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Editors

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Glide, playful waves, and murmur softly!
No, rush quickly,
Making the banks and cliffs resound
frequently!
The joy that stirs our waters,
Which moves every wave to surge,
Rips through the barriers,
Set by astonishment and shyness.

Johann Sebastian Bach, Chorus from
Cantata BWV 206,
Glide playful waves, and murmur softly!
1735

Preface

The concept of the Anthropocene, conceived from the renewed, invigorating perspective afforded by geography, invites us to reflect on the role played by human societies in the history of the biosphere and our impact on its subsystems. The human footprint on the hydrosphere is increasingly apparent, and evidence of this is patent in the effects—both direct and indirect—on the quality, quantity and availability of the Earth's water. Today, and in the coming decades, our planet's natural phenomena, intensified by processes of climate change, will be subject to increasingly critical circumstances. The resulting global uncertainty needs to be carefully assessed and considered when deciding what measures need to be taken in all spheres, be it scientific, technical, social and political.

It is against this backdrop that the current book turns its attention to the urban rivers that flow through our cities and, at the broader scale, our metropolitan territories. Urban rivers have been defined from many different perspectives, but might best be characterised as those ecosystems of permanent flowing water that have been intensely altered by human transformations. These are rivers that have lost their so-called 'espace de liberté', their floodplains having been largely urbanised, their water courses channelised and transformed into linear spaces, and their riverbeds diverted and, even, eliminated. Urban rivers have been placed at the service of society's economic and extractive needs, and these impacts manifest themselves in a multiplicity of ways, dependent fundamentally on the technical-political vision of water afforded in each given place and moment in time.

The study of urban rivers poses challenges of great interest for geography. First, as a holistic and synthetic science, it allows us to address the relationship between society and nature from a range of different perspectives, which we bring together in this book by incorporating research conducted in the different branches of the discipline: including physical geography and geomorphology, urban geography, spatial planning and territorial organisation, regional geography, the geohistorical study of landscape and the geography of tourism. To these, we incorporate the confluent perspectives provided by the environmental sciences, ecology, hydrology, water engineering and urban planning. All these fields of study converge to offer, in the course of the book, a global vision of urban rivers.

Second, the very configuration of these spaces, hybrids of the natural and the artificial, shows the need to address the study of their complexity, overcoming sectoral visions that have historically prioritised the analysis of territories in isolation of their anthropic impacts. Urban rivers reflect the new reality of the Anthropocene and we cannot ignore this fact nor consider it devoid of scientific interest, no matter how transformed, urbanised and altered they may be. Urban rivers deserve to be reconsidered, revalued and rethought, above all as an integral part of the strategic planning conducted by government entities.

This book contains sixteen chapters that offer evidence of the need to consider urban rivers as an interdisciplinary field, in which geography has a leading role to play. To reflect this, the book adopts a transversal perspective and is divided into three main sections: **Geomorphology** (four chapters), **Planning** (six chapters) and **Perception** (five chapters). The studies of urban rivers concentrate mainly on southwestern Europe (France, Spain and Portugal), but cases are also included from Latin America. By way of introduction, chapter 1 (Olcina, Farguell & Santasusagna) summarises the particular problems in each of these three areas and brings to the table the main questions of debate that are then addressed more specifically in the following chapters.

The first section of the book, dedicated to the **Geomorphology** of urban rivers, emphasises the fact that river courses continue to erode, transport sediment and undergo variations in their flow regimes despite the reduction in their river space. It also describes and analyses interventions to mitigate, minimise or avoid these hydrogeomorphological processes. Thus, chapter 2 (Francos & Sánchez) describes the significance of the flood risk factor and the increasing vulnerability of urban areas to it, while chapter 3 stresses the effects of this hazard in urban areas subject to the growth brought by tourism, as illustrated by the case of the island of Mallorca (Rosselló & Grimalt). Chapter 4 (Farguell, Ochoa & Chavez) highlights the existence of these hidden or mitigated river processes when undertaking actions of river restoration, while chapter 5 (Yuste & Martínez) provides examples of how degraded river spaces can be recovered and reports the successful outcomes of such interventions.

The second section of the book examines the **Planning** processes carried out by urban, metropolitan and regional public entities when designating land uses and drawing up technical projects, sustainability policies and strategies for the revitalisation of urban river spaces from both a current and a historical evolutionary perspective. Chapter 6 (Rode) reports the experiences of small and medium river cities in France, to shed light on the processes of deurbanisation, re-naturalisation and adaptation to the challenges of global change. Chapter 7 (Santasusagna) examines the conception that city authorities have of urban rivers, especially when opting to implement the *gardenscape* model that has been so widely copied around the world. Chapter 8 (Valette & Hatvany) focuses specifically on several medium and large cities in the Garonne river valley and, from a geohistorical perspective, shows the evolution and adaptation of these cities to the river. Chapter 9 (Portugués) undertakes a case study of the city of Valencia and shows how a change in vision and awareness on the part of the city hall has guided the metamorphosis of the river Turia over the last half century. From a broader metropolitan scale, chapter 10 (Dournel) highlights

the diversity of strategies adopted in the river cities that form part of Île-de-France region, with a particular concern for its wetlands. Chapter 11 (Rendón, Zúñiga & Santasusagna) turns its attention to the Huatanay in the Peruvian city of Cusco, a river whose extreme alterations and high levels of pollution mean its sustainable management faces an uncertain future.

Finally, the third section of the book explores society's **Perception** of the urban river and reflects on considerations of its importance and utility within the framework of the city. How is the passage of the river perceived? Does society consider it a hazard or an asset? And how does society perceive the river restoration measures along their courses in recent decades? Chapter 12 (Bonifácio) focuses on advances in neurourbanism and the consideration of river spaces as positive and necessary for the good mental health and quality of life of urban dwellers. Chapter 13 (Ollero, Albero, Boné, Díaz-Morlán, Pirchi & Marchioro) illustrates an example of the social perception of three rivers that converge in the city of Zaragoza and highlights the different impact society can have on each of them. Chapter 14 (Pavón, Benages-Albert, Vall-Casas, Garcia & Ribas) reflects on the transformations that have taken place in Barcelona's area of influence and which have facilitated a marked improvement in the characteristics and values of the river landscape. Chapter 15 (Cuello) makes a strong case for the need to use the river as an element of learning and perception in environmental education, in order to create a society that is aware of, and sensitised and committed to, the health of its urban rivers. Chapter 16 (Tort & López) turns its attention to hydronymy as a way of knowing and discovering society's perception of urban river environments.

In short, this book presents a series of concepts, ideas and case studies that facilitate an understanding of the geomorphological processes that characterise our cities' intensely transformed rivers; the plans, projects and policies of territorial and urban planning associated with these ecosystems; and, also, the way in which the urban river is perceived by citizens and river stakeholders.

It is our hope that this book will be useful not only for geographers interested in the river–city relationship and all the different approaches that might be adopted in its study, but also for those in other disciplines and professions that work in river environments. Our objective has been to leave a record of a very specific reality: urban rivers have enormous untapped potential, and if we can improve them and allow them to recover, then they can provide greater well-being in densely urbanised environments with their evident need for more open space.

Barcelona, Catalonia (Spain) Joaquim Farguell Pérez
December 2023 Albert Santasusagna Riu

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Chapter 1
Urban and Metropolitan Rivers: Current Processes, Trends and Challenges

Jorge Olcina Cantos, Joaquim Farguell Pérez, and Albert Santasusagna Riu

Abstract What is an urban river? What physical factors characterise it? What social implications does it have, above all, for urban planning and risk management? And, what historical, heritage and cultural values can we ascribe to it? These and other questions are specifically addressed in this chapter, with the aim of responding in a concise, structured manner to the objectives that this book sets itself. The urban river presents a quite specific geomorphology, one subject to notable alterations as the result of human transformations in the course of history. Thus, to the changes wrought by the civil works that sought the domestication of river channels as they run through the urban fabric have been added urban-territorial planning actions that seek the most appropriate form of technical-political management, measures that have marked much of the evolution of urban rivers. Social perceptions of the urban river, moreover, are critical for understanding the attitudes, values and influences that derive from their cultural representation at each moment in history. Urban rivers today are an object of study of great geographical interest, best analysed by adopting an integrative perspective that concerns itself with the physical, social, economic and cultural factors that come together in the river territory.

Keywords Hydro-geomorphological dynamics · Structural works · Urban and territorial planning · Historical change · Social perceptions · Heritage value

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1.1 Introduction

Providing a definition of an *urban river* is far from straightforward, despite numerous studies of the effects that urbanisation has on rivers and on fluvial systems in general (Wolman 1967; Paul and Meyer 2001; Schumm 2005; Gregory 2006). Indeed, Durán et al. (2020), in seeking to define the urban river, highlight the absence of any clear concept of the phenomenon but, at the same time, identify a number of different perspectives from which a definition might usefully be established. Thus, they propose a conceptualisation of the urban river based on the union of its physical and geomorphological features—including the river channel and adjacent areas—with those aspects derived, in the specific case of Spain, from regulations governing the *dominio público hidráulico* or public water domain, and which specify what should be understood by the river environment, including its floodplains. In short, the authors provide a definition that combines aspects of a river's physical geography with those related to its management and prevailing legislation (Durán et al. 2020).

This definition holds in the case of Spain, thanks to the legal definition of the *dominio público hidráulico*; however, in the English-speaking world, rivers are deemed *natural* up to the point at which the deforestation of part of a river basin for its subsequent urbanisation changes the land cover and, in so doing, transforms the behaviour of the river, modifying the basin's hydrological and geomorphological processes—thus, a *natural* river channel becomes *urbanised*. In short, the changes made in the basin have an impact on the fluvial system downstream of the point of modification, precisely because the basin conditions have been modified (Wolman 1967; Gregory and Chin 2002; Gregory 2006).

What the two definitions have in common is the importance conceded to hydro-geomorphological processes, given that the specific morphology of a channel depends on the slope of the terrain, the fluvial regime and the occurrence of extreme hydrological events (floods) and the magnitude and characteristics of the sediment transported, all of which is determined by the characteristics of the basin's climate and lithology, as well as its land cover (Schumm 2005).

Urban rivers are, in conclusion, rivers that have experienced a transformation of their channel and adjacent land cover as a result of processes of construction and urbanisation that alter their catchment. Such a transformation is characterised by intense modifications of the erodible corridor as a result of major civil works that seek to prevent the river channel from behaving naturally: that is, from forming its own riverbed, adapting to the valley slope and shaping the floodplains that make up the channel's migration zone (Kondolf et al. 2012).

1.2 The Main Alterations Made to Rivers in Urban Areas

Urban or *urbanised* rivers have been subject to significant alterations so that any similarities with *natural* rivers are few, in terms of both their morphology and function, which include given features of the river ecosystem and the hydro-geomorphological processes inherent to the river's work. The urbanisation of the geographical space simplifies the complex river structure to that of a drainage channel, normally to facilitate a series of urban advantages, but in the process the characteristics of the fluvial system are destroyed (Kondolf et al., 2012).

In terms of their morphology, urban rivers are tamed and channelised so as to segregate them from their own floodplain, and they are artificially straightened in order to reduce the number and length of meanders (i.e., their sinuosity) and, thus, increase the channel slope (Chin 2006). These far-reaching modifications are carried out with the goal of avoiding the flooding of the spaces colonised for urban and industrial expansion, but also of accelerating the flow so that, during an eventual flood, the water circulates as quickly as possible (Kondolf et al. 2012). Apart from these modifications to the channel, the width of an urban river tends to increase (Chin and Gregory 2005; Chin 2006; Kondolf 2012); however, in some cases and for reasons of space, the width of a river has been known to decrease, the case, for example, of the river Congost in Granollers (Barcelona, Spain) (Farguell et al. 2022).

But channelisation is not solely responsible for the loss of shape and the disruption of the hydro-geomorphological dynamics suffered by urban rivers; there are other factors that influence this degradation. Wolman (1967) was the first to describe how the processes of urbanisation—which he broke down into distinct phases—impact this dynamic. Thus, starting from a supposed steady-state equilibrium, the construction or urbanisation phase is characterised by increased erosion rates due to exposure of a bare surface, which results in an increase in the sediment yield accumulating in the channel. Once construction is complete, there is an obvious increase in impervious surfaces, which means infiltration is virtually eliminated. This leads to an excess of runoff water that is quickly drained into the river via a system of gutters and drains, reducing the lag between the precipitation episode and the river's peak discharge (Dunne and Leopold 1978; Gregory and Chin 2011). As a result, a change is wrought in the magnitude and frequency of flood events, and in the flood return period, which also has consequences for the river ecosystem (Poff et al. 1997).

These alterations can also be related to changes in the fluvial regime and in the quality of the circulating water by changing the frequency of low flows, as wastewater treated in plants is poured into the river.

The runoff from impervious urban areas introduces large amounts of nutrients, pollutants and heavy metals into rivers. In heavy rainfall events, effluents overwhelm the sewage system and solid waste is discharged and transported in the rivers. This not only impacts water quality but also the quality of the river sediments, which may contain organic contaminants. These are transported and, once sedimented, can modify the quality of the floodplains and beaches (Kevin et al. 2008).

Fig. 1.1 Undercutting of flood protection walls on the river Congost in Granollers (Barcelona, Spain). *Source* Joaquim Farguell (October) 2022

It is also common in urban areas that the bed of the river is eroded due to the low sediment load. An increase in the water flow energy tends to result in the erosion and incision of the waterbed, posing an obvious hazard to the infrastructure built along the channel—most typically bridges—but also the channel infrastructure itself, which is at risk of caving in during repeated flood episodes (Fig. 1.1).

Despite the significant alterations suffered by river channels in the urban environment, measures can be taken to improve their hydro-morphology and the quality of their waters. Current understanding of the hydro-geomorphological dynamics of river systems, as furnished by the geographical discipline of fluvial geomorphology, has led to numerous river restoration actions (Gregory et al. 2008; García et al. 2021). And although such actions are unlikely to restore the river space to its condition prior to human intervention (Dufour and Piégay 2009), restoration based on the recovery of hydro-geomorphological processes is deemed the best form of management to recover the space's functions (Fig. 1.2), as well as river habitats and the fluvial ecosystem in general (Bernhart and Palmer 2007), and also the most likely to guarantee success (Wohl 2015). The recovery of hydro-geomorphological processes and the restitution of a river regime in accordance with natural dynamics should lead to the river ecosystem *healing itself*, in a process whereby the river acts as the agent that restores its space and maintains it over time (Kondolf 2011).

Fig. 1.2 Images of the river Congost (Granollers, Barcelona). In **a** the river is channelised and immobilised by parallel roads, while in **b** the hydro-geomorphological processes and the channel's morphology have been recovered following the elimination of these roads. *Source* Images taken from Google Earth (2021)

Apart from the recovery of these fluvial processes, improvements to drainage systems have also been studied with the aim of mitigating alterations to the channel caused by the excess runoff attributable to the impervious nature of urban areas. The reduction in channel discharge should favour the recovery of river habitats to conditions comparable to those of non-urban rivers (Anim et al. 2018). Similarly, recommendations have been made to adopt river restoration measures both for the recovery of natural river regimes and for seeking to recover a river morphology that is as natural as possible so as to restore the habitats and ecology of the river ecosystem (Anim et al. 2019).

Studies of this type are crucial for determining which elements or processes contribute to improving a river ecosystem given that a consensus has yet to be reached as to what *river restoration* actually means. For some, it is a form of river space management, while for others it means creating or maintaining some of the river's landscape qualities, or the building of structures to reduce flood risk, or improving the fish habitat and water quality or creating recreational areas (Wohl et al. 2015). Whatever the target pursued, river restoration only acquires sense when society demands an improvement of the river space and its environment, actions that have repercussions for an improvement in the quality of life of urban dwellers (Wohl et al. 2005).

This means that river restoration is perhaps best approached by adopting a holistic, transversal perspective of the river basin (Gregory and Chin 2002). Moreover, as

human societies increasingly tend to concentrate in urban areas, urban ecology and the cultural and socioeconomic characteristics of urban dwellers are rapidly establishing themselves as a consolidated branch of research (Gurnell et al. 2007). Likewise, river restoration is also emerging as a branch of scientific research within geography, in which hydrology and fluvial geomorphology, together with spatial planning and management, have a leading role to play.

1.3 Urban Planning as a Tool: Recent River Transformations

1.3.1 The Historical Absence of Planning: The Achilles' Heel of Urban Rivers

Rivers have been exploited as a basic resource since historical times. Indeed, being able to access water both for personal consumption and for farming has meant urban areas, and their associated agricultural activities, have grown up adjacent to their courses. Yet, while rivers have been a fundamental resource in human development, they also represent a hazard when their rate of discharge is not as expected, be it because of an excess or deficit of water.

Until the second half of the twentieth century, any actions implemented in urban river channels were fundamentally structural in nature, a response to episodes of flooding that could be particularly destructive of human communities. After that date, the expansion or diversion of rivers, the building of levees and dykes and the creation of urban parks and river walks along their banks all became common actions in the urban rivers of developed countries. Indeed, regulations governing the planning of water, land and the wider territory all recognise the need to incorporate analyses of the associated flood hazard, analyses which today form part of a city's hydrological and urban-territorial plan.

As societies have advanced, attitudes towards urban river channels have undergone significant changes. From a resource deemed essential for supplying the water required by the city, urban rivers became a dumping ground for the waste generated by the urban environment, the economic activities that grew up along its banks and the river transport that plied their trade on its waters. In countries and regions without the sufficient technological or economic capacity, urban rivers quickly become vile channels of pollution. If, in addition, the fluvial behaviour of the urban channel presents frequent hydrological extremes (especially floods), then they become hazardous spaces devoid of any urban attraction. Only when river risk management practices and the quality of the river's waters can guarantee the existence of a healthy, safe river environment can river courses be revalued as quality urban spaces and riverfront programmes be deployed that include leisure spaces, river walks and urban reforms. Yet, to date, this only occurs in cities in advanced countries that

have adopted the requisite environmental and urban regulations to implement the sustainable management of their rivers.

In a city's urban plan, the authorities have traditionally considered rivers as a complementary element—one of embellishment—of the city's system of spaces free from urban development. Only since the end of the twentieth century, with the adoption of sustainability as a guiding principle of spatial planning, has the urban river course been considered an important part of the urban fabric's green and blue infrastructure. As a result, riverfront renewal projects have been developed, with the creation of ecological corridors that value the importance of the geomorphological and biogeographic wealth of the river channel.

An additional concern is those river channels without water that occupy significant spaces in arid and semi-arid zones of the planet and in relation to which urban planning has been scarce. Indeed, on occasions, their existence has been ignored and they have been incorporated directly into the street map, as streets and avenues that are exposed to all the risks of the flood hazard. Such environments have been allowed to form owing to the absence of adequate protective regulations (generally the case in developing countries) or non-compliance with existing norms (generally the case in more advanced countries) (Fig. 1.3).

Urban planning has as its goal the definition of a spatial model that establishes present and future land uses in a city and its surrounding territory (or municipal area). In developed countries, this is a legally regulated process in which the objectives and requisites are first identified for the establishment of this spatial plan. In short, it is a regulated act where the land typologies defined by legislation (Land Use and Urban Planning Law) are clearly laid down. In these land categories, river channels form part of the system deemed free from urban development, that is, space that must be protected or whose uses—especially residential uses—are restricted due to its ecological value or the dangers posed by evident hazards.

Cities can, therefore, regulate the banks of a river course that crosses the urban fabric, but they cannot intervene in the public water domain, which is regulated by the water authorities. River channels, by definition, form part of this public domain and this space is subject to strict measures of environmental or hazard protection. What can be managed in a city's urban plan are the riverside areas, albeit taking into consideration any restrictions in use that may derive from the flood risk maps and the risk management measures provided for under law. In the EU, the water policy (60/2000) and the assessment and management of flood risk (60/2007) directives establish guidelines for the management of river courses in the territory, including urban areas. The quality of circulating waters and the reduction of flood risks by limiting the occupation of riverside spaces underpin all territorial and urban planning actions. In less advanced countries, the absence of norms regulating territorial processes condemns river courses to be spaces of pollution and results in the hazardous occupation of river banks and of the channel itself; in short, insalubrious areas highly vulnerable to flooding. And this despite initiatives and projects carried out in recent years by international organisations aimed at implementing the UN's sustainable development goal 6—that is, access to clean water and sanitation, and investment to ensure the management of hydrological extremes.

Fig. 1.3 Contrasting examples of territorial planning and the management of urban river channels: Above, a planned urban stretch of a river course in the river Segre park (Lleida, Spain); below, a heavily polluted, unplanned stretch of the river in the suburb of Dharavi (Mumbai, India). *Source* (top) https://urbanisme.paeria.cat/sostenibilitat/aigua/pla-del-riu-segre-a-lleida. Universal access; (bottom) https://es.123rf.com/photo_149854255_barrios-pobres-y-empobrecidos-de-dharavi-en-la-ciudad-de-mumbai.html. Universalaccess

1.3.2 *Managing Extreme Hydrological Events: The Adaptation of Cities to River Floods*

Flooding in the urban environment converts the water resource into a hazard. The flood risk can be quantified in terms of the specific hazard level represented by a river course and the degree of human occupation of its river environment. Flood management has evolved through various stages with the emergence of new techniques and methods for analysing the spatial risk. Thus, we have seen an evolution from the celebration of the flood in ancient societies, where river flooding was a method of natural fertilisation of the fields occupying the floodplain, to the dread generated by such catastrophic events among traditional societies—until the end of the Modern Age—with insufficient knowledge of engineering techniques that might *contain* the flood and guarantee human lives and property. The advances in hydraulic knowledge that occurred in the nineteenth and, above all, twentieth centuries paved the way for the development of high-impact structural actions in urban river courses, especially in developed countries. Floods are, in the words of White (1945), always "watery marauders which do no good, and against which society wages a bitter battle" to control. This, in short, is the old paradigm of flood management that places all its confidence in the effectiveness of large hydraulic engineering works (dam construction, channelisation, diversion, flood walls and dykes).

Since the end of the twentieth century, however, new theoretical and methodological approaches have emerged to manage the flood risk in urban areas that call into question the blind trust placed in such infrastructure. Moreover, catastrophic flood events—in terms of their economic toll and the number of lives claimed—in river channels controlled by civil works highlight the need for alternative risk reduction policies. The celebration of the Earth Summit in Rio de Janeiro in 1992, which led to the adoption of Agenda 21, a series of actions implemented eventually at the local level and the deployment of the European Territorial Strategy (1999), at the European level, to promote sustainability in land use planning have opened the door to the incorporation of risk management in territorial plans. This strategy has been adopted by developed and developing countries and regions alike, in the case of the latter with the help of international organisations and actions (United Nations, World Bank, development aid programmes) (Fig. 1.4).

In Europe, in the aftermath of the floods of the large central European rivers in 1997 and 2002, a new way of addressing the flood risk was adopted in the light of the ineffectiveness of the continent's major hydraulic works. The occupation of spaces at high risk of flooding by urban uses, services and infrastructure had resulted in considerable economic losses and numerous fatalities. The European Commission, in response, issued a flood risk management directive 60/2007 requiring European countries to draw up flood risk maps and management plans as part of their territorial planning measures. The Member States have assumed their responsibilities in this regard, while at the state level, the norms regulating the use of water supplies in the public domain have been improved and flood risk reduction plans have been introduced within territorial plans. In Spain, for example, the regions or autonomous

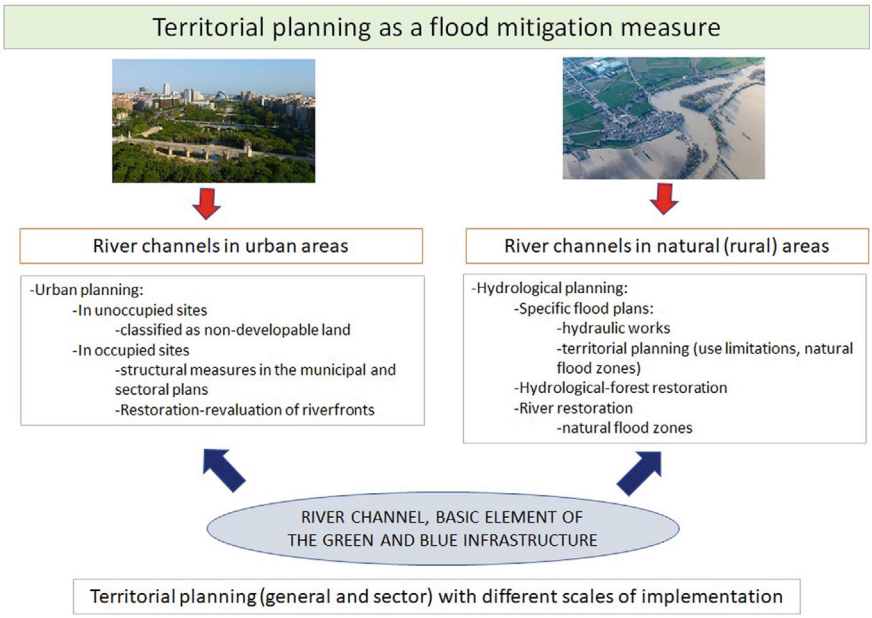
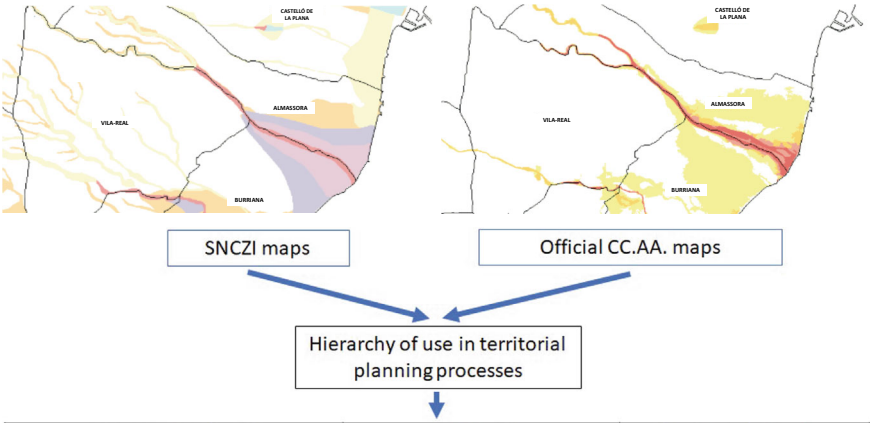


Fig. 1.4 Territorial planning as a flood mitigation measure. *Source* Authors

communities (e.g., Catalonia, Basque Country, Valencian Country, Balearic Islands, Andalusia) have played a leading role in the development of such policies. At the same time, the country's municipalities employ their urban planning tools to reduce the likelihood of the flood risk, while the maintenance of the river course as it flows through the urban centre is the responsibility of the town or city council. Land use legislation should provide precise regulations prohibiting the implementation of permanent uses in high-risk flood areas. In developed countries, urban planning regulations require that land at risk of flooding is not zoned as suitable for development, with official accreditation of this risk being demonstrated by the flood risk map, which has to be presented in any planning process. Here, it should be borne in mind that a hierarchy applies to the use of flood risk maps within prevailing territorial planning regulations, given that mapping may be undertaken by different tiers of government in accordance with the powers assigned to them. In Spain, for example, priority is given to the national SNCZI (*Sistema Nacional de Cartografía de Zonas Inundables*) maps over those of the autonomous communities (CC.AA. in their Spanish abbreviation) for the same mapped area (Fig. 1.5).

Territorial planning tools for flood risk mitigation have incorporated the idea of creating natural flood zones, or providing *room for rivers*, in urban centres to reduce the magnitude of floods. And, more recently, sustainable urban drainage systems (SuDS) have been built, adapted to cope with the intense rainfall events that can cause such damage to towns and cities. This design and construction of SuDS has accelerated in recent decades against the backdrop of climate change attributable to



AREA OF APPLICATION	PRIORITY	COMPLEMENTARY USE
In areas mapped by both entities	SNCZI	Official CC.AA. maps (if available)
In areas not mapped by SNCZI	Official CC.AA. maps (if available)	Other official maps (civil protection)
In areas not mapped by any entity	Flood studies (regulations of CC.AA. sectoral plans, if available)	Other official maps (civil protection)

Fig. 1.5 Official flood risk maps in Spain for territorial planning. *Source* Authors

the anthropogenic greenhouse effect, which in many regions of the world is modifying the type of precipitation that falls, with marked increases in intensity. Some cities have built stormwater tanks and floodable parks to store excess flood water, thus reducing the vulnerability of certain urban areas. These waters, moreover, can also be incorporated into the urban water management cycle, following their purification and regeneration (Fig. 1.6).

Flood management in many urban areas of advanced countries is today based on hydrological information systems that use sensors for the continuous measurement of rainfall and river discharge data. With this information and real-time, small-scale weather predictions (using downscaling methods), flood warning systems can be designed for populations, together with emergency management plans. In Europe, for example, the EU-Alert system has recently been activated, based on the transmission of territorial warnings from official civil protection agencies via mobile telephone operators.

Finally, a measure that has a great impact but which has been employed little to date, even in advanced areas, is flood risk education based on the teaching in schools of disaster management processes and guidelines for action against natural hazards. Flood risk education programmes combined with the effective communication of such risks (using media and government sources) are essential for reducing the human risk factor, especially in hazardous geographical areas.

Fig. 1.6 Stormwater tank (SuDS) in Barcelona for the storage of urban surface runoff from rainfall events. *Source* Barcelona City Council. Stormwater tank plan (Universal access)

1.3.3 The Rediscovery of Riverfronts and the Social Connectivity of Urban Rivers. A New Opportunity for Green and Blue Infrastructure

Territorial and urban planning incorporating flood risk management measures has made possible the renewal and regeneration of riverfronts in many cities around the world. River channels, with a regular hydrology and steady flow, have become much prized green (or blue) ecological spaces that have to be protected in accordance with hydrological, environmental and urban planning regulations. These urban river-front renewal programmes have generally been launched following extraordinary catastrophic flood episodes and, while precedents can be found in the modern age, most projects (of urban reform and expansion) have been developed in cities of the developed world since the mid-nineteenth century.

In Spain, for example, the main projects undertaken include the channelisation and beautification of the river Segura as it flows through Murcia (1785), and, later, in the twentieth century, the actions to channelise and divert the Guadalquivir in Seville, the Turia in Valencia, and various river channels in the Basque Country following the floods of August 1983 and the reaches of the river Segura between Murcia and its mouth in southern Valencia. In each case, the urban–river front was redeveloped as a space for city leisure and recreation. In some instances, these river regeneration programmes in urban environments were not a direct response to the flood risk, but

rather to the need to reform and adapt these spaces to a city's new social needs as regards leisure and green areas. This is the case, for example, of the *Madrid Rio* project on the course of the river Manzanares (Fig. 1.7).

In this way, the river channel has become a basic element of a territory's green and blue infrastructure. In many territories, spatial planning today actually centres on the design of its green infrastructure, as a planning tool, dependent on the development of a territorial information system, that incorporates all those elements to be protected, or which have a limited use, as determined by the significance of their ecology and heritage, their socio-cultural importance and their risk value. Examples of best practices in the incorporation of the river channel into the green and blue infrastructure of a spatial plan can be found in the *Directrices de Ordenación del Territorio* (Territorial Planning Guidelines) of the Basque Country (2019) and the *Plan de Acción Territorial* (Territorial Action Plan) for flood risk reduction in the Valencian Country (2014) (Fig. 1.8).

1.4 The Perception of Urban Rivers as Social and Cultural Phenomena

As we have sought to stress, rivers occupy a privileged position in the development of human societies. Water is at the root of the organisation of humanised space, and rivers have served as flows of connection and communication between peoples and cultures; yet, as complex, diverse ecosystems subject to constant change, they have also been responsible for negative, at times, catastrophic events. Around the globe, the urban phenomenon rose up and was consolidated near bodies of water, and this has given rise to significant risks in the relationship between rivers and urban areas.

Yet, urban rivers, in addition to being considered interesting objects of study for geomorphology, can also be understood from a social perspective and, therefore, observed as cultural phenomena. The river–city interaction has given rise to an endless number of distinct scenarios: historical facts, artistic expressions, heritages, mythologies and memories, scenarios and values that contribute to forming a multiplicity of diverse views and perceptions of a given urban river landscape. Both from the perspective of their historical evolution and from that of the present day, urban rivers have been perceived as complex, attractive elements from a range of different viewpoints. In this brief section of the chapter, we outline the basic ideas that have sought to relate urban rivers and society's changing perception of them.

Fig. 1.7 Transformation of the Turia river channel in the city of Valencia: Above, the new channel in the south of the city (South Plan); below, recovery of the former Turia riverbed as it passes through the urban heart of Valencia and transformation into a green and leisure space for citizens. *Source* (top) Valencia City Council (Universal access); (bottom) José Luis Filpo (published under Wikimedia Commons licence)

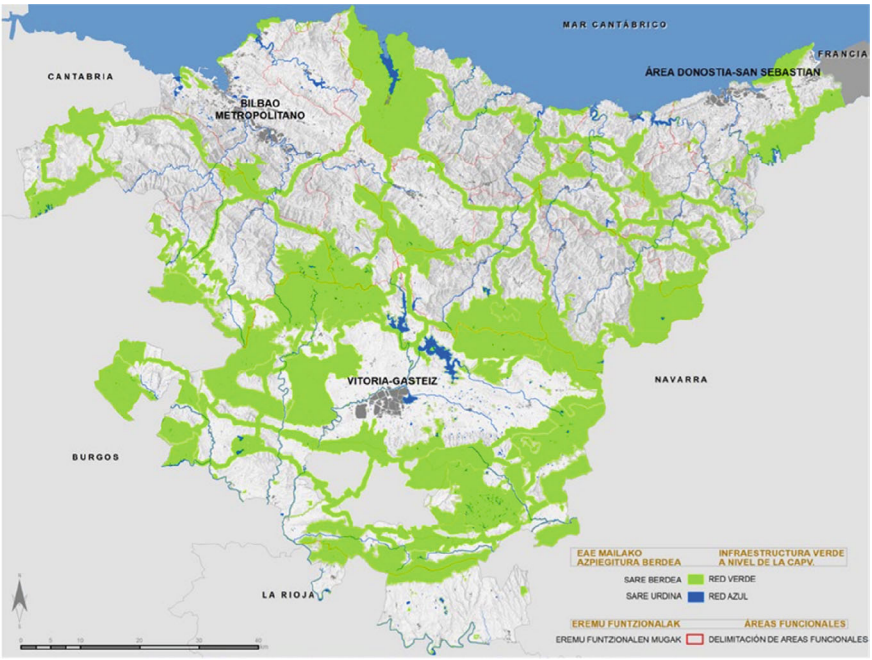


Fig. 1.8 Green and blue infrastructure in the autonomous community of the Basque Country. *Source Directrices de Ordenación del Territorio. Lurraldea 2040* (2019). Available at: https://www.euskadi.eus/directrices-de-ordenacion-territorial-dot/web01-a2lurral/es/

1.4.1 How Urban Rivers Have Been Perceived in the Course of Their History?

The passage of history has had a varied impact on the evolution of the river–city relationship, not solely from a utilitarian or productive perspective, referring exclusively to the way rivers have been transformed and used for specific purposes in urban contexts, but also in terms of society's perception of them. Indeed, perceptions of what a river is and what it is not, the purposes it does and does not serve, and the advantages and drawbacks of living near it are what have marked various stages of socialisation. Saraiva (1999, 2009) proposes an evolution in the human perception of urban rivers that develops through different phases, albeit without a fixed chronology, since it is by no means a globally shared process.

In Fig. 1.9, we seek to adapt and complement the ideas of this author, emphasising three fundamental questions that, in our view, ought to be highlighted in any such analysis: that is, the *attitude* of society towards a river (be it one of respect, adaptation, subordination and awareness), its *social value* (which, for practical purposes, derives from specific beliefs, uses and techniques, which are manifest in a technical-political agenda) and, finally, the *impacts* on the hydrosystem derived from this social perception. Broadly speaking, we identify a shifting, pendular relationship, which