travel cost method (CTCM) of the Vembanad lake. The consumer surplus per trip by combining visitor frequencies with inferred locations for visitors was also achieved.

This technique provides a tool for the economic valuation of recreation at large scales and low implementation costs. The study further combined the estimated per-trip benefits with the visitation rates under different water quality and wetland extension scenarios to investigate the implications of different management approaches. The study concluded that crowdsourcing methodologies, such as utilizing geotagged metadata from social media, were efficient approaches for valuating recreational ecosystem services.

In addition, the results of CTCM, which represents the mapping of nature-based recreational patterns, showed that the results were consistent with economic theory in terms of travel cost and income variables. Therefore, the CTCM is a suitable technique for estimating the information of individuals who do not voluntarily share it in their public profiles. Moreover, the study showed that improving water quality to the extent that it supports wildlife and fisheries would increase the economic benefits (almost 4 million USD) annually from the wetland's recreational services.

Pueyo-Ros et al. [128] assessed the socio-economic of a coastal wetland located of tourist destination named Pletera. The study analyzed whether the ecological restoration of the coastal wetland would affect its recreational demand. The study consists of a survey using a questionnaire from the visitors and residents of Pletera from July to September 2015, which are the peak visit months. A combined model of travel costs (TC) and contingent behaviors (CB) was used to evaluate the impact of ecological restoration on the destination's recreational value. After obtaining the visitor profile, a cluster analysis and subsequent comparisons were performed to understand how restoration affects tourists' contingent behavior.

The visitors were also divided into three groups, including indifference, recreation, and protection. The indifference group, which included 109 visitors, had the lowest ecological preferences of Pletera. The recreation group with 42 visitors was characterized by three variables: access to the wetland by car, the access restrictions, and the visitors' gender, i.e., 100% male. The protection group had 81 visitors who had more visits than the other two groups; they used cars the least compared to the other groups. This group also had a more eco-centric perspective.

The results of the combined model of TC and CB depicted that the restoration did not greatly influence the recreational value of the wetland. The cluster analysis of the three groups, i.e., indifference, recreation, and protection, illustrated three different attitudes toward the ecological restoration of the wetland. The results showed that the visitor profile highlights the difference between the actual and contingent visit rates.

Visitors attracted by the natural environment visit the wetland more often, while visitors who use the wetland for recreational purposes usually have fewer visits. The methodology used in the study showed that the changes in recreational demand after ecological restoration highly depended on the visitors' sociodemographic profiles. The results also suggested that ecological restoration will favor visitors and the tourism sector and positively impact the Pletera region's demand, including recreational beach opportunities.

Lankia et al. [129] investigated the impact of water quality changes on swimming behavior and recreation benefits. The core objective of this paper centered on swimming since swimming is the most common water recreation activity in Finland. This is an activity that is directly affected by water quality. Thus, the paper conducted a survey in the fall of 2009 using the internet and e-mail. A study of a total of 1644 sent e-mails achieved a response rate of 41.4%. The survey included two types of questions, including:

(1) general information, such as age, gender, place of residence in Finland, distance to typical visiting swimming sites, number of visits per year, and travel costs;
(2) water quality perceptions included questions about water clarity, i.e., water depth and visibility. In addition, participants were asked whether there were sludge and rocks in the water.

Applying the combined travel cost and contingent behavior method showed that the recreation value of a swimming trip with the current water quality was approximately 16 euros per trip. The results showed that the hypothetical reduction in water visibility to less than 1 m, and a large amount of sludge reduced the recreational value to 9 euros per trip. Improving water quality such that the water visibility is more than 2 m and if there is no increase in sludge, the recreation value of each trip will be 22 euros. In addition, the total annual recreation value of all swimming visits when improving the water quality enhances the recreational benefits by 80–53%. In contradiction, declining the water quality reduces the benefits by approximately 80%.

Vesterinen et al. [130] investigated the association between recreational participation in water activities and water quality. The water activities included swimming, fishing, and boating, and water clarity was used as an indicator of water quality. They also evaluated the consumer surplus of a water recreation day and the marginal social net benefits of an exogenous improvement in water quality. This study first modeled the water recreation participation and participation frequencies for each water activity. Then, they applied the TC method to estimate the value of one water recreation trip.

The value of a water recreation trip was assessed using the TC method for the three recreational activities. The technique also estimated the annual frequency of a one-day trip from home to the last-visited water recreation site. The results showed that water quality did not affect boating, but improving water clarity increased the swimming frequency and the number of anglers and fishing near home waters. The distance to the nearest recreational water did not prevent participation in fishing or boating.

An association between socioeconomic variables and water recreation participation was also found. The number of annual swimming trips and the number of anglers increased with the water clarity. In the water policy scenario, improvement of the water clarity up to one meter for inland and coastal waters was associated with a consumer surplus increase of 6% for swimmers and 15% for fishers.

Lankia et al. [131] conducted a national-level accounting study for nature-based recreation in open access conditions using the United Nations System of Environmental Accounting–Experimental Ecosystem Accounts (SEEA-EEA). This research investigated how recreational services could be integrated into an ecosystem accounting framework at the national level as one of the cultural ecosystem services. The study suggested a model describing how this type of accounting is constructed and how different national data sources assist recreational accounting in physical and monetary terms.

The research calculated the monetary value of outdoor recreation based on consumer surplus estimates achieved applying the travel cost method. As a result, there are almost unlimited possibilities in Finland to enjoy natural areas because of the right of public access for recreational purposes. The area of recreational ecosystems includes 25.8 million hectares of forest land available to the public for recreational purposes. The natural areas for aquatic recreation include 3.4 million hectares of inland water resources and 5.2 million hectares of marine waters.

Based on the research, natural areas in Finland, such as forests, parks, water areas, and, e.g., wetlands, are used for recreation. A total of 90% of recreational visits close to home (daily visits) occur at least in part in forest environments. A total of 50% of the visits occur in parks and open spaces, and 75% include aquatic environments, lakes, ponds, rivers, streams, and marine and coastal environments. Moreover, the location of recreational areas is one of the main elements of recreational opportunities. The presence of natural areas with high recreational facilities for daily use offers well-being to people, particularly in urban areas.

Aazami and Shanazi [132] investigated the impacts of wetlands on people's livelihood through wetland capacity, mainly from tourism and agricultural-related activities in Iran. In this study, two qualitative and quantitative research methods were used. A questionnaire consisted of three sections: A, B, and C. Section A included information about the demographic characteristics of the respondents, such as gender, age, marital status, occupation, and household size.

Section B had information on livelihood assets and wetland community strategies, such as human, social, financial, environmental, and physical assets, and livelihood strategies to support their income. Finally, Section C included information on the vulnerability of wetland community development. The field of vulnerability was divided into three types, namely shocks, trends, and seasonality. Shocks refer to some unexpected occurrences that might affect community livelihoods. Trends refer to changes over time in natural resource stocks and quality that impact community livelihood. Seasonality refers to seasonal changes that constrain the livelihood choices of people.

The results showed that households have different strategies for responding to vulnerabilities. The sale, consumption, and use of wetland goods and services and improved assets were their most important protection against natural and economic shocks. The study indicated that the wetland has contributed to the profitability of small family businesses (tourist services, handicrafts, retail, etc.) and has increased agricultural income and thus their livelihood. Moreover, natural capital was the strongest asset for measuring people's sustainability, having a positive impact on their livelihood. The potential of the wetland in agriculture and livestock, fisheries, and tourism led to improved production and income, stability, and sustainability of the economy. It also provided livelihoods and job opportunities in the region.

Park et al. [133] developed an extended model of goal-directed behavior to analyze the impact of perceived benefits of wetlands on the decision-making process and identified differences between residents and non-residents. The objectives of this study were to:

(*i*) examine whether the perceived benefits of wetland visitors were important in influencing their desire and future intention to visit wetlands,
(*ii*) investigate whether residents and non-residents differed in the causal relationships depicted in the destination decision-making process model.

As a methodology, an online survey was conducted regarding outdoor recreation in Iowa. Out of the 670 people who took part in the survey, 462 were valid for data analysis. A theoretical framework was created as an extended MGB (EMGB) by incorporating the perceived benefits of wetlands into the MGB. The EMGB was recognized as an updated approach to the TPB and MGB to better explain the decision-making process based on multiple cognitive and affective components. The study used an extensive model of goal-directed behavior (MGB) to investigate the decision-making process.

This model describes the decision-making mechanism concerning various factors, such as desire, past experiences, motivational and emotional factors, attitude, subjective norm, and perceived behavioral control, which are introduced in the theory of planned behavior (TPB) and the theory of reasoned action (TRA).

The model of structural equations showed that the perceived benefits of wetlands influence the decision-making process. Desire as a key element (conceptually different from behavioral intention) was essential to link attitudes, predicted emotions, and the frequency of past behavior with behavioral intent. Residents, compared to non-residents, showed that positive attitude and past experience influenced the desire and intention to visit wetlands. The study revealed that the perceived benefits of wetlands played a vital role in strengthening the decision-making process for visiting wetlands.

In addition, marketing managers need to consider the differences between residents and non-residents in the decision-making process for advertising or effective advertising. Moreover, residents showed that a positive attitude towards wetlands plays an important role in creating a strong desire to visit wetlands. They were more likely to revisit wetlands if they were frequent visitors in the past, compared to non-residents. Therefore, tourism operators are encouraged to identify frequent visitors as an important market among residents and develop an appropriate marketing plan to meet the needs and demands of consumers.

Odgaard et al. [45] introduced a new multi-criteria method based on ecosystem services value to optimize the location of restored wetlands to maximize the selected ecosystem services that a wetland can provide. First, five ecosystem service indicators were mapped for wetlands in Denmark (recreational potential, biodiversity, nitrogen mitigation potential, inverse land rent, and flash-flood risk).

For this purpose, the analysis of the catchments that accommodate a reconstructed wetland was performed. Then, the scenario test and analysis of the hotspots were combined to provide future recommendations for the optimal placement of wetlands. The studied scenarios were climate adaptation, aquatic environment protection, land-based economy, and rich nature. Based on these scenarios, the most suitable areas for wetland reconstruction were mapped considering the scenarios and weights of ecosystem service indicators.

The results showed that current reconstructed wetlands were situated in catchments with higher land rent (i.e., agriculture intensive areas), higher nitrogen mitigation, and to some extent, higher flash flood risk. In contrast, lower biodiversity compared to catchments without reconstructed wetlands. Therefore, recreational capacities, increasing biodiversity, and low land rent are not a priority. When optimizing all scenarios, 35 of the 3023 catchments surveyed were particularly suitable. However, out of the 35 identified catchments with high potential, only two hold a reconstructed wetland. This represents a previous placement almost without considering the maximum benefits of ecosystem services.

To conclude this section, there are different forms of wildlife species in urban wetlands that make wetlands attractive places for recreation and leisure time. Indeed, wetlands provide countless recreational activities for people, such as walking, boating, swimming, fishing, trapping, and bird watching. The recreational opportunities offered by water bodies contribute to both physical and mental health. The studies demonstrated that the number of water areas, population, age ranges of people, water quality, and the type of recreational activities were linked in urban areas. The higher the population was, the higher the recreation activity. The water quality also defined the swimming rate, and the age range specified the type of activity, such as swimming, fishing, and boating. Younger people were interested in swimming, and older people were interested in finishing and boating.

7. Urban Wetlands and Social Perceptions

Considering the social perception of natural ecosystems is crucial to the success of conservation programs [134]. The central aspect of this social and environmental perception goes back to the use and non-use of various values that people attribute to natural areas. These are referred to as social values [135]. Successful conservation of natural ecosystems occurs when we identify ecological and economic priorities for specific areas [136]. It also depends on how these priorities align with the social values allocated to these areas by the community [134,137].

Thus, considering the different ways human beings perceive and value natural areas, the social acceptance of conservation plans can be increased [138], and the public can better comprehend the complexity of conservation values [139]. Comprehension of the connections between ecological and social values can help specialists design strategies, e.g., information exchange, incentive schemes, for particular areas that are effective and efficient [140].

Ecosystem assessment has commonly been carried out in a purely ecological framework, regardless of social functioning. However, more recently, it has been determined that we must also define some social measures to preserve and restore the ecosystem [141]. Naturally, everyone interacts with ecosystems and landscapes and makes value assessments. These value assessments reflect how they think and react to these environments [142]. Therefore, people are sensitive to how ecosystems function, landscape features, and change over time [143]. However, the perception of the ecological situation and value estimated by experts may conflict with public opinion [144].

Therefore, these differences must be adapted. The adaptation can be made by linking the value and function of the ecosystem, i.e., by identifying the ecological parameters that adequately describe the ecological function and perceived value both for people and experts [141].

Different values may be related to the environment. These values include aesthetics, recreation, biology, and economics [145]. For example, perceiving the aesthetics of the environment is directly related to emotional processes and may create a strong social motivation to preserve ecosystems, without considering environmental function or vulnerability. Therefore, considering aesthetic perception is useful for environmental protection and restoration because it increases the motivation of social support for environmental protection [146].

People's perceptions and preferences about ecosystems are impressed by personal, geographical, and social characteristics. These characteristics include age, gender, income, political orientation, environmental organizations, moral beliefs, use and non-use of specific areas, life experiences, and living environment [147].

Due to the importance of improving social perceptions about the urban wetland and understanding the possible approaches, in the following, we conducted a review on this topic, and we summarize the objectives, methodologies, and findings of the reviewed articles in Table 6.

Table 6. Urban wetlands and social perceptions.

Reference	Objective	Methodology	Findings
South Korea (Do and Kim, 2020) [148]	Analyzing metadata and contents of the photos taken in South Korean wetlands	Using API, respectively 69 and 287 geotagged photos collected from wetlands	Preferred visiting times depended on tourism attractions in specific seasons as well as parts of the day
New York, US (Sonti et al., 2020) [149]	Examining how and why people use the "natural" and "landscaped areas" of New York city parkland	21 parks were selected in five New York City boroughs, including parks larger than 400 acres	More people visit landscape areas to bring children to the park and visit forest areas and wetlands much less than the landscape areas
Victoria, Australia (Dobbie, 2013) [150]	Investigating the public aesthetic preferences and its relationship with conceptual perceptual tools for wetlands	Used selected connotative perceptual constructs that were rated on a 7-point Likert scale	Proved preference for water and vegetation is relevant aesthetic feature. The preference of the wetland improves with increasing amount of water
Benslimane, Morocco (Bouahim et al., 2015) [151]	Investigating the social perception of ecosystem services and vulnerability analysis associated with temporary-flooded wetlands	101 ponds were selected and conducted interviews with well-known experts and 110 household	60% of respondents found ponds very useful and highlighted place attachment and cultural values
Tubul-Raqui, Chile (Rojas et al., 2017) [147]	Evaluating the social perception of ES in a coastal wetland after the earthquake in Tubul-Raqui, Chile	Used surveys and data collection to analyze the social perception or perceived benefits of ES	The highest value is related to cultural services. Wetlands can provide opportunities for services related to recreation, local identity, science, and environmental education
Lyon, France (Cottet et al., 2013) [141]	Investigating the relationship between perception of wetland aesthetics and healthiness with wetlands ecological functioning	A questionnaire containing photos of the wetland was presented to people who were asked to evaluate the two perceptual criteria of aesthetics and environmental health	People's perceptions of the aesthetics of the wetland strongly depended on visual criteria
Xochimilco, Mexico (Torres-Lima et al., 2018) [152]	Studying the variables of socio-economic, environmental, and regional economic management that affect the population's perceptions of wetland	Used an approach that focuses on area characteristics and fieldwork was conducted between April and May 2010	Education helps to create a positive local perception of urban wetland. For some participants value of wetland based on the aesthetic qualities and its potential use as a reserve for human habitation
Nova Scotia, Canada (Manuel, 2003) [153]	Investigating public awareness and perceptions of small urban wetlands in Halifax and Nova Scotia, Canada	Three wetlands were selected for examination and use of questionnaire with 65 participants	Participants were interested in the environment and recreation. Residents liked wetlands and had positive views about them

Table 6. *Cont.*

Reference	Objective	Methodology	Findings
Alberta, Canada (Rooney et al., 2015) [55]	Comparing NWs with CWs to examine residents' perceptions of the environmental services of NWs and CWs with their biophysical values	Three sample sets of 20–34 people were considered for interview to conducted a survey of social values	More than 80% of participants reported that NWs value biodiversity and groundwater recharge services, nearly 90% of the participants found value in the aesthetics of the CWs
Helsingborg city of Sweden (Pedersen et al., 2019) [154]	Identifying urban wetland areas contribute to the well-being and quality of life	Environmental psychology tools were distributed in questionnaires in three municipalities with wetland areas	Wetland areas were perceived by residents as contributing to their quality of life

Sonti et al. [149] examined how and why people use the "natural" and "landscaped areas" of New York City parkland. They used random field interviews with 955 park users to examine the differences in park use and the reasons for visiting the park. In this interview, when looking at the differences in park use and the reasons for visiting it, the site type and the gender of the respondents were considered. The data was collected from June to August 2014 to assess the use, value, and social significance of City parks that contain "natural areas."

As a case study, 21 parks were selected in five New York City boroughs, including parks larger than 400 acres and small parks containing at least one natural area. This research showed that more people visited landscape areas to bring children to the park and visited forest areas and wetlands much less than the landscape areas. For visitors to urban forests and wetlands, the feeling of shelter, attachment to the place, and the opportunity to experience nature were more valued.

At the same time, those who visit landscape areas were interested in a particular park quality or activity. Notably, urban wetlands mostly attracted walkers, dog walkers, and cyclists. Visitors who mentioned their priorities for landscaped areas were concerned that these natural urban areas are not safe and accessible to themselves or their children. The research also found that men and women perceived urban natural areas differently. Women were more likely to visit the park with their children and visit more landscapes than natural areas.

Moreover, people who participated in environmental groups visit the park's natural areas more often than those not involved in these groups. These results provide a platform for natural resource managers and urban planners as they investigate to improve park accessibility, visitor experience, and the perception of safety for all park users.

Dobbie [150] investigated the public aesthetic preferences and their relationship with conceptual perceptual tools for freshwater wetlands. For the sustainable management of wetlands, social preferences and sociodemographic attributes for wetlands in the urban area must be identified and understood. As a methodology, the study used selected connotative perceptual constructs rated on a 7-point Likert scale. The grades of evaluation were labeled "strongly", "moderately", and "slightly" with "neutral" describing the midpoint.

In the perceptual classification of Victorian freshwater wetlands, connotative constructs with the highest frequency of occurrence were selected to construct rating scales. Using the Kasmar environmental lexicon descriptors, these constructs were defined as 'orderly', 'open', 'healthy', 'natural', 'attractive', and 'varied'. Since perception primarily occurs visually, photos (N = 70) were used as a substitute for real landscapes in the perception of landscape and preference studies. Images were displayed to participants in two versions of the PowerPoint presentation with reverse slide order. Participants, including 241 adults (Minimum age 18), were selected from community groups in Melbourne, the capital of Victoria.

Descriptive statistical analysis was performed using SPSS 14 software. Preference categories included five preference categories: 'brown grasslands', 'green grasslands', 'wetlands with emergent vegetation', 'treed wetlands', and 'wetlands with open water'. Different preferences in the wetland category were influenced by the presence of water and the type and color of vegetation. Statistically, there were three different groups: grasslands, open wetlands, and treed wetlands. Wet wetlands were preferred to dry wetlands.

"Green grasslands" and "brown grasslands" were equally least preferred, as 'grasslands', followed by 'wetlands with emergent vegetation' and 'wetlands with open water', as "open wetlands". 'Treed wetlands' were the most preferred. This study showed that, for wetlands, the preference for water and vegetation was a relevant aesthetic feature. The preference of the wetland improves with the increasing amount of water. In addition, it showed the effect of increasing the amount of water and green space on the preference of built and natural environments.

Preference for urban environments increases with the presence of water. As long as the edge between the land and water is visible, indicating safety when moving around areas, the preference for natural environments increased with water. The presence of water is an important sign of wetland health in wet wetlands, deduced from the clarity and movement of water and the existence of water vegetation. In dry wetlands, the color of the vegetation indicates health. In general, the color, and the freshness or dominance of green vegetation, increase the preference for natural landscapes.

Do and Kim [148] analyzed the metadata and contents of the photographs taken in South Korean wetlands. They paid attention to the color embedded in each object in the environment since the color is a stimulus that impacts the human mind and reflects the person's inner state. Therefore, it is assumed that the color of the wetland photograph shows the preferences of the wetland feature. Using the Flickr programming interface (API), the scientists collected 69 and 287 geotagged photos in Oppo wetlands and Suncheon bay.

Photographs were taken between 1 January 2007 and 31 December 2018. In this study, deep learning was used to analyze the images. Using Deep Learning Object detection, photographic subjects were identified from the contents of the image, which allows for quantitative analysis of the object. The results showed that many people were photographed near the starting points of wetland routes. Preference of visiting time depends on the tourist attractions in particular seasons and parts of the day. Investigation of the photos indicated that most visitors took photos of landscapes, such as fog and sunsets.

These results were consistent with their preferred visiting time, such as mornings for fog and evenings for sunsets. Most images' color was a dark greyish yellow, often evoking negative emotions, such as sadness, despair, fear, and humiliation, as shown in the study of the relationship between color and emotion. The characteristics of wetlands expressed in gray can also additionally deliver bad connotations. Nevertheless, based only on the colors of the photos, we cannot conclude that visitors' beliefs of the wetlands are bad. On the other hand, analysis of facial expressions of emotion, such as joy, surprise, sadness, anger, disgust, and fear of photos taken in the Oppo and Sancheon Bay lagoons, showed that most visitors smile in the pictures, expressing happiness.

Bouahim et al. [151] investigated the social perception of ecosystem services and vulnerability analysis associated with temporary-flooded wetlands. In this study, 101 ponds were randomly selected in Morocco. Information from each pond was gathered, including geographic coordinates, size, nature of the surrounding environment, ownership, land uses, proximity to roads/tracks, distance to habitats, and distance to the city. A vulnerability index was estimated for each pond and land use to evaluate, quantify, rate, and map threats in the study area.

This method was adopted by conducting interviews with well-known experts in ecology and social economics of natural habitats. Data related to the impact of human activities, such as grazing, recreation, drainage, cultivation, and urbanization on the plant communities were collected in 32 temporary ponds in the study area and used to define the indicators. For a socio-economic perception survey, 110 random households living near ponds in three municipalities were selected. Interviews were performed from May to July 2008 using questionnaires that were previously tested in a pilot study.

The questionnaire consisted of five main sections: (i) socio-economic status of households, (ii) information about ponds and the services they provide, (iii) land use according to the local population, (iv) land ownership and guardianship, and (v) threat perception. Most interviewees stated that they observed the destruction of ponds over the past decade. The main threats perceived by the participants included the reduction of forage and water resources (threat to species), the use of ponds to drain and uncontrolled water pollution (threat of ecosystem destruction), and the extraction of building materials, urbanization and agriculture (threat to eliminate the ecosystem).

A total of 60% of respondents found ponds very useful and highlighted place attachment and cultural values. There were 19% of respondents who stated that ponds were not important and did not provide any services to the community. The threat map demonstrated that 22% of ponds were vulnerable and 23% were threatened in the short term.

Threat evaluation and mapping indicated higher threat levels for ponds located in farm landscapes and private land. This study showed that the disappearance of ponds after their conversion into agricultural land is part of eliminating the ecosystem. Ponds are considered areas that can be transformed into farmland to feed the growing local population. Conversely, forest environments have protected the ponds because their number has remained constant for the same time. Therefore, government services' management of forest environments has been essential in preserving ponds for the past 50 years.

Rojas et al. [147] evaluated the social perception of ecosystem services in a coastal wetlands after the earthquake. They executed a semi-structured survey to analyze the social perception of the perceived benefits of ecosystem services, which was divided into three stages: (i) design a survey, (ii) determine the population and size of the sample, and (iii) data analysis. They conducted 175 surveys in the study area. The data were investigated using IBM SPSS (Statistical Package for the Social Sciences). Perception scores obtained on the Likert scale were determined using Cronbach's alpha coefficient. This method generally applies to all ecosystem services.

The results indicated that the highest value was related to cultural services. In addition, the study area as an ecosystem can provide opportunities for services related to recreation, local identity, science, and environmental education. In this survey, the perceived values for hazard regulation services varied by gender. Accordingly, this issue is crucial for women. This difference in perception of gender could be related to the post-disaster economic effects that have significantly increased the unemployment rate among women.

In addition, the high frequency of natural disasters, such as tsunamis and floods, can positively affect the population's beneficial valuation of the wetland. Since wetlands are essential for mitigating the effects of such catastrophes, they are socially valued as post-earthquake recovery spaces, especially if wetlands provide biophysical properties and biodiversity, including water, bird species, micromammals, and amphibians.

Cottet et al. [141] investigated the relationship between human perception of wetland aesthetics and healthiness with wetlands ecological functioning in France. To this end, a photo questionnaire was provided to 403 laypeople and self-identified experts from Ain River wetlands. Two objectives were defined: (1) identification of various parameters, both visual and ecological, that affect the perception of the value of these ecosystems; (2) comparison of the perceptions of experts and laypeople. A questionnaire containing 16 photos of the wetland was presented to the people, and they were asked to evaluate each image according to the two perceptual criteria of aesthetics and environmental health. In addition, a set of photographs focusing on the water was collected from the study area. Photos were selected and classified based on two criteria:

(i) A visual criterion (4 classes): reflective water, transparent water with visible substrate, water with floating aquatic vegetation, and water with aquatic vegetation growing under the water's surface.

(*ii*) An ecological parameter about the nutritional status of the wetland (three classes): eutrophic, mesotrophic, and oligotrophic.

Participants were asked to use an "analogous visual scale" to rate the photos. This scale was first developed in medicine to treat pain and has recently been used to study landscape perception. The scale is continuous and limited to evaluation terms ("very high aesthetic value" vs. "no aesthetic value", "very healthy" vs. "not at all healthy"). Participants were asked to point out their evaluation on a relevant scale. Intergroup comparisons were used to analyze the effect of visual and ecological parameters on participants' perceptions, i.e., assessing the aesthetics and healthiness of the wetland.

The relationship between the environmental characteristics of wetlands and their understanding was analyzed with parametric statistical tests (ANOVA test and Tukey test). This method is a factorial analysis of correspondence about the occurrence of word classes used to describe wetlands. As a result, the study showed that people's perceiving of the aesthetics of the wetland strongly depends on visual criteria. The perceptions of laypeople and experts were equally affected by these parameters. The study revealed certain specific features of wetlands affecting perception. These included the transparency and color of the water, the presence and appearance of aquatic vegetation, and the presence of sediment in aquatic habitats.

Torres-Lima et al. [152] studied the socio-economic, environmental, and regional economic management variables that affect the population's perceptions of an urban wetland in Mexico City. As a methodology, this study used an approach that focused on area characteristics and fieldwork was conducted between April and May 2010. An initial pre-test was used to determine the main factors. In this test, factors or elements were considered that limit or define decisions or sustainability conditions from a combination of social processes and their interaction with the environment. These factors were included in the final survey as variables.

Sociodemographic data were collected using a survey modified from a pre-test on three factors that boost and restrict wetland sustainability. These factors included socioeconomic, environmental, and regional data and on perceived agendas for urban wetland planning. Locals were asked to express their level of perception of the sociological-economic implications for each term (where 1 = strongly, 2 = slightly, and 3 = little). This study showed that the functional characteristics of the wetland landscape were interpreted from different perspectives according to five major factors of practical statistical importance: age, sex, education, ownership, and indigenousness.

In peri-urban areas, agriculture is a potential source of employment and income without formal education requirements. The competence of farmers for urban or agricultural work is still associated with economic benefits for regional development. Therefore, education helps to create a positive local perception of urban wetlands. Education happens by enabling people to receive and interpret information about their environment and regional context.

For some participants, evaluation of the urban landscape was based on the view of aesthetic qualities and its potential use as a reserve for human habitation. On the other hand, the spatial organization of natural resources for environmental and agricultural production purposes makes it possible for other major populations to manage their rural-urban territory.

Manuel [153] investigated public awareness and perceptions of small urban wetlands. The research was a case study to examine the response to urban wetlands. Different sites were selected to identify similarities and differences in response to varying types of wetlands in different neighborhood settings. Three wetlands were chosen from 18 candidate sites that met the following criteria: less than 2.0 hectares, separate from adjacent water systems, natural and under "unmanaged" conditions, and located in an easily identifiable urban or peri-urban residential neighborhood.

In this study, 65 households were selected for each neighborhood, and interviews were conducted in summer and late spring 1996–97. The questionnaire consisted of 30 main questions organized into four sections; a combination of yes/no questions, open-ended questions, and Likert-scaled (1 to 5) prescribed statements. The questionnaire asked participants about:

(*i*) demographic information and household orientation to environmental issues and outdoor activities;
(*ii*) knowledge or perception of the boundaries of the neighborhood, community character, and the natural areas in the neighborhood;
(*iii*) specific information regarding the wetland site, including awareness, knowledge, and observation of the wetland; use of the wetland; understanding of the advantages or disadvantages related to wetlands; and attitudes toward or perceptions about wetlands; and
(*iv*) general orientation to the values of "naturalness" and " wetlandness" in an urban environment.

The text of some questions allowed participants to incorporate the experience of other households in some of the answers. The study showed that participants were interested in the environment and recreation. Residents liked their neighborhoods, and they had a positive view of urban nature, especially their local wetlands. However, despite their positive estimation of environmental considerations and their agreement with the benefits of urban natural sites, these people paid little attention to the small wetlands.

On the other hand, they did not completely ignore or have unkind feelings to the wetlands, and they were not hostile to the wetlands. People who reported using the areas (almost half of the participants) explained using them for different purposes (skating, catching frogs, picking flowers, socializing, and enjoying being in a natural place). They widely accepted wetlands as part of their neighborhoods and enjoyed the areas.

Rooney et al. [55] compared natural wetlands with stormwater wetlands and stormwater ponds to examine resident perceptions of the environmental services of natural wetlands and stormwater ponds with their biophysical values. For the study, 72 wetlands were selected, belonging to four types: natural wetlands, natural wetlands impacted by agriculture, stormwater wetlands, and stormwater ponds. Each subset consisted of six wetlands, and three sample sets of 20–34 people were considered for an interview to survey social values.

The survey participants reported that they assessed many of the values of ecosystem services in the natural wetlands, agricultural wetlands, and stormwater management facilities they visited. More than 80% of the participants reported that they value biodiversity and groundwater recharge services for natural wetlands, which is, in fact, commensurate with the biophysical assessment. Remarkably, nearly 90% of the participants found value in the aesthetics of the stormwater pond, despite supporting few songbirds or other animals and having a simple strip of mainly invasive, upland vegetation. However, participants were largely mistaken (57%) in believing that groundwater recharge was valuable in impermeable stormwater ponds.

Participants gained almost as much value (slightly more than 68%) in natural wetlands (75%) as in stormwater ponds. Overall, more than 90% of study participants recognized the flood control provided by storm ponds, the main reason for their existence. Respondents in the natural heritage of natural wetlands (40%) found similar value to storm ponds (49%).

Pedersen et al. [154] identified whether peri-urban and urban wetland areas contributed to the well-being and quality of life of the surrounding residents and investigated their value compared to two other types of green spaces (i.e., parks and urban forests). The study evaluated the perception of local people of wetland areas inside or near their neighborhoods. This survey was conducted using a questionnaire. This research was based on proper environmental psychology tools, distributed by postal questionnaire in three municipalities with wetland areas of different structures and locations among residents. The data were analyzed statistically in IBM SPSS. A total of 473 people participated in this survey and completed the questionnaire.

It appeared that residents perceived wetland areas as contributing to their quality of life. Participants responded that the wetland area contributes to multiple aspects of quality of life, such as dealing with nature and experiencing aesthetics. These areas also promote activities that support well-being. In addition, these areas appeared of high repair quality and evoked positive responses. Furthermore, recognizing and indicating the value of cultural ecosystem services can increase the total value attributed to urban wetland areas.

All wetland areas were rated high on most of the measured concepts. Still, their value relative to other green areas differed, possibly depending on the accessibility of the wetland and the availability of other green areas. The place and extent of integration of the wetland area into the residential area determine which aspects of quality of life are most satisfactory. Wetland areas can be attributed to the value of cultural ecosystem services based on how residents perceive their contribution to their quality of life. These values can be added to provisional and regulating ecosystem services and form the basis of planning for urban environments.

In summary, effective management, maintenance, and protection of wetlands are directly related to the positive public perceptions about urban wetlands values. Therefore, to improve public perceptions, there is a need for communication between people and urban governors, providing public awareness about urban wetlands and their services and values. Furthermore, enhancing public perceptions about the benefits of wetlands can support the protection and maintaining these natural and valuable resources.

8. Summary and Research Gaps

In this section, we summarize the reviewed topics in this article. We also address the research gaps and directions, where we identified during our review.

8.1. Urban Wetlands and Biodiversity

Land-use changes, from natural habitat to agricultural or urban land, are the primary factor that reduces biodiversity in urban wetlands. Most of the studies reviewed in this article examined the biodiversity of fauna and flora in wetlands at different time intervals in different years. These studies, for example, monitored vegetation establishment, water quality improvement, and animal colonization [69]. In addition to providing biodiversity, urban wetlands offer a wide range of ecosystem services: urban wetlands, e.g., they create a network of distributed and discrete habitat patches that facilitate the movement of species through the landscape [92,155].

Urban wetlands indeed contain a more significant proportion of biodiversity than other habitats. Therefore, ecological restoration allows contributing to the conservation of endangered species that have specific habitat requirements. The interaction between biodiversity and species is beneficial for human societies [86,90,91]. In addition, the interaction between humans and urban wetlands biodiversity stands as a natural and anthropological process. To improve people's interaction and wetland biodiversity, adaptive wetlands management approaches, policies and practices are needed [90].

Despite the valuable and massive work performed in the literature, the reviewed research in this article highlights the following research gaps concerning the linkage between biodiversity, humans, and the urban wetlands:

(i) Wetlands also are considered as ecological traps. What are the challenges associated with these ecological traps? [82].
(ii) How can we effectively manage constructed wetlands in urban landscapes? [82].
(iii) How do constructed (e.g., treatment) wetlands play an essential role in contributing to biodiversity locally and globally? [87].

Answering these research gaps would require effective management and preservation of wetlands. However, to improve the biodiversity in wetlands, research should aim to obtain novel and proper management plans specifically for urban wetlands [87]. For example, the studies that focus on continuous restoration and maintenance programs can be promoted to ensure that urban wetlands function efficiently [82]. As a result, the efficient functions of urban wetlands would enrich biodiversity and solve ecological traps by improving the habitat quality for animals living in these wetlands.

On the other hand, wetlands as ecological traps result directly from inefficient management activities. Thus, prevention actions, such as reducing pollutant exposure, periodic urban wetland restoration services, and design management programs for high-risk species [87] can overcome the challenges associated with ecological traps and therefore improve the biodiversity in urban wetlands.

8.2. Urban Wetlands and Urban Heat Islands

The UHI effect directly relates to the current climate change, which has an influential impact on global warming. The studies surveyed in this article reported the reduction of temperature in places near blue spaces (such as wetlands, ponds, lakes, and rivers) in urban regions [65,101]. The temperature reduction is due to the cooling effects of these blue spaces, which have different features, such as scale, location, shape, geometry, distance, and hydrology [4,101].

Indeed, features, such as the numbers, sizes, and locations of blue spaces, specify the amounts and levels of the cooling effects in urban areas. For example, a large blue space was found to provide a powerful cooling effect on the surrounding area, while a few small lakes affected a higher percentage of the city [108].

Due to the crucial roles of blue spaces in reducing UHI, special attention should be given to these blue spaces within urban studies. Indeed, governments and urban planners can use the blue space resources in cities to plan and design sustainable living environments with minimizing UHIs in urban areas [13,65,108].

However, most of the studies in the literature aimed at finding solutions for reducing UHI in cities, yet there are a great number of challenges associated with UHI as follows:

(i) How do blue spaces with different features (such as shapes and sizes) have considerable cooling effects on local thermal environments? What is the impact of an individual blue space, such as a wetland or a lake in a city? [107].
(ii) A higher distance from the blue space means a greater average surface temperature and weaker wetland regulation. How do UHIs vary with the increase of distance from a wetland? [65].
(iii) How do wetlands' shapes and positions impact the cooling effects of wetlands? [105].
(iv) Urban wetlands have a more powerful cooling effect than green spaces. What is the reason that high-density buildings and riverbanks limit the spatial extent of the cooling effect? [101].
(v) The type of land cover (such as vegetation and constructions) around blue spaces also significantly impacts UHI changes. How does the type of land cover around blue spaces impact UHIs in urban areas? [13].
(vi) When green spaces, e.g., forests and blue spaces, are located beside each other, why do they create a mutually dependent environment and offer synergistic cooling? [4].
(vii) Why and how is properly weighting the sizes and locations of blue spaces helpful for urban planning? [108].

Overcoming these challenges would require knowledge on wetlands characteristics, such as their shape, size, location, and distance from other urban spaces, such as forests, lakes, rivers, and built environments. As reviewed in this paper, some studies have taken these features into account when evaluating and discussing the cooling effects of wetlands.

For instance, while the land cover around wetlands directly impacts the cooling effect of wetlands [13], the compact shape of wetlands and square- and round-shaped wetlands can reduce the environmental temperature better than elongated or elongated irregular shapes [107]. In addition, the cooling effects of the wetlands have been realized to be significant close to cities [105]. However, in the literature, there are limited studies on the relation between urban wetlands and UHI characteristics, and therefore performing research on the topic is highly important. This importance stems from the current global warming situation.

8.3. Urban Wetlands and Urban Sustainability

Our article was focused on studies regarding the role of wetlands (whether natural or constructed) in increasing urban sustainability. Different types of water space, such as wetlands, ponds, river basins, and marshes, play an essential role in improving environmental sustainability. These promote the urban well-being of local environments and enable economic development [117,118].

The studies reviewed in this article highlight the importance and impact of water bodies, such as wetlands and ponds, rivers, basins, or marshes, providing sustainability and enabling the adaptation of urban areas to climate change. These water bodies affect urban microclimates and provide ecosystem services [115,116,119]. The studies emphasized the development and protection of wetlands in urban areas since wetlands are nature-based solutions that create livable and sustainable cities that are resilient in the face of climate change [58,116,117]. In addition, to increase urban sustainability, due to the resilience of wetland ecosystems, studies suggested that a balance should be established between land use and wetland rehabilitation in urban ecosystems [114].

Indeed, many studies are aiming at solving the challenges associated with urban sustainability. However, these studies address the following research gaps for further exploration:

(i) What transformations are created when enclosed coastal wetlands are implemented in these environments? [114].
(ii) How does afforestation contribute to the conservation of soil and water in urban wetlands? [58].
(iii) How does ecotourism, such as bird watching, improve environmental conditions and benefit economic spillovers? [117].
(iv) How does aquaculture implementation in environmentally sensitive areas reduce the extra constraints in financial and human resources? [117].
(v) How does wetland vegetation, such as mangroves, help reduce tsunami damage in coastal wetlands in urban areas? [116].

Exploring these research gaps would require investigating the functionalities of wetlands in urban areas, which can help create liveable and sustainable cities. Among the diverse functionalities of wetlands, ecotourism is one of the best sources of income [114]. Therefore, ecotourism provided by wetlands, such as bird watching, can help the conservation of urban wetlands by spending the payments for maintaining and improving wetlands functionalities. In addition, developing local aquaculture, for instance, in coastal wetlands, would facilitate a long-term sustainable economic activity for locals by creating a local food economy.

By applying appropriate management strategies, the established economy can be used to benefit the wetlands and aquatic environments and provide sustainable environments [117]. Therefore, obtaining answers for the research questions on this topic by considering the functionalities of wetlands in urban settings would promote achieving a balance, for example, between economic activities and the protection of wetlands. This would offer efficient management strategies and hence provide sustainable urban environments.

8.4. Urban Wetlands and Recreational Values

The studies reviewed in this article analyzed wetlands as valuable opportunities for nature-based recreation. Studies emphasized the importance of raising public awareness about the conservation of water bodies, such as wetlands in the urban context. The reviewed articles highlighted the role and significance of water bodies, such as wetlands in providing opportunities for nature-based recreation services [31]. Some of the studies indicated that the locations of water bodies are essential for defining the recreational opportunities in urban areas [131]. The extensive recreational opportunities provided by wetlands included fishing, swimming, bird watching, and walking, which positively affect people's physical and mental health [129–131].

The recreational opportunities offered by water bodies also provide economic benefits in urban areas. Therefore, most of the studies used travel cost methods to estimate the monetary values of water bodies. Travel cost methods are based on the cost of travel to recreational sites and are widely used in the economic evaluation of the benefits of outdoor recreations [125,127–131,156]. Moreover, the studies state that the financial crisis does not directly impact the economic valuation of the recreational aspects of these wetlands [125]. However, reduced water quality decreases recreational activity, such as swimming, but does not affect activities, such as boating and fishing [129–131]. In addition, improving water quality to the extent that it supports wildlife and fisheries would increase economic benefits [127,132].

Indeed, creating a positive attitude toward wetlands and raising awareness about wetlands' social and cultural benefits in cities has an essential role in forming a strong desire to visit wetlands. Therefore, public awareness about the recreational benefits would support protecting and maintaining these natural and valuable resources [45,133].

In addition to the valuable works and results presented in the surveyed articles, these studies suggested the following as potential research gaps and future research topics:

(i) Studies suggested peoples' incomes as an indicator to estimate the economic values of wetland. Is considering incomes an appropriate indicator? [125].
(ii) What are the other approaches except for the travel cost method to analyze the economic value of wetland recreational services? [125].
(iii) What are the missing links between governance partnerships and local people to develop ecotourism and conserve wetlands at the national and international levels? [132].
(iv) How can considering some behavioral variables, such as motivation, satisfaction, experience, and place attachment, help better understand wetland visitors' attitudes and behaviors? [133].
(v) How do different wetland environmental settings or geographical locations affect visitor behavior when visiting wetlands? [133].

Finding answers to these questions requires paying attention to the recreational values of wetlands as a nature-based solution. The recreational use of wetlands, e.g., ecotourism, is aligned with wetland conservation, as ecotourism promotes the local economy through local resources (i.e., wetlands). Therefore, managing the local economy can benefit the preservation of urban wetlands and significantly improve their recreational values [132]. In addition, behavioral variables, such as motivation, satisfaction, experiences, and perceptions about wetlands as well as travel cost methods can be applied to assess the recreational values of urban wetlands [125,133].

However, despite the findings in the existing studies, further research is needed to understand the parameters affecting the recreational values offered by urban wetlands as some studies argue about the inefficiency of applying specific approaches, such as travel cost methods. Moreover, since wetlands offer diverse recreations for people, wetlands can provide well-being and healthier living environments due to the emergence of mega-cities.

8.5. Urban Wetlands and Social Perceptions

The reviewed studies frequently used a questionnaire for evaluating people's perceptions about wetlands. However, the number of articles that used questionnaires to study water bodies is limited compared to the studies that assessed green spaces, such as forests and parks. To this end, there is a great opportunity for conducting questionnaire-based studies for water bodies.

The perception factors used in the studies provide a platform for natural resource managers and urban planners to improve urban wetland accessibility, visitor experience, and perception of safety for all users [157]. The reviewed articles reported that specific characteristics of wetlands, including water quality, transparency, and color of water, presence, the appearance of aquatic vegetation, and the presence of sediment in aquatic habitats, affect peoples' perceptions [55,141,150].

Visitors of urban forests and natural wetlands paid more attention to the opportunity to experience nature, their sense of the place, and place attachment. The visitors of constructed wetlands paid more attention to the quality or a particular activity [147]. Moreover, the studies also found that personal factors, such as peoples' gender and their experience with wetlands were more influential than environmental and social factors, such as the locations and recreational opportunities offered by wetlands. For example, females had more fear of spending their leisure time in places with crime(s) [149].

Due to the importance of peoples' social perception of wetlands in urban areas, there is a great need for further research. Hence, the studies in the literature suggest exploring the following research questions:

(i) How can a better understanding of urban wetlands' social values and perceptions help decision-makers achieve their social and environmental management goals? [149].
(ii) What educational and interpretation programs are useful to increase the tendency for sustainable management of wetlands through wetland rehabilitation projects? [150].
(iii) How can improving wetland conservation management by linking natural science (vulnerability assessment) with social sciences (understanding ecosystem services) help to improve the social perception of urban wetlands? [151].
(iv) How does identifying the value of cultural ecosystem services that enable increasing urban wetlands' values help in understanding social perceptions? [154].

Exploring these research questions requires considering the social perceptions about urban wetlands. To improve people's perception of wetlands and increase public awareness about the importance of wetlands and their ecosystem services, there is the need for an efficient management strategy that involves individuals and all relevant stakeholders [149]. Furthermore, wetlands should be considered as important resources that offer tangible benefits for the economy, biodiversity, and local communities.

The management, policies, educational programs, and urban planning should integrate these natural resources into the urban environment [154]. Further research is needed to realize the causes affecting people's perception of urban wetlands and further illustrate the linkage between the perception and wetlands. More research on the topic would enable efficient management strategies and urban planning alongside the increase of urbanization, thus, supporting livable cities.

9. Discussion and Conclusions

Wetlands offer a wide range of ecosystem services. In urban areas, wetlands offer many benefits, such as cooling the urban environment, providing habitats for wildlife, recreational opportunities, water quality improvement, and mitigation for urban areas to cope with the effects of climate change. Wetlands located in urban and peri-urban areas, especially, play an important role in urban sustainability by providing valuable services. However, urban wetlands are usually not included in urban planning decisions, which often leads to weak governance. Urban wetlands need protection, restoration, and management to maintain the valuable services they provide.

Urban wetlands are more vulnerable to human intervention and destruction than any other ecosystem. The main drivers of the destruction and extinction of urban wetlands include population growth, uncontrolled urban construction, eutrophication, contamination, land conversion, drainage, changed water regime, over-exploitation, and biodiversity loss due to invasive alien species. It is estimated that climate change has led to the extinction and destruction of many wetlands, reducing their species and increasing the growing pressure on wetland ecosystems. Thus, growing pressures will reduce the functionality of wetlands to mitigate the effects of climate change and result in further reductions in human well-being.

In addition, the potential and help of stakeholders and individual citizens or groups of volunteers interested in cooperating in the development and maintenance of water environments bring innumerable ecological and social benefits to the urban environment. In the same way, with the help of academics, stakeholders, and local actors, governments conduct appropriate decisions and implement nature-based solutions to solve the intense environmental, economic, and social problems sourced from grand challenges, such as those posed by climate change.

In conclusion, urban wetlands should be managed sustainably by involving individuals and all relevant stakeholders as well as increasing public awareness about the importance of wetlands and their ecosystem services and benefits. In addition, policies, urban planning, and management should consider wetlands as blue infrastructures and integrate wetlands into the urban environment as they offer tangible benefits for the economy, biodiversity, and local communities. In short, policies should support and improve urban wetlands since they play an essential role in achieving sustainability in cities.

In this article, we reviewed the theoretical background of wetlands in urban areas, i.e., constructed wetlands and their relations to ecosystems values offered for urban environments and inhabitants. These values included the *sustainability*, *biodiversity*, *urban heat islands*, *social perception*, and *recreation* benefits offered to people in cities.

We systematically evaluated the role of wetlands in an urban environment. Specifically, for each study, we reviewed the objectives, methodologies, and findings. Moreover, we summarized the critical research gaps addressed in the reviewed articles, highlighted the significant open research challenges, and addressed future research directions in this field of study. For example, as potential research directions, we found less research on the consideration of wetlands in urban planning decisions and using this green-blue infrastructure as a solution to adapt to climate change, both of which are important for understanding the impact of urban wetlands.

As future works, we plan to explore improving the condition of wetlands by assessing resident perceptions of urban wetlands. To this end, we plan to collect questionnaire-based data from residents of a district in Helsinki regarding the functionalities of urban wetlands and propose approaches for planning and redesigning an old pond as a new urban wetland. We also plan to study the history of urban wetlands in Helsinki for almost the past century and evaluate their functions and services to learn lessons about the parameters sustaining these wetlands. In addition, we aim to identify the existing policies for maintaining wetlands in urban areas and propose methods and practices for improving these policies and decision-making.

Author Contributions: S.A. was involved in conceptualization, planning and writing the manuscript, designing the layout and the structure, editing and revising the manuscript. P.N. helped in conceptualization, supervised, edited and revised the manuscript. A.O. co-supervised, reviewed and revised the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The authors would like to thank the library of the University of Helsinki (HULib) for supporting the article processing charge of this article.

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

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