sustainability

MDPI

Review

Human–River Encounter Sites: Looking for Harmony between Humans and Nature in Cities

Aude Zingraff-Hamed [1,2,*], Mathieu Bonnefond [2,3], Sebastien Bonthoux [2,4], Nicolas Legay [2,4], Sabine Greulich [2], Amélie Robert [2], Vincent Rotgé [2,5], José Serrano [2,5], Yixin Cao [2], Raita Bala [5], Alvin Vazha [2], Rebecca E. Tharme [6,7] and Karl M. Wantzen [2,8]

1 Strategic Landscape Planning and Management, Center of Life and Food Sciences Weihenstephan, Technical University of Munich, Emil-Ramann-Str. 6, 85354 Freising, Germany
2 Interdisciplinary Research Center Cities, Territories, Environment and Society (UMR CNRS 7324 CITERES), University of Tours, 37204 Tours, France; mathieu.bonnefond@univ-tours.fr (M.B.); sebastien.bonthoux@insa-cvl.fr (S.B.); nicolas.legay@insa-cvl.fr (N.L.); greulich@univ-tours.fr (S.G.); amelie.robert@univ-tours.fr (A.R.); vincent.rotge@univ-tours.fr (V.R.); jose.serrano@univ-tours.fr (J.S.); yixin.cao@etu.univ-tours.fr (Y.C.); alvinvmanuel@gmail.com (A.V.); karl.wantzen@univ-tours.f (K.M.W.)
3 Conservatoire National des Arts et Métiers/National Conservatory of Arts and Crafts, EA 4630 GεF–Laboratoire Géomatique et Foncier/Geomatic and Land Tenure Laboratory, 292 rue St Martin, 75003 Paris, France
4 INSA Centre Val de Loire, Campus de Blois, 3 Rue de la Chocolaterie, 41000 Blois, France
5 POLYTECH Tours, 64 Avenue Jean Portalis, 37200 Tours, France; raitabl@gmail.com
6 LE STUDIUM Loire Valley Institute for Advanced Studies, Orléans & Tours, and CITERES, CNRS, University of Tours, 37204 Tours, France; rebeccatharme@riverfutures.com
7 Riverfutures, Cressbrook, Derbyshire SK17 8SA, UK
8 Chair of Applied Aquatic Ecology and UNESCO Chair "River Culture-Fleuves et Patrimoine", CNRS UMR CITERES, University of Tours, 37000 Tours, France
* Correspondence: aude.zingraff-hamed@tum.de; Tel.: +49-8161-71-4671

Citation: Zingraff-Hamed, A.; Bonnefond, M.; Bonthoux, S.; Legay, N.; Greulich, S.; Robert, A.; Rotgé, V.; Serrano, J.; Cao, Y.; Bala, R.; et al. Human–River Encounter Sites: Looking for Harmony between Humans and Nature in Cities. *Sustainability* **2021**, *13*, 2864. https://doi.org/10.3390/su13052864

Academic Editors: Isabel Banos-González, Julia Martínez-Fernández and Hossein Bonakdari

Received: 28 December 2020
Accepted: 3 March 2021
Published: 6 March 2021

Abstract: Human welfare depends on the health of nature. Decades of ill-conceived management practices caused a decline in the quality of human life, as well as in biological and cultural diversity. Simultaneously, they increased social and ecological risks. For instance, mismanagement of urban rivers jeopardizes their ecological health and ability to provide ecosystem services. While demands for responsible urban riverscape design that fulfill both human and ecosystem needs are increasing, explicit recommendations to achieve these ambitious goals are still lacking. We present a first attempt of a conceptualization of Human–River Encounter Sites for urban rivers that targets reconciliation between humans and nature within urban river corridors. It builds upon the River Culture Concept with literature reviews and experiences from river restoration projects. We identify six tenets that are important to develop guidelines for Human–River Encounter Sites: health, safety, functionality, accessibility, collaboration, and awareness. This paper presents how these tenets can collectively help to harmonize the needs of citizens and biota, and to mitigate the current urban river crisis. This contribution feeds the debate on sustainable socio-ecological management of urban rivers and provides guidelines for the implementation of future urban river restorations and management efforts.

Keywords: urban river; socio-ecological system; river culture; human–river relationship; river restoration

1. Introduction

Rivers are mirrors of societies [1]. Riverscapes deliver to people a broad range of ecosystem services (ES) [2,3] including freshwater, building material, and food. They also regulate our environment through, for example, air and water purification, and climate and flood regulation. Cultural services, such as recreational, spiritual, educational, and therapeutic activities, are also diverse [4]. In acknowledging their significance, the role and exploitation of these contributions of rivers to human development and well-being are increasingly taken into account in political agendas across the world, including decision-making processes and planning strategies [2,5]. Historically, the management of riverscapes greatly emphasized resource exploitation. This has led to increasing environmental stressors and a decreasing resilience in riverine ecosystems thereby jeopardizing their life support functions [4]. As a result, many rivers are in a critical state worldwide while their ecosystem services are altered [6]. In this sense, it may be stated that rivers and humans have intertwined destinies. Thus, a global study on freshwater management showed that human water security and river biodiversity have been both negatively impacted over the last decades by the stressors responsible for eco-hydrological and morphological alterations [5].

Worldwide urbanization has greatly accelerated this process. Thus, urban rivers, namely river sections crossing large cities [7], have experienced pressures which in some parts of the world have increased in frequency and magnitude [8]. Over half of the world's population already lives within three kilometers from a surface water body [9]. In 2018, 55% of the world's population lived in urban areas, and by 2050, this will increase to 68% [10], especially in the Global South. Urbanization has already led to the dramatic loss and degradation of natural areas. In many instances, entire ecosystems or major habitats have been severely encroached on or even completely converted into built-up or artificial urban land [11,12]. Effects of urbanization on freshwater systems have been explained as an "urban stream syndrome", where urbanization results in, among other negative impacts, flashier stream and river hydrographs, elevated concentrations of nutrients and other pollutants, and reduced biotic richness [13]. More recently, the urban stream syndrome has been expanded to an urban hydro-system syndrome [8] that encompasses both the ecological challenges of the river–floodplain system and the complex social and administrative conflicts of interests that accompany any attempt to mitigate them.

Urban rivers are socio-ecological systems [14,15] since human cultures are inextricably linked to the ecological states of rivers [4], and river degradations cause loss of ecosystem services [4]. Centuries of urban planning traditionally focused on exploiting river ecosystem services, and fighting against flood risks neglected other socio-ecological interactions [16]. There is a large variety of socio-ecological interactions between humans and rivers throughout human history; however, observations made in many places allow us to make some generalizations. In ancient times, river-system planning was a basis for building a city. With rapid population growth and increasing hydro-morphological changes, in the 20th century, urban rivers were in many parts of the world, as in Europe, North and South America, and also in China, only perceived as hazardous and unpleasant and often associated with disease and flooding, and any remaining natural flood terraces, riparian zones, and wetlands were considered unsafe and became abandoned wastelands [17]. Consequently, in many European cities for example, rivers were buried or diverted to avoid risks, but these measures also removed most traces of cultural relationships between the city and the river. Massive water pollution, which began with industrialization and intensive economic growth in the Global North, and is now also pervasive in the Global South has had (and continues to have) high social, economic, and environmental costs [18]. In 2017, over 80% of all wastewater worldwide was still returned to the environment without being treated, and most forms of pollution are projected to rise in all regions of the world, which puts human health at risk [18] and further triggers negative human perceptions of rivers as dirty, unattractive environments, and sources of foul odors and diseases [8]. In China, precise definitions and standards are given to the term "urban black-odorous water bodies", which exist widely in rivers and lakes [19]. Finally, public awareness, including public knowledge and understanding of riverine ecosystems, and knowledge of wildlife have been gradually lost.

Increasingly, the recognition of this loss has led societies to acknowledge that essential ecosystem services, notably freshwater provisioning, and amenities strongly depend on river health and resilience. This in turn makes it necessary to adapt ecosystem management accordingly. Against this backdrop, ecosystem restoration has been gaining ground as an appropriate solution for improving the chemical, biological, and hydro-morphological quality of degraded water bodies [20]. In some parts of the world, supportive policies have also evolved that have encouraged river restoration and provided essential regulatory support, such as the Water Framework Directive in the European Union [21]. Unfortunately, while the restoration of urban rivers is urgently needed, the implementation of restoration measures in urban areas is significantly constrained by the physical lack of suitable space and the oftentimes poor condition of natural ecosystem attributes and dynamics [22]. These "domesticated" ecosystems [23] might appear so disturbed that full recovery of historically good ecological quality is impossible. For instance, European urban rivers are often classed as Heavily Modified or Artificial Water Bodies that are so substantially changed in character that it is assumed that they cannot meet a "good ecological status" [21]. It must be noted that river restoration projects in urban contexts usually include additional objectives, such as creating recreational and leisure environments [7,24].

Against this background, the main purpose of this paper is to contribute to a new agenda for decision-makers and specialists toward restoring a healthy relationship between rivers and urban inhabitants. Specifically, it aims to develop a comprehensive approach to conserve nature in urban corridors, which in cities are among the last urban areas that include natural habitats and tracts of unbuilt land. It takes the approach that the conservation of "ordinary nature" necessitates an ecology of reconciliation and, hence, the involvement of local communities [25]. Moving a step further, it acknowledges that taking ordinary nature into account draws into the fundamental man/nature relationship [26].

To achieve such objectives, this paper advocates to create occasions and space for humans in cities to experience riverine ecosystems so humans can develop positive feelings for these ecosystems and, at the same time, to improve the ecology and functionality of urban rivers. Our suggestion is the creation of Human–River Encounter Sites (HRES) based on a multi-disciplinary approach that embraces the contributions of both life sciences and social sciences. HRES are meant to be an operational model to re-establish a relationship that reconciles human activities with ecological dynamics. The principle of HRES is produced by a multidisciplinary team of researchers, and the proposed model of Human–River Encounter Sites is generic. It sets a framework for the world's rivers and is flexible so that it can be adapted to local contexts.

This paper has three main objectives: (i) to present the conceptual rationale for HRES, (ii) to provide practical recommendations on how to use these principles as a guide for the establishment of such sites, and (iii) to inspire more socio-ecological river restorations and management in urban contexts to better reconciliate humans and nature.

The model was developed by integrating existing socio-ecological approaches, examples from urban restoration projects in different parts of the world, and a review of elements contributing human well-being and riverine ecosystem integrity. This publication is, however, not a systematic literature review.

2. A Conceptual Basis for Urban Human–River Encounter Sites (HRES)

The principle of HRES is built on the central themes of the River Culture Concept [4], as well as on long-term knowledge and case study site observations (Figure 1), including knowledge from the literature. It differs from the concepts of waterfront and riverside since it applies the socio-ecological concept and does not give priority to human development. Strongly based on scientific observation and following the socio-ecological approach [27,28], the concept of "River Culture" [4] is based on the principles that river biological and cultural diversity are affected by the same driving forces and consequently, the welfare of human beings is intimately linked to the ecological quality of their environment. "River Culture" describes sustainable management of riverscapes based on the combination of learning from natural adaptive mechanisms and human use practices that respect the maintenance of ecosystem functions. It also considers the improved valuation of the river by (re-)establishing emotional or spiritual linkages. It recognizes that protecting and restoring biological diversity and ecosystem function in river–floodplain systems is likely to improve the cultural diversity linked to the river. Urban rivers (or sections of them) are HRES when they ensure the realization of co-benefits for people and nature and the coexistence of biological and cultural diversity. As the definition of a HRES is generic, it has the potential for being applied across the entire spectrum of river and society types, without limitations due to governance and management systems or hydro-morphological settings.

The conceptual basis of HRES is founded on six main tenets: health, safety, functionality, accessibility, collaboration, and awareness (Figure 2). These tenets should be seen as a preliminary set and should stimulate discussion at the levels of scientific research and practical implementation. For each tenet, we provide a description below in terms of its central importance in the context of HRES, an integrative review of its conceptual underpinnings in the natural and social sciences, selected applied examples, and recommendations for its implementation in attempt to establish HRES.

Figure 1. Cases supporting the definition of Human–River Encounter Sites.

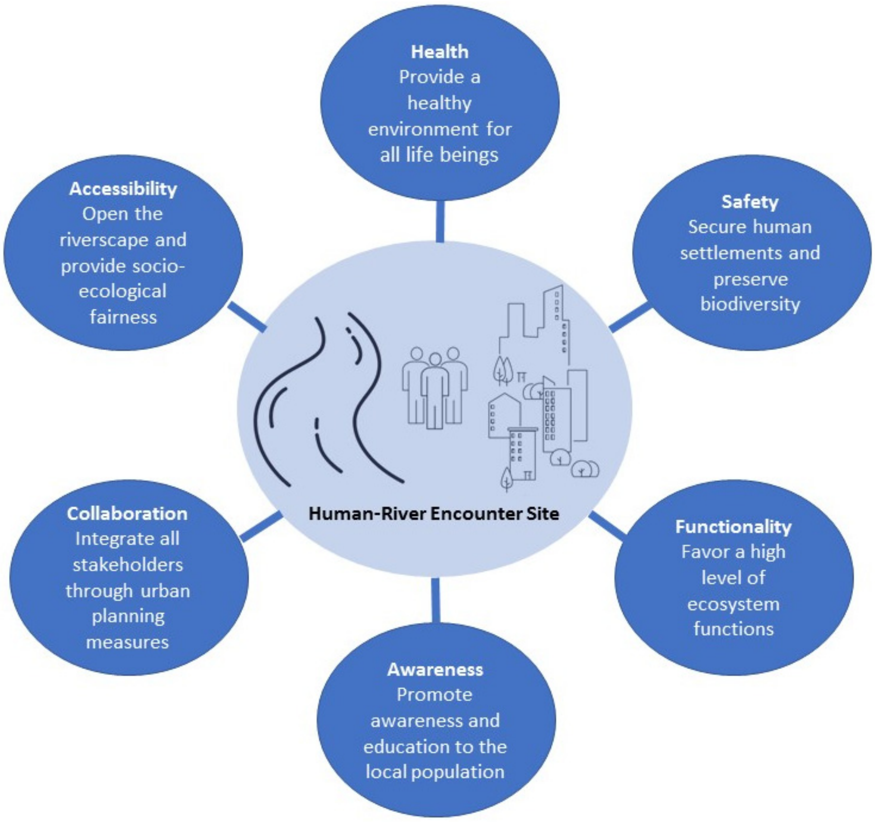

Figure 2. Tenets for the implementation of urban Human–River Encounter Sites.

2.1. Tenet 1—Health: Provide a Healthy Environment for All Living Beings

Any HRES should be able to provide a healthy environment for all living beings as a primary goal. In the preamble of the constitution of the World Health Organization (WHO) (1946), human health is defined as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Social scientists have since suggested to more explicitly include psychosocial well-being and a spiritual dimension of health [29]. In our article, the welfare of human beings and the quality of life of other beings (animals and plants), and the ecosystems which underpin them, are considered as non-dissociable. This is consistent with the view of an increasing number of scholars that nature, e.g., biodiversity, ecosystem services, and humans, e.g., human health and well-being, are all interdependent, e.g., [30–32]. The link between healthy wetlands and the well-being of neighboring human communities is emphasized, for example, in a joint report by Ramsar Convention on Wetlands and the WHO [33].

Defining river health is more complex than defining human health, since not only one type of organism with its specific needs is involved, but a whole ecosystem comprising abiotic parameters, ecological processes, multiple organisms, and a network of complex interactions. Since the 1990s, approaches to evaluate river health have taken into account physical, chemical, and biological aspects e.g., [34]. For instance, Karr [35] defined an environment as healthy when the supply of goods and services required by both human and non-human residents is sustained. From this point of view, river health is arguably especially impacted and further at risk in urbanized areas. The survival of many plant and animal species is at stake in urban environments after decades, if not centuries, of river channel modification, water abstraction, pollution, and increased impervious surface area, all of which have already contributed to biodiversity declines e.g., [8,36]. Especially, in the Global South but also in many cases in the Global North, rivers are unhealthy due to water pollution as a result of fast urban growth and insufficient sewage and solid waste treatment [8]. In this regard, a variety of environmentally sustainable municipal wastewater treatment measures should be considered to help maintain the health of the river in urban areas, such as the microalgal-bacterial granular sludge process [37,38]. Furthermore, by regulating the temperature, this process helps in the improvement of wastewater quality by reducing the maximum amount of chemical oxygen demand and phosphorus in the water.

Morphological and flow restoration examples aimed at improving river health are numerous [7], but even if physical habitats are fitting to species needs, the chemical quality of the water bodies is often insufficient [36], especially in the Global South [8]. In the European Union, water quality has generally improved, due to the implementation of the Water Framework Directive (WFD) [39], but at a high cost [18]. Furthermore, even after 20 years of implementation of this directive, 60% of European water bodies have not yet achieved good ecological status, and 56% are under pressure from point source or diffuse pollution [40]. Furthermore, while the hydro-morphological status of European rivers has improved slightly since 2000, this remains the second most important pressure (40%) on water bodies [40] after chemical pollution. Finally, other pressures that are less-studied impact fauna and flora. For instance, impact of light in cities has a strongly negative impact on biota, especially on the emergence of aquatic insects. Nocturnal birds can be disturbed or killed by nocturnal illumination, but this factor has not been sufficiently considered at present [41].

The linkage between human health and environmental quality of urban ecosystems has been increasingly investigated over the last few years [42]. Despite the extreme adaptability of human beings to different environments, there are clearly identified factors that have negative (e.g., noise, dust, and heat) or positive (e.g., green space, aesthetics, and recreation) influence on physical and psychological human health in urban environments. People in urban areas are particularly exposed to so-called "civilization diseases" [43] or are increasingly exposed to "environmental" and other non-communicable diseases [44]. Recent studies examine the potential mechanisms behind the physical and mental health benefits gained from natural surroundings and green spaces in urban contexts [45,46]. The "therapeutic landscapes" approach [47] uses the benefits of natural surroundings for physical, mental, or spiritual healing [48]. Overall, natural sceneries that are often perceived as more complex than man-made environments induce a "soft" fascination to many people, refocus effortless attention, and promote psychological restoration [42]. Emerging stressors for human health can also be mitigated by incorporating more space for nature in cities. As one example, public space with intensive greening and tree cover plays an important role by cooling the city climate [49]. Several studies more specifically investigate "blue space" as a new color in therapeutic landscapes [50], since views and sounds of water reduce stress [50] and are relaxing [51]. Still water has been found to be associated with the feeling of peace, and moving water with enthusiasm, energy, and excitement [52]. However, apart from such beneficial effects, urban riverine habitats may also have negative impacts on human health. Polluted waters carry the risk of direct poisoning through contact or consumption, or eutrophication may introduce collateral, negative effects of waterborne diseases [53,54]. Additionally, poorly restored riparian habitats are often rapidly invaded by plants possessing toxic or allergenic properties, e.g., *Ambrosia*.

In the context of HRES, hydro-morphological restoration that allows more natural processes to occur and enables views of and contact with the water is recommended to reduce stressors for humans and improve ecosystem health. However, before establishing a HRES safe for human recreational use, the quality characteristics necessary to secure human and environmental health, including water quality, natural flow patterns, and hydrological connectivity between floodplain water bodies and the mainstream of the river, should be provided.

2.2. Tenet 2—Safety: Secure Human Settlements and Conserve Biodiversity

The creation of HRES in cities includes the apparently paradoxical task of reconciling the intrinsically dynamic nature of rivers with the human demand for stability (e.g., in water supply) and protection from floods. A HRES should allow for flooding processes to occur as naturally as feasible within a certain scale and alleviate existing flooding risk for the inhabitants. We define flood safety as securing human settlements in a responsible way that makes the best possible use of the potential of nature without inhibiting the magnitude and pattern of high flow events which are known to support essential ecosystem functions and services [4]. A key challenge when working on city–water interfaces is to combine ecological dynamics, urban hydraulics, and waterscape scenery in a coherent manner [55,56].

Riparian zones are naturally subject to flooding as a result of seasonal hydrological patterns. The natural flow regime [57] maintains habitat dynamics, the biodiversity of riverbanks, floodplains and estuaries, as well as ecosystem functions, such as sediment transport and nutrient assimilation [58]. In river–floodplain systems, cyclical disturbance and vegetation successions result in a shifting mosaic of diverse habitats. Moreover, the timing of a flood (as well as a low flow event) is important for the lifecycles of many aquatic and floodplain organisms. Traditional engineering methods for the mitigation of flood risk and prevention of flooding alter these spatio-temporal dynamics, resulting in biodiversity decline, disruption of ecosystem functions, modification of riparian community composition from wetland to terrestrial species [59], and increased dominance of non-native species over native species [60].

Most cities located on or near rivers are subject to flood risk, especially in instances where it was believed that built infrastructure, notably dikes (levees) and flood control dams, could control flooding (e.g., as in the 1950s to 1990s in much of Europe). Recent climate change events, however, show that many cities are in underestimated flood risk zones [61], such as the city of Mumbai [62], and increasingly, reinsurance companies decline to insure buildings in high risk areas [63]. The study of long-term hydrology, hydrodynamics, and the inclusion of the potential effects of climate change to address hydrological stochasticity have become the baseline of many urban river development projects. In the past, hydraulic and hydrodynamic modelling were limited, and urban development practices tended to be largely reliant on grey infrastructure to prevent flooding. This led to the disproportionate use of hard engineering options, such as tall dikes and complete deforestation of riparian floodplains upstream of and within cities. Recent two and three dimensional approaches allow more realistic assessments of flood risk, including the influence of vegetation and sediment dynamics on flow patterns [64], and resilience in flood-prone areas [65]. These approaches have increasingly enabled the reintroduction of dynamic riverine landscapes in the urban spaces, including uninformed configurations of green infrastructures which are also labeled "nature-based solutions" (NBS) e.g., [66,67].

A number of good examples of NBS exist [68]. In the past years, flood expansion areas have become a part of strategies for resilient urban planning [69,70]. Going beyond hard engineering flood protection, these strategies place emphasis on diversified risk management with the transition from a "vertical" strategy (dike) to a more "horizontal" approach (e.g., near-natural wetland for flood detention) that makes space for the river in the city [71]. For instance, the new submersible neighborhood on the former Matra industrial site along the Sauldre at Romorantin-Lanthenay (France) was created to contain the floods. In particular, an increase of mitigation projects that have already proved themselves as robust, resilient, sustainable, and cost-effective solutions have been documented [72]. They include parks with temporarily flooded pastures, wet meadows, or recreational zones, e.g., [73]. In addition to flood risk mitigation, river restoration projects may boost natural habitats and high quality biodiversity. In the case of the re-established meander loop of Norfolk River Wensum (England), for instance, 31 aquatic plant species, and target fish species, such as bullhead and brown trout, were observed within one year after restoration [74]. On the contrary, "grey solutions", such as the gigantic tanks built to protect Rio de Janeiro, Brazil, from floods during the 2016 Olympic Games [75], have shown limited success in flood mitigation, while yielding no benefits for or even negative effects on biodiversity. Options such as the re-vegetation of previously wholly impervious surfaces, the construction of rain gardens around stormwater drains, the strategic restoration and construction of wetlands to increase overall infiltration capacity, and the use of natural wetland areas to temporarily store excess water during rains and floods are increasingly being considered by planners [76]. One example is the Green Roof Initiative in Rotterdam, Netherlands [77]. However, large-scale implementation of NBS is rare. One example is the Sponge City Program in China composed of 30 pilot cities, including Wuhan, Beijing, Tianjin, and Shanghai [78,79]. The number of sponge cities was increased to more than 370 in 2020. Three main approaches were applied: water filtration, infiltration and collection, and storage or use [80]. Results for the city of Fuzhou, for example, show that flood storage capacity increased by 950,000 m^3, water quality of 102 urban rivers and streams were improved, and more than 400 km of riverfront greenways and 168 green parks were created [81].

Urban multiple-use river floodplains and other wetlands such as HRES need to reflect a balance of nature-based and engineered solutions. When designing new urban settlements, planners and decision-makers should allow sufficient non-built land to accommodate potential floods. Current changes in urban mobility from individual to shared cars may offer opportunities to use riverside parking grounds that will become obsolete in the future. In already built-up, or "mature" urban settlements, especially in flood-prone areas, over-densification should be stopped. In addition, whenever possible, land should be reclaimed and "de-artificialized", and land use should enable ecosystem processes.

2.3. Tenet 3—Functionality: Target a High Level of Ecosystem Functions

Achieving a high degree of ecosystem functionality for both humans and other living organisms should be a central objective for planning HRES. Ecosystem functions (EF) depend on river biophysical characteristics and the processes triggered by interacting components [82]. While ecosystem services are the benefits that human societies obtain from ecosystems, ecosystem functions include ecosystem processes or processes that support biota. These are functions that are not attributable to ecosystem services and are vital for maintaining the biodiversity and the health of ecosystems and thus, their resilience to cope with environmental and societal change.

River–floodplain systems extend across a range of habitats, from scarcely vegetated sediment banks, shrublands to several types of floodplain forest, and shallow, slow-flowing or standing backwaters. They are of great value to society, such as in the case of agricultural land. Besides the provision and regulation services, they provide cultural, educational, recreational, and scenic value to humans [2]. Rivers attracted the first human settlements and are consequently the scene of many archaeological and historical sites [4]. River corridors are culture and language propagation axes [83]. Due to their provisioning services, such as timber and food, rivers have been drivers of economic development. However, river degradation to exploit ES caused dysfunction of the ecosystem and ES losses.

However, many urban restoration projects focus on form rather than functions. They aim for greening the floodplain by creating parks to increase recreational potential without restoring near-natural riparian and floodplain areas and processes. Restoration results are then limited, and sensitive native species may not re-establish [84]. Furthermore, cultural ecosystem services in cities, including recreation, while performing important societal functions, may conflict with other ecosystem functions, such as support of functional habitats for sensitive species. For example, urban river restoration may recreate habitats for endangered species but intense recreational use may jeopardize recovery potential [85]. Still, the attempt is valuable and should be combined with user management and public education. In fact, near-natural urban floodplains are valuable in providing the "wilderness experience" needed to leverage nature conservation and empathy for nature.

In the case of HRES, the river and its floodplain should provide sufficient, suitable habitats to support a high proportion of self-sustaining native biodiversity and ecosystem processes. These habitats require the re-establishment of: (1) more natural water and sediment dynamics, (2) space for floodplains and river channels to remain active and as unconfined as possible, and (3) connectivity between the mainstream of the river and the floodplain. While the first requirement can only be fulfilled including a river basin scale management strategy, the last two concern the management of urban space. A HRES should be designed to maximize the benefits and reduce the negative tradeoffs between ecosystem functions and optimal service provisioning described above. This may be possible, on the one hand, by recreating, or allowing near natural and typical floodplain habitats and, on the other, by integrating different types of responsible socio-economic uses [8,84].

2.4. Tenet 4—Accessibility: Open up the Riverscape and Ensure Socio-Ecological Fairness

A HRES should ensure socio-ecological fairness, meaning that it should be accessible for all living organisms. Accessibility for humans can be defined as making space equally usable, by paying attention to the needs of poor, disadvantaged, and marginalized groups [86], as well as eliminating the restrictions created by closed private properties or transport limitations. However, human accessibility should not mean a decrease in the accessibility for other biota, especially those depending on the riverine ecosystem.

International treaties, conventions, and directives such as the Migratory Bird Treaty Act of 1918, the Marine Mammal Protection Act, the Convention on Migratory Species, the European Birds Directive, and the European Habitats Directive intend to insure that biota have accessibility to ecosystems [87]. However, biota migration processes are further impaired by the destruction and fragmentation of habitats by localized human activities [88] or by increased mortality rates along migration corridors [89]. In the European Union, despite the goals of the Water Framework Directive, more than one million barriers hinder fish migration in rivers [40], and most urban river mouths, estuaries, and deltas have groundsills. Similar conditions prevail in North America. In the Global South, no attempts have yet been made to assess and quantify the impacts by smaller dams, culverts, etc., which are most common in cities. Cities represent hydraulic, chemical, thermal, acoustic, and optical barriers to access for instream and riverine biota. This is a critical issue not only for species conservation, but also because of the great cultural and economic importance of animal migrations for cities [8]. Civil society may also have an important role in nature conservation efforts as public interest in migratory species is strong. For instance, many tour companies and town festivals profit from faunal river migrations [89]. Public pressure can lead to changes in conservation laws on wildlife migration, such as the Migratory Bird Treaty Act [90] and lobbying for the implementation of socio-ecological resilient waterscapes [91].

As defined in the preamble of the European Landscape Convention [92], landscape is "our common heritage, contributes to the formation of local cultures, and consolidates the individual and social identity". Thus, the riverine area including shores and banks should be accessible for all socio-demographic and minority groups, in terms of age, gender, origin, race, and reduced mobility, to ensure equity, equality, and inclusion. The gentrification processes commonly occurring in European urban areas, and slum development in the emerging countries, may hamper this.

Creating green areas along rivers to provide recreational spaces and ensure biodiversity corridors is clearly desirable. However, it is important not to confound these two objectives, which are not necessarily the same and may even occasionally be in conflict [85]. Several options exist to balance accessibility for humans and biota. For example, it is advisable to establish better protected nature reserves upstream and downstream from the city, as well as well-protected steppingstones within the city, so that the ecological connectivity is assured. Within the city, the accessibility to the most sensitive habitats can be reduced, whereas other similar, but less sensitive habitats can be made easier to reach. Public education also plays an important role. Increased habitat connectivity may also have inconveniences although rare. One such example is that of invasive species [93].

Ecological restoration efforts intend to restore the habitats and erase migration and dispersal barriers along the entire river catchment [94]. Consequently, it is important to integrate the urban matrix into large scale ecological corridor concepts, to avoid gene flow disruption [95], or disbalance of biocenosis by negative selection on migratory species [96].

For HRES, all aspects of accessibility to public spaces should be considered and different types of pathways should be available to fit to all types of users. Informational signage and other guidance elements have to be put in place to provide information about river and floodplain areas and restricted or prohibited activities, to protect both people and the environment.

2.5. Tenet 5—Collaboration: Integrate All Stakeholders through Urban Planning Measures

A key component of the HRES concept is collaborative planning. The interplay of stakeholders concerned with urban river restoration is complex and varies considerably between sites. While reshaping urban riverine areas requires a strong mandate by the local municipality, initiatives for HRES projects may follow different approaches.

A top-down approach is a result of strongly directed control from the political administration. Often, a political enabler or "local champion" [97] carries out the project and their career success depends on the project outcomes. For example, in Frankfurt am Main, Germany, during the 1980s, the city mayor launched an initiative "Back to the River!" that entailed repositioning the facades of buildings to face the river, and redefining urban space as riverine green space. Today, the city has reclaimed its identity that is characterized by the Main River, which has become an important element of the sense of place. A recent example is the national policy of the River Chief System in China, issued in 2016, where the River Chiefs are responsible for the management of all rivers and lakes under their jurisdiction and empowered to facilitate cross-departmental cooperation. Although it is new, the policy has already proved to be efficient in river pollution control [8].

In bottom-up approaches, advocacy groups drive urban planning projects. The entities that drive the projects reflect the diverse customs, values, worldviews, and social behaviors of local society [97]. For example, in the Isar River case, civil society pressured the local government to transform an ongoing flood risk mitigation project that was employing hard engineering into a nature-based solution to fit all interest groups involved in the planning process [98]. A famous example from the Global South for bottom-up river restoration is the "Manuelzão" project in Belo Horizonte, Brazil, which was originally initiated as a health care action project to reduce water borne diseases [8].

An intermediate approach combines the valuation of ecosystem services and real estate prices [8]. For example, the restoration of the Gudbrandsdalen River in Lillehammer (Norway) was a result of an in-depth investigation of the most cost-effective and sustainable solutions. Many restorations aim to identify solutions with the best economic returns [99] instead of also considering non-monetary benefits [100]. Civic ecology has a social dimension and it can directly generate cultural ecosystems services, such as recreation and education [101]. The involvement of urban inhabitants in ecosystem stewardship provides a sense of community and creates the clear expectation that inhabitants should care for ecosystems [102].

Interactive collaborative processes, such as living laboratories, are becoming more popular and enable the inclusion of all relevant stakeholders into the planning process [103–105]. The process of the co-design of a solution by a network of private, governmental, technical, and scientific partners enables the creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts [106]. Furthermore, solution co-design by all stakeholders promotes a collective feeling of ownership of the solution and the willingness to fund supporting measures. Processes for HRES creation must efficiently integrate the values, views, and needs of the numerous stakeholders to identify, and as much as possible, resolve trade-offs among them. It is important that this process is iterative, with several rounds of planning and decision making, as sustainable development plans need time to mature [8,107].

2.6. Tenet 6—Awareness: Promote Awareness and Education among the Local Population

Human–River Encounter Sites offer the opportunity to re-establish human–river relationships and to leverage care and empathy for nature. Therefore, they can play an important role in environmental education.

The positive emotional connection that is created between individuals or groups and geographic locations and their characteristics (sense of place), is developed through affective, cognitive, and behavioral processes [108]. A similar feeling-link sentiment between a person and environment is *topophilia*, which describes the emotional bond between people and place or setting [109]. However, memory decay and vanishing experiences of encounters with nature are issues of great concern today, particularly considering that children tend to spend significantly less time outdoors than they did in previous generations. Yet, childhood experience is critical for adulthood experience [110]. Moreover, in urban populations, direct and personal experiences of nature are rare [111]. As a consequence, since commitment to nature and biodiversity conservation is likely a function of the frequent and/or profound personal experiences people have of nature [112], the "extinction of experience" [113] could be a problem not only for the emotional and physical well-being of present populations, but also for nature conservation. Therefore, strategies and opportunities to actively observe and experience nature are needed [114].

In some countries, and more commonly in the Global South, the deterioration of human–river relationships is recent. As a result, public awareness of nature still remains and can be revived by bringing back the river as the main element of the urban fabric, as is the case with the Capibaribe Park project in the city of Recife, Brazil [8]. The recent improvement of water quality in the European Union has led to an impressive recovery of cultural and recreational uses of rivers, as shown by the Thames [115] and Rhine [116] rivers. In re-daylighting previously canalized urban streams in Zürich, Switzerland, water quality improvement played an important role in the acceptance of the restoration project by city residents [117]. Planning of residential areas along the Waal River in the Netherlands showed the need to consider local people's attachments to the river to understand their preferences for management practices [118]. In Wuhan, China, the Changjiang (Yangtze River) Civilization Museum was built in 2015 as a new landmark of the city for demonstrating artifacts and specimens related to the "mother river"–Yangtze civilization. Particularly, the need for creating narrative bonding with places has been underlined to develop the place identity and human–river relationship. Conversion of natural river structures into artificial canals still takes place, and often goes along with a neglect of traditional river practices and eviction of conventional river users.

The analyses of city residents' perception of the natural river features suggest potential congruencies between aesthetic judgment and ecosystem functions [119]. Using photomontages, Junker and Buchecker [120] found that in Switzerland, people's aesthetic preferences were positively associated with eco-morphological qualities of rivers, including flow variability, embankment structure, and the presence of a large amount of deadwood in the river channel. These results show that people seem to eschew "hard" engineering techniques for river management in favor of natural approaches that more effectively reconcile ecological and social objectives. However, cultural differences have also a strong influence on the definition of landscape attractiveness. For example, while German urban populations value more natural landscape forms, French urban populations prefer well-defined, geometrical forms [121]. Even within the same social group, some features, such as wooden logs or braided river channels, are perceived negatively or positively by different people [122]. However, some commonalities exist. For example, natural, organic shapes and pleasant sounds and smells receive positive attention [120].

People's positive perceptions can also be fostered by facilitating physical accessibility to urban rivers and by promoting recreational activities. Recreational interest is supported by various studies in different cultural and geographical contexts (i.e., Belgium, Turkey, southern China, Japan). Indeed, the value that residents assign to river areas increases after the conversion of this area into a space that favors multiple uses, such as walking, cycling, or quiet contemplation [123–126]. It has been demonstrated that such life experiences improve the ecological awareness in favor of river ecosystems [110].

The implementation of the HRES should go beyond the simple addition of informational signage for the public. The ecological quality, accessibility, and multi-functionality of a site should enable an in-situ experience with nature, as well as stimulating citizen awareness of ecological values and biodiversity. This can be done, for example, by creating observation points, pathways through different habitats, and designated areas for children to play and experience nature. This in-situ experience should be combined with education programs focused on the understanding of river systems. Indeed, students have often simplified visions of basic river ecology and the role of abiotic components, which can limit the understanding of sustainable management measures [127]. The process of emotional connection between restored riverscapes and local residents may take a long time and vary with the characteristics of users. It can be facilitated by maintaining transparency during the restoration process and establishing a common vision that combines ecological and social objectives.

3. Implications

The findings presented in this paper provide valuable insights for practice. Six interconnected tenets of the Human–River Encounter Sites concept can be used to guide efforts to maintain or restore rivers in urban settings for the benefits of both people and the environment: (i) provide a healthy environment for all living beings, (ii) secure human settlements in a responsible way while avoiding detrimental impacts to biological and cultural diversity, (iii) favor ecosystem-based management that achieves a high quality of ecosystem functions, (iv) make urban riverfronts fair and accessible to local populations as well as to biota to achieve greater socio-ecological balance, (v) reach out to all stakeholders, including those active in nature conservation and civil society, to reach a consensus on urban planning measures in achieving a fair balance between natural conservation and urban development requirements and objectives, and finally, (vi) promote in-situ education and empathy towards nature among the wider community to engage the public and leverage public awareness and concern for nature conservation. We identified some measures to serve as examples for implementing the Human–River Encounter Sites approach (Table 1).

Table 1. Examples of potential measures that can be implemented to create or enhance Human–River Encounter Sites (HRES) in urban environments and their various contributions to the principles that characterize these sites.

Measures for Potential Application for Urban HRES	Relative Contribution to the HRES Tenets						Impact
	Health	Safety	Functionality	Accessibility	Awareness	Participation	Temporal and Spatial Impact
Integrate HRES into a network strategy of urban green and blue spaces and pathways	+	+	+	+			Long-term, large scale
Establish "islands of natural noise" in the city for acoustic stress reduction	+		+		+		Short-term, local scale
Reduce optical stress by establishing adequate vegetation and building light-absorbing structures	+	+	+				Short-term, local scale
Adapt lighting techniques to avoid light trapping of phototactic insects while assuring citizen safety							Short-, middle-, and long-term, local scale
Integrate riparian corridors into climate change mitigation strategies	+	+		+	+		Long-term, large scale
Better integrate urban flood management into integrative river basin management (IRBM)		+	+			+	Middle to long-term, large scale
Increase water storage capacity within natural areas		+	+		+		Middle to long-term, large scale
Connect urban flood zones to groundwater		+	+				Short- to long-term, regional scale
Reestablish or secure more natural flood dynamics and connectivity	+		+			+	Long-term, large scale
Incorporate flood-adapted architecture	+	+	+		+		Short- to long-term, local scale
Reduce use conflicts		+	+	+		+	Short- to long-term, local scale
Avoid the creation of conflicts between desired ecosystem services	+		+				Short- to long-term, local to large scale
Allow natural disturbance to reduce maintenance cost	+		+		+	+	Short- to long-term, local scale
Balance public access with restrictions that allow nature conservation		+	+	+	+		Short-term, local scale
Educate stakeholders to develop empathy for nature		+			+	+	Middle to long-term, large scale

Table 1. *Cont.*

Measures for Potential Application for Urban HRES	Relative Contribution to the HRES Tenets						Impact
	Health	Safety	Functionality	Accessibility	Awareness	Participation	Temporal and Spatial Impact
Reinforce social fairness			+		+	+	Short-term, local scale
Increase attractiveness, aesthetics, and stimulate visitor curiosity	+		+	+	+	+	Short-term, local scale
Collaborate with civil society		+	+		+		Middle to long-term, large scale
Promote collaborative planning that includes all potential interest groups					+	+	Middle to long-term, large scale
Communicate success stories and failures					+		Middle to long-term, large scale

+ means that the measure participate in the tenet.

4. Conclusions

Urban rivers worldwide and their related societies are in a crisis. Ecological degradation caused by mismanagement and mono-functionality led to the rupture of the human–river relationship and a massive loss of biological and cultural diversity. This contribution presents the principle of Human–River Encounter Sites that is built on the central themes of the River Culture Concept [4] and aims to provide a guideline and example to achieve harmony between human and nature at urban river sites. The contributions aim to (i) present the conceptual rationale for Human–River Encounter Sites, (ii) provide practical recommendations, and (iii) inspire the implementation of future urban river restoration that creates harmony between humans and nature.

The Human–River Encounter Sites approach as presented in this paper elaborates on the central issue of the River Culture Concept; namely, the achievement of a more harmonious coexistence of biological and cultural diversity, and especially focuses on the urban context. The list of the six main tenets should be seen as a preliminary set and should stimulate discussion at the levels of scientific research and practical implementation.

Still too few examples of good practices exist, but they can help to increase our knowledge. From an urban planning perspective, while the need to more responsibly design riverscapes within urban settings to fulfill both human and ecosystem needs is gaining ground, explicit recommendations to achieve this ambitious goal remain limited. Recommendations can be drawn from the literature and also drawn from cases that have been used to support each of the tenets proposed for establishing an urban Human–River Encounter Site. Individual measures can be drawn from this set to help strengthen the interrelationships between rivers and people in the context of urban development. It is our intention that these suggested measures and the concept of a HRES will also stimulate debate on the sustainable socio-ecological management of urban rivers.

This paper should be seen as a first attempt to provide conceptual elements for mitigating the urban human–river crisis by harmonizing the needs of the two primary actors: citizens and the ecosystem (with its biota). We believe that the HRES approach has the potential to support a new direction in socio-ecological river planning and management. Future research is needed to further develop the existing tenets based on existing good practices and societal discussion. Two important questions that still remain, but that should be of great interest in the further elaboration of the conceptual basis of HRES, are (i) how natural can rivers become when the entire catchment is highly urbanized, and (ii) to what degree of river wildness is acceptable by the society, especially in urban spaces? This paper presents reconciliation potential. Future research should further focus on the central and difficult issue of identifying and resolving trade-offs between competing river management objectives and interventions, and the social, economic, and political challenges that go with such trade-offs.

Author Contributions: Conceptualization, K.M.W.; validation, A.Z.-H., M.B., S.B., N.L., S.G., A.R., V.R., J.S., Y.C., R.B., A.V., R.E.T., and K.M.W.; investigation, A.Z.-H., M.B., S.B., N.L., S.G., A.R., V.R., J.S., Y.C., R.B., A.V., R.E.T.; writing—original draft preparation, A.Z.-H. and K.M.W.; writing—review and editing, A.Z.-H., M.B., S.B., N.L., S.G., A.R., V.R., J.S., Y.C., R.B., A.V., R.E.T., and K.M.W.; visualization, Y.C. and A.Z.-H.; supervision, K.M.W. All authors have read and agreed to the published version of the manuscript.

Funding: A.Z.-H. received funding from the Horizon 2020 research and innovation programme by the European Union under grant agreement No. 776681 (www.phusicos.eu, accessed on 31 January 2021). This paper has been written under the auspices of UNESCO Chair 'River Culture–Fleuves et Patrimoine' granted to K.M.W. Y.C. is a PhD fellow of the China Scholarship Council. R.E.T. was supported by LE STUDIUM Loire Valley Institute for Advanced Studies, Orléans and Tours, France, with funding from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement No. 665790.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The study did not report any data.

Acknowledgments: The study is published under the auspices of the UNESCO Chair 'River Culture–Fleuves et Patrimoine' granted to K.M.W., and we are grateful to CNRS for a "Delegation Grant" 2020–2021. The paper resulted from several online workshops by the CNRS UMR 7324 CITERES of the University of Tours and we thank all our colleagues for their input. We would also like to thank the authors' funding institutions. This work was performed within the framework of the ZAL (LTSER Zone Atelier Loire).

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Béthemont, J. La société au miroir du fleuve. In *Le Fleuve et ses Metamorphoses*; Piquet, F., Ed.; Erudition: Paris, France, 1993; pp. 13–17.
2. Böck, K.; Polt, R.; Schülting, L. Ecosystem Services in River Landscapes. In *Riverine Ecosystem Management*; Schmutz, J.S., Ed.; Springer: Berlin/Heidelberg, Germany, 2018; Volume 8.
3. Schindler, S.; Sebesvari, Z.; Damm, C.; Euller, K.; Mauerhofer, V.; Schneidergruber, A.; Biró, M.; Essl, F.; Kanka, R.; Lauwaars, S.G.; et al. Multifunctionality of floodplain landscapes: Relating management options to ecosystem services. *Landsc. Ecol.* **2014**, *29*, 229–244. [CrossRef]
4. Wantzen, K.M.; Ballouche, A.; Longuet, I.; Bao, I.; Bocoum, H.; Cissé, L.; Chauhan, M.; Girard, P.; Gopal, B.; Kane, A.; et al. River Culture: An eco-social approach to mitigate the biological and cultural diversity crisis in riverscapes. *Ecohydrol. Hydrobiol.* **2016**, *16*, 7–18. [CrossRef]
5. Vörösmarty, C.J.; McIntyre, P.B.; Gessner, M.O.; Dudgeon, D.; Prusevich, A.; Green, P.; Glidden, S.; Bunn, S.E.; Sullivan, C.A.; Liermann, C.R.; et al. Global threats to human water security and river biodiversity. *Nature* **2010**, *467*, 555–561. [CrossRef]
6. Albert, J.S.; Destouni, G.; Duke-Sylvester, S.M.; Magurran, A.E.; Oberdorff, T.; Reis, R.E.; Winemiller, K.O.; Ripple, W.J. Scientists' warning to humanity on the freshwater biodiversity crisis. *Ambio* **2020**, *50*, 85–94. [CrossRef]
7. Zingraff-Hamed, A.; Greulich, S.; Pauleit, S.; Wantzen, K.M. Urban and rural river restoration in France: A typology. *Restor. Ecol.* **2017**, *25*, 994–1004. [CrossRef]
8. Wantzen, K.M.; Alves, C.B.M.; Badiane, S.D.; Bala, R.; Blettler, M.; Callisto, M.; Cao, Y.; Kolb, M.; Kondolf, G.M.; Leite, M.F.; et al. Urban Stream and Wetland Restoration in the Global South—A DPSIR Analysis. *Sustainability* **2019**, *11*, 4975. [CrossRef]
9. Kummu, M.; de Moel, H.; Ward, P.J.; Varis, O. How Close Do We Live to Water? A Global Analysis of Population Distance to Freshwater Bodies. *PLoS ONE* **2011**, *6*, e20578. [CrossRef] [PubMed]
10. UN. *The World's Cities in 2018*; United Nation: San Francisco, CA, USA, 2018.
11. Guastella, G.; Oueslati, W.; Pareglio, S. Patterns of Urban Spatial Expansion in European Cities. *Sustainability* **2019**, *11*, 2247. [CrossRef]
12. Qian, Y.; Wu, Z. Study on Urban Expansion Using the Spatial and Temporal Dynamic Changes in the Impervious Surface in Nanjing. *Sustainability* **2019**, *11*, 933. [CrossRef]
13. Walsh, C.J.; Roy, A.H.; Feminella, J.W.; Cottingham, P.D.; Groffman, P.M.; Morgan, R.P. The urban stream syndrome: Current knowledge and the search for a cure. *J. N. Am. Benthol. Soc.* **2005**, *24*, 706–723. [CrossRef]
14. Zingraff-Hamed, A. *Urban River Restoration: A Socio-Ecological Approach*; Technical University of Munich and University of Tours: Munich, Germany, 2018.
15. Zingraff-Hamed, A.; Lupp, G.; Bäumler, K.; Huang, J.; Pauleit, S. The Isar River: Social Pride as a Driver of River Restoration. In *River Culture—Life as a Dance to the Rhythm of the Waters*; Wantzen, K.M., Ed.; UNESCO Publishing: Paris, France, 2021.
16. Romain, F. *La Construction Contemporaine des Paysages Fluviaux Urbains: Le Fleuve, une Infrastructure Paysagère au Service d'une Image de Renaturation Urbaine—Le Cas de Deux Villes Nord Méditerranéennes: Perpignan et Montpellier*; École National Supérieure du Paysage: Versailles, Fance, 2010.
17. Cottet, M.; Piegay, H.; Bornette, G. Does human perception of wetland aesthetics and healthiness relate to ecological functioning? *J. Environ. Manag.* **2013**, *128*, 1012–1022. [CrossRef] [PubMed]
18. OECD. *Diffuse Pollution, Degraded Waters: Emerging Policy Solutions*; OECD: Paris, France, 2017.
19. Cao, J.; Sun, Q.; Zhao, D.; Xu, M.; Shen, Q.; Wang, D.; Wang, Y.; Ding, S. A critical review of the appearance of black-odorous waterbodies in China and treatment methods. *J. Hazard. Mater.* **2020**, *385*, 121511. [CrossRef] [PubMed]
20. SER The SER International Primer on Ecological Restoration. Available online: www.ser.org (accessed on 12 January 2021).
21. Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. In *Communities*; Official Journal of the Europe: Brussels, Belgium, 2000; p. 72.
22. Bernhardt, E.S.; Palmer, M.A. Restoring streams in an urbanizing world. *Freshw. Biol.* **2007**, *52*, 738–751. [CrossRef]
23. Tockner, K.; Pusch, M.; Gessner, J.; Wolter, C. Domesticated ecosystems and novel communities: Challenges for the management of large rivers. *Ecohydrol. Hydrobiol.* **2011**, *11*, 167–174. [CrossRef]

24. Perini, K.; Sabbion, P. River Thames, England—Strategies and Technique. In *Urban Sustainability and River Restoration*; Sabbion, P., Ed.; Wiley: Hoboken, NJ, USA, 2016; pp. 138–150.
25. Miller, J.R. Restoration, reconciliation and reconnecting with nature nearly. *Biol. Conserv.* **2006**, *127*, 356–361. [CrossRef]
26. Godet, L. La nature ordinaire dans le monde occidental. *Espace Géographique* **2010**, *39*, 295–308. [CrossRef]
27. Ostrom, E. Coping with tragedies of the commons. *Annu. Rev. Political Sci.* **1999**, *2*, 493–535. [CrossRef]
28. Ostrom, E. A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Sciences* **2009**, *325*, 419–422. [CrossRef]
29. Larson, J.S. The World Health Organization's Definition of Health: Social versus Spiritual Health. *Soc. Indic. Res.* **1996**, *38*, 181–192. [CrossRef]
30. Haines-Young, R.; Potschin, M. The Links between Biodiversity, Ecosystem Services and Human Well-Being. In *Ecosystem Ecology*; Raffaelli, D.G., Frid, C.L.J., Eds.; Cambridge University Press: Cambridge, UK, 2010; pp. 110–139.
31. Abraham, A.; Sommerhalder, K.; Abel, T. Landscape and well-being: A scoping study on the health-promoting impact of outdoor environments. *Int. J. Public Health* **2010**, *55*, 59–69. [CrossRef] [PubMed]
32. Sandifer, P.A.; Sutton-Grier, A.E.; Ward, B.P. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. *Ecosyst. Serv.* **2015**, *12*, 1–15. [CrossRef]
33. Horwitz, P.; Finlayson, M.; Weinstein, P. *Healthy Wetlands, Healthy People: A Review of Wetlands and Human Health Interactions*; Secretariat of the Ramsar Convention on Wetlands: Gland, Switzerland, 2012; Volume 6.
34. Norris, R.H.; Thoms, M.C. What is river health? *Freshw. Biol.* **1999**, *41*, 197–209. [CrossRef]
35. Karr, J.R. Defining and measuring river health. *Freshw. Biol.* **1999**, *41*, 221–234. [CrossRef]
36. Vaz, S.S.S.; Dias, A.; Dutra, E.; Pavanin, A.; Morelli, S.; Pereira, B. The impact of water pollution on fish species in southeast region of Goiás, Brazil. *J. Toxicol. Environ. Health* **2016**, *79*, 8–16.
37. Ma, Y.; Liu, Y. Turning food waste to energy and resources towards a great environmental and economic sustainability: An innovative integrated biological approach. *Biotechnol. Adv.* **2019**, *37*, 107414. [CrossRef] [PubMed]
38. Ji, B.; Zhang, M.; Gu, J.; Ma, Y.; Liu, Y. A self-sustaining synergetic microalgal-bacterial granular sludge process towards energy-efficient and environmentally sustainable municipal wastewater treatment. *Water Res.* **2020**, *179*, 115884. [CrossRef] [PubMed]
39. Hering, D.; Borja, A.; Carstensen, J.; Carvalho, L.; Elliott, M.; Feld, C.K.; Heiskanen, A.-S.; Johnson, R.K.; Moe, J.; Pont, D.; et al. The European Water Framework Directive at the age of 10: A critical review of the achievements with recommendations for the future. *Sci. Total Environ.* **2010**, *408*, 4007–4019. [CrossRef]
40. EEA. *European Waters—Assessment of Status and Pressures 2018*; EEA: Luxembourg, 2018; p. 90.
41. Reid, A.J.; Carlson, A.K.; Creed, I.F.; Eliason, E.J.; Gell, P.A.; Johnson, P.T.J.; Kidd, K.A.; MacCormack, T.J.; Olden, J.D.; Ormerod, S.J.; et al. Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biol. Rev.* **2018**. [CrossRef] [PubMed]
42. Kaplan, S. The restorative benefits of nature: Toward an integrative framework. *J. Environ. Psychol.* **1995**, *15*, 169–182. [CrossRef]
43. Carrera-Bastos, P.; Fontes, O.; Keefe, J.; Lindeberg, S.; Cordain, L. The western diet and lifestyle and diseases of civilization. *Dove Press Sci. Med. Res.* **2011**, *2*, 15–35. [CrossRef]
44. Prüss-Ustün, A.; Wolf, J.; Corvalán, C.; Neville, T.; Bos, R.; Neira, M. Diseases due to unhealthy environments: An updated estimate of the global burden of disease attributable to environmental determinants of health. *J. Public Health* **2016**, *39*, 464–475. [CrossRef] [PubMed]
45. Fuller Richard, A.; Irvine Katherine, N.; Devine-Wright, P.; Warren Philip, H.; Gaston Kevin, J. Psychological benefits of greenspace increase with biodiversity. *Biol. Lett.* **2007**, *3*, 390–394. [CrossRef] [PubMed]
46. Hartig, T.; Mitchell, R.; De Vries, S.; Frumkin, H. Nature and health. *Annu. Rev. Public Health* **2014**, *35*, 207–228. [CrossRef] [PubMed]
47. Gesler, W.M. *Healing Places*; Rowman & Littlefield: Lanham, MD, USA, 2003.
48. Jiang, S. Therapeutic landscapes and healing gardens: A review of Chinese literature in relation to the studies in western countries. *Front. Archit. Res.* **2014**, *3*, 141–153. [CrossRef]
49. Zölch, T.; Rahman, M.A.; Pfleiderer, E.; Wagner, G.; Pauleit, S. Designing public squares with green infrastructure to optimize human thermal comfort. *Build. Environ.* **2019**, *149*, 640–654.
50. Völker, S.; Kistemann, T. The impact of blue space on human health and well-being–Salutogenetic health effects of inland surface waters: A review. *Int. J. Hyg. Environ. Health* **2011**, *214*, 449–460. [CrossRef]
51. White, M.; Smith, A.; Humphryes, K.; Pahl, S.; Snelling, D.; Depledge, M. Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *J. Environ. Psychol.* **2010**, *30*, 482–493. [CrossRef]
52. Düzenli, T.; Mumcu, S.; Yılmaz, S.; Özbilen, A. Water reflections on the social dimension of place: Different waterscapes and related activity patterns. *Türkiye Orman. Derg.* **2014**, *15*, 148–157. [CrossRef]
53. Pakasi, L.S. Health risks associated with recreational water activities. *Iop Conf. Ser. Mater. Sci. Eng.* **2018**, *434*, 012329. [CrossRef]
54. Forstinus, N.O.; Ikechukwu, N.E.; Emenike, M.P.; Christiana, A.O. Water and Waterborne Diseases: A Review. *Int. J. Trop. Dis. Health* **2016**, *12*, 1–14. [CrossRef]
55. Rode, S.; Guevara, S.; Bonnefond, M. Resilience in urban development projects in flood-prone areas: A challenge to urban design professionals. *Town Plan. Rev.* **2018**, *89*, 167–190. [CrossRef]

56. Nillesen, A.L.; Kok, M. An integrated approach to flood risk management and spatial quality for a Netherlands river polder area. *Mitig. Adapt. Strateg. Glob. Chang.* **2015**, *6*, 949–966. [CrossRef] [PubMed]
57. Poff, N.L.; Allan, J.D.; Bain, M.B.; Karr, J.R.; Prestegaard, K.L.; Richter, B.D.; Sparks, R.E.; Stromberg, J.C. The Natural Flow Regime. *BioScience* **1997**, *47*, 769–784. [CrossRef]
58. Junk, W.J.; Wantzen, K. The Flood Pulse Concept: New Aspects, Approaches and Applications—An Update. In Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries, Food and Agriculture Organization of the United Nations (FAO) and the Mekong River Commission (MRC), Phnom Penh, Cambodia, 11–14 February 2003; FAO Publications: Rome, Italy, 2004; Volume II.
59. Catford, J.A.; Downes, B.J.; Gippel, C.J.; Vesk, P.A. Flow regulation reduces native plant cover and facilitates exotic invasion in riparian wetlands. *J. Appl. Ecol.* **2011**, *48*, 432–442. [CrossRef]
60. Richardson, D.M.; Holmes, P.M.; Esler, K.J.; Galatowitsch, S.M.; Stromberg, J.C.; Kirkman, S.P.; Pyšek, P.; Hobbs, R.J. Riparian vegetation: Degradation, alien plant invasions, and restoration prospects. *Divers. Distrib.* **2007**, *13*, 126–139. [CrossRef]
61. Kundzewicz, Z.W.; Kanae, S.; Seneviratne, S.I.; Handmer, J.; Nicholls, N.; Peduzzi, P.; Mechler, R.; Bouwer, L.M.; Arnell, N.; Mach, K.; et al. Flood risk and climate change: Global and regional perspectives. *Hydrol. Sci. J.* **2014**, *59*, 1–28. [CrossRef]
62. Ranger, N.; Hallegatte, S.; Bhattacharya, S.; Bachu, M.; Priya, S.; Dhore, K.; Rafique, F.; Mathur, P.; Naville, N.; Henriet, F.; et al. An assessment of the potential impact of climate change on flood risk in Mumbai. *Clim. Chang.* **2011**, *104*, 139–167. [CrossRef]
63. Zurich-Group. *European Floods: Using Lessons Learned to Reduce Risks*; Zurich-Group: Zürich, Switzerland, 2013; p. 14.
64. Rutschmann, P. *Modellversuch ISARPLAN*; TUM: Munich, Germany, 2007; p. 8.
65. Bonnefond, M. La modélisation hydraulique comme condition de la résilience des projets d'aménagement urbain en zone inondable ? *Rev. Houille Blanche* **2018**, *3*, 25–33. [CrossRef]
66. Vörösmarty, C.J.; Osuna, V.R.; Koehler, D.A.; Klop, P.; Spengler, J.D.; Buonocore, J.J.; Cak, A.D.; Tessler, Z.D.; Corsi, F.; Green, P.A.; et al. Scientifically assess impacts of sustainable investments. *Science* **2018**, *359*, 523–525. [CrossRef] [PubMed]
67. WB. *Implementing Nature-Based Flood Protection: Principles and Implementation Guidance*; World Bank: Washington, DC, USA, 2017; p. 32.
68. Prominski, M.; Stokman, A.; Zeller, S.; Stimberg, D.; Voermanek, H. River Space Design—Planning. In *Strategies, Methods and Projects for Urban Rivers*; Birkhäuser: Basel, Switzerland, 2017.
69. Barroca, B.; Hubert, G. Urbaniser les zones inondables, est-ce concevable? *Développement Durable Et Territ.* **2008**, 7413. [CrossRef]
70. Liao, K.-H. A Theory on Urban Resilience to Floods—A Basis for Alternative Planning Practices. *Ecol. Soc.* **2012**, *17*, 4. [CrossRef]
71. Warner, J.F.; van Buuren, A.; Edelenbos, J. *Making Space for the River: Governance Experiences with Multifunctional River Flood Management in the US and Europe*; IWA Publishing: London, UK, 2012.
72. Fournier, M.; Larrue, C.; Alexander, M.; Hegger, D.; Bakker, M.; Pettersson, M.; Crabbé, A.; Mees, H.; Chorynski, A. Flood risk mitigation in Europe: How far away are we from the aspired forms of adaptive governance? *Ecol. Soc.* **2016**, *21*, 4. [CrossRef]
73. Bonnefond, M.; Fournier, M.; Servain, S.; Gralepois, M. La transaction foncière comme mode de régulation en matière de protection contre les inondations. Analyse à partir de deux zones d'expansions de crue: l'Île Saint Aubin (Angers) et le déversoir de la Bouillie (Blois). *Risques Urbains* **2017**. [CrossRef]
74. Addy, S.; Cooksley, S.; Dodd, N.; Waylen, K.; Stockan, J.; Byg, A.; Holstead, K. *River Restoration and Biodiversity*; IUCN: Gland, Switzerland, 2016.
75. Miguez, M.G.; Veról, A.P.; Mascarenhas, F.C.B.; Santos, R.B.; Martingil, M.C. Compensatory technique s on urban drainage for flood control with the aid of mathematical modelling: A case study in Rio de Janeiro City. *WIT Trans. Built Environ.* **2012**, *122*, 227–238.
76. Palmer, M.A.; Hondula, K.L.; Koch, B.J. Ecological Restoration of Streams and Rivers: Shifting Strategies and Shifting Goals. *Annu. Rev. Ecol. Evol. Syst.* **2014**, *45*, 247. [CrossRef]
77. Tillie, N.; Borsboom-van Beurden, J.; Doepel, D.; Aarts, M. Exploring a Stakeholder Based Urban Densification and Greening Agenda for Rotterdam Inner City—Accelerating the Transition to a Liveable Low Carbon City. *Sustainability* **2018**, *10*, 1927. [CrossRef]
78. Chan, F.K.S.; Griffiths, J.A.; Higgitt, D.; Xu, S.; Zhu, F.; Tang, Y.-T.; Xu, Y.; Thorne, C.R. "Sponge City" in China—A breakthrough of planning and flood risk management in the urban context. *Land Use Policy* **2018**, *76*, 772–778. [CrossRef]
79. Sun Youli, C.Q. Sponge City Construction Performance Evaluation System and Method. *Archit. Cult.* **2018**, *1*, 154–157.
80. Li Lan, L.F. Key Scientific Problems and Thoughts on the Construction of "Sponge City". *Acta Ecol. Sin.* **2018**, *38*, 2599–2606.
81. Zevenbergen, C.; Fu, D.; Pathirana, A. Transitioning to Sponge Cities: Challenges and Opportunities to Address Urban Water Problems in China. *Water* **2018**, *10*, 1230. [CrossRef]
82. de Groot, R.S.; Wilson, M.A.; Boumans, R.M.J. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecol. Econ.* **2002**, *41*, 393–408. [CrossRef]
83. Muhar, S.; Muhar, A.; Egger, G.; Siegrist, D.; abderhalden-Raba, A.; Aigner, J.; Arnaud, F.; Aschwanden, H.; Becsi, R.; Belleudy, P.; et al. *Rivers of the Alps*; Haupt Nature: Berne, Germany, 2019; Volume 1, p. 512.
84. Zingraff-Hamed, A.; Noack, M.; Greulich, S.; Schwarzwälder, K.; Pauleit, S.; Wantzen, K.M. Model-Based Evaluation of the Effects of River Discharge Modulations on Physical Fish Habitat Quality. *Water* **2018**, *10*, 374. [CrossRef]
85. Zingraff-Hamed, A.; Noack, M.; Greulich, S.; Schwarzwälder, K.; Wantzen, K.M.; Pauleit, S. Model-Based Evaluation of Urban River Restoration: Conflicts between Sensitive Fish Species and Recreational Users. *Sustainability* **2018**, *10*, 1747. [CrossRef]

86. UNESCO. *World Water Development Report of 2019*; UNESCO: Paris, France, 2019; p. 186.
87. Morgera, E. *WildLife Law and the Empowerment of the Poor*; United Nation: Rome, Italy, 2010; p. 340.
88. Prideaux, B.; Cooper, M. *River Tourism*; CABI: Wallingford, UK, 2009.
89. Meretsky, V.J.; Atwell, J.W.; Hyman, J.B. Migration and conservation: Frameworks, Gaps and Synergies in Science, Law, and Management. *Environ. Law* **2011**, *41*, 447–534. [PubMed]
90. Kunich, J.C. The Uncertainty of Life and Death: The Precautionary Principle, Gödel, and the Hotspots Wager. *Mich. State Int. Law* **2008**, *1*, 4.
91. Zingraff-Hamed, A.; Martin, J.; Lupp, G.; Linnerooth-Bayer, J.; Pauleit, S. Designing a Resilient Waterscape Using a Living Lab and Catalyzing Polycentric Governance. *Landsc. Archit. Front.* **2019**, *7*, 12–31.
92. CE. European Landscape Convention. In *Europe*; Concil of Europe: Florence, Italy, 2000.
93. Manenti, R.; Ghia, D.; Fea, G.; Ficetola, G.F.; Padoa-Schioppa, E.; Canedoli, C. Causes and consequences of crayfish extinction: Stream connectivity, habitat changes, alien species and ecosystem services. *Freshw. Biol.* **2019**, *64*, 284–293. [CrossRef]
94. Woolsey, S.; Capelli, F.; Gonser, T.; Hoehn, E.; Hostmann, M.; Junker, B.; Paetzold, A.; Roulier, C.; Schweizer, S.; Tiegs, S.D.; et al. A strategy to assess river restoration success. *Freshw. Biol.* **2007**, *52*, 752–769. [CrossRef]
95. Aguilar, R.; Ashworth, L.; Galetto, L.; Aizen, M.A. Plant reproductive susceptibility to habitat fragmentation: Review and synthesis through a meta-analysis. *Ecol. Lett.* **2006**, *9*, 968–980. [CrossRef]
96. Van Rossum, F.; Triest, L. Pollen dispersal in an insect-pollinated wet meadow herb along an urban river. *Landsc. Urban Plan.* **2010**, *95*, 201–208. [CrossRef]
97. Martin, J.; Bayer, J.; Liu, W.; Scolobig, A. *Delivrable 5.1: NBS In-depth Case Study Analysis of the Characteristics of Successful Governance Models*; EU: Vienna, Austria, 2019.
98. Rossano, F. Isar Plan: The Wild as the New Urban? *Contour* **2016**, *1*, 20.
99. Perosa, F.; Disse, M.; Zingraff-Hamed, A. Extended Cost-Benefit Analysis through Ecosystem Services to Evaluate Floodplain Restoration Measures in the Danube River Basin. In Proceedings of the System Risk Conference, Berlin, Germany, 17–19 September 2019.
100. Pugliese, F.; Caroppi, G.; Zingraff Hamed, A.; Lupp, G.; Giugni, M. Nature-Based Solutions (NBSs) Application for Hydro-Environment Enhancement. A Case Study of the Isar River. *Environ. Sci. Proc.* **2020**, *2*, 30. [CrossRef]
101. Krasny, M.E.; Russ, A.; Tibdall, K.G.; Elmqvist, T. Civic ecology practices: Participatory approaches to generating and measuring ecosystems services in cities. *Ecosyst. Serv.* **2014**, *7*, 177–186. [CrossRef]
102. Sakurai, R.; Kobory, H.; Nkamura, M.; Kikuchi, T. Factors influencing public participation in conservation activities in urban areas: A case study in Yokohama, Japan. *Biol. Conserv.* **2015**, *184*, 424–430. [CrossRef]
103. Fohlmeister, S.; Zingraff-Hamed, A.; Lupp, G.; Pauleit, S. Guiding Framework for Tailored Living Lab Establishment at Concept and Demonstrator Case Study Sites. Deliverable 3.1. 2018. Available online: https://phusicos.eu/wp-content/uploads/2018/10/D3_1_GF_Final_Version_complete_201807312-Disclaimers.pdf (accessed on 31 January 2021).
104. Zingraff-Hamed, A.; Hüesker, F.; Lupp, G.; Begg, C.; Huang, J.; Oen, A.; Vojinovic, Z.; Kuhlicke, C.; Pauleit, S. Stakeholder Mapping to Co-Create Nature-Based Solutions: Who Is on Board? *Sustainability* **2020**, *12*, 8625. [CrossRef]
105. Lupp, G.; Zingraff-Hamed, A.; Huang, J.; Oen, A.; Pauleit, S. Living Labs—A Concept for Co-Designing Nature-Based Solutions. *Sustainability* **2021**, *13*, 188. [CrossRef]
106. Leminen, S. Coordination and Participation in Living Lab Networks. *Technol. Innov. Manag. Rev.* **2013**, *3*, 5–14. [CrossRef]
107. Grêt-Regamey, A.; Altwegg, J.; Sirén, E.A.; van Strien, M.J.; Weibel, B. Integrating ecosystem services into spatial planning—A spatial decision support tool. *Landsc. Urban Plan.* **2017**, *165*, 206–219. [CrossRef]
108. Scannell, L.; Gifford, R. Defining Place Attachment: A Tripartite Organizing Framework. *J. Environ. Psychol.* **2010**, *30*, 1–10. [CrossRef]
109. Tuan, Y.F. *Topophilia: A Study of Environmental Perceptions, Attitudes, and Values*; Columbia University Press: New York, NY, USA, 1990.
110. Julian, J.P.; Daly, G.S.; Weaver, R.C. University Students' Social Demand of a Blue Space and the Influence of Life Experiences. *Sustainability* **2018**, *10*, 3178. [CrossRef]
111. Cox, D.T.C.; Hudson, H.L.; Shanahan, D.F.; Fuller, R.A.; Gaston, K.J. The rarity of direct experiences of nature in an urban population. *Landsc. Urban Plan.* **2017**, *160*, 79–84. [CrossRef]
112. Prévot, A.-C.; Cheval, H.; Raymond, R.; Cosquer, A. Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. *Biol. Conserv.* **2018**, *226*, 1–8. [CrossRef]
113. Soga, M.; Gaston, K.J. Extinction of experience: The loss of human–nature interactions. *Front. Ecol. Environ.* **2016**, *14*, 94–101. [CrossRef]
114. Sampson, S.D. *How to Raise a Wild Child: The Art and Science of Falling in Love with Nature*, 1st ed.; Houghton Mifflin Harcourt: Boston, MS, USA, 2015; p. 352.
115. Griffiths, A.M.; Ellis, J.S.; Clifton-Dey, D.; Machado-Schiaffino, G.; Bright, D.; Garcia-Vazquez, E.; Stevens, J.R. Restoration versus recolonisation: The origin of Atlantic salmon (*Salmo salar* L.) currently in the River Thames. *Biol. Conserv.* **2011**, *144*, 2733–2738. [CrossRef]
116. Wantzen, K.M.; Uehlinger, U.; Van der Velde, G.; Leuven, R.S.E.W.; Schmitt, L.; Beisel, J.N. The Rhine River Basin. In *Rivers of Europe*; Tockner, K.Z.C., Robinson, C.T., Eds.; Academic Press: London, UK, 2020; Volume 2, in press.

117. Conradin, F.; Buchli, R. The Zurich Stream Day-Lighting Program. In *Enhancing Urban Environment by Environmental Upgrading and Restoration*; Marsalek, J., Sztruhar, D., Giulianelli, M., Urbonas, B., Eds.; Springer: Dordrecht, The Netherland, 2004.
118. Verbrugge, L.N.; Van den Born, R.J.; Lenders, H.J. Exploring public perception of non-native species from a visions of nature perspective. *Environ. Manag.* **2013**, *52*, 1562–1573. [CrossRef] [PubMed]
119. Tribot, A.-S.; Carabeux, Q.; Deter, J.; Claverie, T.; Villéger, S.; Mouquet, N. Confronting species aesthetics with ecological functions in coral reef fish. *Sci. Rep.* **2018**, *8*, 11733. [CrossRef]
120. Junker, B.; Buchecker, M. Aesthetic preferences versus ecological objectives in river restorations. *Landsc. Urban Plan.* **2008**, *85*, 141–154. [CrossRef]
121. Zingraff-Hamed, A.; Greulich, S.; Wantzen, K.M.; Pauleit, S. Societal Drivers of European Water Governance: A Comparison of Urban River Restoration Practices in France and Germany. *Water* **2017**, *9*, 206. [CrossRef]
122. Le Lay, Y.F.; Piegay, H.; Riviere-Honegger, A. Perception of braided river landscapes: Implications for public participation and sustainable management. *J. Environ. Manag.* **2013**, *119*, 1–12. [CrossRef]
123. Asakawa, S.; Yoshida, K.; Yabe, K. Perceptions of urban stream corridors within the greenway system of Sapporo, Japan. *Landsc. Urban Plan.* **2004**, *68*, 167–182. [CrossRef]
124. Chen, W.Y.; Hua, J.; Liekens, I.; Broekx, S. Preference heterogeneity and scale heterogeneity in urban river restoration: A comparative study between Brussels and Guangzhou using discrete choice experiments. *Landsc. Urban Plan.* **2018**, *173*, 9–22. [CrossRef]
125. Özgüner, H.; Eraslan, Ş.; Yilmaz, S. Public perception of landscape restoration along a degraded urban streamside. *Land Degrad. Dev.* **2012**, *23*, 24–33. [CrossRef]
126. Rodríguez-Lozano, P.; Woelfle-Erskine, C.; Bogan, M.T.; Carlson, S.M. Are Non-Perennial Rivers Considered as Valuable and Worthy of Conservation as Perennial Rivers? *Sustainability* **2020**, *12*, 5782. [CrossRef]
127. Ladrera, R.; Rodríguez-Lozano, P.; Verkaik, I.; Prat, N.; Díez, J.R. What Do Students Know about Rivers and Their Management? Analysis by Educational Stages and Territories. *Sustainability* **2020**, *12*, 8719. [CrossRef]