Supplementary S1. Experiences in the rehabilitation of urban rivers 17 MAY 2022

Name of project or initiative	City	Country	Type of initiative	Activities performed/ performed	Reference (if academic publication) or link
Elbe Harbour Facilities	Hamburg	Germany		The head of a former shipping dock was filled in and converted into a waterfront area used as a swimming and sunbathing area.	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In *European Commission. 5 th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage"* (Vol. 2).
Emscher, Deininghauser Bach	Castrop-Rauxel (Emscherregio n)	Germany	Citizen	Measures to increase rainwater infiltration. Gray infrastructure with green elements. Trees, hedges, and vegetation in alleys and streets. Green playgrounds/schools. Green riverside areas. (Semi)natural urban parks and green areas. Large urban parks or forests. Blue zones. River/stream/canal/estuary. Green areas for water management. Sustainable urban drainage systems.	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In *European Commission. 5 th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage"* (Vol. 2). https://naturvation.eu/nbs/essen/restoration-emscher-river
Isar	Munich	Germany	Government with citizen participation	Installation of ultraviolet light treatment plants. Concrete barriers and dams were eliminated.	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In *European Commission. 5 th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage"* (Vol. 2).
Cooks River Litter Prevention Strategy	Sydney	Australia	Citizen–government	Wetlands, rain gardens, parks and park improvements, trails and bridges, and kayak docks.	https://rivercanoeclub.org.au/wp-content/uploads/2021/09/Litter-strategy-v05-highres.pdf
Alterbachsystem,	Salzburg	Austria	Government	Soil-bioengineering measures were implemented at the Alterbachsystem. Habitat quality was improved; for example, post-scheme, there were nine different species of fish compared to one species before the project was implemented.	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In European Commission. 5 th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage" (Vol. 2).
Wadi Hanifah Comprehensive Development Project	Riyadh	Saudi Arabia	Government	Moving 88.3 million cu ft of soil (cut and fill), the narrowing or removal of 26.6 miles of roadways, the removal of 23 miles of pipes and overhead utilities, nine major parks, five lakes (totaling 62 acres), 4.6 miles of pedestrian promenades, and 29 miles of recreational trails. River and urban wastewater are treated through a bioremediation process that uses a food chain approach to capture nutrients and pathogens. A total of 1,805 planting cells were installed in 35 distinct configurations adapted to micro-conditions along the riverbed. These serve as hotbeds for seed propagation and promote renaturation. The cells include a total of 28,021 ornamental trees (7 different species or varieties), 6,000 date palm trees, 40,166 shrubs (20 different species or varieties), and 44,719 grasses (8 different	https://www.landscapeperformance.org/case-study-briefs/wadi-hanifah#/sustainable-features

				species or varieties). A total of 35 native plant species were reintroduced. Thirty toilet blocks and seven hundred and thirty signs for environmental interpretation were implemented	
Interlocal Roundtable of the Salitre River Basin	Bogotá	Colombia	Citizen	Organization of forums on urban rivers.	http://www.riosalitre.org/index.html
Chapinero	Bogotá	Colombia	Citizen–government	The implementation of this restoration phase began with the adaptation of the land, controlling invasive species, eliminating solid waste and debris, fencing, layout, hollowing, and finally planting, which was monitored and maintained for 3 years, the minimum time required to ensure that the restoration was successful. See pg. 193 for species of trees planted.	Bejarano, P. 2014. Editor. Historia ambiental y recuperación integral de los territorios asociados a quebradas y ríos en Bogotá (caso Chapinero). Secretaría Distrital de Ambiente, Alcaldía Local de Chapinero y Conservación Internacional Colombia. Bogotá, Colombia. 336 pp
Megaproject: Ciudad Río	Bogotá	Colombia	Government at different levels	Mega-project to decontaminate the river and create 60 kilometers of tree-lined embankments and parks on both banks. It is a 30-year initiative.	https://bogota.gov.co/mi-ciudad/ambiente/el-rio-bogota-sera-columna-vertebral-de-la-ciudad
River Parks	Medellín	Colombia	Government	Ten-year urban mega-project for urban reorganization along the river to reconnect the riverbanks, generating public spaces since the river was perceived as a "no place". Green areas, bicycle lanes, cycle paths, cycle ports, pedestrian walkways, benches, and a botanical garden were created.	Medellín's Parques del Río, the only Colombian project to win WAF" 30 Nov 2018. ArchDaily Mexico. Accessed 13 Sep 2021. and Laura Sáenz. "What is the Parques del Río project in Medellín up to?" 19 Oct 2016. ArchDaily Mexico. Accessed 13 Sep 2021. https://www.archdaily.mx/mx/797527/en-que-esta-el-proyecto-parques-del-rio-en-medellin
La Ronda del Sinú and extensions	Montería	Colombia	Government (city)	The linear park is considered the largest in the world (Wikipedia). An ecological zone was established for environmental education; a cultural zone with a museum and theater, and an outdoor exhibition area with viewpoints, exercise areas, bicycle paths, children's play areas, markets, stores, restaurants, docks, and pedestrian areas. There is also a proposal for an agrotourism corridor.	https://www.eltiempo.com/mas-contenido/monteria-la-ciudad-que-le-devolvio-la-importancia-al-rio-405604
Malecon 2000 Project	Guayaquil	Ecuador	Government and private	It was mainly a work of urban regeneration and tourist attraction. In the 2.5 km, there are monuments, museums, gardens, fountains, restaurants, shopping centers, restaurants, and docks to take boats for sightseeing tours.	Navas, P.G. Malecón 2000. The Beginning of Urban Regeneration in Guayaquil: A Project Approach. Master's Thesis. FLACSO, Ecuador.

Los Angeles River Master Plan	Los Angeles	USA	Citizen/ Government/ Private	“Urban acupuncture", adaptations in residences to capture and re-use water in homes and schools. This includes: water catchment farms, gardens and sidewalk plantings, retrofitting recreational areas (12) along the river, and retrofitting existing bridges to provide increased channel width for hydrologic and hábitat improvements and allow continuous creek adjacent circulation along Pacoima and Tujunga Wash easements. Project aims are to remove concrete, increase the infiltration of groundwater, and facilitate the removal of sediment, trash, and metals before the confluence with the L.A. River, increasing habitat improving flood protection.	Otto, B., McCormick, K., & Leccese, M. (2004). Ecological riverfront design: Restoring rivers, connecting communities. APA Planning Advisory Service Reports, 518-519, 1-170. www.theriverproject.org/lariver. www.ladpw.org/ https://www.waterla.org/strategies wmd/watershed/LA/LA_River_Plan.cfm For examples of native plants used: https://calscape.org/
Meadow Creek Stream Restoration	Charlottesville, Virginia	USA	Government	Meander reconstruction, boulder paddling, and J-logging to stabilize banks and wetland construction; among the 19,000 trees and shrubs are black willow, silky dogwood, red oak, common persimmon, sweet pepperbush, common elderberry, and buttonbush predominate. The nearly 50,000 herbaceous plugs include soft rush, cardinal's blossom, reed sedge, reed canary grass, deer tongue grass, bird grass, sweet wood reed, and Virginia wild rye. Project also includes the development of parks and conservation areas, multi-use trails, and the assignment of signage indicating the park as an ecological restoration site.	https://www.landscapeperformance.org/case-study-briefs/meadow-creek-restoration#/sustainable-features
Glenstone	Maryland	USA	Government	Trails, 4 acres of lawns, and pastures were converted to sustainable meadows planted with all native species, including little bluestem (Schizachyrium scoparium) and purple top (Tridens flavus). In total, there are 85,968 feet of unmowed turf consisting of a mix of radar chewing fescue, hard lighthouse fescue, and creeping red navigator's fescue, which minimize mowing and water use. A total of 9,200 new trees were planted on-site, including tulip poplar (Liriodendron tulipifera), eastern redbud (Cercis canadensis), and American hornbeam (Carpinus caroliniana). Four hundred trees ranging in size from 5 to 30 inches in caliper were moved, stocked, and replanted on site. There is also a water garden with 4,389 planted plants, catchment cisterns, and composting of city waste.	https://www.landscapeperformance.org/case-study-briefs/glenstone#/lessons-learned
Cheonggyecheon River	Seoul	Korea	Government	Removal of the concrete highway that covered the river, construction of trails and bike paths, construction of pedestrian and car bridges, connectivity to other means of transportation and opening of new transportation schemes, re-establishment of connections between streams, pumps to establish a constant and permanent flow of 40 cm, construction of willow swamps, marshes, low areas, and mating areas for fish, terraced vertical walls, natural stones to bridge the river, and salvaged construction materials from the old concrete structure.	Kim, H., & Jung, Y. (2019). Is Cheonggyecheon sustainable? A systematic literature review of stream restoration in Seoul, South Korea. Sustainable Cities and Society, 45 (April 2018), 59-69. https://doi.org/10.1016/j.scs.2018.11.018 https://www.landscapeperformance.org/case-study-briefs/cheonggyecheon-stream-restoration#/sustainable-features

Lick Run Watershed	Cincinnati, Ohio	USA	Government, citizens, business	New storm sewers, bioswales, daylighting rivers and streams, stormwater detention basins, rain gardens, waterfront parks, biofiltration gardens, and a mile-long constructed waterway.	Naturally Resilient Communities http://nrcsolutions.org/case-study-2/
Los Dínamos River	CDMX	Mexico	Governmental with several city agencies involved and the mayor's offices of Magdalena Coyoacán and Coyoacán.	Cleaning and desilting, construction of gabion dams, rescue and cleaning of the upper part of the river (Los Dínamos), construction of a marginal drainage system to prevent the discharge of domestic wastewater, and recovery of the public space downstream (Coyoacán). Projects are also planned to promote rainwater harvesting, drinking water treatment, and wastewater treatment.	https://jefaturadegobierno.cdmx.gob.mx/comunicacion/nota/recupera-gobierno-capitalino-rio-magdalena-integralmente, https://www.sectei.cdmx.gob.mx/comunicacion/nota/al-rescate-del-rio-magdalena-ultimo-rio-vivo-y-fuente-esencial-ambiental-social-y-economica-de-la-cdmx http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-62662017000600053#fn1
Arroyo Tierras	Morelia, Michoacan	Mexico	Neighbor initiative	Cleaning of margins, the establishment of gardens on the borders of the river, construction of terraces with cement, rocks or tires, planting of agaves, pines, and diversity of ornamental and edible plants such as cactus (nopal), pomegranate, and maguey, among others.	This is the case study of the main research performed by the first author as part of her postdoctoral research at the National School of Higher Education, UNAM, Mexico.
Parque Lineal Quetzalapan Sedeño	Xalapa, Veracruz	Mexico	Citizen, NGO, and governmental	Thirteen km along the Sedeño river that crosses the city of Xalapa. Construction of pedestrian bridges, waterscapes, terraces, environmental education campaigns, cleanup campaigns, and educational vegetable gardens, among other actions.	https://www.facebook.com/parque.lineal.quetzalapan.sedeno/photos
Bagmati Action Plan	Kathmandu	Nepal	Governmental/ Other initiatives from international civil associations, NGOs, private sector, governmental agencies, and volunteers	Channeling the river to eliminate the risk of flooding, reclaiming land located on flood plains, and developing roads and sewerage networks connecting these areas to the rest of the city. The strategy calls for the creation of an urban park around the river and the restoration of historic buildings, such as temples and Dharamshala (historic rest houses for religious pilgrims currently inhabited by local people), which are located adjacent to the flood plains. Solid waste cleanups on the river banks and awareness campaigns are also planned.	https://dialnet.unirioja.es/servlet/articulo?codigo=6290403
Master Plan for the Rimac River Restoration Project: Promoting its recovery	Lima	Peru	Governmental cooperation between South Korea and Peru	To recover the river's water quality in 10 years, 15 projects based on the following components will be implemented: the development of water resources and the construction of reservoirs; the implementation of domestic and industrial wastewater and solid waste treatment plants; the establishment of programs to protect and reinforce the riverbank against flooding; and the reforestation and development of recreational areas and improvement of the river's flow.	https://www.construccionyvivienda.com/2019/05/03/plan-maestro-del-proyecto-restauracion-del-rio-rimac-impulsando-su-recuperacion/
SWITCH project	Lodz	Poland	Local government	Development of an overall approach to urban planning based on the Blue–Green Grid concept. Design and construction of three stormwater reservoirs (completed in 2006, 2009, and 2010) and a sequential sedimentation biofiltration system for stormwater	https://climate-adapt.eea.europa.eu/metadata/case-studies/urban-river-restoration-a-sustainable-

				purification (completed in 2011), which resulted in a broader plan for the rehabilitation of the Sokołówka River and a plan for the development of the Sokołówka River Park.	strategy-for-storm-water-management-in-lodz-poland
River Quaggy-Chinbrook meadows	London Borough of Lewisham	United Kingdom	Governmental	The purpose was to improve flood protection on-site and downstream. A concrete channel dividing an urban park was reshaped following historical information, "restoring" meanders, riffles, pools, and flood plains, and allowing for the natural development of the river course. Additionally, the adjacent park area was landscaped to raise the public amenity value. The idea is to frame the development of the city through a network of river systems (restored) and green spaces (agricultural areas, parks, and brownfields).	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In *European Commission. 5 th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage"* (Vol. 2). https://restorerivers.eu/wiki/index.php?title=Case_study%3ARiver_Quaggy-_Chinbrook_meadows#Project_overview
Restoration of the Colorado River Delta	U.S.-Mexico border	USA and Mexico	Governmental cooperation between Mex and USA and academics, and communities, tourism sector. NGOs, foundations, etc.	Changes in regulations and water use agreements in the two countries when there are surpluses and reductions in times of drought. Wetland restoration and efforts to increase water flow.	SER Mexico: Wetland Restoration at Three Sites in the Colorado River Delta. 2022. https://www.ser-rrc.org/project/mexico-wetland-restoration-at-three-sites-in-the-colorado-river-delta/
Torrente Mugnone	Florence	Italia	Governement	The water quality of the Mugnone Brook was ameliorated by burying a public wastewater inlet under the bank and by obtaining natural pretreatment. Further modifications of the riverbanks and the river bed with willow piles, boulder riprap, groyns, etc., upgrade the stream morphology and improve the oxygen balance of the water. New turbulence helped riverine species to resettle in the once artificial stream. The first project in Italy to enhance an urban stream was in 1990.	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In European Commission. 5 th Framework Programme, Key Action 4 “City of tomorrow and cultural heritage“ (Vol. 2).
Grand Park Garone	Toulouse	France	Municipal government	A total of 428 trees and shrubs of local and specific species of the Garonne riparian forest were planted: 58 smooth elms, 54 glutinous alders, 68 white willows, 65 southern ash trees, 60 pedunculate oaks, and 113 vanier willows. Installation all along the path of 43 benches with wooden seats, promoting contemplation on the river (simple benches, sunbathing against the dike, sitting–standing), 26 baskets for the cleanliness of the site, a shared sports hall (tennis, kayaking, water skiing), a pedestrian/cycle bridge, plantations and newly vegetated areas (39 tall trees, 100 baliveaux to reinforce the riparian forest), providing an increase of 4,400 m² of vegetated areas, and a landscaped and educational vegetable garden.	https://una.city/nbs/toulouse/grand-park-garonne

Seine River	Paris	France	Governmental and other sectors involved	Investment in wastewater treatment plants, in 2008 they had 2000. Changes in legislation that fined factories and companies that dumped substances into the river. Incentives to farmers in the areas per hectare for not polluting. Creation of a kind of a "water parliament" at the basin level, which includes the public sector, mayors, institutions, farmers, consumers, and community boards.	Poudevigne et al. 2002. A systems approach to river restoration: a case study in the lower Seine Valley, France. River Research and Applications 18:239-247.
Restore the Anacostia River	Washington D.C.	USA	Governmental	Reintroduction of 17 fish species. Implementation of fishing permits. Construction of wetlands and water gardens. Restoration in various areas and riparian zones. Environmental education in schools and collaboration with civil associations. Dredging in several contaminated areas of the river (remediation). Retrofitting. Green infrastructure projects such as permeable pavement in streets and parking lots, bioretention, and drainage separation.	https://restoretheanacostiariver.com/ https://dcwater.com/sites/default/files/pictures/2017%200112%20GI%20Practices%20on%20ROW_0.jpg
Santa Fe River Restoration Action Strategy	Santa Fe	USA	Governmental and citizen	"Daylighting", discovering rivers and streams; the linear greenway park takes inspiration from historic irrigation techniques to naturally infiltrate, treat, and convey stormwater to irrigate riparian species. Locally appropriate plantings help to stabilize the riverbank and buffer areas, and provide cover and breeding areas for native animal species. The centerpiece of the restoration effort is the construction of pedestrian and cyclist paths along the river through the most densely populated neighborhood in the city.	http://nrcsolutions.org/santa-fe-river-restoration-new-mexico/
Santa Cruz Riverbank and Ecosystem Restoration,	Pima County, Arizona	USA	Governmental	Over 10,000 trees and cacti were planted. Irrigation was achieved using captured and reclaimed water. An array of plants and animals were incorporated, along with species-appropriate habitats such as raptor perches. Erosion control and management were achieved through a layered approach that fuses traditional "grey" infrastructure methods with a nature-based approach. Soil cement and gabions were used to stabilize at-risk areas, while heavily eroded banks were terraced to mimic the river's historical condition. Public access was integrated directly within the project's restoration areas, including approximately eight continuous miles of multi-use paths, several parking areas, seating, and an equestrian staging area. Additionally, daylighting of streams and rivers, floodplain restoration, mapping, green parking lots, waterfront park, and floodwater detention were implemented.	http://nrcsolutions.org/santa-cruz-riverbank-and-ecosystem-restoration-pima-county-arizona/
Bogotá River	Bogotá	Colombia	Public–private	Settling of river banks by placing rocks and longitudinal banks, dredging, and maintenance of the waterway to keep a depth of 7 feet.	Monroy, R., & Honey-Rosés, J. (2016). *Urban River Restoration and Planning in Latin America: A systematic review*. Water Planning Lab, School of Community and Regional Planning. University of British Columbia. September 2016.

Bogota River megaproject	Bogotá	Colombia	Governmental	Approximately 68 km intervention for hydraulic adequacy and water quality improvement. Construction of linear and ecological corridors, pedestrian and bike paths, and passive and active recreational spaces, planting of 500,000 trees of native species, expansion of the Salitre water treatment plant, construction of more water treatment plants, plus the relocation of 188 families established in the riverbank area.	Monroy, R., & Honey-Rosés, J. (2016). *Urban River Restoration and Planning in Latin America: A systematic review*. Water Planning Lab, School of Community and Regional Planning. University of British Columbia. September 2016.
Medellín River Botanical Park	Medellín	Colombia	Governmental	The park program seeks to develop environmental awareness, preserve species native to the region, connect the valley's biotic network and protect it from rapid urban growth, generate cultural scenarios along the river axis to enrich the quality of public space and infrastructure for citizens, offer spaces for learning through multiple landscapes and vegetation, and offer sports scenarios to achieve an integral park where the inhabitants of the valley can recreate and educate themselves.	Monroy, R., & Honey-Rosés, J. (2016). *Urban River Restoration and Planning in Latin America: A systematic review*. Water Planning Lab, School of Community and Regional Planning. University of British Columbia. September 2016. https://www.arquine.com/parque-botanico-rio-medellin/
London Wetland Center/ Wildfowl & Wetlands Trust	London	England	Citizen, Charity	Rehabilitate wetlands using logs and branches to slow flow, aid infiltration, and prevent flooding. Restore native fish and native plants, and recover aquatic life and migrant birds. Use of nature-based solutions.	https://www.wwt.org.uk/our-work/projects/sloughs-urban-wetlands/
Fosso della Bella Monaca	Rome	Italy	Governmental	The goals of the project were to maintain a constant water flow, treatment of solid waste, consolidation, and enhancement of the morphology and vegetation of the riverbed to give back an adjacent area to the citizens and foster active participation and education projects.	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In *European Commission. 5 th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage"* (Vol. 2).
Mud Creek, Toronto	Toronto	Canada	Citizen	Mud Creek, which functions as a stormwater sewer, has been day-lighted and turned into a series of extended detention ponds. Now the site cleanses runoff pollution and functions as a nature education site at the newly restored Don Valley Brickworks.	Jochen, S., Olfert, A., Tourbier, J., Gersdorf, I., & Schwager, T. (2004). Existing Urban River Rehabilitation Schemes. In *European Commission. 5 th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage"* (Vol. 2).

Supplementary S2. Classification of sources reviewed

		Reference									Total
		Academic	*Dissemination*	*Government*	*Manual*	*Analytical Framework*	*NGO*	*Public Policy*	*Proposal*	*Report*	
Location	**Germany**	2	0	0	0	0	0	0	0	0	**2**
	Argentina	1	0	0	0	0	0	0	0	0	**1**
	Asia	1	0	0	0	0	0	0	0	0	**1**
	Australia	1	0	0	0	0	0	0	0	0	**1**
	Austria	1	0	0	0	0	0	0	0	0	**1**
	Bolivia	1	0	0	0	0	0	0	0	0	**1**
	Brazil	1	0	0	0	0	0	0	0	0	**1**
	Chile	3	0	0	0	0	0	0	0	0	**3**
	China	5	0	0	0	0	0	0	0	0	**5**
	Costa Rica	1	0	0	0	0	0	0	0	0	**1**
	USA	21	1	0	1	0	2	0	0	1	**26**
	Slovakia	1	0	0	0	0	0	0	0	0	**1**
	Spain	4	0	0	0	0	0	0	0	0	**4**
	Europe	3	0	1	1	0	0	0	0	0	**5**
	France	1	0	0	0	0	0	0	0	0	**1**
	Global	30	0	3	1	1	0	0	0	0	**35**

	Holland	1	0	0	0	0	0	0	0	0	**1**
	Japan	1	0	0	0	0	0	0	0	0	**1**
	South Korea	2	0	0	0	0	0	0	0	0	**2**
	Latin America	2	0	0	0	0	0	0	0	0	**2**
	Mexico	16	0	0	0	0	0	1	1	0	**18**
	North America	2	0	0	0	0	0	0	0	0	**2**
	Portugal	1	0	0	0	0	0	0	0	0	**1**
	United Kingdom	3	0	0	0	0	0	0	0	0	**3**
	South Africa	1	0	0	0	0	0	0	0	0	**1**
	Sweden	1	0	0	0	0	0	0	0	0	**1**
Total		**107**	**1**	**4**	**3**	**1**	**2**	**1**	**1**	**1**	**121**

Supplementary S3. Glossary

The definitions included in this glossary come from a variety of sources. Most descriptions include the sources of information. However, in the cases where no reference was found, and the concepts are straightforward, we included a description from the authors.

Content

Bank-stabilization measures (stream barbs, vanes, bendway weirs, spur dikes, and log jams)

Bank stabilization measures respond to bank erosion processes. Before implementing any one strategy and structure, it is important to identify the primary bank instability mechanism involved. There are various types of streambank stabilization structures, including stream barbs, vanes, bendway weirs, spur dikes, and log jams. These structures are most commonly made of rock or wood (Yochum, S., & Reynolds, L., 2020).

Log-jams are similar to structures known as engineered log jams, large woody debris structures, and wood complexes. They are log structures that deflect erosive flows, promote sediment deposition, and increase flow resistance.

A cross-vane is a control structure that decreases near-bank shear stress, velocity, and stream power but increases the energy in the center of the channel. The structure establishes grade control, reduces bank erosion, creates a stable width/depth ratio, and maintains channel capacity while maintaining sediment transport capacity and sediment competence.

Reference:

Rosgen, D. L. (2006). Cross-Vane, W-weir, and J-hook vane Structures (Updated 2006) Description, Design, and Application for Stream Stabilization and River Restoration. www.wildlandhydrology.com

Yochum, S.E., Reynolds, L.V. (2020). Guidance for Stream Restoration. U.S. Department of Agriculture, Forest Service; U.S. Department of Interior, Bureau of Land Management; Forest Service National Stream & Aquatic Ecology Center Technical Note TN-102.5. Fort Collins, Colorado.

Bench areas

Areas with benches where people can take a rest and sit near the river. Bench areas are a very important measure to incentivize the recreational use of rehabilitated river areas.

Bikeways, cycle paths, bike paths

A bike path "is a bikeway separated from motorized traffic and dedicated to cycling or shared with pedestrians or other non-motorized users. A path or lane for the use of bicycles." In river rehabilitation projects, these are built on the riversides and may connect to other transportation infrastructures such as bridges, roads, and highways.

Reference: Bike path. Wikipedia, https://en.wikipedia.org/wiki/Bike_path (accessed on 16 June 2022).

Biofiltration

Conventional biofiltration refers to filtration processes where the filter is comprised of porous material that is colonized by indigenous microbial communities and where these micro-organisms perform at least one of the essential functions of the filtration process. In both industrialized and industrializing countries, biofilters such as granular active carbon (GAC) filters, rapid sand filters (RSFs), and slow sand filters (SSFs) are key processes in the biotreatment of drinking water. The main purpose of biofiltration is the removal of biodegradable organic carbon; nonetheless, a wide variety of possible filter configurations, together with a broad range of different water types and pretreatment methods, contribute to extremely diverse biofiltration performance results.

Reference:

Hammes, F., Velten, S., Egli, T. & Juhna, T. (2011) Biotreatment of Drinking Water, Editor(s): Murray Moo-Young, Comprehensive Biotechnology (Second Edition), Academic Press, Pg. 517-530

Bioswales

Bioswales are an aesthetically pleasing alternative to concrete gutters and storm sewers; they employ vegetated low-lying areas or troughs that use a mix of plant materials and specialized soil mixes to treat, absorb, and convey stormwater runoff. They convey stormwater runoff from parking lots or roadways into storm sewer systems or other retention areas. The main difference between bioswales and rain gardens is that the primary purpose of bioswales is to transport water from one area to another (often ending in a rain garden); this maximizes the amount of time that rainwater spends in the swale, increasing the removal of silt and pollutants. Bioswales provide spaces that may create habitats for birds, butterflies, and local wildlife. The infiltration process retains stormwater runoff and reduces sediments, turbidity, heavy metals, and pollutant loading.

Bioswales consist of vegetated, mulched, or xeriscaped channels often designed to manage larger amounts of runoff from a specified impervious area, e.g., a road. Bioswales consist of a drainage course with sloped sides and vegetation or compost in the center. Similar to rain gardens, vegetation chosen for bioswales must have a high tolerance to wet conditions

Some additional economical, public health, and social co-benefits are reduced water treatment costs and healthier natural areas for recreational purposes.

Reference: Natural Resilient Communities, http://nrcsolutions.org/bioswales/

Bertule, M., Lloyd, J., Korsgaard, L., Dalton, J., Welling, R., Barchiesi, S., & Smith, M. (2014). Green Infrastructure. Guide for Water Management: Ecosystem-based management approaches for water-related infrastructure projects. United Nations Environment Programme, DHI, IUCN, The Nature Conservancy.

Bioremediation

Bioremediation is defined as the process whereby (mostly) organic wastes can be biologically degraded under controlled conditions to an innocuous state. It employs living organisms, most notably micro-organisms, to degrade pollutants to convert them into a less toxic or nontoxic form. Suitable organisms can be bacteria, fungi, or plants, which have the physiological abilities to degrade, detoxify, or render the contaminants harmless.

Reference: Anastasios I. Zouboulis et al. 2019. Encyclopedia of Environmental Health (Second Edition).

Blue areas/waterscapes

These are spaces where people can come into contact with water, also called waterscapes (as in landscapes). These can be, according to Herzog (1985): (1) mountain waterscapes, (2) swampy areas, (3) rivers, lakes, and ponds, and (4) large bodies of water.

Reference: Thomas R. Herzog. A cognitive analysis of preference for waterscapes. Journal of Environmental Psychology, Volume 5, Issue 3, 1985, Pages 225-241, ISSN 0272-4944, https://doi.org/10.1016/S0272-4944(85)80024-4. (Accessed on 18 April 2022).

Botanical garden

A botanical garden is a garden dedicated to the collection, cultivation, preservation, and display of a variety of plants, which are typically labeled with their botanical names.

Reference: Wikipedia. Botanical Garden. https://en.wikipedia.org/wiki/Botanical_garden (Accessed on 16 June 2022).

Compost

Compost is organic material that can be added to soil to help plants grow (EPA, 2022). It is commonly prepared by decomposing plant and food waste and recycling organic materials. The resulting mixture is rich in plant nutrients and beneficial organisms, such as worms and fungal mycelium. Compost improves soil fertility in gardens, landscaping, horticulture, urban agriculture, and organic farming.

Reference: Wikipedia, Compost, https://en.wikipedia.org/wiki/Compost

EPA. Composting at Home. https://www.epa.gov/recycle/composting-home (Accessed on 21 April 2022)

Connectivity to other means of transportation

This action refers to connecting rivers to means of transportation by constructing paths and cycle paths on the riversides that connect to roads or other transportation infrastructure, as well as to parks and other recreational green areas. The idea is that by connecting rehabilitated urban rivers with other means of transportation, these spaces will become more accessible and attractive to the general public.

Reference:

Monclús Fraga, F. J. (2002). Ríos, ciudades, parques fluviales, corredores verdes. In de la Cal, P. & Pellicer, F. (Eds.), *Ríos y Ciudades. Aportaciones para la recuperación de los ríos y riberas de Zaragoza* (2181st ed., p. 404). Fernando el Católico.

Control of invasive species

An invasive species can be any kind of living organism—an amphibian (such as the cane toad), plant, insect, fish, fungus, bacteria, or even an organism's seeds or eggs—that is not native to an ecosystem and causes harm. Invasive species can harm the environment, the economy, or even human health. They can grow and reproduce quickly and spread aggressively, with the potential to cause harm.

Many methods attempt to control invasive species, from manual methods such as extraction to biological and genetic methods. Many publications exist on the subject in specialized journals (3,150,000 results for "control of invasive species" on Google scholar on April 16th, 2022).

Reference:

The National Wildlife Federation. Invasive Species. https://www.nwf.org/Educational-Resources/Wildlife-Guide/Threats-to-Wildlife/Invasive-Species (Accessed on 16 June 2022).

Construction of marshes, low-lying areas, and artificial wetlands

Salt marshes are low-lying coastal wetlands blanketed by tall grasses that can withstand daily flooding during high tide. Many species of birds, crabs, and insects make these coastal habitats their home. An important function is to protect nearby communities from flooding. In addition, salt marshes provide many benefits, including cleaner water and air (National Park Service, 2022).

Wetlands are transitional areas between land and water. The boundaries between wetlands and uplands or deep water are not always distinct. The term "wetlands: All wetlands, natural or constructed, freshwater or salt, have one characteristic in common, the periodic presence of surface or near-surface water. In most wetlands, hydrologic conditions are such that the substrate is saturated long enough during the growing season to create oxygen-poor conditions in the substrate. The lack of oxygen creates reducing (oxygen-poor) conditions within the substrate and limits vegetation to those species that are adapted to low-oxygen environments (Davis, n.d.).

Reference:

Davis, L. A handbook of constructed wetlands. USDA-Natural Resources Conservation Service and the US Environmental Protection Agency-Region III. Pennsylvania Department of Environmental Resources, 1995.

National Park Service, https://www.nps.gov/articles/studying-salt-marsh-change.htm (Accessed on18 April 2022).

Construction of piers or beaches

A pier is a structure (such as a breakwater) extending into navigable water for use as a landing place or promenade or to protect or form a harbor.

A beach is a shore of a body of water covered by sand, gravel, or larger rock fragments, according to the Merriam-Webster dictionary.

Piers and beaches in urban river rehabilitation projects promote active recreation activities, such as kayaking, canoeing, and group sports such as volleyball, among others.

Reference:

Merriam Webster Dictionary, Piers, Beaches. https://www.merriam-webster.com/ (Accessed on 18 April 2022).

Construction of reservoirs

A reservoir is an artificial lake where water is collected and kept in quantity for use. Rainwater reservoirs provide a large capacity to collect and slow infiltration. However, they should not be too large due to the limitation of available space in cities. Reservoirs are usually situated in remote areas, parks, and residential areas. They may fulfill the functions of aesthetic and recreational facilities. Tanks planted with water-loving plants enrich the urban landscape and help to improve the quality of retained rainwater (Zubala and Patro, 2015). However, there are many disadvantages, such as loss of high-quality agricultural land, displacement of people, changes to downstream flow patterns, and impacts on fish migration and microclimates (CIWEM, 2005).

References:

Merriam-Webster Dictionary, Reservoir https://www.merriam-webster.com/

CIWEM. (2005). Policy Position Statement. www.ciwem.org

Zubala, T., & Patro, M. (2015). Rainwater Reservoirs in the Urban Landscape- Case Study. *Journal of Ecological Engineering*, *16*(5). https://doi.org/10.12911/22998993/60468

Construction of willow swamps

Willow swamps are swamps where willows predominate; such is the case of Reed's Basket Willow Swamp Park in Staten Island.

Reference: NYC Parks, Reed's Basket Willow Swamp Park, https://www.nycgovparks.org/parks/reeds-basket-willow-swamp-park/

"Daylighting" streams and rivers

Stream daylighting is a relatively new approach that brings these buried waterways back to life by physically uncovering and restoring them. Daylighting is an applicable technique to assist communities in reducing polluted runoff, addressing flash flooding concerns, and improving the livability of the built environment.

Reference:

Trice, A. (n.d.). Daylighting Streams: Breathing Life into Urban Streams and Communities. https://www.americanrivers.org/conservation-resource/daylighting-streams-breathing-life-urban-streams-communities/# (Accessed on 18 April 2022).

Desilting

Desilting is used to remove suspended silt from the water of a stream.

Reference:

Merriam-Webster Dictionary. "Desilt." https://www.merriam-webster.com/dictionary/desilt. (Accessed on 18 April 2022).

Ecological zone for environmental education (Nature education sites)

In the Project Avenida Ronda del Sinú, in Montería, Colombia, an ecological zone for environmental education was habilitated. It is "the quietest part, on which the guama de mono forest extends; it is also rich in fauna and flora and will be oriented towards environmental education" (Garcés-Prettel and Jaramillo-Echeverri, 2017). Zones for environmental education can also be integrated with other activities, such as scheduling special activities and programs for community schools and hiring river guides and experts from varied ethnic and economic backgrounds, to interpret riverfront cultural sites to various groups within the local population (Otto et al., 2004).

Reference:

Wikipedia, Ronda del Sinú, https://es.wikipedia.org/wiki/Ronda_del_Sin%C3%BA

Garcés-Prettel, M. E., & Jaramillo-Echeverri, L. G. (2017). Avenida ronda del Sinú: Entre espacios y significados. Revista Luna Azul, 44, 247–264. https://revistasojs.ucaldas.edu.co/index.php/lunazul/article/view/3836

Otto, B., Mccormick, K., & Leccese, M. (2004). *Ecological Riverfront Design: American Planning Association Planning Advisory Service Report Number 518-519 Restoring Rivers, Connecting Communities*.

Educational vegetable garden

An educational vegetable garden is a garden that focuses on producing vegetables and is mostly used for educational purposes.

Environmental education and river cleanup campaigns

These are actions organized mostly by non-governmental organizations and citizen groups to involve residents in the cleaning of rivers. They focus specifically on picking up solid waste (trash).

Environmental interpretation signs

These are signs that usually include information about the species present, their habitat, or ecosystem. The signs may be implemented in educational gardens, ecotouristic paths, cycle paths, and other spaces.

Equine exhibition area and sports arenas

A public space that is part of a rehabilitated river area, where activities involving horses are performed. A sports arena is a space where sports can be conducted, but also a performance space for sports so that people can "watch" sports live. Both the equine exhibition area and the sports arenas have a recreational function but also serve as attractions to rehabilitated river areas.

Fines and incentives on river use across a region

In many regions of the world, governments that share water bodies have created agreements to improve the use of water resources. Some of the legal instruments mentioned in the experiences studied include fines for river polluters and incentives for those who comply with the laws. International directives have been created in some regions, such as the Water Framework Directive for the European Union.

Fish mating areas

A fish mating area can be a small pond or an enclosure where male and female fish are placed together for them to spawn naturally.

Reference:

FAO. Fish Propagation. https://www.fao.org/fishery/docs/CDrom/FAO_Training/FAO_Training/General/x6709e/x6709e09.htm (Accessed on 18 April 2022).

Floodplain restoration

A floodplain is an area bordering a river that naturally provides space for the retention of flood and rainwater. Major floodplain roles have been lost due to land drainage, intensive urbanization, and river channelization. The objective is to restore them, their retention capacity, and ecosystem functions, by reconnecting them to the river. Some restoration measures may include: modification of the channel, removal of the legacy sediment, creation of lakes or ponds in the floodplain, new/modification of agricultural practices, afforestation, etc., plantation of native grasses, shrubs, and trees, creation of grassy basins and swales, wetland creation, invasive species removal, and riparian buffer installation and development.

Reference:

Natural Water Retention Measures. Floodplain Restoration and Management, http://nwrm.eu/measure/floodplain-restoration-and-management (Accessed on 16 June 2022).

Gabion dams

These structures are semi-permanent rock barriers which are built across the section of the channel, reducing upstream flow velocity, retaining sediments, and promoting water infiltration. Gabions weirs are porous hydraulic structures with minimal adverse impact on the water environment and are considered to be more environmentally friendly than most impermeable weirs. They are considered elastic structures, which can easily be adapted to the geometric conditions in a natural channel.

Reference:

1. Velázquez, L.; Ventura-Ramos, E.; Revuelta-Acosta, J.D. Effectiveness of Gabions Dams on Sediment Retention: A Case Study. *J. Environ. Sci. Eng. A* **2016**, *5*, 516–521. https://doi.org/10.17265/2162-5298/2016.10.004.

Green areas for water management

Refer to Rain Gardens, Bioswales, Retrofits, and Green parking lots. This refers to green area that is specifically designed to be integrated into water management strategies in the city.

Green parking lots

Green parking lots incorporate permeable or semi-permeable paving and porous design techniques to reduce stormwater runoff volume. In addition to the permeable pavement, they often reduce or eliminate curbing and include extensive landscaping, which treats runoff and improves the appearance of the parking lot while also improving water quality by filtering and removing pollutants from stormwater.

Reference:

Naturally Resilient Communities, Green Parking Lots, http://nrcsolutions.org/solution-4/ (Accessed on 16 June 2022).

Green Playground

A green playground is a place where natural elements complement standard play equipment. Synthetic surfaces are replaced with natural ones, e.g., earth, sand, or grass. Children have garden elements made of natural materials, such as a mound or an earth path with tree bough edges, elements of live vegetation: a shrub maze, a hut made of live wicker, or paths for activities made of tree trunks and logs, at their disposal. In addition, children can play freely, using sand and water. A significant part is formed by zones intended for plant cultivation and insect observation, e.g., green beds, fruit bushes, and insect houses.

Reference:

URBACT, 2021- Natural Playgrounds of Poznan, https://urbact.eu/natural-playgrounds-poznan (Accessed on 16 June 2022)

Green riverside areas

Green areas habilitated on the riversides, which commonly include benches, recreational infrastructure such as playgrounds, and other elements, such as cycle paths, trees, grasses, and other types of vegetation.

Installation of ultraviolet light treatment plants

These plants use ultraviolet light as the disinfection method. Ultraviolet light is nature's disinfection method. UV light rays are found in natural sunlight. Ultraviolet light disinfection involves exposing water to UV light rays. The UV light rays penetrate micro-organisms and destroy their ability to reproduce. They are no longer able to cause infection and illness and are therefore harmless.

Reference:

Winnipeg, Water and Waste Department, Ultraviolet light disinfection. https://winnipeg.ca/waterandwaste/water/treatment/uv.stm (Accessed on 16 June 2022).

Large parks or urban forests (may include ornamental trees)

Urban forests encompass the trees and shrubs in an urban area (Escobedo et al., 2011), including trees in yards, along streets and utility corridors, in protected areas, and in watersheds (Millet et al., 2015). This includes individual trees, street trees, green spaces with trees, and even the associated vegetation (Konijnendijk et al., 2006) and the soil beneath the trees.

References:

Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: analyzing ecosystem services and disservices. Environmental Pollution (Barking, Essex: 1987), 159(8–9), 2078–2087.

Konijnendijk, C. C., Ricard, R. M., Kenney, A., & Randrup, T. B. (2006). Defining urban forestry – A comparative perspective of North America and Europe. Urban Forestry & Urban Greening, 4(3–4), 93–103.

Miller, R. W., Hauer, R. J., & Werner, L. P. (2015). Urban forestry: planning and managing urban greenspaces. Waveland Press, Illinois.

Lineal ecological corridor

A thin strip of vegetation used by wildlife potentially allows the movement of biotic factors between two areas (European Environment Agency, 2022). Corridors help maintain or recover a certain degree of cohesion in otherwise fragmented ecosystems. Through the connection of fragmented habitats, the viability of animal and plant species is improved by enlarging habitats, for example, to improve the search for food, dispersion of young animals, and re-use of "empty" habitats. Due to climate change, the borders of suitable habitats are continuously changing. Therefore, many species need to be able to migrate over great distances.

References:

European Environment Agency. Ecological Corridor, https://www.eea.europa.eu/help/glossary/eea-glossary/ecological-corridor. (Accessed on 18 April 2022).

SICIREC. (n.d.). *Ecological corridors and biodiversity*. from http://www.sicirec.org/definitions/corridors (Accessed on 20 April 2022).

Mapping

Mapping rivers with the participation of local residents can be a strategy to achieve environmental education goals, as well as to disseminate relevant information regarding river rehabilitation projects; it also helps local residents become acquainted with the problems of their rivers and to better understand the actions of local governments to deal with those problems. Many studies have used participatory mapping methods to learn about people´s perceptions of risks associated with river dynamics in cities and to integrate this knowledge into flood-risk prevention strategies (Klonner et al., 2021).

Referencia:

Klonner, C., Usón, T. J., Aeschbach, N., & Höfle, B. (2021). Participatory Mapping and Visualization of Local Knowledge: An Example from Eberbach, Germany. *International Journal of Disaster Risk Science*, *12*(1), 56–71. https://doi.org/10.1007/s13753-020-00312-8

Marginal drainage for domestic wastewater

Museums

The construction of museums on riversides, mainly with an environmental education focus. All these interventions aim to attract users to the rehabilitated areas and to profit from this interaction to educate the general public about nature and its benefits.

Organization of forums on urban rivers

Organization of open forums to talk about river issues with residents of the city and the river area, and local governments, businesses, and NGOs.

Participation of neighbors in planting and caring for plants

Usually, this refers to the non-governmental organizations that promote urban river rehabilitation and integrate their actions and activities to encourage the participation of residents. Some of these actions may be planting and caring for the plants and gardens that have been planted.

Passive and active recreational areas

Passive recreation generally encompasses the less intensive range of outdoor activities compatible with preserving natural resource functions such as wildlife habitat and floodplain protection.

Active recreation is a leisure-time physical activity undertaken outside of structured, competition sports. Activities may include walking, gym workouts, cycling, running/jogging, aerobics/exercising activities, swimming, kayaking, and canoeing, among others.

Reference:

Bedford Conservation Commission, Passive Recreation. https://www.bedfordma.gov/conservation-commission/pages/passive-recreation

Victoria State Government. Sport and Recreation. https://sport.vic.gov.au/our-work/participation/active-recreation#:~:text=Active%20recreation%20is%20leisure%20time,living%2C%20active%20transport%20and%20sport (accessed on 16 June 2022).

Permeable pavement

Permeable pavement is a porous urban surface that catches precipitation and surface runoff, storing it in a reservoir while slowly allowing it to infiltrate into the soil below. It is composed of open-pore pavers, concrete, or asphalt with an underlying stone reservoir. Permeable pavement catches precipitation and surface runoff, storing it in the reservoir while slowly allowing it to infiltrate into the soil below or discharge via a drain tile. The most common uses of permeable pavement are parking lots, low-traffic roads, sidewalks, and driveways.

Reference:

Upper Midwest Water Science Center. 2019. Evaluating the potential benefits of permeable pavement on the quantity and quality of stormwater runoff https://www.usgs.gov/centers/upper-midwest-water-science-center/science/evaluating-potential-benefits-permeable-pavement#:~:text=Permeable%20pavement%20is%20a%20porous,of%20pollutants%20and%20runoff%20volume (Accessed on 16 June 2022).

Public toilets

A public toilet, restroom, public bathroom, or washroom is a room or small building with toilets (or urinals) and sinks for use by the general public.

Reference: Wikipedia. Public Toilet. https://en.wikipedia.org/wiki/Public_toilet (Accessed on 16 June 2022).

Pumps to establish a constant river/streamflow

This applies particularly to the Cheonggyecheon case. In this river, water is only naturally present during the summer rainy season. To guarantee constant water flow, 120,000 tons of water from the Han River and several subway pump stations are pumped and treated and returned so that the Cheonggyecheon can have a consistent flow with an average depth of 40 centimeters.

Reference:

Landscape Performance Series. Cheonggyecheon Stream Restoration Project. https://www.landscapeperformance.org/case-study-briefs/cheonggyecheon-stream-restoration#/sustainable-features (accessed on 18 April 2022).

Rain gardens

Rain gardens are landscaped depressions designed to infiltrate and filter stormwater runoff, containing vegetation and sometimes an underdrain. Rain gardens are designed specifically to withstand high amounts of rainfall, stormwater runoff, as well as high concentrations of nutrients typically found in the stormwater runoff, particularly nitrogen and phosphorus; this helps minimize the amount of rainwater that enters storm drains. Therefore, their design includes careful consideration of the choice of appropriate soils and plants. Rain gardens can be dug at the bottom of slopes to collect rainwater and usually take the form of shallow, vegetated basins, gathering rainwater from, e.g., disconnected downspouts or other impervious surfaces.

Reference:

Bertule, M., Lloyd, J., Korsgaard, L., Dalton, J., Welling, R., Barchiesi, S., & Smith, M. (2014). Green Infrastructure. Guide for Water Management: Ecosystem-based management approaches for water-related infrastructure projects. United Nations Environment Programme, DHI, IUCN, The Nature Conservancy.

Rainwater harvesting

Water harvesting refers to the redirection of rainwater and stormwater runoff and storage for productive use (agriculture, drinking water, and more). A wide variety of rainwater harvesting techniques exist, and the choice of the specific solution depends greatly on the area available for catchment, as well as the end-use intended. Water harvesting techniques can be divided into two main types: in situ and ex situ. In situ rainwater harvesting captures and stores rainfall in the location where it falls or arrives as runoff from higher lands. Examples of in situ water harvesting include terracing, pitting, and conservation tillage practices; often, these are identical to measures used for soil conservation. Ex situ water harvesting uses systems where rainwater is captured in areas external to the final water storage. Capture areas, in this case, include natural soil surfaces or rooftops, roads, and pavements in urban areas. Water is stored in natural or artificial reservoirs with little or no infiltration capacity. Examples include capturing and storing water in dams, wells, ponds, cisterns, etc.

Reference:

Bertule, M., Lloyd, J., Korsgaard, L., Dalton, J., Welling, R., Barchiesi, S., & Smith, M. (2014). Green Infrastructure. Guide for Water Management: Ecosystem-based management approaches for water-related infrastructure projects. United Nations Environment Programme, DHI, IUCN, The Nature Conservancy.

Reconstruction of meanders

A river meander is a U-form taken by the river, allowing it to decrease water velocity. In the past, rivers have been straightened by cutting off meanders. Many rivers in northern and western Europe have been straightened and channelized to, for example, facilitate log floating and/or speed up the drainage of water and control/limit the river bed movements. Channelizing was also a way to gain land for cultivation. River re-meandering consists of creating a new meandering course or reconnecting cut-off meanders, slowing down the river flow. The new form of the river channel creates new flow conditions and very often positively impacts on biodiversity and sedimentation. The newly created or reconnected meanders also provide habitats for a wide range of aquatic and land species of plants and animals.

Reference: Natural Water Retention Measures. Re-meandering. http://nwrm.eu/measure/re-meandering (Accessed on 16 June 2022).

Re-establishment of connections between streams

Connectivity is the degree to which components of a system are connected and interact through various transport mechanisms. Water movement through a river system is the primary mechanism providing physical connectivity both within river networks and between those networks and the surrounding landscape (Fullerton et al., 2010). The biological connectivity among the system's populations of aquatic and semiaquatic organisms also determines river system structure and function (Bornette et al., 1998; Steiger et al., 2005; Meyer et al., 2007). Biological connectivity is established through the active and passive movements of living organisms or their reproductive materials (e.g., seeds, eggs, genes) through space (e.g., dispersal, migration) or time (e.g., dormancy). As the materials are transported downstream, connectivity between streams and wetlands provides opportunities for material and energy fluxes to be altered sequentially by multiple streams and wetlands (Newbold et al., 1981; Ensign and Doyle, 2006). The proportion, form, and type of material that ultimately reaches downstream waters is a result of the aggregate effect of these sequential fluxes. Landscape alterations can deeply impact hydrologic and biological connectivity. Some of the most common alterations are dams, channelization, agricultural ditches, and wetland drainage, among others. Reconnecting rivers and streams requires a knowledge-based approach to learning how the connection and isolation of streams interact with other hydrologic elements in a specific basin (Leibowitz et al., 2018). The methods used to reconnect a river and floodplain depend on the cause of disconnection. Some actions to reconnect streams to floodplains may be setting back levees, installing a floodplain terrace, installing log jams using local timber material, replanting native riparian plants to support a natural vegetation community (Loos and Shader, 2016), dam removal, rebuilding culverts crossing under roads (Housatonic Valley Association, 2018), among many other actions, some of which are described in this document.

References:

Bornette, G., Amoros, C., Lamouroux, N., (1998). Aquatic Plant Diversity in Riverine Wetlands: The Role of Connectivity. Freshwater Biology. 39:267–283.

Ensign S.H., Doyle M.W. (2006). Nutrient Spiraling in Streams and River Networks. Journal of Geophysical Research-Biogeosciences. 111

Fullerton, A.H., Burnett, K.M., Steel, E.A. et al. (2010). Hydrological Connectivity for Riverine Fish: Measurement Challenges and Research Opportunities. Freshwater Biology. 55:2215–2237.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6071435/ (accessed on 16 June 2022).

Housatonic Valley Association. (2018). New culvert on Churchill Brook helps fish and reduces flood risks - Housatonic Valley Association. https://hvatoday.org/new-culvert-on-churchill-brook-helps-fish-and-reduces-flood-risks/ (accessed on 16 June 2022).

Leibowitz, S.G., Wigington, P.J., Schofield, K.A., Alexander, L.C., Vanderhoof, M.K., & Golden, H.E. (2018). Connectivity of Streams and Wetlands to Downstream Waters: An Integrated Systems Framework. EPA. Public Access. J Am Water Resour Assoc, 54(2), 298–322. https://doi.org/10.1111/1752-1688.12631

Loos, J., & Shader, E. (2016). Reconnecting Rivers to Floodplains.

Meyer, J.L., Strayer, D.L., Wallace, J.B., Eggert, S.L., Helfman, G.S., Leonard, N.E. (2007). The Contribution of Headwater Streams to Biodiversity in River Networks. Journal of the American Water Resources Association. 43:86–103.

Newbold, J.D., Elwood, J.W., O'Neill, R.V., Van Winkle, W. (1981). Measuring Nutrient Spiralling in Streams. Canadian Journal of Fisheries and Aquatic Sciences. 38:860–863.

Steiger, J., Tabacchi, E., Dufour, S., Corenblit, D., Peiry, J.L. (2005). Hydrogeomorphic Processes Affecting Riparian Habitat within Alluvial Channel–Floodplain River Systems: A Review for the Temperate Zone. River Research and Applications. 21:719–737.

Regulatory changes and water use agreements in a region of Europe/North America: Multisector water parliament at a regional level

The European Union´s Water Framework Directive has made it easier for countries to reach agreements with neighboring countries on their shared waters (rivers, lakes, etc.). Some regions have based regional agreements on this directive and implemented measures such as fines and incentives for more sustainable water management. In other areas of the world, new international agreements are being reached to improve water resource management.

Reference:

EU. Introduction to the EU Water Framework Directive. Available online: https://ec.europa.eu/environment/water/water-framework/info/intro_en.htm (accessed on 2 June 2022).

Reintroduction of fish species

Reintroduction efforts involve releasing fishes into the wild to re-establish populations in areas where the species has been lost. Reintroduction can be performed by removing individuals from one population to re-establish a population in a formerly occupied location (i.e., translocation; Galloway et al. 2016) or by using captive-breeding efforts, which typically involve a greater degree of research effort and supporting infrastructure (e.g., dedicated hatchery facilities).

Reference:

Galloway, B.T., Muhlfeld C.C., Guy C.S., Downs C.C., and Fredenberg W.A. A framework for assessing the feasibility of native fish conservation translocations: applications to threatened Bull Trout. N. Am. J. Fish. Manage. 2016. 36(4): 754–768.

Lamothe, K.A.; Drake, D.A.R.; Pitcher, T.E.; Broome, J.E.; Dextrase, A.J.; Gillespie, A.; Mandrak, N.E.; Poesch, M.S.; Reid, S.M.; Vachon, N. Reintroduction of fishes in Canada: a review of research progress for SARA-listed species. Environmental Reviews. 2019. 27(4): 575-599. https://doi.org/10.1139/er-2019-0010

Reintroduction of native plants

Reintroduction is the deliberate establishment of individuals of a species into an area and/or habitat where it has become extirpated with the specific aim of establishing a viable, self-sustaining population for conservation purposes. Plant reintroduction can involve the establishment of an extirpated species into a relatively intact habitat, or it can be part of the restoration of a degraded habitat.

Reference:

Maunder, M. (1992). Plant reintroduction: an overview. Biodivers Conserv 1, 51–61 https://doi.org/10.1007/BF00700250 (accessed on 18 April 2022).

Relocation of families living along the riverbed

In many cities around the world, historical dynamics have led to the establishment of human settlements in zones that entail natural hazards, such as river beds. Climate change and ecosystem degradation have exacerbated such risks, making the relocation of communities at risk an imperative. Some river rehabilitation projects integrate the relocation of families at risk to safer zones. In addition to the advantages, there are many obstacles to performing relocations, such as the history of the settlement, the economic incentives or disincentives, the cultural heritage, resistance to initiating life in a new place, etc.

Reference:

Carbon Brief. (2017). Guest post: Adapting to climate change through 'managed retreat'. https://www.carbonbrief.org/guest-post-adapting-climate-change-through-managed-retreat (accessed on 16 June 2022).

Hino, M., Field, C. & Mach, K. (2017). Managed retreat as a response to natural hazard risk. Nature Clim Change 7, 364–370. https://doi.org/10.1038/nclimate3252

Removal of concrete barriers and dams

At present, there are many barriers in rivers that could be eliminated due to their lack of use, obtaining with it the longitudinal continuity of the flows and the connectivity of the fluvial habitat recovery. Barriers are obstacles to the longitudinal continuity of the natural flow, represented by hydraulic engineering transverse structures, including large dams, weirs, and dikes. Depending on their height, all dams suppose a more or less impassable barrier for migratory fish species of the river and concern the dispersion of the seeds, drift of macroinvertebrates, and transport and distribution of the sediments along the riverbed. One of the most suitable and effective measures to solve this obstacle is to reduce the height of the dam, or even the demolition of the dam, to restore the primitive conditions of the river. The techniques for dam demolition or to make the fluvial continuity effective must be designed following the peculiarities of every dam (size, type, location, etc.), the characteristics of the river and its catchment area, and the aims of the demolition (restoration of the river, maintenance of recreative activities, use of river banks, etc.).

References:

REFORM. Restoring rivers for effective catchment Management. Remove barrier. https://wiki.reformrivers.eu/index.php/Remove_barrier

NWRM. Removal of dams and other longitudinal barriers. http://nwrm.eu/measure/removal-dams-and-other-longitudinal-barriers#:~:text=Removing%20them%20consists%20in%20destroying,as%20sedimentary%20and%20ecological%20continuity. (Accessed on 19 June 2022).

Retention ponds

Retention ponds are permanent pond areas with landscaped banks and surroundings to provide additional storage capacity during rainfall events. They are created using an existing natural depression, excavating a new depression, or constructing embankments. Retention ponds can provide both water quality treatment and stormwater attenuation by providing additional storage capacity to retain runoff and release this at a controlled rate. Ponds can be designed to control runoff from all storms by storing surface drainage and releasing it slowly once the risk of flooding has passed. Runoff from each rain event is detained and treated in the pond. The retention time and still water promote pollutant removal through sedimentation, while aquatic vegetation and biological uptake mechanisms offer additional treatment.

As part of public open spaces, well-designed and maintained ponds can offer aesthetic, amenity, and ecological benefits to the urban landscape. They are designed to support emergent and submerged aquatic vegetation along their shoreline. They can be effectively incorporated into parks through good landscape design.

Reference:

NWRM. Individual NWRM Retention ponds. http://nwrm.eu/sites/default/files/nwrm_ressources/u11_-_retention_ponds.pdf (accessed on 19 April 2022).

Retrofits (sidewalk drains to capture rainwater)

Retrofits are improvements to existing stormwater management practices so that they provide a water quality function. Stormwater retrofits help restore watersheds by treating stormwater in locations where water can be captured and treated before it reaches streams. They are typically installed within the stream corridor or upland areas to capture and treat stormwater runoff before it is delivered to other water bodies. Retrofits are one of the primary practices used to restore sub-watersheds since they can remove pollutants, promote more natural hydrology, and minimize stream channel erosion.

Stormwater retrofit goals may include, among other things, the correction of prior design or performance deficiencies, disconnecting impervious areas, flood mitigation, improving recharge and infiltration performance, demonstrating new technologies, addressing pollutants of concern, and supporting stream restoration activities

References:

EPA Ohio. What Is a Storm Water Retrofit? https://owl.cwp.org/mdocs-posts/urban-subwatershed-restoration-manual-series-manual-3/ (Accessed on 21 April 2022).

Schueler, T. (2007). Urban stormwater retrofit practices. Manual 3. Small Watershed Restoration Manual Series. U.S. EPA. Center for Watershed Protection. Ellicott City, MD.

Re-use of demolition material of old canal structures

In the Cheonggyecheon river, construction materials were salvaged and re-used from the concrete deck structure and elevated highway demolition. All of the scrap iron and 95% of waste concrete and asphalt were re-used. Other projects also integrate this idea, but there has been little documentation on the details of removals, such as integration in rehabilitation plans, use of machinery, or where exactly is the material salvaged being used.

Reference:

Landscape Performance Series. Cheonggyecheon Stream Restoration Project. https://www.landscapeperformance.org/case-study-briefs/cheonggyecheon-stream-restoration#/sustainable-features (accessed on 18 April 2022).

Sidewalk gardens and plantings (see also "retrofits")

Coupled with retrofits, sidewalk gardens and plantings are part of a strategy where river restoration also happens at the street level. Sidewalk gardens can enhance water infiltration and help break down pollution so that contaminants do not reach rivers and streams. The L.A. River Project is one to emphasize these actions.

Soil bioengineering

Soil bioengineering combines the use of engineering design principles with biological and ecological concepts to construct and assure the survival of living plant communities that will naturally control erosion and flooding. Horticultural principles are applied to establish plant communities. Structures that apply bioengineering principles are built to help protect communities as they grow to maturity and function as they would in their natural settings.

Reference:

Eubanks, E. D. Meadows. (2002). Chapter 5. Soil Bioengineering Techniques. In A Soil Bioengineering Guide for Streambank and Lakeshore Stabilization. FS-683P. San Dimas, CA: U.S. Department of Agriculture, Forest Service, National Technology and Development Program.

Solid waste cleanup

Solid waste cleanup campaigns are an important way to involve the public in river rehabilitation strategies. Governments are also responsible for integrating solid waste cleanup as part of their river rehabilitation projects and strategies. Significant contaminant sources include agricultural chemical use, wastewater discharges from public sewer and on-site wastewater disposal systems, solid and hazardous waste landfills, storage tanks, and industrial materials spill and waste impoundments (Otto et al., 2004). Governments, citizens, and businesses must each take part of their responsibility to reduce, manage and safely dispose of different types of waste. The Compendium of Global Good Practices for Urban Solid Waste Management by PEARL (2015) proposes the following strategies (gathered from real case studies): at-source segregation of wastes, improved collection, re-use and recycling, resource recovery, and social participation in the waste management processes.

Otto, B., Mccormick, K., & Leccese, M. (2004). *Ecological Riverfront Design: American Planning Association Planning Advisory Service Report Number 518-519 Restoring Rivers, Connecting Communities*. https://www.planning.org/publications/report/9026851/ (accessed on 17 June 2022).

Peer Experiences and Reflective Learning (PEARL). (2015). *Urban Solid Waste Management*. https://smartnet.niua.org/sites/default/files/resources/NIUA-PEARL%20Global%20Good%20Practices%20SWM.pdf (accessed on 16 June 2022).

Shopping areas

Construction of shopping areas, market facilities, or promotion of farmers´ markets on the rehabilitated riverside areas has become an important objective of urban river rehabilitation projects. The objective of habilitating markets on the parks along riversides is to attract users and improve the cultural, economic, and social life of rehabilitated areas. Otto et al. (2004:45) argue that "Economic revitalization along riverfronts, such as new mixed-use development with housing, restaurants or cafés, and open space, is more successful when it includes visual and physical access to the water". Maintaining old cultural markets as well as creating new shopping spaces must be part of integral rehabilitation strategies.

Reference:

Otto, B., Mccormick, K., & Leccese, M. (2004). *Ecological Riverfront Design: American Planning Association Planning Advisory Service Report Number 518*-519 Restoring Rivers, Connecting Communities: Helmsdale, UK, 2004.

Sustainable urban drainage systems

Unlike conventional drainage focusing on "end-of-pipe" or "at the point of the problem" solutions, with small and decentralized techniques, sustainable drainage systems can largely alleviate the adverse impacts of non-point source pollution to urban water bodies. Such solutions rely on local treatment, re-use, infiltration, retention, and conveyance of water runoff in urban areas and thus are better adapted to sustainable principles. At the same time, there is a rising acknowledgement of the positive effects of such systems on the urban landscape. It is suggested to treat water as a positive source in sustainable drainage design to create new recreational sites in the urban landscape. By doing so, the urban water is no longer hidden from the public but used as an asset to increase user satisfaction and perceived values. Sustainable drainage design is a multi-disciplinary research field that requires knowledge from specialists with different backgrounds (Zhou, 2014).

Sustainable drainage systems (also known as SuDS, SUDS, or sustainable urban drainage systems) are practices that aim to align modern drainage systems with natural water processes and are part of a larger green infrastructure strategy. SuDS efforts make urban drainage systems more compatible with components of the natural water cycle, such as storm surge overflow, soil percolation, and bio-filtration. These efforts hope to mitigate the effect human development has had or may have on the natural water cycle, particularly surface runoff and water pollution trends (Wikipedia, 2022).

Key Principles

According to the Local Government Association (2022), SuDS essentially operate through infiltration where possible and attenuation combined with the slow conveyance. Many SuDS solutions employ a combination of attenuation and infiltration. In situations where infiltration is not an option, for example, because of the soil type, the favored method is attenuation. Good SuDS design should follow the SuDS philosophy, which calls for the inclusion of several key principles: a management train using several SuDS components in series and characterizing areas into land use and drainage type; source control, e.g., managing runoff as close as possible to where it falls as rain; managing water on the surface, for example, wherever possible, runoff should be managed on the Surface; early and effective engagement, considering the use of SuDS at the earliest stages of site selection and design.

Good practice with attenuation and slow conveyance type SuDS is to use ‘soft engineered' surface features rather than underground storage and to align the conveyance train with exceedance flood routing.

Reference:

Local Government Association, Sustainable drainage systems https://www.local.gov.uk/topics/severe-weather/flooding/sustainable-drainage-systems (Accessed: 04-20-22)

Wikipedia. Sustainable Drainage System https://en.wikipedia.org/w/index.php?title=Sustainable_drainage_system&oldid=1083174153 (accessed on 16 June 2022).

Zhou, Q. A (2014). Review of Sustainable Urban Drainage Systems Considering the Climate Change and Urbanization Impacts. Water 2014, 6, 976-992. https://doi.org/10.3390/w6040976

Tree planting and transplanting (Hedgerow planting and transplanting, row planting with pioneer species, also planting of native grasses and shrubs)

Promoting the presence and re-establishment of vegetation is one of the most important urban river rehabilitation goals. Among the actions integrated into these projects are: tree and shrub planting and transplanting, planting of hedgerows, planting of native grasses, as well as planting other types of vegetation (See vegetable garden; urban food forestry, for example).

Trees are an important component of riparian habitats. Their root systems can increase bank stability, and the shade they provide helps maintain lower water temperatures, which can be beneficial to many aquatic species as the climate warms (Richardson et al., 2021). Riparian habitats play a crucial role in delivering numerous ecosystem services (Haase, 2017; Riis et al., 2020; Groffman et al., 2003), preventing the transfer of nutrients and sediments in freshwater systems (Uggeldahl and Olsen, 2019), and serving as migration corridors (Aziz and Rasidi, 2014).

Shrubs and hedgerows

A hedgerow is a planted line of shrubs that is over 20 metres long, is less than 5 metres wide, and contains at least 80% native shrubs. Hedgerows can improve water quality by trapping sediment, nutrients, and pollutants before they reach watercourses, improve air quality by removing particles and pollutants from the air, absorb carbon dioxide from the atmosphere and store it in their wood, and contribute to the character and appearance of landscapes. In the projects reviewed, hedgerows may be planted on riversides, riverbanks, or in other areas adjacent to or close to rivers (gov.uk, 2022).

In general, when planting trees and shrubs on a river bank, the aim should be to re-create semi-natural riparian woodland using native species appropriate to the local area (SEPA, 2009).

Reference:

gov.uk, Plant and manage hedgerows. https://www.gov.uk/guidance/plant-and-manage-hedgerows (Accessed on21 April 2022).

Groffman, P. M., Bain, D. J., Band, L. E., Belt, K. T., Brush, G. S., Grove, J. M., Pouyat, R. v., Yesilonis, I. C., & Zipperer, W. C. (2003). Down by the riverside: Urban riparian ecology. *Frontiers in Ecology and the Environment*, *1*(6), 315–321. https://doi.org/10.1890/1540-9295(2003)001[0315:DBTRUR]2.0.CO;2

Haase, D., & Haase, D. (2017). Urban Wetlands and Riparian Forests as a Nature-Based Solution for Climate Change Adaptation in Cities and Their Surroundings. *Theory and Practice of Urban Sustainability Transitions*, 111–121. https://doi.org/10.1007/978-3-319-56091-5_7

Keeley, A. T. H., Ackerly, D. D., & Cameron, R. (n.d.). *IOP Conference Series: Earth and Environmental Science. The role of green corridors for wildlife conservation in urban landscape: A literature review*. https://doi.org/10.1088/1755-1315/18/1/012093

Richardson, M., Soloviev, M., Toscano, A., & Hofman, J. (2021). The Urban River Syndrome: Achieving Sustainability Against a Backdrop of Accelerating Change. *J. Environ. Res. Public Health*, *18*. https://doi.org/10.3390/ijerph18126406

Riis, T., Kelly Quinn, M., Aguiar, F. C., Manolaki, P., Bruno, D., Bejarano, M. D., Clerici, N., Fernandes, R., Franco, J. C., Pettit, N., Portela, A. P., Tammeorg, O., Tammeorg, P., Rodríguez-González, P. M., & Dufour, S. (n.d.). *Overview Articles. Global Overview of Ecosystem Services Provided by Riparian Vegetation*. https://doi.org/10.1093/biosci/biaa041

Scottish Environment Protection Agency (SEPA). (2009). Engineering in the Water Environment. Good Practice Guide. Riparian Vegetation Management.

Uggeldahl, K. C., & Olsen, S. B. (2019). Public preferences for co-benefits of riparian buffer strips. In Denmark: An economic valuation study. *Journal of Environmental Management*, *239*, 342–351. https://doi.org/10.1016/J.JENVMAN.2019.03.078

Trails (River parkways), bridges, and kayak ports

Connectivity along the riversides and with other means of transportation is an essential element of many river rehabilitation strategies. There is also the recreational element, which is integrated through the construction of trails, bridges, or kayak ports. In some cases, rocks are used as bridges to cross streams as part of recreational trails.

River parkways consist of trails and park spaces along rivers and other water bodies that connect not just parklands, recreation spaces, and nature preserves but also residences, schools, civic buildings, retail, workplaces, and transit centers. River parkways encourage communities to reconnect with nature while also improving the local environment to combat health issues related to the urban heat island effect and air and water pollution. They also have the additional benefit of supporting wildlife and plant diversity and enriching the outdoor experience. However, the existence of river parkways alone does not directly constitute healthy communities; the design of parkways needs to be addressed to ensure use and safety. Without incorporating aesthetic, multi-use, and safety features, people will not be motivated to use the facilities provided. Adequate lighting, a well-maintained landscape, and safe routes are essential for communities to fully benefit from the healthy activities made possible by river parkways. The synergy between physical activity, exposure to the natural environment, and effective infrastructure design make urban river parkways an invaluable source of mental and physical health benefits.

Reference:

American Trails. (2014). Study Cites Health Benefits of Urban River Parkways. https://www.americantrails.org/resources/study-cites-health-benefits-of-urban-river-parkways

Urban Food Forestry

According to Clark and Nicholas (2013), urban food forestry is “a multifunctional approach that combines elements of urban agriculture, urban forestry, and agroforestry into […] ‘‘urban food forestry’’(UFF). Urban food forestry is ‘‘the intentional and strategic use of woody perennial food-producing species in urban edible landscapes to improve the sustainability and resilience of urban communities’’ (Clark and Nicholas, 2013: 1652). The emphasis on perennial woody fruit- and nut-producing species (food trees) distinguishes UFF from conventional forms of both urban agriculture and urban forestry. Urban food forestry can more efficiently integrate ecosystem services into landscapes and minimize trade-offs through the strategic use and combination of multifunctional species that embody services of both urban forestry, such as air quality, water and climate regulation, oxygen production, erosion control, and biodiversity habitat (Konijnendijk, 2003; Nowak, 2007), and urban agriculture, including increasing community food security, public health, social capital, and microenterprise opportunities (Brown and Jameton 2000; FAO/WHO 2004; Lovell 2010;), while also integrating agroecological design practices of agroforestry to further enhance ecosystem service provision (Clark and Nicholas, 2013).

Reference:

Brown K.H., Jameton A.L. (2000) Public health implications of urban agriculture. J Public Health Policy 21(1):20–39

Clark, K. H., & Nicholas, K. A. (2013). Introducing urban food forestry: A multifunctional approach to increase food security and provide ecosystem services. *Landscape Ecology*, *28*(9), 1649–1669. https://doi.org/10.1007/s10980-013-9903-z

FAO/WHO. (2004). Fruit and vegetables for health. Report of a joint FAO/WHO workshop. 1–3 Sept 2004, Kobe, Japan

Konijnendijk, C.C. (2003) A decade of urban forestry in Europe. For Policy and Econo 5(2):173–186

Lovell, S.T. (2010). Multifunctional urban agriculture for sustainable land use planning in the United States. Sustain-ability 2:2499–2522

Nowak, D.J., Dwyer, J.F. (2007) Benefits and costs of urban forest ecosystems. In: Kuser JE (ed) Urban and community forestry in the Northeast. Springer, Netherlands, pp 25–46

Vertical green walls

Vertical greenery or green walls, as the name suggests, refers to greenery on vertical facades (National Parks Board, 2017). Large areas of connected river walls ('wallscapes') through heavily engineered urban rivers represent potential sites for the enactment of reconciliation ecology via habitat improvement in urban ecosystems (Francis and Simon, 2012). They are built mainly for aesthetic and ecological benefits. The level of maintenance is often dependent on the design and safe accessibility of these vegetated vertical surfaces (National Parks Board, 2017). Living walls utilize plants to derive benefits not only in visual terms but also in regard to amenity, biodiversity, termal efficiency, and amelioration of pollutants, all for a very small ground-level footprint. Vertical walls can potentially provide a food source for invertebrates on which, in turn, other invertebrates and birds may feed. They also provide breeding and nesting habitats for invertebrates, birds, and possibly bats and are ideal for including artificial animal breeding structures such as nest boxes or bat roosting boxes. A living wall can be part of an overall city greening strategy linking ground-level open space with street trees, water courses, and living roofs (Greater London Authority, 2008).

References:

Francis, R. & Hoggart, S. The flora of urban river wallscapes. River Research and Applications. 2012, 28. 10.1002/rra.1497.

Greater London Authority. *Living Roofs and Walls - Technical Report: Supporting London Plan Policy*. London. 2008. https://www.london.gov.uk/sites/default/files/living-roofs.pdf (Accessed on 16 June 2022).

National Parks Board. (2017). *A handbook on developing sustainable highrise gardens. Bringing greenery skywards.* Building and Construction Authority (BCA), Housing and Development Board (HDB), Ministry of Manpower (MOM), National Environment Agency (NEA), National Parks Board (NParks), Public Utilities Board (PUB) and Singapore Civil Defence Force (SCDF). Singapore. https://www.nparks.gov.sg/-/media/srg/files/handbook-1.pdf (Accessed on 18 April 2022).

Water garden or aquatic garden

Water gardens are gardens or parts of a garden where water dominates as the principal element. These gardens focus mainly on water, but they can also house fish or waterfowl. Water gardens can be almost any size or depth; however, they are often small and relatively shallow. This is because most water plants are depth sensitive. Aquatic gardens can include a bog garden for plants that enjoy waterlogged soil, or they can focus on a particular species of aquatic plants, such as water lilies.

Reference:

Wikipedia. Water Garden. https://en.wikipedia.org/wiki/Water_garden (Accessed on 26 April 2022).

Additionally, find more references on specific plants to use in water gardens in:

IOWA State University., Water Gardens: Aquatic Plants https://www.extension.iastate.edu/smallfarms/water-gardens-aquatic-plants (accessed on 29 April 2022).

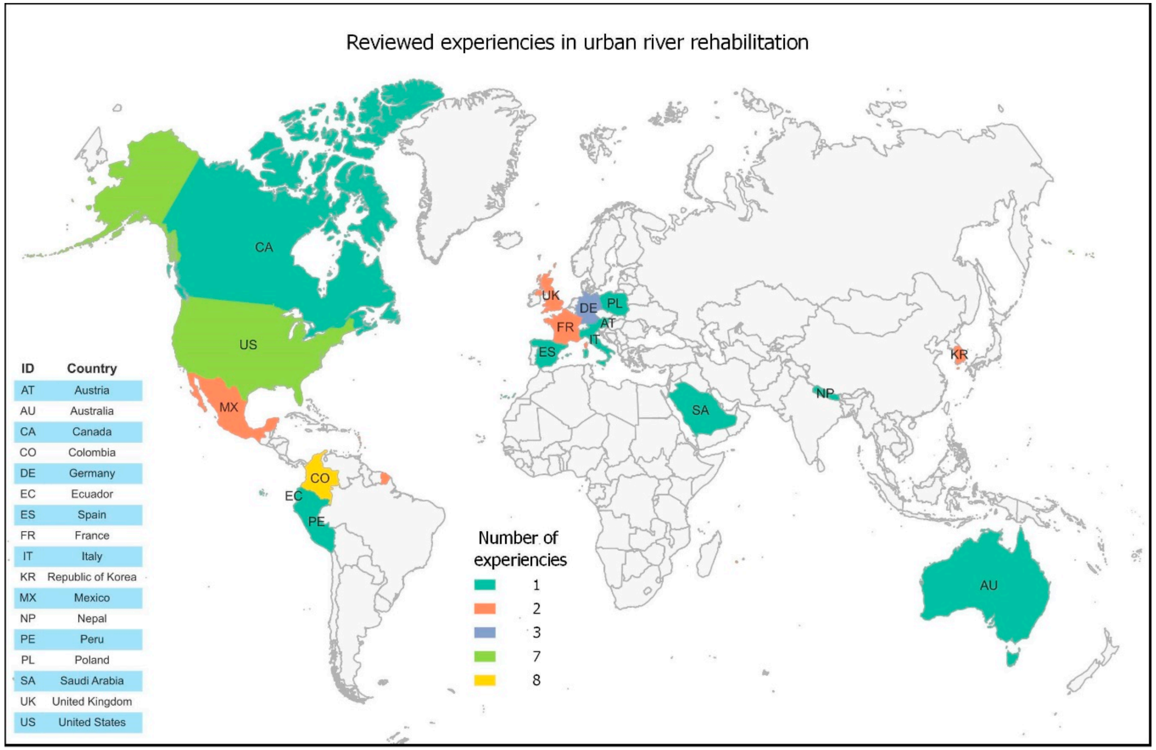
Wetlands

"Wetlands are unique ecosystems that are either permanently or seasonally inundated with water, supporting species that are adapted to live there. They're dynamic, changing with the seasons and over time into different forms. Often, types of wetland habitat work together as part of an intricate ecosystem, home to a huge diversity of wildlife". They encompass a broad range of wet environments that include rivers and streams, floodplains, estuaries and deltas, lakes, ponds, ditches, wet grasslands, marshes, mudflats, peat bogs, mangroves, reedbeds, and coral reefs (WWT, 2022).

Reference:

Wildfowl & Wetlands Trust, Wetlands, https://www.wwt.org.uk/discover-wetlands/wetlands/ (Accessed on 27 April 2022).

Supplementary S4. Map of reviewed experiences in urban river rehabilitation



Map 1: Map of reviewed experiences in urban river rehabilitation. The map shows the countries where the selected experiences are located, and the number of cases is shown in different colors (Map design: Cesar Sanchez J., 2021). As can be seen, some countries and regions in the world concentrate most of the experiences. More information is published every day with examples of cases in other parts of the world, but it is evident that urban river rehabilitation still has a long way to go in countries in the Southern Hemisphere, where policies are mostly focused on industrialization and not yet on environmental preservation.