Urban River Restoration and Planning in Latin America: A systematic review

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Abstract

Urban rivers are opportunities for innovative urban planning, ecological restoration and the creation of valuable public space. Globally, there is interest in restoring urban rivers to meet environmental and public goals. We systematically search the academic and grey literatures in both English and Spanish to identify cases, trends, and examples of successful urban river restoration projects in Latin America. The search of the academic literature in English and Spanish revealed that the documentation on urban river restoration projects is sparse and dispersed. Peer-reviewed articles presented specialized studies but not comprehensive descriptions of the restoration or planning process. The review of the grey literature in Spanish was much more successful in uncovering information about urban river restoration projects and plans, even though few official plans were found. Our systematic search of the academic literature identified 20 cases from 7 countries, while the grey literature search revealed 45 projects from 12 countries. We analyzed four cases in greater depth: The Bogotá, Medellín and Magdalena rivers in Colombia and the Rímac river in Peru. We found that corridors, parks and greenways are the most common elements of river restoration projects. The renewed spaces often include recreational areas and bicycle paths. The drivers that motivate the restoration projects are diverse. The Magdalena river project aims to improve fluvial transportation, commerce and trade along the river. The Bogotá river project intends to restore the environmental quality and landscape as a result of a public and legal claim. The Medellín project aims to create new public space and connect west-east neighborhoods for solving segregation. Finally, the Rímac river project was motivated by transportation interests and sought to provide Lima with green spaces; however, the case was cancelled and led to controversy. Ultimately, we uncovered fewer urban river restoration plans than we anticipated. Nevertheless, the potential remains large, and in the next decade, we foresee that there will be a new wave of urban river restoration planning in Latin America that will improve the quality of life for residents, and the environmental conditions of urban rivers.

Keywords: Bogota, ecological restoration, flooding, landscape, Latin America, Magdalena, Medellin, public space, Rimac, rivers, river restoration, urban planning

Palabras Clave: América latina, Bogotá, espacio público, inundaciones, Magdalena, Medellín, planeación urbana, restauración de ríos urbanos, restauración ecológica, Rímac

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1. Introduction

Urban rivers are critical natural features that serve to connect society and nature in urban settlements. Urban rivers may be used as corridors that connect neighborhoods, move water, transport goods, or provide enhanced habitat for biodiversity. Rivers may also help preserve the historical and cultural elements of a city and drive the local economy. But urban rivers can also divide a city, collect waste, be a source of bad odors, and be perceived as a flooding threat. When the conditions of urban rivers deteriorate, they tend to become polluted, impaired, and ignored or forgotten.

Yet urban rivers remain opportunities for innovative urban planning, ecological restoration and the creation of valuable public space. Given the potential that exist in most urban rivers, there is considerable interest in re-thinking these spaces to provide public benefits, ecological services and improved water management. Urban river restoration projects confront multiple complexities, tradeoffs and competing needs, which can make planning for urban rivers especially difficult (Wohl et al., 2005).

Case comparisons of urban river restoration projects can help municipal planners, engineers or architects in their own design of a river restoration project. Prominski and colleagues (2012) provide an exhaustive review of urban river restoration projects in Europe, with a focus on projects in Germany and northern Europe (Prominski, Stokman, Stimberg, & Zeller, 2012). Through the examination of nearly one hundred restoration projects, they develop a typology of projects and intervention strategies to address common restoration challenges in urban environments. In this way, they use a cross case comparison to contribute to both the theory and practice of urban river restoration. River restoration cases compilations have also been created for the U.S: such as the one presented by Bernhardt et al. (2005) where a database was built from a metadata classification of projects, and the one where Jenkinson and collegues (2006) present an available international and U.S. databases for locating stream restoration projects.

In Latin America, there are fewer resources documenting experiences in urban river restoration. International organizations and initiatives, as UNWater, present few cases in Latin America as part of a river restoration network. Another example is the “Seeds of a Latin Network on Fluvial and Aquatic Ecosystems Restoration” (SERELAREFA) project, created to foster the river restoration while providing fundamental conceptual, methodological and operational framework (SERELAREFA, 2011). They present useful information in regards legislation, methodologies and experiences. However, the SERELAREFA database focuses on the ecological components of fluvial restoration, rather than the planning process or projects that have been executed. As a result, there is no complete and exhaustive review of urban river restoration projects in Latin America. This paper aims to fill this gap, by providing a systematic review of urban river restoration projects in Latin America.

We conducted a systematic review in order to generate results that are reliable, traceable and replicable. A systematic review is a scientific tool to appraise, summarize and communicate results of unmanageable quantities of research (Hussain, Hussain, Bhandari, & Morshed, 2011). Is important to take advantage of the existing available information and practices in river restoration to measure outcomes and learn from successes and failures. We anticipate that practitioners, decision-makers, professional planner or citizen may be able to use this study to contextualize their own river restoration efforts in Latin America. To that end,

this systematic review can be a basis or background for further specialized studies on urban rivers and urban planning.

2. Method: Systematic Review

We systematically reviewed the academic and grey literature to identify cases of urban river restoration plans and projects in Latin America. Our methodology involves 4 stages: the search, narrowing and filtering, the selection of cases and the analysis of cases. In the search stage, we reviewed three sources of literature: first, the academic literature in English; second, the academic literature in Spanish; and third, the grey literature in Spanish. By searching in both languages we aimed to capture most of the rivers that are being restored or planned to be restored in the Latin American region. While the English sources gave us an international overview the Spanish documentation provided more details on the local projects. Because we anticipated that many urban river restoration projects would not be described in the academic literature, we also searched the grey literature using Google's online search platform. We restricted our search results to hits from 2000 to 2016 in order to focus on the most recent cases and current trends.

In the second stage, we narrowed the searches with a first filter by titles and abstracts for both the academic and grey literature. Further, in order to find only Latin American cases related to rivers a second filter was applied for the two academic literatures by categorizing the articles´ content into specific river restoration actions.

In the third stage, we identified cases by their frequency of their appearance in our search results and the ones with a high frequency were selected. In the fourth stage, we analyzed the selected cases.

2.1 Search

We searched the English academic literature on June 8th and 9th, 2016, using six search combinations: (1) "river restoration" AND "best practices" OR "case study"; (2) "river restoration" AND "plan"; (3) "river restoration plan"; (4) "river" AND "urban planning"; (5) "river" AND "urban" AND "plan"; (6) "river" AND "public space". We separately introduced these keywords in nine databases: Web of Science, CAB Direct, Avery Index to Architectural Periodicals, Art Full Text, PAIS index, Urban Studies Abstracts, Worldwide Political Science Abstracts, Engineering Village and GreenFILE (Appendix 1).

We performed the search of the Spanish academic literature between June 13th and 15th, 2016, and used five search combinations: (1) ("recuperación" AND "río") OR ("restauración" AND "río") OR ("rehabilitación" AND "río") OR ("rescate" AND "río"); (2) "río" AND "plan" AND "urbano"; (3) "río" AND "planeación urbana"; (4) ("fluvial" OR "río") AND ("parque" OR "paseo" OR "corredor"); (5) "recuperación del río". We searched seven databases with published academic literature in Spanish: Fuente Academica Premier, Hospitality & Tourism Complete, PRISMA database, Web of Science, OECD and Redalyc (Appendix 2). For this last database, the searches that resulted in more than 4,000 hits were not inspected.

The Spanish grey literature search was performed on June 16th, 2016 with only one search combination; this way we would have a manageable amount of results. The combination was chosen from the ones that gave the best results in the Spanish academic literature and from adding the words "plan" and "proyecto" in our intention to capture official plans. If during the search a file that provided the master plan for a project was found, it was downloaded.

2.2 Narrowing

In the academic literature, we first filtered based on title and abstract, and selected a subset of articles that seemed to be related with (i) a Latin American river and (ii) a river restoration project or activity.

Following this initial filter, we applied a second filter to narrow the studies in our review. An exploration of each article's content led us to identify if they proposed a specific river restoration action. Articles were categorized according its restoration action proposal in: flooding, infrastructure, public space, ecological or water quality (Table 1). Those that did not fit with our criteria were excluded. With this our final academic literature sample, in English and Spanish, was established.

Table 1. River restoration actions categories

CATEGORY	DESCRIPTION
FLOODING	Presents a study pertaining to flooding or risk that conducted a river restoration measure
INFRASTRUCTURE	Suggest a technical or engineering intervention in the river´s space, surrounding or geometry (channels, dams, bridges)
PUBLIC SPACE & LANDSCAPE	Presents a re-design of the river´s landscape or recommendation for the adaptation of the river´s surrounding spaces for recreational uses
ECOLOGICAL	Suggests an action for restoring the river´s natural balance, vegetation or fauna conservation
WATER QUALITY	Recommends a measure for improving a river´s water quality

Independently, we examined the grey literature search results from Google. A record was created for only the rivers of Latin America that appeared during the search. This record included the name of the river, the country and the frequency in which they were mentioned. In this way we pretended to keep a record of the geographical location of rivers, for which a project is presented or proposed.

2.3 Selection of cases

A case, in our study, is conceived as a particular river that is located in the Latin America region and in which governmental, private or public interests are creating river restoration actions and plans. The frequencies in search results were important for identifying cases that are more mentioned or more studied. We categorized each potential case into three levels: high frequency, medium frequency, and low frequency.

The frequency criteria were used in both academic and grey literature reviews but with different specifications (Table 2). The cases which had a high frequency were selected for a further analysis; with the hope of selecting cases appearing in both the academic and grey literature.

Table 2. Frequency definition for academic review

FREQUENCY	SEARCH FREQUENCY FOR ACADEMIC REVIEW	SEARCH FREQUENCY FOR GREY LITERATURE REVIEW
HIGH	Appeared 3 or more times	Appeared more than 5 times
MEDIUM	Appeared 2 times	Appeared 3 to 5 times
LOW	Appeared once	Appeared once or twice

2.4 Cases analysis

For each of the selected cases, we reviewed all the information that came up during our searches. We identified data and information that described a case on its generality and review them in detail. Every case is structured in the same way and presents the following information: the context of the city and the river´s description, details and specifications of the proposed project or projects, and most relevant information in terms of the project´s status or performance.

3. Results

3.1 Search

The search in the academic English literature revealed a total of 3,398 articles with duplicates. A high number of Brazilian articles appeared in our searches and they might be due to language use. Brazilian academic articles were found to be written in Portuguese with English abstracts, while some of them were written in English but not in Spanish. For this search we can highlight that the fourth search combination, "river" AND "urban planning", was the most effective one for gathering river restoration studies.

In the Spanish academic literature, we examined a total of 8,165 articles with duplicates. The number of results and the variety of studies in different countries grew significantly with the use of Spanish search combinations. This means, Latin America information appears more in Spanish than in English sources. In this search, we found that when using the first combination: ("recuperación" AND "río") OR ("restauración" AND "río") OR ("rehabilitación" AND "río") OR ("rescate" AND "río"), provided us with the most relevant articles related to river restoration. The word "recuperación" appeared to be the most common in article titles.

For the academic literature, the idea of performing the search in two languages was successful because we were able to gather the Brazilian projects that did not appeared in the Spanish academic search. In other words, we could identify studies all around the region. Even so, in the academic literature we were not able to find any official plans.

For the grey literature, as explained in the method, we attempted only one search combination. It was constructed using the word "recuperación" AND "río" that worked the best in the Spanish academic literature search plus the words "plan" and "proyecto", these words were added with the aim of finding specific plans. Our search revealed 260 results which included information about projects in Latin America, Spain and other countries. The used combination was: (("recuperación del río" AND "plan") OR ("recuperación del río" AND "proyecto")). Is important to mention that if no date specification was given the results were around 300,000.

3.2 Narrowing

The initial filter for the academic literature, generated 66 academic references after duplicates, 38 from the English search and 28 from the Spanish search. From the total 38 in the English search, 24 articles described studies in Brazil and the rest in Argentina, Chile, Colombia, Cuba, Mexico and Uruguay. In comparison with the English search, the Spanish search had only one article from Brazil.

After the second filter, keeping only the articles that present a specific river restoration action, we kept and categorized 22 articles. They were classified based on the type of information they present in their content (Table 3).

Table 3. Academic literature categorized river restoration actions

ARTICLE TITLE	COUNTRY	CITY	RIVER	FLOODING	INFRASTRUCTURE	PUBLIC SPACE & LANDSCAPE	ECOLOGICAL	WATER QUALITY
SELECTION OF SUSTAINABLE PROJECTS FOR FLOODPLAIN RESTORATION AND URBAN WASTEWATER MANAGEMENT AT THE LOWER CHUBUT RIVER VALLEY (ARGENTINA) (ARES & SERRA, 2008)	Argentina	N/S	Chubut	X	X			X
A ORILLAS DEL RÍO. LA RELACIÓN PUERTO-CIUDAD EN LA TRANSFORMACIÓN URBANA DE ROSARIO (C. GALIMBERTI, 2015)	Argentina	Rosario	Paraná			X		
LA REINVENCIÓN DEL RÍO DESDE LO RECREATIVO. LA TRANSFORMACIÓN DE LA RIBERA METROPOLITANA DE ROSARIO (ARGENTINA) DESDE UNA MIRADA SOBRE EL ESPACIO PÚBLICO Y LAS HUELLAS PATRIMONIALES (C. I. GALIMBERTI, 2014)	Argentina	Rosario	Paraná		X	X		
FLOOD RISK ASSESSMENT AND MANAGEMENT: A CASE STUDY IN RIO DE JANEIRO (M G MIGUEZ, VERÓL, & BIANCHINI, 2013)	Brazil	Rio de Janeiro	Dona Eugenia	X	X	X		X
URBAN FLOODS IN LOWLANDS—LEVEE SYSTEMS, UNPLANNED URBAN GROWTH AND RIVER RESTORATION ALTERNATIVE: A CASE STUDY IN BRAZIL (GOMES, VERÓL, MARTINS, & MOURA, 2015)	Brazil	Rio de Janeiro	Iguacu-Sarapuí River Basin/ Botas	X	X	X	X	
MULTI-CRITERIA SPATIAL DECISION ANALYSIS FOR DEMARCATION OF GREENWAY: A CASE STUDY OF THE CITY OF RIO CLARO, SAO PAULO, BRAZIL (GIORDANO & SETTI, 2008)	Brazil	Sao Paulo	Corumbataí			X	X	X
IMPLEMENTATION OF RIVERSIDE PARKS IN THE CITY OF SÃO PAULO – PROGRESS AND CONSTRAINTS (SILVA-SÁNCHEZ & JACOBI, 2014)	Brazil	Sao Paulo	N/S			X		
INNOVATION IN ENVIRONMENTAL GOVERNANCE IN THE CITY OF SÃO PAULO: IMPLEMENTATION OF LINEAR PARKS (SILVA-SANCHEZ & JACOBI, 2013)	Brazil	Sao Paulo	Guarapiranga Basin		X	X		
PLANNING AND DESIGN OF URBAN FLOOD CONTROL MEASURES: ASSESSING EFFECTS COMBINATION (MARCELO GOMES MIGUEZ, MASCARENHAS, DE MAGALHÃES, & D'ALTERIO, 2009)	Brazil	Rio de Janeiro	Joana	X	X	X	X	
COMMUNITY PARTICIPATION IN FLOOD MAPPING IN THE AMAZON THROUGH INTERDISCIPLINARY METHODS (NOGUEIRA DE ANDRADE & SZLAFSZTEIN, 2015)	Brazil	Santarém	Amazon/ Tapajós	X				

ARTICLE TITLE	COUNTRY	CITY	RIVER	FLOODING	INFRASTRUCTURE	PUBLIC SPACE & LANDSCAPE	ECOLOGICAL	WATER QUALITY
CONTIGUOUS URBAN RIVERS SHOULD NOT BE NECESSARILY SUBMITTED TO THE SAME MANAGEMENT PLAN: THE CASE OF TIETÊ AND PINHEIROS RIVERS (SÃO PAULO-BRAZIL) (CUNHA ET AL., 2011)	Brazil	Sao Paulo	Tiete/ Pinheiros					X
PRIORITY TARGETS FOR ENVIRONMENTAL RESEARCH IN THE SINOS RIVER BASIN (SPILKI & TUNDISI, 2010)	Brazil	Rio Grande do Sul	Sinos				X	X
REC THE POPULAR STRUGGLE (MONTEIRO & CARVALHO, 2014)	Brazil	Recife	Capibaribe		X	X		X
PASEO RIBEREÑO RÍO HUASCO (LOBIANO & ARAYA, 2009)	Chile	Vallenar	Huasco			X		
PROYECTO INTEGRAL MARINA DEL SOL S.A. (UNIVERSIDAD DEL BIO-BIO, 2008)	Chile	Arauco	Andalién	X	X			
INFRAESTRUCTURA VERDE, SERVICIOS ECOSISTÉMICOS Y SUS APORTES PARA ENFRENTAR EL CAMBIO CLIMÁTICO EN CIUDADES: EL CASO DEL CORREDOR RIBEREÑO DEL RÍO MAPOCHO EN SANTIAGO DE CHILE (A. E. VÁSQUEZ, 2016)	Chile	Santiago	Mapocho			X		
EL ESPACIO PÚBLICO DE CONCEPCIÓN. SU RELACIÓN CON LOS PLANES REGULADORES URBANOS (1940-2004) (PÉREZ & ESPINOZA, 2006)	Chile	Concepcion	Bío Bío			X		
ESPACIO PÚBLICO, RESIGNIFICACIÓN Y NEOLIBERIZACIÓN EN CALI (URIBE & FRANCO, 2013)	Colombia	Cali	Cali			X		
IMPACTO DE OBRAS DE PROTECCIÓN CONTRA INUNDACIONES EN LA HIDRODINÁMICA DEL RIO CAUCA TRAMO LA BALSA- LA VIRGINIA (RAMÍREZ, BOCANEGRA, & SANDOVAL, 2006)	Colombia	Cali	Cauca	X	X			
BASES PARA EL MANEJO INTEGRADO DEL RÍO MARTÍN PÉREZ (I. TORRES & MARTÍN, 2005)	Cuba	La Habana	Martín Perez			X	X	X
ESTRATEGIA PARA LA CREACIÓN DEL CORREDOR TURÍSTICO FLUVIAL NACAJUCA-TECOLUTA (VEGA, 2015)	Mexico	Tabasco	Nacajuca-tecoluta			X	X	
ESTRATEGIAS DE INTERVENCIÓN EN ÁREAS URBANAS INUNDABLES: EL CASO BELLA UNIÓN, URUGUAY (PIPERNO & SIERRA, 2013)	Uruguay	Bella Union	Uruguay	X		X		

*N/S (not specified in the text)

Within this review, it was clear that river restoration efforts are not new in Latin America, and they can be traced back to the 1970s and 1980s when there was a claim among the population of Rosario in Argentina to stop giving the back to the Paraná river (Galimberti, 2014). Silva-Sanchez & Jacobi (2013) mentions that projects for environmental recovery included water and sewage collection systems; as well as urbanization projects, housing construction and resettlement programs since 1990s. Another example is the Paseo ribereño río Huasco, which was product of the concern of architects to create multifunctional public spaces, the project was divided in several stages developed between 1994 and 2009 (Lobiano & Araya, 2009).

The reviewed articles seek to evaluate, support or add to past and current projects but official plans were not found during the academic search. This might be because urban plans are written by governments and are not published in academic journals. Urban plans exist all around in Latin America and even without uncovering a document itself, in our review 7 from 22 articles make a clear allusion to a specific local plan. In regard to the architectural designs, even that we searched on specialized architectural databases we were not able to uncover a design project and maybe they might be published in different databases that the consulted in our review.

The nature of the plans varied, some of them refer to governmental urban strategies, others to water management, flooding, sustainability and land use planning. For example, the Water Resources Master Plan for Iguaçu-Sarapuí rivers focuses on flood control (M G Miguez, Veról, & Bianchini, 2013), the Strategic Master Plan for the city of Sao Paulo establishes urban actions and interventions to recover the municipality´s water courses (Silva-Sánchez & Jacobi, 2014), and the Sectional North Shore Plan of the Bío Bío river (Plan Seccional Ribera Norte del río Bío Bío) proposes an interconnection of public spaces for restoring the river (Pérez & Espinoza, 2006).

Studies present how parks and greenways are used as river restoration actions. These elements address public space and landscape needs. The city of Sao Paulo created seventeen parks in different regions between 2002 and 2012, promoting public spaces and reintegrating creeks into the city as social-environmental systems (Silva-Sánchez & Jacobi, 2013). Giordano & Setti (2008) propose a greenway along the Coumbataí River in Brazil. And in Cali Colombia, linear parks are one of the three types of public spaces proposed in local plans (Uribe & Franco, 2013).

In general, parks and greenways include recreative areas and cycle paths. Santiago de Chile has a riparian corridor along the Mapocho River, and the project called “Mapocho 42K” proposes the construction of a cycle path (Vásquez, 2016). Monteiro & Carvalho (2014) presents a network of open spaces in the Capibaribe Park Project at Brazil with cycle and pedestrian paths.

Urban parks and flooding parks appeared to be proposals for connecting rivers with society. M G Miguez et al. (2013) considered an urban park in the middle reach of the river for recreational purposes and to substitute the irregular occupation of river banks.

Also, the suggestion for relocating population in flooding risk areas is highly considered during river restoration. A case in Sao Paulo show us a success in relocating the population that was concentrated on risky bank creeks areas. For the implementation of the proposed park, over six hundred families living in precarious and risk locations were moved (Silva-Sanchez & Jacobi, 2013).

A case in Rio de Janeiro intends to relocate people in risky conditions and especially the ones living in sub-habitations over the river banks. The authors propose to relocate the population in flood proofing new buildings (M G Miguez, Veról, & Bianchini, 2013). Another example is the case in Uruguay in which authors propose housing policies and the delimitation of relocation zones. The study evaluates the compatibility between the residential use and flood return periods to strategize relocation in flooded urban areas (Piperno & Sierra, 2013). These proposals, along with structural delimitations, pretend to give back space to the river and decreasing flood hazards.

From the reviewed articles, 70% discussed or propose an action for public space, 39% for infrastructure, 35% for flooding and only 30% discussed about ecological and water quality actions. Clearly, studies proposed to create public spaces for restoring rivers; while ecological and water quality studies are performed but not always mentioned as river restoration recommendations.

We found that three articles in our review include 4 of the 5 river restoration actions categories. Miguez, Veról & Bianchini (2013), based on an overall assessment, say that river restoration scenario produced minor flood risks compared to traditional alternatives. In the article, authors present a scenario for Dona Eugenia River in Rio de Janeiro where they propose a natural composition upstream with an extension of the natural park, an urban park, detention reservoirs in the middle reach of the river, and a wetland at the downstream for temporary storage and as a quality control measure.

Gomes et al. (2015) present four case studies in the Iguacu-Sarapuí River Basin. This study proposes an interconnection of reservoirs, relocation, creation of fluvial parks and environmental parks for the Jardim Levee Systems. For the Sarapuí River, they discuss the recovery of old existing levee, the implementation of a connected reservoir, and the creation of multifunctional areas. In the Iguacu River, they propose actions such as the opening of a levee system, removing dykes, and restoring the river space. Finally, for the Botas River they propose to preserve floodplains and control urban growth with the establishment of formal environmental preservation areas.

Gomes et al. (2009) propose a combination of structural and non-structural measures for urban flood control. Some actions such as damping storage, reforestation, on-site detention, detention reservoirs at squares and parks, reservoirs at slope areas, and traditional canalization measures were assumed as essential. They conclude that the combination of interventions can solve flooding problems while restoring a river area.

3.3 Selection of cases

As explained in the previous section, during the academic literature review, English and Spanish, we narrowed to 22 articles that met our criteria. They describe 20 cases in 7 countries (Table 4).

Table 4. River restoration cases in Latin America identified from the academic literature

NO.	RIVER	COUNTRY	FRECUENCY
1	Chubut	Argentina	Low
2	Paraná	Argentina	Medium
3	Dona Eugenia	Brazil	Low
4	Iguacu/Sarapuí	Brazil	Low
5	Corumbataí	Brazil	Low
6	Sinos	Brazil	Low
7	Guarapiranga	Brazil	Low
8	Joana	Brazil	Low
9	Amazon/Tapajós	Brazil	Low
10	Tiete/Pinheiros	Brazil	Low
11	Capibaribe	Brazil	Low
12	Huasco	Chile	Low
13	Andalién	Chile	Low
14	Mapocho	Chile	Low
15	Bío Bío	Chile	Low
16	Cali	Colombia	Low
17	Cauca	Colombia	Low
18	Martín Pérez	Cuba	Low
19	Nacajuca-tecoluta	Mexico	Low
20	Uruguay	Uruguay	Low

The academic literature review did not show any case with a high frequency of search results. Parana river, in Argentina, was the only river that appeared twice in the review. This result suggests that researchers are working on different river bodies, without much overlap.

We also identified instances in which research was conducted on tributaries or upstream of a larger river stem. Some projects present a case of a river connected to a bigger one, for example Cauca and Cali in Colombia or Iguacu river and Tiete river with the Paraná river. With this, we can see that river restoration efforts in Latin America are being considered for tributaries as well as for main rivers.

The Grey Literature review, including only the rivers in Latin America, came up with 45 cases in 12 countries (Table 5).

Table 5. River restoration cases in Latin America identified from the grey literature

NO.	RIVER	COUNTRY	FRECUENCY
1	Salí**	Argentina	Low
2	Suquía	Argentina	Low
3	Negro	Argentina	Low
4	Arenales**	Argentina	Low
5	Yaguari	Bolivia	Low
6	Rocha de Cochabamba**	Bolivia	Low
7	Tamborada	Bolivia	Low
8	Vallenar	Chile	Medium
9	Copiapó	Chile	Medium
10	Mapocho	Chile	Low
11	La Serena	Chile	Low
12	Calle	Chile	Low
13	Medellín**	Colombia	High
14	Magdalena	Colombia	High
15	Bogotá**	Colombia	High
16	Manzanares	Colombia	Medium
17	Unete	Colombia	Low
18	Cali	Colombia	Medium
19	Cauca	Colombia	Medium
20	Tunjuelo	Colombia	Low
21	Fucha	Colombia	Low
22	Pance	Colombia	Low
23	Soacha	Colombia	Low
24	Parrita	Costa Rica	Low
25	Monjas**	Ecuador	Low
26	Cutuchi	Ecuador	Low
27	Manchángara	Ecuador	Medium
28	Acelhuate	El Salvador	Low
29	Cholulteca	Honduras	Low
30	Magdalena**	Mexico	Medium
31	La piedad	Mexico	Medium
32	Tijuana	Mexico	Low
33	Sabinal	Mexico	Low
34	Nazas	Mexico	Low
35	Cuautla	Mexico	Medium
36	Sabinas	Mexico	Low
37	Atoyac	Mexico	Medium

38	Verde- Rimac	Peru	High
39	Huantanay	Peru	Medium
40	Mantaro	Peru	Low
41	Chili/quilca	Peru	Low
42	Ramís	Peru	Low
43	Lurín**	Peru	Low
44	Nigua	Rep.Domin	Low
45	Orituco/Guárico	Venezuela	Low

** A Plan document appeared during the search

In comparison with the academic literature list, this one revealed a greater variety of countries and rivers. In the grey literature review, cases appeared in different extents and in different stages of implementation. There were cases only mentioned in news articles as a future project or as a municipal project, while others were part of a developed governmental plan or private project. The countries with more cases were Colombia (24%), Mexico (18%) and Peru (13%). These countries are working hard in restoring their rivers as well as in publishing their projects.

The cases that we found to overlap in both literatures were: Parana, Mapocho, Cali and Cauca rivers. This means they appeared to have background technical studies as well as information published in news, and governmental plans. Importantly, there was little overlap between the cases identified in the grey literature results, with what was identified in the systematic search of the academic literature. This result suggests there remains insufficient collaboration between practitioners and the academy, or that urban river restoration projects are not being well documented in the academic literature. Rather, the grey literature appears to be a more useful resource for learning about current projects and plans to reform urban rivers in Latin America.

3.4 Cases analysis

We selected four cases to analyze in greater detail, three from Colombia, and one from Peru. These cases had considerable more information, and contained features that made them particularly interesting. We describe only four cases in greater detail, because analyzing all 45 cases from the grey literature and 20 cases from the academic literature was not possible. Below we review the cases of the Magdalena, Bogotá, Medellín rivers in Colombia and Rímac river in Peru.

4. Cases

4.1 Magdalena River

The Magdalena River flows through the western part of Colombian and multiple agencies have jurisdiction over the basin, 734 municipalities in 13 states. The river flows south from the Andean Cordilleras Central and Oriental to the Caribbean Sea in the north The Magdalena river basin is the social, environmental and economic heart of Colombia and home to 80% of the nation's 48 million inhabitants (The Nature Conservancy, n.d.). The river is 1,467km in length and receives waters from the San Jorge, César and Cauca rivers (Brittanica, 2016).

The Recovery Project of the Navigability of the Magdalena River is a planned intervention of 908km between La Dorada (Caldas), Puerto Salgar (Cundinamarca) and Barranquilla (Atlántico). It aims to reduce 40% of the national freight industry costs and to establish a multimodal transportation system in the country with seaports, river ports, roads and air transport. It is estimated that the works last 13 and a half years (Mejía, 2014). The project was awarded to the consortium Navalena SAS on August, 15 2014 (Diario del Huila, 2014) and the restoration officially started on December 11, 2014 (Vicepresidencia, 2014). The consortium is formed by Obredecht Brazil and Contracts & Securities of Barranquilla (Figueroa, 2016).

The project is motivated by commerce and transportation. It seeks to make Colombia more competitive in the international market. Additionally, is stated to achieve a greater fuel economy and address an environmental benefit by generating less greenhouse gases by replacing land transport (Mejía, 2014).

The project is organized in two type of public works, first the channeling works that include the placement of rocks and longitudinal dykes for settle the river banks and to bring water to a main channel without affecting the original one. Second, the dredging and maintenance of the waterway to keep the waterway with 7 feet deep, 52m wide and 900m minimum bend radius all year long (CORMAGDALENA, 2016). Nowadays, the Magdalena river mobilize 1.5 million tons per year and is expected to achieve 10 million tons with the Project (Vicepresidencia, 2014).

The contract is a Public-Private-Partnership and the investment is estimated to be 2.5 billion Colombian pesos (Figueroa, 2016). The investment will be raised with contributions from the nation, departments and municipalities, and from Cormagdalena and Ecopetrol (El pilón, 2013). The 70% of the total investment will go to civil and hydraulic works, while the rest will be for maintenance and dredging (Mejía, 2014). But the project expects to contribute 0.25% of GDP between 2016 and 2026, reduce businessmen expenses in 10% to 50%, create jobs, and increase the foreign trade (Acosta, 2016).

Is important to mention that the proposed project arose diverse opinions and is polemic among experts. The engineer Jaime Iván Ordóñez, president of the Water Resources Engineering Commission of the Colombian Society of Engineers, says the project has no technical feasibility and represents a risk transporting loads such as oil, coal, and similar mineral products. Also, he states the project is unrealizable because of its magnitude and runtime. This is presented to be a reason why other expert companies withdrew from the project tender. Regarding the river's navigability, the natural sedimentation is a major constraint and it has been since 1823. The engineer also states that studies were not used when making the project and tests were not performed in laboratories at a physical scale (El Espectador de Bogotá, 2014). The project seems to be restricted to benefit a few companies (El Espectador de Bogotá, 2014) and to be immersed on uncertainties regarding the executing company (V. Torres, 2016). In 2016, the financial close appeared to be not completed and the project on loan by the contractor, but with intentions of continuing (V. Torres, 2016). This presents an infrastructure scope on navigability to achieve river restoration.

4.2 Bogotá River

The Bogotá river is located on the west of the Savannah of Bogotá about 2640 m above sea level on a high plateau in the Andes mountains (Off2 Travels, n.d.-a). It runs through 41 municipalities

with 1.3 million inhabitants (DAMA, 2004) and also through the Bogotá District with 6.763 million inhabitants in 2005 (UN, 2005). From the total basin population 75% is urban and 25% is rural (Urbano, 2014). The channel length of the Bogotá river is 380 km, with a basin total area of 6,000km^2 (DAMA, 2004).

The river restoration project is called "Megaproyecto del río Bogotá" and is directed by the Regional Autonomous Corporation of Cundinamarca (Vásquez, 2014). It is planned to be a 68.8km intervention which includes a hydraulic adequacy and water quality improvement (Noticias Colombianas, 2015). The project includes the construction of a linear ecological corridor with pedestrian and bike paths, the construction of passive and active recreational spaces, the plantation of 500,000 trees native species, the extension of the existing Salitre Waste Water Treatment Plant in Soacha (WWTP), and the construction of the Canoas WWTP (El Nuevo Siglo, 2014). Plus, the relocation of 188 families stablished in the riverbank area is planned by giving them three subsides covering their property´s total value (Noticias Colombianas, 2015).

The project will be developed during the next 35 years and three main objectives were established to achieve an ecological sustainable restoration. First, to have a river with minimal aesthetic conditions, second to make its water usable without risks, and third to transform the river into a stable ecosystem capable of sustaining life (Publimetro, 2014).

Despite different quantities presented in diverse sources, it is clear that the river restoration project´s investment is valuated in more than USD 500 million (Cabana, 2011). It is financed by the city's resources from property taxes and by a World Bank loan of USD 250 million (Lucero & Vengoechea, 2014). The World Bank granted a 20 years credit plan to indict the river, build the WWTPs and to recover the river´s life in the middle and low basin (Buitrago, 2011).

The project was moved by a legislative claim and is an answer to the legal judgment stated in March 28, 2014 by the institution exercising advisory functions of the supreme organ of government. It declares that 23 national entities and 43 municipal administrations are responsible of the environmental catastrophe in the river, and they needed to trace strategies for its sanitation and restoration (Publimetro, 2014). The total intervention progress in 2015 was of 52.2km, and during the first stage the San Nicolas park was built and around 50,000 trees planted (Noticias Colombianas, 2015). The project is still in process and up today several actions have been concreted. Some of them are the 6 million square meters of sediments removed (El Nuevo Siglo, 2014) so the dredged areas in the middle river basin reach depths of up to 8m, the extension of the riverbed from 30m to 60m, and the construction of marginal slopes dimensions based on over a hundred years flood return period studies (Lucero & Vengoechea, 2014)

Within the review we found that the information about this project is very accessible and homogenous, it presents approximately the same data and details in every source. Also, is important to highlight that the project was cataloged as a model in a continental level at the Integrated Management Seminar in Buenos Aires and in a national level recognized by the Superior Council of Ecologies Environmental Organizations as the best environmental project in Colombia in 2014 (Noticias Colombianas, 2015).

4.3 Medellín River

Medellín is the second largest city in Colombia and the capital of the department of Antioquia and lies within the Aburrá valley at an elevation of 1500 m. The city has 2.1 million inhabitants (UN, 2005) and is divided by the Medellin River, also known as Porce River, which also runs through other 8 municipalities (Off2 Travels, n.d.-b). The river has an approximate 100 km total length and presents mostly an urban feature, it is a tributary of the Nechi River which flows into the Cauca river (Cardona, n.d.).

Parques del Río Medellín is a project that aims to renew the strategic intervention areas of the river with a corridor that will provide urban vitality and public spaces. The project also intends to recover natural and landscape values; and reassess the river's civic, historical, and representative characteristics.

The project aims to address the deficit of public space and to connect west-east neighborhoods. It is part of the Land Use Plan of Medellín (POT) and the proposed actions includes an environmental corridor as a main ecological structure, the construction of protection edges and the addressing of urban renewal with land use. Further, it includes the introduction of city´s equipment and urbanistic operations through urban parks and densification of the river´s areas. The corridor will have river parks, recreational metropolitan parks, plazas and civil parks as an effort to maximize public accessibility and meeting. The project itself is a strategy for obtaining effective green space to $7m^2$ per habitant. Additionally, the project plans to relocate the population and activities that invades 60m of the river shore ("Antecedentes Parque del Río Medellín," 2011). 34km of pedestrian paths and 32km of cyclepaths are going to be created in 10 years; transforming 19.8km of ways into green areas for the city (SPDA Actualidad Ambiental, 2015).

The cost will be of USD 1.72 million and the stage of the project is not clear but it seems to be in progress (SPDA Actualidad Ambiental, 2015).

The project is interconnected with other local plans. As an example the Parques del Río Medellín project is contemplated in the Mobility Master Plan for the Metropolitan Region Aburrá Valley, in which the corridor will respect the bands corresponding to the national railway and it will add value to the "vial local" project by enable the river highway between Ancón Sur and Ancón Norte. Also, the project promotes the non-motorized transport and is coordinated within the General Vial Project for the Medellín River Park ("Antecedentes Parque del Río Medellín," 2011).

4.4 Rimac River

Lima is the largest city and capital of Peru. The urban area is known as the Metropolitan Lima, and its population in 2007 was of 8,473 million (UN, 2007). The city lies on Peru´s desert coast but also is located on the central coast of the country, on the shores of the Pacific Ocean and extended over the valleys of the rivers Chillón, Rímac and Lurín (Universia, n.d.). The Rímac river, also known as "Río Hablador", is a main water source for the city, fulfilling industrial and domestic demands. The river´s main channel length is 134 km and two major tributaries the Santa Eulalia and San Mateo rivers (Orbegoso & Alcántara, 1998).

The private iniciative (PI) Vía Parque Rímac, first known as PI Línea Amarilla, is a 23km express vial system with 14km of existing ways and 9km of new ones intended to vacate and rehabilitate 25 hectares of green spaces and equipment. At the same time, this project was part of the Road Plan

of the Metropolitan Highway System (Ord. N° 341-MML) and part of the planned "vía de evitamiento". These plans along with the Vía Parque Rímac project planned to create a continuous 100km path for connecting Lima´s ends in 20 minutes and to derive the traffic into a 2km tunnel under the Rímac´s riverbed at the historic center. Additionally, the project included a fund for relocating 266 families that live in extreme poverty in the riverbank area, such as the The Shipiba indigenous community which is established in the Cantagallo region. The project, in coordination with the Integral Involuntary Resettlement Plan, planned to relocate that population in new multifamily housing (Zeballos, 2012). The Multisectoral Commission for the Recovery of Water Quality in the Rímac River was created for coordinate, establish, determine and take actions about the Rímac river restoration project (La Republica, 2015).

The project was clearly motivated to address transit issues, as well as landscape and ecological problems in the city. The PI Vía Parque Rímac contemplated a referential investment amount of USD 461 million and was proposed to pay for itself with road tolls (Zeballos, 2012). But the restoration project was cancelled in 2015 by the Lima´s Metropolitan Municipality and the funds were allocated to the construction of a bypass on "avenida 28 de Julio" (SPDA Actualidad Ambiental, 2015).

The same year, in July 19th 2015 the effort to restore the river was addressed by an international cooperation. The Korean public Enterprise K-Water and the Pyunghwa company presented a final report where they discussed the structure of the Recovery Master Plan for the Rímac River. They highlighted the predisposition for a voluntary funding to the implementation of an Information Center of Water Resources. These efforts are the result of the Agreement on Cooperation in Water Resources Management and Basin Development signed between Peru and South Korea in October 16, 2012.

The Korean-Peruvian Master Plan included three stages of implementation: water cleaning, improve water quality by building reservoirs, and achieve high standard sustainable maintenance. This Plan intends to divide the Rímac Basin into three preservation zones, six restoration zones, and two riverside zones. It was proposed to reuse the treated water from the Taboada Water Treatment Plant, and to build a dam to ensure reliable water supply during dry seasons (Informa, 2015). The execution time was expected to be of 9 months, but it is not clear if the Plan is still in progress and if is associated with the previous restoration project.

The situation with the Rímac River restoration is complicated. The first project Vía Parque Rímac was expected by the citizens to be implemented. The cancellation of the project was very controversial and diverse opinions appeared within the reviewed information. Also, the cancellation deprived the city of having green spaces and to improve the quality of life of informal settlements and indigenous population. At some point the Vía Parque Rímac project was one of the most important vial infrastructure projects in Latin America (Zeballos, 2012).

Regarding the Korean-Peruvian collaboration, the project seems to be ambitious but not further information was available to make a deeper insight.

5 Conclusions

This systematic review allowed us to survey the river restoration projects taking place in Latin America. The results show us the variety, extents and status of the projects by country. Within this review we found that Brazilian academic articles were found mostly in English, and the use of the Spanish language led us to find a greater variety of results. We found that the scope in the academic articles is narrow and deep. They give recommendations based on knowledge and feedback to the proposed actions. The academic literature encourages decisions and actions to be supported by technical analysis, mathematical modeling, or original ecological and biophysical research. Also, articles provide technical feedback and support to diverse actions. Even without an official plan in the academic literature, studies refer to local plans.

We found that river restoration efforts are not new in Latin America and can be traced since 1970s when the public called for the recovery of the river's space and sanitation. Studies present parks and greenways to be considered in a great extent into river restoration projects. In these spaces, recreational areas and cycle paths are constructed.

We found more cases of river restoration projects in our search of the grey literature, and given the vast amount of information available online, it is likely that additional cases may be left undocumented. The grey literature search succeeded in revealing many active or proposed projects in Latin America, but also included many projects in Spain. Even so, more Latin American projects appear in the search and valuable information was found in news articles, the popular press or opinion articles.

The Magdalena river project aimed to address commercial and fluvial transportation needs. They are trying to make a navigable river for making the local commerce more affordable. Several considerations in regards public space, ecological restoration or public participation are excluded as well as technical support. The river restoration proposal is different for this river and does not follow the common traditional ways of restoration in Latin America.

The Bogotá river project was intended to restore the environmental quality and landscape. The project itself is a result of a public and legal claim that involves several stages and objectives. It seeks to recover the river's balance and provide valuable public spaces for the population. The project remains in progress and the information found in the grey literature is clear and homogenous.

The Medellín river project is aims to increase public space in the city and to connect west-east neighborhoods avoiding segregation. The intention is to restore the river as well as the connection between the population and the river. The found information is dispersed and does not provide details about the current project's status.

The Rímac river project was motivated by transportation interests and sought to provide Lima with green spaces. The cancellation of the project was controversial and generated diverse public opinions. Later, an international collaboration (Korean-Peruvian) Plan was presented, but the relation with the previous project and its status was not possible to determine.

We found that little information is published on urban river restoration projects, and if it is published, it is highly dispersed and mostly in the grey literature. There remains no single source or database of urban river restoration projects. We also found that our review of the academic

literature, regardless of the language, gave us a very different set of projects and cases than our results from the grey literature review. This lack of overlap suggests that researchers and practitioners are examining and writing about different cases at different locations.

Collaboration between practitioners and the academy may help citizens and practitioners address urban river problems. Involving students and universities in the early stages of a river restoration project may help generate new ideas and creative approaches to meeting the needs for public space, restored ecosystems, and safe flood control (Arroyo-Robles et al 2016). The intrinsic interdisciplinary of river restoration work may also explain why our systematic search of the academic literature did not reveal peer-review articles that provided a comprehensive or holistic review of restoration projects. Rather, the disciplinary journals published articles that addressed one narrow component of a larger restoration effort. Nevertheless, our review shows that urban river restoration projects are increasingly common in Latin America and people are raising awareness of the importance of urban rivers.

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7 Appendixes

Appendix 1. **English Academic literature search summary**

Database	Total Hits	Filtering conditions	Total references (after duplicates)
"river restoration" AND "best practices" OR "case study"			
Web of science	98	(i) Discusses about a Latin America river, (ii) Discusses about a river restoration action	2
CAB direct	1		0
Avery Index to Architectural Periodicals	1		0
Art Full Text	1		0
PAIS index	1		0
Urban Studies Abstracts	8		0
Worldwide political science abstracts	1		0
Engineering Village	137		1
GreenFILE	26		0
		TOTAL	**3**
"river restoration" AND "plan"			
Web of science	38		1
CAB direct	147		1
Avery Index to Architectural Periodicals	3		0
Art Full Text	8		0
PAIS index	2		0
Urban Studies Abstracts	28		0
Worldwide political science abstracts	1		0
Engineering Village	19		0
GreenFILE	27		0
		TOTAL	**2**
"river restoration plan"			
Web of science	17		0
CAB direct	11		0
Avery Index to	0		0

Architectural Periodicals			
Art Full Text	0		0
PAIS index	0		0
Urban Studies Abstracts	0		0
Worldwide political science abstracts	0		0
Engineering Village	4		1
GreenFILE	4		0
		TOTAL	**1**
		“river” AND “urban planning”	
Web of science	251		12 (9)
CAB direct	168		7
Avery Index to Architectural Periodicals	10		0
Art Full Text	322		2
PAIS index	113		0
Urban Studies Abstracts	269		5 (3)
Worldwide political science abstracts	9		0
Engineering Village	533		4
GreenFILE	125		0
		TOTAL	**25**
		“river” AND “urban” AND “plan”	
Web of science	297		4 (2)
CAB direct	31		0
Avery Index to Architectural Periodicals	68		0
Art Full Text	120		1
PAIS index	15		0
Urban Studies Abstracts	73		0
Worldwide political science abstracts	7		0
Engineering Village	196		0
GreenFILE	48		0
		TOTAL	**3**
		“river” AND “public space”	
Web of science	44		4 (3)
CAB direct	8		0
Avery Index to	17		0

Architectural Periodicals			
Art Full Text	40		1
PAIS index	2		0
Urban Studies Abstracts	5		0
Worldwide political science abstracts	3		0
Engineering Village	41		0
GreenFILE	0		0
		TOTAL	**4**
		Grand Total	**38**

Appendix 2. **Spanish Academic literature search summary**

Database	Total Hits	Filtering conditions	Total references (after duplicates)
(“recuperación” AND “río”) OR (“restauración” AND “río”) OR (“rehabilitación” AND “río”) OR (“rescate” AND “río”)			
Fuente Academica Premier	114	(i) discuses a Latin America river, (ii)discusses a river restoration action	4
Hospitality & Tourism Complete	4		0
PRISMA database	958		9 (7)
Web of Science	32		0
OECD	32		0
Redalyc	3907		1
		TOTAL	**12**
“río” AND “plan” AND “urbano”			
Fuente Academica Premier	9		2 (1)
Hospitality & Tourism Complete	0		0
PRISMA database	265		2
Web of Science	9		1 (0)
OECD	32		0
		TOTAL	**3**
“río” AND “planeación urbana”			
Fuente Academica Premier	2		0
Hospitality & Tourism Complete	0		0
PRISMA database	30		1
Web of Science	0		0
OECD	0		0
Redalyc	1328		1
		TOTAL	**2**
(“fluvial” OR “río”) AND (“parque” OR “paseo” OR “corredor”)			
Fuente Academica Premier	149		0
Hospitality & Tourism Complete	30		2
PRISMA database	708		4 (2)
Web of Science	473		1
OECD	19		0
		TOTAL	**5**
“recuperación del río”			
Fuente Academica Premier	1		0
Hospitality & Tourism Complete	0		0
PRISMA database	3		1
Web of Science	2		0
OECD	1		0
Redalyc	57		6 (5)
		TOTAL	**6**

Grand Total	**28**