Reimagining Urban River Bathing in Europe: A Multisectoral and Interdisciplinary Dive into Lyon's Rivers (France)

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Abstract

Urban river bathing is re-emerging across Europe, driven by social demand and climate change impacts. The Urban Bathing consortium is at the forefront of studying the challenges and opportunities of creating and managing healthy, safe, and accessible river bathing spaces. Through interdisciplinary collaboration among researchers and stakeholders, the consortium proposed an analytical framework, identifying seven critical dimensions for urban river bathing: the history and revival of city-river relationships, legal and regulatory frameworks, bathing water quality, river drowning risks, river ecosystems, social perspectives, and urban planning. By examining these dimensions with state-of-the-art approaches and drawing on Lyon's experiences, the study provides scientific insights and practical recommendations for future sustainable urban river bathing development. These include revitalizing historical city-river connections, aligning local regulations with EU guidance, advancing holistic microbial water quality control, enhancing safety measures, incorporating ecological considerations, balancing competing river uses in urban planning, addressing social needs for inclusive river governance.

Graphical abstract

Keywords: climate change, Europe, interdisciplinary research, urban river, river bathing/swimming, river management

1. Introduction

Today, more than half of the global population resides within 3 km of a surface freshwater body (Kummu et al. 2011). In response to the multifaceted challenges of climate change, urban planning increasingly prioritizes blue-green spaces to enhance public health, well-being, and ecological resilience, particularly in densely populated or socioeconomically disadvantaged areas (Corburn 2017). As part of this shift, in cities, river bathing has gained attention as a way to reconnect citizens with nature. Through the river cooling effect (RCE), urban rivers play a critical role in mitigating the urban heat island effect as river waters and vegetation absorb heat from the air and dissipate it through evaporation and evapotranspiration, creating cooler microclimates in surrounding areas (Park et al. 2019; Wang et al. 2022). With freshwater quality enhanced by river restoration, urban rivers are being transformed by integrating promenades and leisure amenities, enabling these water bodies to support various types of recreation, often including formal/informal bathing (Wuijts et al. 2022). Simultaneously, the COVID-19 pandemic has intensified urban residents' desire for nature-based outdoor experiences (Jakstis et al., 2023), while hotter summers driven by climate change have further fuelled interest in accessible rivers – particularly during the summer months.

Historically, the term "bathing" referred to the use of natural waters for hygiene or therapeutic purposes—often out of necessity, particularly before the widespread adoption of indoor plumbing. In contrast, swimming emerged in the late 19th and 20th centuries in Europe, associated with recreation and sport (Carr 2022; Terret 1994; Adams 2015). While the two terms carried separate meanings in the past, this article uses them interchangeably in the contemporary context of leisure river use. For consistency with EU policy frameworks, we adopt the term "bathing" in this article as defined in the European Union's Bathing Water Directive (EU BWD).

In France, inland bathing opportunities are limited, and stringent regulatory frameworks constrain access to lakes/rivers for recreational use (Maghakian et al. 2024). Urban residents often view existing facilities, i.e., swimming pools and designated beaches, as insufficient, particularly given the rising summer temperatures (Bell et al. 2007). The integration of urban rivers into public life is attracting increasing attention, driven by the growing demand for innovative solutions to enhance urban liveability and adapt to climate change. Programs such as improving river water quality and reopening the Seine River for swimming during the 2024 Paris Olympics—supported by strong political commitment—exemplify this trend. Meanwhile,

grassroots movements are advocating for the right to swim in urban rivers, which remains largely prohibited in major French cities. Together, these developments underscore the need to enhance freshwater quality, reimagine urban rivers as both ecological and recreational assets, and recognize bathing practices as a meaningful contribution to urban sustainability. Addressing the complexities of this issue requires cross-disciplinary research into regulatory frameworks (e.g., prohibitions or permissions), environmental conditions (instream water and riverbanks), social dynamics (e.g., public perceptions and preferences regarding rivers), among other factors. Equally important is fostering transdisciplinary dialogue with policymakers, NGOs, practitioners, and urban planners to understand the real-world implications. Using Lyon—a French city shaped by the Rhône and Saône rivers—as a case study, this article explores the potential of urban river bathing in advancing future sustainable development in Europe.

In Lyon, a densely populated metropolis in south-eastern France with 1.4 million inhabitants, approximately 4,700 residents per km², and the second-largest urban area in the country, an inter-sectoral consortium called "Studio Baignades Urbaines[2]" (Consortium for Urban Bathing), was established in 2020-2021 as part of the LabEx IMU (Intelligence des Mondes Urbains) at the Université de Lyon. From 2002 to 2007, Lyon's riverbanks along the Rhône River underwent major revitalization, transforming into popular destinations for recreational activities—relaxation, sports, and festivities—attracting both residents and visitors. They allow people to reconnect with the river while providing cooling areas during increasingly frequent heatwaves (Alonso and Renard 2020). On the long run, this transformation is predicted to improve citizens' quality of life (Everard and Moggridge 2012) and help mitigate extreme weather events due to climate change impacts. Building on this progress, the consortium brought together researchers from various fields along with stakeholders—including NGOs, urban planners, and rescue services—to explore the opportunities and challenges of creating safe, accessible river bathing spaces through inter- and transdisciplinary collaboration.

Despite being prohibited due to public safety and health concerns, there has been a noticeable rise in illegal river bathing in Lyon during the summer, resulting in an increase in drowning incidents in the Rhône and Saône rivers, as reported by the SDMIS firefighters[3], the

[2] https://imu.universite-lyon.fr/studios/baignades-urbaines/baignades-urbaines-279604.kjsp#:~:text=L'objectif%20du%20studio%20baignades,et%20des%20p%C3%A9riodes%20de%20canicules.

[3] Service Départemental et Métropolitain d'Incendie et de Secours (Departmental and Metropolitan Fire and Rescue Service) is a public body responsible for fire prevention, protection, and firefighting in the Lyon metropolitan area and the Rhône department.

125 rescue service in Lyon (Maghakian et al. 2024). In response, the SDMIS approached fluid
126 mechanics, hydrology, and geography laboratories[4] at the Université de Lyon in 2019 to seek
127 expertise in better anticipating these accidents and enhancing the effectiveness of rescue
128 operations. Recognizing the inherently multidisciplinary nature of urban river bathing, this
129 initial cooperation inspired a broader collaboration incorporating researchers from
130 anthropology, ecology, microbiology, chemistry, history, engineering, and architecture, from
131 Lyon, Rennes and Liège. It also engaged a wide range of stakeholders including the National
132 School of Police, Lyon Institute of Forensic Medicine, VNF[5], Metropolis of Lyon, EDF[6], inter-
133 municipal organizations like the Grand Parc Miribel Jonage, and NGOs like bather groups and
134 ALMNS[7].

135

136 **2. Methodology**

137 This study adopts a mixed-methods research design integrating qualitative and
138 quantitative data collection and analysis techniques to examine the challenges and opportunities
139 of urban river bathing. The approach is grounded in an inter- and trans-disciplinary process,
140 combining literature review, expert interviews, stakeholder engagement, field observations, and
141 public surveys. Lyon was chosen as a case study for in-depth analysis.

142 **2.1. Analytical framework development**

143 The analytical framework underpinning this study was developed through a
144 combination of literature analysis and participatory events. An extensive review of academic
145 and grey literature across disciplines—including public health, ecology, urban planning, legal
146 studies, and social sciences—was conducted to identify the key themes and knowledge gaps
147 concerning urban river bathing in Europe. This process was complemented by an
148 interdisciplinary colloquium in December 2022 titled "Crossed Perspectives on Urban River
149 Bathing[8]", which convened over 45 researchers in France. Seven recurring dimensions emerged:
150 (i) history and revival, (ii) regulation and laws, (iii) water quality, (iv) drowning and safety, (v)
151 river ecosystems, (vi) social perspectives, and (vii) urban planning. These dimensions and their

[4] They include EVS (UMR 5600 Environment City Society - CNRS), LMFA (Laboratory of Fluid Mechanics and Acoustics - UMR 5509), RiverLy (UR RiverLy, Centre INRAE Lyon-Grenoble)
[5] Voies navigables de France (Navigable Waterways of France) is the French navigation authority responsible for the management of France's inland waterways network and the associated facilities.
[6] Électricité de France (Electricity of France) is a French electric utility company owned by the government of France.
[7] A l'eau MNS (A Water MNS) is a civil safety association dedicated to first aid, rescue, training, and community engagement.
[8] https://imu.universite-lyon.fr/regards-croises-sur-la-baignade-en-riviere-urbaine-colloque--287313.kjsp

guiding questions (Fig. 1) form the basis of our analytical framework and structure the presentation of results (see 2.4).

This framework was subsequently refined through a series of six riverside walks (Holstead et al., 2025) with river stakeholders in Lyon from 2022 to 2024, organized by the Consortium. These walks engaged non-academic participants in situated observations and discussions, fostering embodied reflection on human–river relationships in the urban landscape.

2.2. Data collection

To operationalize the framework and apply it to the Lyon context, the study proceeded through five key steps. First, a literature review of urban river bathing initiatives and policies worldwide, along with an analysis of EU regulations, was conducted to establish a baseline for European cities. Second, interviews were carried out with researchers and key actors in Lyon (during the colloquium and riverside walks)—including rescue service personnel, public health officials, urban planners, ecologists, and historians—to gather diverse perspectives on bathing-related risks, management policies, and environmental dynamics. Third, historical archives and local records were examined to trace the evolution of bathing practices in Lyon, with comparisons made to other European cities. Fourth, a large-scale public survey (n = 1,166; see section 3.6) was administered in 2022 to assess citizen perceptions, concerns, and cultural ties related to urban river bathing in Lyon. Finally, field observations were conducted at both authorized and unauthorized bathing sites in Lyon to document user behaviours, environmental conditions, and safety challenges.

2.3. Case study

Lyon was selected as the case study because it exemplifies the legal and regulatory context in France, where strict bathing prohibitions persist despite growing public interest in river access. Moreover, Lyon is among the cities expected to be particularly affected by climate change: the Rhône department currently records the highest number of heatwave days and events in France, reflecting the broader trend of increasingly extreme summer temperatures across Europe. To situate Lyon’s case within a wider European perspective, we also draw on examples from other cities such as Paris, Berlin, and several Swiss cities.

Lyon also benefits from the research team's proximity and years of dedicated study. The research team (Consortium) has a long engagement with river stakeholders and access to localized knowledge (e.g., historical archives, social survey) in Lyon. In 2023, the Consortium

183 received funding from the French National Research Agency (ANR) for Assistance in Search
184 of Victims in Watercourses (ARCO, project number: ANR-23-CE39-0012) [9] research project.
185 In 2024, the Consortium expanded its scope to include pan-European studies and joined the
186 global River Cities Network[10], enabling further comparative research between Lyon and global
187 cities (Cao, 2024).

188 **2.4. Results organization**

189 In Europe, the push to establish a 'right to swim' in rivers aims to inspire citizens to
190 engage with and restore urban ecosystems, transforming users into active stakeholders in river
191 conservation and advocates for cleaner water (Directorate-General for Environment 2025).
192 Rather than advocating for or against urban river bathing, this study aims to critically assess the
193 risks, opportunities, and governance challenges of enabling such practices sustainably in
194 European cities. We hope that the interdisciplinary insights and innovative practices generated
195 through our work in Lyon will serve as a valuable resource for other major European cities
196 facing similar challenges and opportunities.

197 To achieve it, this article is organized around seven key topics formulated in the
198 framework developed in 2.1 (Fig. 1): history/culture provides temporal context and revival
199 trends (section 3.1); regulation outlines the legal/institutional contexts (section 3.2); water
200 quality (section 3.3) and drowning (section 3.4) management on public health and safety;
201 possible impacts on river ecosystems (section 3.5); social perspectives illuminate community
202 attitudes and equity issues (section 3.6); and urban planning integrates these insights into spatial
203 and infrastructural strategies (section 3.7). This holistic framework ensures that biophysical and
204 socio-cultural considerations are examined in tandem. The results present each topic as follows:
205 (i) a review of European-wide context and literature; (ii) an analysis of Lyon's experience, and
206 (iii) preliminary recommendations for other European cities. This structure allows for both
207 contextual specificity and trans-local applicability. Finally, the article presents a cross-cutting
208 discussion with operational recommendations—highlighting both opportunities and challenges
209 across the seven themes—for guiding sustainable urban river bathing development.

[9] https://anr.fr/Project-ANR-23-CE39-0012
[10] https://www.rivercities.world/

Figure 1. The seven key topics and their guiding questions, developed through literature review and transdisciplinary collaboration.

3. Results

3.1. *We both step and do not step into the same river*[11] (history and revival)

[11] Said Heraclitus, a Greek philosopher (circa 6th century BCE). Original text: Ποταμὸς τοῖς αὐτοῖς ἐμβαίνομέν τε καὶ οὐκ ἐμβαίνομεν.

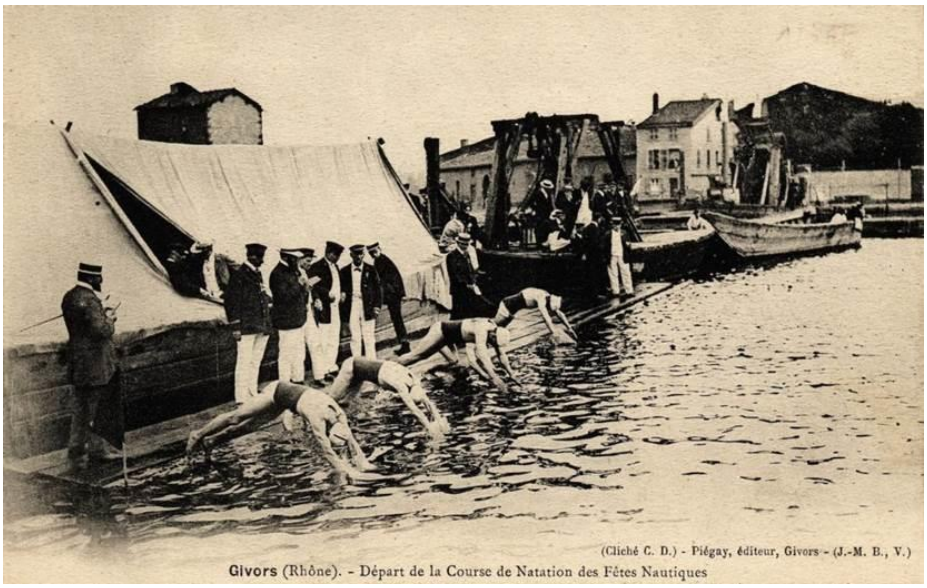


Figure 2. Start of the Swimming Race during the Nautical Festival in Givors, Rhône River, circa 1905. Source: Coll Dürenmatt Mdfr Bibliothèque municipale Lyon.

In ancient times, civilizations such as the Greeks and Romans valued river swimming for fitness and recreation (Vasile et al. 2023). However, this practice declined during the medieval period due to urbanization and shifting religious views. By the 19th century, river bathing regained popularity as improved sanitation, changing hygiene norms, and expanded rail networks made riverside resorts more accessible. Municipal investments in public baths and the rise of a middle-class leisure played a key role in this revival (Adams 2015, see example in Fig. 2). The Industrial Revolution significantly impacted wild bathing/swimming in Europe, as water quality in rivers, lakes, and seas deteriorated, and urban rivers were channelized for navigation. As a result, many major European cities, including Paris and Berlin, imposed bans on river bathing due to sanitary concerns and/or conflicts with river traffic, with both cities introducing major restrictions as early as 1925 (Kraemer 2021; Moutiez 2021). In the late 20th century, initiatives aimed at democratizing swimming as an urban sport, such as France's "Plan 1000 Piscines," led to the construction of public pools, making swimming accessible across social classes and establishing disinfected pools as the primary venue for swimming/bathing in Europe (Hachet 2023). Since then, in most major European cities, river bathing has been banned, and memories of this once-vibrant tradition have largely faded.

The city of Lyon serves as an example of this evolution. Historically, Lyon's rivers played a central role in the bathing culture, with organized river bathing thriving from the late 18th to the mid-20th century for hygiene and leisure (Haouari 2023). Two main forms of river bathing were documented in archives: floating baths, which transitioned from public bathing

facilities in the 18th century to floating swimming pools for training by the 20th century, and informal riverside beaches located outside urban boundaries, often managed by private operators without authorization. Early regulations focused on maintaining public order by addressing issues of indecency and unruliness. By the late 19th century, due to the major risk of drowning (Gouillon 2024), safety became primary concerns, leading to an official ban on unsupervised bathing within Lyon in 1883 (Terret 1994). The mid-20th century saw stricter water quality controls and heightened safety standards, which further limited river bathing; the phenomenon nearly disappeared in Lyon by the 1960s. Urban growth and the formalization of regional governance, beginning with the establishment of the Urban Community of Lyon in 1969 and later the Metropolis of Lyon in 2015, further restricted access to the rivers in and around Lyon. Today, only one authorized lake bathing site serves as a poignant reminder of the once-vital relationship between Lyon Metropolis and its rivers (Fig. 4). With the "extinction" of river bathing, citizens of Lyon have turned to alternative options, e.g., indoor swimming pools, private facilities, and travel to coastal destinations—a trend shared by residents of many European cities.

From the 1980s to the 1990s, enhancements in wastewater management and ecological restoration, supported by the implementation of European directives – the Urban Wastewater Treatment Directive (91/271/CEE UWWD, 1991) and the Water Framework Directive (WFD) (2000/60/CE, 2000) – largely improved water quality in European rivers (European Parliament and Council of the European Union 2000). As a consequence, the 21st century has seen a resurgence of river swimming/bathing cultures in many cities (Globevnik et al. 2022). Notably, Paris has embarked on an ambitious project to host swimming competitions in the Seine River during the 2024 Olympic Games and to open it to the public by 2025 (Lestel et al. 2023). Grassroots initiatives have emerged from across Europe. Launched in 2002 by the European Rivers Network, the Big Jump [12] promotes public engagement with Europe's neglected waterways, attracting 200,000 participants to over 2,400 events across 34 countries so far[13]. In 2024, this movement expanded globally with the Swimmable Cities Alliance[14], a coalition of 49 cities across 21 countries. The alliance is dedicated to reclaiming the right to bathe in urban waters, advocating for equitable access to rivers, and fostering active community engagement. This movement has started to influence Lyon (Ville de Lyon 2025), where the tradition of river

[12] https://bigjump.org/
[13] https://bigjump.org/about-big-jump/#:~:text=The%20Big%20Jump%20seeks%20to,a%20record%20number%20of%20events
[14] https://www.swimmablecities.org/

bathing has been forgotten due to social and economic changes. In response, the Lyon Metropolis is exploring innovative ways to restore this cultural heritage by reintroducing bathing in the Rhône and Saône rivers (see section 3.7).

3.2. *Baignade interdite - bathing prohibited* (law and regulations)

Figure 3. Bathing in the Rhône River is prohibited in Lyon, as it is in most French municipalities. Source: Mouillaud Richard.

The EU BWD, originally introduced in 1976 (76/160/EEC) and revised in 2006 (2006/7/EC), provides a comprehensive framework for monitoring, assessing, and managing bathing waters across EU Member States. It defines "bathing waters", as surface waters where large numbers of people are expected to bathe and where no permanent prohibition or advisory against bathing has been issued. The 2006 directive distinguishes between inland and coastal bathing waters to address their differing ecological and pollution dynamics. Member States are required to annually identify all designated bathing sites, clarify the duration of the bathing season, and establish bathing water profiles with quality assessment in accordance with BWD's microbiological parameters – categorizing them as "poor," "sufficient," "good," or "excellent." The guidance also emphasizes public participation and transparency, mandating the active dissemination of information on bathing water quality and management measures throughout the bathing season. This legal tool ensures that EU countries comply with regulatory standards, prioritizing the protection of public health and the environment.

France implements the BWD through the Water and Aquatic Environments Act of December 30, 2006, integrating its provisions into the French Public Health Code (notably Articles L.1332-1 and following). French law incorporates the BWD classification system; national regulations are developed by the Ministry of Health in collaboration with other relevant ministries, while Regional Health Agencies conduct water quality monitoring and health inspections.

At the municipal level, the mayor is responsible for regulating bathing waters, ensuring safety, and communicating bathing conditions under Article L.2213-23 of the French General Code of Local Authorities. This includes overseeing shore and water sports, designating supervised bathing zones, and imposing restrictions or bans on rivers when necessary for safety (e.g., strong currents, rocks) or public health concerns (e.g., bacteria, algae, pollution). Non-compliance with municipal bathing restrictions constitutes a second-class contravention, punishable by a fine of up to €150, as outlined in Articles L.31-13 and R.610-5 of the French Penal Code. In most cases, French local authorities, as a precautionary measure, prefer to prohibit bathing in their territory. This allows them to avoid the risk of litigation in the event of a bathing accident and, consequently, to prevent administrative and criminal liability before the courts (Fig. 3).

The only designated bathing area in Lyon with an updated bathing water profile is in the Grand Parc Miribel Jonage (Fig. 4)[15], a gravel pit lake where supervised swimming is permitted during the summer season. While it has consistently received an "excellent" bathing water quality rating over the past years, it is situated in a (gravel pit) lake essentially fed by the sediment aquifer of the Rhône River. Despite city-wide restrictions, illegal bathing is commonly observed along the Rhône and Saône rivers during the summer months (Fig. 4), and enforcement proves challenging.

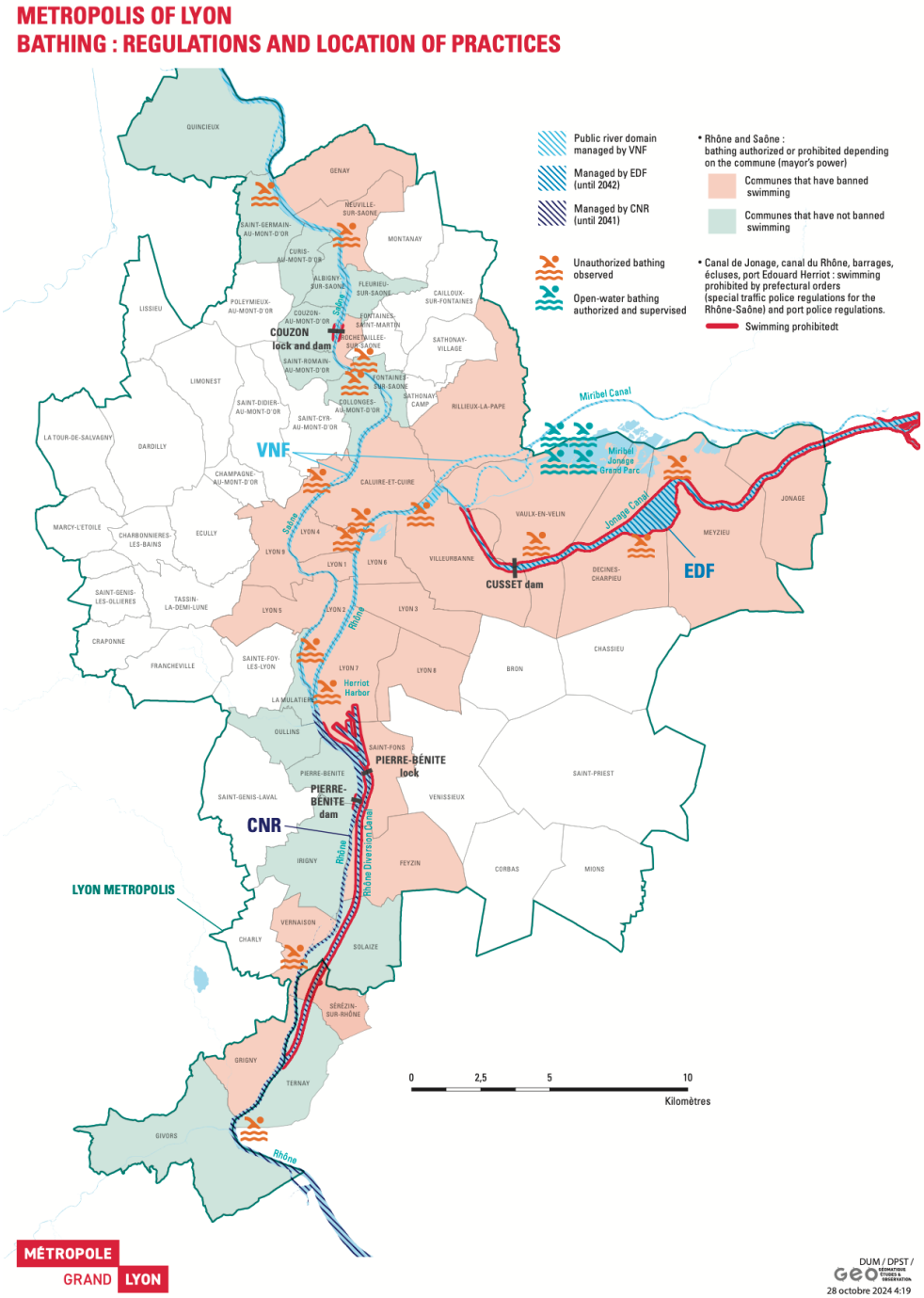
Across Europe, bathing water quality has been improving under the BWD, with 85% of the bathing sites rated excellent and 96% meeting minimum standards in 2023. Coastal waters generally outperform inland waters, likely due to the rivers' lower dilution capacity (European Environment Agency 2024). These numbers reveal the management challenges associated with improving river bathing water quality (see section 3.3). Law and regulations define the

[15] The Grand Parc de Miribel Jonage is not directly fed by the Rhône River—except during exceptional flood events—but it is the only officially designated bathing site in the Lyon metropolitan area and complies with EU BWD monitoring standards. As such, it remains a relevant case, illustrating regulated water quality management and the revival of river-related recreational practices in Lyon.

responsibilities of authorities in ensuring bathing safety and public health, thereby shaping the extent to which urban river bathing practices are widely permitted or strictly prohibited—a situation that varies across European countries. In Switzerland, for instance, where urban river bathing is prevalent, all lakes and rivers are public domain. Each canton establishes its own laws, requiring local authorities to ensure accessibility to river/lake banks – they must designate areas within their territory as public beaches along these banks, maintain health standards, and monitor water quality. For example, the canton of Geneva is required to designate bathing areas intended for swimming, as stated in Article 2A of the "Loi sur la protection générale des rives du lac du canton de Genève" (Law on the General Protection of Lake Shores in the Canton of Geneva)[16] of December 4, 1992. Today, while grassroots initiatives across Europe increasingly advocate for recognizing the fundamental right to bathe in open waters, no such right is currently established in European law. These new unregulated practices attributed to the rapid evolution of societal norms and values, as observed in Lyon (Fig. 4), would call for a new regulatory framework that reconsider individual responsibility regarding the associated risks (e.g., drowning, water pollution) and the potential conflict with other river uses (e.g., navigation, biodiversity, hydropower).

An emerging legal approach to river governance involves granting legal personhood to rivers, recognizing them as living entities with inherent rights. Pioneered with the Whanganui River in New Zealand (2017), it marks a fundamental shift from perceiving rivers as resources to acknowledging them as rights-bearing subjects (O'Donnell & Talbot-Jones, 2018). Although not yet adopted in Europe, this approach emphasizes stewardship and could empower advocacy groups to demand stronger protections—and potentially permissions for sustainable public use—on behalf of the river itself. In the European context, it may shape future regulations on river bathing by balancing human recreational rights with the river's right to ecological integrity.

[16] Legal frameworks for recreational water use—either the law about Lake Geneva or the EU BWD—apply uniformly to inland waters, including both lakes and rivers.



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345 Figure 4. Map of authorized and unauthorized river bathing areas in the Lyon Metropolis (as
346 of 2024). Source: Lyon Metropolis.

347

348 **3.3. Bathing in *dark waters*[17] (water quality)**

349

[17] Dark Water, an American film by Walter Salles (2005)

3.3.1. EU BWD monitoring requirements, sources and health risks of microbial contamination

Water quality is a key concern for decision-makers regarding river bathing. The EU BWD defines bathing water quality based on physico-chemical and microbiological criteria, with mandatory indicators of faecal contamination of *E. coli* and intestinal enterococci. Chemical monitoring in bathing areas is required only when specific risks are identified (e.g., downstream agricultural, industrial, or urban activities). Basic monitoring, e.g., turbidity, can help detect potential risks like harmful algal blooms, which may signal eutrophication and the presence of cyanotoxins. Designated bathing waters require at least four samples per season, with one collected before the season starts. BWD's indicators, *E. coli* and intestinal enterococci, while not covering all health risks, have been validated over time as reliable and cost-efficient tools for preventing major outbreaks caused by faecal organisms and human pathogens responsible for gastrointestinal illnesses (Cournoyer et al. 2022) and infections, e.g., *Pseudomonas aeruginosa*-associated swimmer's ear, skin or lung infections (Wade et al. 2013). However, studies (Krupska et al. 2024) show that many pathogens in surface waters do not always correlate with these traditional indicators. To address broader health concerns, some countries, like France, also monitor cyanobacteria and cyanotoxins in stagnant waters, in line with World Health Organization (WHO) guidelines (WHO 2021).

In cities, major sources of microbiological contamination include wastewater treatment plant discharges, combined sewer overflows (CSOs), and urban runoff (Passerat et al. 2011; Kistemann et al. 2016). As a result, bathing water profiles required by BWD are often unfavourable in urban rivers. Additional sources of faecal pollution include wildlife, domestic animals, and zoonotic pathogens (Munoz et al. 2024). Fine sediments (<63 µm) in rivers can act as reservoirs for pathogens (Chávez-Díaz et al. 2020) and harmful micropollutants, e.g., pesticides and heavy metals (Mourier et al. 2014). These sediments may resuspend during floods, management activities, or water sports like swimming, potentially increasing health risks. Addressing all these contamination issues requires well-designed sampling strategies and monitoring systems, especially during storm events in spring/summer when water quality can fluctuate rapidly. During the Paris 2024 Olympic Games, advanced in situ tools[18,19] (Angelescu

[18] https://fluidion.com/
[19] https://www.coliminder.com/

et al. 2019; Burnet et al. 2021) were deployed to monitor the bathing water quality of the Seine River and Ourcq Canal.

3.3.2. Lyon's water quality management approaches and climate change impacts

In the Lyon Metropolis, bathing in the Rhône and Saône rivers is prohibited (Fig. 4), and as a result, no microbial water quality monitoring or assessment has been conducted for urban rivers. Nevertheless, extensive research has examined the impact of CSOs on microbial biodiversity in their tributaries. Studies have shown that urban runoff events discharge pathogenic bacteria, including *E. coli*, intestinal enterococci, and *Pseudomonas aeruginosa*, into these waterways. Hydrodynamic, geomorphological, and geochemical conditions influence the development, persistence, and downstream transport of bacteria during both flood events and low-flow periods (Navratil et al. 2020). Research also indicates that regulations limiting stormwater discharges significantly reduce faecal bacterial pollution in downstream rivers (Pozzi et al. 2024). In response to the growing concerns over stormwater overflows and polluted urban runoff, the latest revision of the EU Urban Wastewater Treatment Directive (2024/3019) identifies these as key pollution sources requiring measures for mitigation. Achieving this goal necessitates policies that minimize impervious surfaces and promote stormwater source control measures, such as infiltration basins and green roofs (Hamel et al. 2024; Fletcher et al. 2024). The Lyon Metropolis has been implementing such policies for decades, working in collaboration with interdisciplinary research laboratories to assess the risks and impacts of evolving urban water management practices (Bacot et al. 2022).

In many European cities, aging wastewater infrastructure and the impacts of climate change have led to a rise in CSOs during increasingly intense summer storms, making it unrealistic to completely prevent these discharges (Gogien et al. 2023). Despite this, river bathing could serve as a powerful catalyst for advancing public policies to reduce urban runoff during rainfall events. Research has revealed a link between biodiversity loss and the emergence of pathogens (Keesing et al. 2010), highlighting the need to characterize aquatic microbiota to assess the effectiveness of control measures (Kodera et al. 2023). In channelized rivers, climate change exacerbates microbial (Sterk et al. 2015) and chemical (Meynet et al. 2020) risks, particularly during summer low-flow periods. In Lyon, the Rhône River is projected to experience a decline in low-flow characteristic discharges (-13% at the outlet compared to 1960–1990 and approximately -20% by 2055) and a rise in temperature (+4.5°C downstream currently, with an additional +1°C expected by 2050; BRLi 2023). These changes will reduce

412 the river's capacity to dilute wastewater and CSO effluent, increasing the risk of contamination.
413 Addressing these challenges requires monitoring a broader range of microorganisms and
414 microbial diversity, as well as analyzing physico-chemical conditions, CSOs, and other
415 environmental factors that influence the persistence and behavior of pathogens in rivers.
416 Illnesses that are emerging and/or linked to animals, e.g., vector-borne emerging or re-emerging
417 diseases like schistosomiasis (also known as bilharzia) (Boissier et al., 2016) or leptospirosis
418 (Guillois et al., 2017), add complexity to monitoring efforts. Another enlightening health risk
419 due to climate change-induced increases in water temperature is cyanobacterial blooms, or
420 "blue-green algae," which release harmful cyanotoxins that can cause skin rashes, respiratory
421 issues, and, in extreme cases, severe liver damage in bathers (Falconer and Humpage 2005).
422 While the EU BWD recommends monitoring cyanobacterial risks under conditions favourable
423 for blooms, it does not mandate regular monitoring throughout the bathing season. While
424 France follows WHO guidelines (2021) to monitor cyanobacteria and their toxins in calm or
425 stagnant waters, this is not the norm across European countries.

426

427 **3.4. *Still waters run deep* (river drowning)**

428 Drowning accounts for about 1,000 deaths daily worldwide (Peden et al. 2016; WHO
429 2017). Within the WHO European region, drowning mortality rates are lower than the global
430 average but remain a leading cause of death among individuals under 25 and those over 75
431 (Peden et al. 2022). Urban rivers used for recreational activities, are hotspots for drowning
432 incidents – often associated with alcohol or substance use, especially among young men
433 (Stephenson et al. 2020; Carey et al. 2024). Additional risk factors include strong currents, water
434 turbidity, risky behaviours, e.g., bridge jumping (Brice et al. 2013), and the presence of solid
435 waste (Strasiotto et al. 2022). Despite the multifaceted causes of river drownings, prevention is
436 achievable through targeted measures, e.g., identifying high-risk locations and time periods,
437 implementing warning signage, patrolling, and enhancing rescue operations (Reijnen et al.
438 2018). However, inconsistent data collection and insufficient reporting across regions pose
439 challenges to implementing evidence-based interventions (Peden et al. 2022).

440 To address this challenge, a multi-year study on the epidemiology of drownings in Lyon
441 analysed 386 fatal and non-fatal incidents on the Saône and Rhône rivers between 2015 and
442 2021 (Maghakian et al. 2024). This research is complemented by the work of forensic
443 pathologists, who use information gathered from the police. In Lyon, every deceased person

presumed to have drowned undergoes a forensic autopsy to confirm the cause of death, identify potential risk factors (e.g., alcohol, narcotics), and collect relevant details for studying drifting phenomena, e.g., body weight, clothing, and the state of decomposition. Autopsies also help determine whether the victim drowned at the location where the body was found, their last known signs of life, and their medical history (e.g., depression, suicide attempts, or drug use). Findings revealed that drowning is not only a physical risk but also a social one, influenced by public awareness, behavior, and (even) education levels. Drowning victims in Lyon were categorized into three main groups (Maghakian et al. 2024): i) those involved in accidental falls or suicides in high, turbid waters during winter; ii) those engaging in recreational jumping or friendly challenges; and iii) those swimming in unsupervised areas on hot, sunny summer days. Results confirm that young (15-29 years old) men are overrepresented among drowning victims and demonstrate that environmental factors alone (e.g. discharge, flow current, turbidity) cannot fully explain the complexity of drowning risks in urban rivers. Other aspects – legislation, climate, population demographics, swimming skills, historical river use, and alcohol consumption – vary significantly from one country or city to another.

Compared to accidents in pools or lakes, urban rivers pose unique challenges for prevention, surveillance, and rescue operations (Bierens 2009) due to turbid waters, obstacles on the riverbed, strong flow velocities, and the need to cover large search areas urgently. Probabilistic models specifically designed to assist search operations in rivers are lacking, as most existing studies focus on marine environments (Stone et al. 2014). Unlike marine models, river-specific models must account for vertical motion influenced by freshwater density, lung water content, and body decomposition (Delhez et al. 2024). Delhez et al. (2023) advance this research by incorporating these effects and highlighting the importance of reliable witness testimonies to improve prediction accuracy. The effective validation of such new modelling frameworks requires enhanced field data collection.

Despite ongoing research into the epidemiology of river drownings, effective prevention measures are limited. Globally, the WHO emphasizes the importance of enhancing swimming skills, particularly among children, and implementing strategies to restrict access to hazardous water bodies. In the WHO European Region, proposed drowning prevention measures include pool fencing, training in rescue and resuscitation techniques, promoting the use of flotation devices, enforcing watercraft safety regulations, and developing targeted policies to address alcohol-related drownings (Peden et al. 2022). Building on findings from Lyon, future research should emphasize transdisciplinary collaboration among forensic experts, first responders, and

judicial authorities to develop a holistic understanding of drowning incidents. Furthermore, evidence-based science communication is crucial for bridging the gap between research and policymaking. Initiatives such as riverside walks with stakeholders, organized by the Consortium in Lyon, exemplify this potential.

3.5. Bathing with nonhumans (river ecosystems)

Urban river bathing reconnects city residents with their natural surroundings, promoting greater awareness of the fragility of aquatic ecosystems. However, its ecological impacts are an emerging area of concern, with research indicating important yet understudied consequences for freshwater ecosystems. Few studies have isolated the specific effects of bathing alone, as these are often entangled with those of other activities. Most research emphasized water pollution from personal care products like sun scream (Brausch and Rand 2011), while other ecological disturbances, e.g., simplified food webs and cascading ecosystem effects, have received comparatively less attention (Schafft et al. 2021). Recreational bathing can directly damage riparian and aquatic habitats through trampling, sediment compaction, and vegetation loss, which lead to shifts in plant community composition and reduced species richness and diversity (Meyer et al. 2021, 2023; Schafft et al. 2021). Ground-nesting birds often rely on sandy beaches and sediment bars for reproduction—areas also favored by humans for bathing access—resulting in trampled nests and increased chick mortality. Efforts to improve human access, such as vegetation removal (sometimes affecting rare plant species) and the use of open fires, further degrade these habitats and disturb other wildlife, e.g., bats. Although less studied, submerged vegetation may be similarly affected, often resulting in bare, unvegetated zones, although at larger spatial scales, more tolerant species may coexist with sensitive ones (Bertrin et al. 2018; Schafft et al. 2024). Animal (e.g., fish) populations can be impacted indirectly through habitat degradation and directly through human presence and noise, disrupting their behaviours like foraging and breeding, incurring energetic costs, and potentially reducing population sizes (Schafft et al. 2021). Despite these concerns, quantifying these impacts remains methodologically challenging due to the variability in bathing practices and the influence of other activities. Bridging this gap requires targeted research to better understand the possible positive and negative ecological implications related to urban river bathing.

Lyon rivers illustrate the challenge of balancing recreation and ecology, as urban dwellers seek nature and refreshment through river bathing, often extending beyond city

boundaries (see section 3.2). Urban rivers, as biodiversity hotspots, serve as critical ecological corridors linking urban and rural areas for wildlife. Restoration efforts in Lyon—such as the renaturation of the Ruisseau des Planches (Brun et al. 2014)—have demonstrated the potential of urban rivers to support the return of native flora and fauna and foster ecological recovery. However, challenges persist. For instance, sediment re-injection programs upstream of Lyon, aimed at restoring aquatic habitats in the Rhône River, have faced resistance over safety concerns in potential bathing areas. This conflict between preserving ecological restoration efforts and accommodating the growing popularity of river bathing presents an emerging management challenge. The nearby Ain River, a Rhône tributary 30 km upstream of Lyon and a regional biodiversity hotspot, is already under ecological pressure, particularly on summer weekends when large crowds—mainly from Lyon—lead to habitat degradation and strain the river's ecosystems.

To balance ecological preservation with the social benefits of urban river bathing, a sustainable approach is essential. Priority should be given to impact assessments that evaluate the ecological effects of river bathing (Wuijts et al. 2018), considering factors such as visitor numbers, behaviours, frequency, duration, and activity locations (Shi et al. 2024). Mitigation strategies, such as spatial zoning and habitat buffering, can help reduce environmental disturbances by designating specific bathing areas and protecting sensitive habitats with barriers to safeguard wildlife and vegetation (Zingraff-Hamed et al. 2018). Some scholars advocate for the 'rights of the river'—recognizing the intrinsic rights of fish and other aquatic life to an undisturbed habitat (Strang 2020)—which supports the case for zoning that preserves certain river sections exclusively for nature. Effective visitor management is also important to prevent overuse, measures like visitor caps, seasonal restrictions, and educational campaigns can be implemented to encourage environmentally responsible behaviour. Ultimately, achieving both social and ecological goals requires collaborative management involving scientists (e.g., ecologists, social scientists), policymakers, and local communities. By fostering ecological stewardship within civil society, urban river bathing can enhance human well-being, protect urban biodiversity, and support the city’s ecological transition. We concur that One Health approach (WHO 2023) is essential: human and river health are interdependent; well-regulated bathing areas, supported by adequate infrastructure and ecological monitoring, can enable people to enjoy rivers while preserving ecosystem integrity (Porcherie et al. 2023).

3.6. *Making a splash*[20] (social perspectives)

Rivers hold significant cultural importance (Wantzen et al. 2016), and in cities, multifunctional riverbanks serve as essential spaces for human-nature interactions (Zingraff-Hamed et al. 2021). Bathing/swimming have been identified as the most active and immersive recreational activities associated with urban rivers, enhancing their "social connectivity" within communities (Kondolf and Pinto 2017). Since the COVID-19 pandemic and in response to summer heat, there has been a notable rise in wild bathing across European countries (Outdoor Swimmer 2021). However, despite this growing interest, societal perspectives on river bathing remain largely underexplored. A 2007 study on Berlin residents' preferences for bathing in rivers/lakes found that beach cleanliness and water quality were the most critical factors and identified three distinct groups of bathers – "modest quality seekers", "pristine seekers", and "comfort and security seekers" – each with varying priorities and willingness to pay for bathing site improvements (Meyerhoff et al. 2010).

In the summer of 2022, a public survey targeting residents of the Lyon Metropolis was conducted using Maptionnaire software[21] to assess public perceptions of river bathing, focusing on site characteristics, amenities, costs, and perceived risks. The questionnaire was distributed via email and social networks, with promotion through Lyon Metropolis communication channels, resulting in 1,166 completed answers (Maghakian et al. 2025). Findings revealed widespread public support for the establishment of designated river bathing sites in Lyon, recognizing them as valuable enhancements to the city. Respondents highlighted three key points: (i) the necessity for cooling options during summer months; (ii) the importance of regulating prevalent illegal and hazardous river bathing practices (see Fig. 4); and (iii) the perceived health and well-being benefits of river bathing. The survey also identified three societal concerns regarding the creation of river bathing sites on the Rhône and Saône rivers. The primary concern was the perception of poor water quality, with residents describing the rivers as polluted due to visible waste, murky water, and the presence of animals like swans and wels catfish. The second concern was an underestimation of drowning risks associated with open water bathing; only 40% of respondents – mainly women – recognized drowning prevention as a priority and acknowledged the role of lifeguards in enhancing safety at bathing sites. Accessibility emerged as a third consideration; many respondents emphasized the need

[20] Quote from Swimmable Cities Alliance: https://www.swimmablecities.org/
[21] Link to online questionnaire: https://new.maptionnaire.com/q/8dz4oja3mub4

for river bathing sites to be well-integrated with public transportation and to include parking facilities (Maghakian et al. 2025). This focus on accessibility likely underpins the strong preference for locating potential bathing sites within the city centre, where access would be easiest for the majority of residents.

On the other hand, river bathing associations—whether NGOs or informal community groups—value the conviviality of collective swimming, the sense of freedom it provides, and advocate for the lifting of bathing bans, either in designated areas or more broadly in urban rivers. In France, many argue that most bans lack a solid legal basis, as none of the three possible justifications—serious pollution, imminent danger, or military zones—are effectively applicable (Belhache 2018). Media discourse also increasingly reflects these societal shifts. For instance, recent headlines have highlighted Lyon's ambition to reopen bathing in the Saône River by 2027, following the example of the Seine in Paris and framing it within the broader trend of 'swimmable cities' (Ville de Lyon, 2025).

The results in Lyon and France align with the growing grassroots movement in Europe advocating for the right to bathe in urban rivers as a shared space and common good (Neskovic and Hein 2015). While societal support for these initiatives is strong, concerns about water quality, safety, and accessibility still hinder top-down approval. Inclusive planning and implementation could help address these issues—e.g., by prioritizing site selection based on accessibility and proximity to public infrastructure, and by providing clear signage and effective public communication regarding safety protocols. Additionally, social science research on how urban river bathing fosters social cohesion and environmental justice in the transformation of urban blue spaces provide further support. Case studies from different European cities, e.g., Swiss cities with a long tradition of river/lake bathhouses (Ruby and Shinohara 2019) and Copenhagen, where 21st-century harbour baths have become popular recreational and tourist destinations (Jensen et al. 2015), can offer valuable comparative perspectives. Site-specific insights can trace the evolution of river bathing culture and guide future developments tailored to community needs.

3.7. Integrating urban planning and river management (urban planning)

Urban rivers and riverfronts, often neglected during the industrialization era in European history, are increasingly being re-designed into public spaces offering multiple benefits, i.e.,

recreational opportunities, urban cooling, flood regulation, and enhancements to human and ecological health (Hunter et al. 2023; Schüle et al. 2019). River bathing has gained prominence as a way to foster human-nature connections and direct interaction with water. However, introducing river bathing into urban environments intensifies the competing uses of rivers, i.e., river traffic, tourism, and biodiversity conservation (Wuijts et al. 2018). Additionally, concerns persist about potential socio-environmental impacts including gentrification, social inequality, and ecological disruptions (Grellier et al. 2017). Decision-making processes for enabling river bathing thus require coordination and collaboration among diverse stakeholders – municipal authorities, state agencies, environmental organizations, and commercial/tourism-related river users – while navigating complex regulatory frameworks and reconciling conflicting priorities. Consequently, achieving consensus on safety, environmental, and operational standards is a persistent barrier to co-developing river bathing initiatives (Puppim de Oliveira et al. 2022).

In Lyon, the vision of urban river bathing is guided by the *Schéma des Usages des Rives Fluviales* (SURF)[22], a comprehensive spatial plan introduced in 2023 by VNF and Lyon Metropolis. SURF outlines 29 actions structured around three core ambitions: i) strengthening the relationship between citizens and rivers, ensuring rivers are accessible and visible to all, and supporting ecological transition; ii) preserving natural heritage and promoting ecological restoration by revegetating riverbanks and creating ecological corridors; iii) prioritizing the development of sustainable transportation options, including urban logistics and passenger transport. Key actions include riverbank renaturation, water quality protection, and the creation of designated urban river bathing sites that can contribute to address overcrowding at the Grand Parc Miribel Jonage, and to manage illegal bathing activities along the Rhône and Saône rivers in increasingly hot summers (Fig. 4; Maghakian et al. 2024). In early 2024, a collaborative project involving Lyon Metropolis, local municipalities, and river management actors – VNF, CNR and EDF – began identifying potential bathing locations in Lyon's rivers through GIS (Geographic Information System)-based assessments. These evaluations consider factors such as water quality, safety, biodiversity, and compatibility with existing river uses – in order to balance recreational needs with ecological and navigational priorities. Each site underwent a detailed evaluation, including a status summary and a proposal referencing similar projects across France and Europe. Based on anticipated constraints, the sites were classified into three categories (medium, strong, and very strong potential for bathing development). Municipalities are then responsible for implementing these plans with support from regional and national

[22] https://www.vnf.fr/vnf/app/uploads/2023/06/SURF_strategie-partenariale-et-plan-dactions-2024-2029.pdf

authorities. This multi-level coordination, grounded in scientific methods, seeks to promote river bathing while balancing diverse stakeholder interests and aligning with broader sustainable development goals.

Lyon's ongoing efforts exemplify a coordinated approach to balancing the diverse uses of rivers and among the stakeholders. To advance river bathing initiatives, future strategies should prioritize open dialogue and collaboration across services, institutions, and stakeholder groups. Integrating these entities into urban planning at all levels of implementation is crucial. Furthermore, aligning development efforts with community needs requires incorporating public participation into project planning, ensuring responsiveness to residents' expectations (see section 3.6; Pluchinotta et al. 2024).

4. Recommendations: key opportunities and challenges for sustainable urban river bathing

The following recommendations are grounded in three complementary sources: (1) the co-authors' collective analysis of the Lyon case study; (2) insights from the interdisciplinary literature on global and European urban river management; and (3) stakeholder workshops and conferences conducted in Lyon between 2022 and 2025. Each recommendation addresses both the challenges and opportunities identified through this process.

These recommendations are interconnected and mutually reinforcing. Adapted regulation (section 4.2) and monitoring – ranging from water quality testing (section 4.3) and ecosystem impacts (section 4.5) to reporting of drowning incidents (section 4.4) – form the foundation for evidence-based management that enables safe river bathing (section 4.7). There is also a recurring emphasis on comparative and collaborative learning – through historical studies (section 4.1), evaluation of legal structures (section 4.2), as well as the exchange of best practices between cities (section 4.7) – highlighting that Lyon's experience can both inform and be enriched by other European contexts. Furthermore, community engagement and education emerged as crucial, from reviving lost bathing cultures (section 4.1) to enhancing safety (section 4.4) and increasing public acceptance (section 4.6). Finally, the importance of integrated approaches – e.g., One Health (section 4.3, 4.5), multi-stakeholder governance (section 4.6), and transdisciplinary collaboration – cuts across all themes and suggests that no single discipline or sector can achieve a swimmable city alone. A holistic, multisectoral strategy – combining technical innovation, legal adaptation, science-policy integration, cultural revival,

ecosystem preservation, and community involvement – is essential for the successful reintroduction of urban river bathing in Europe, addressing the growing popularity of this trend and impacts of climate change.

4.1. History, culture and revival

River bathing, once a widespread leisure activity in Europe, banned during the 20th century in big cities. Recently, grassroots movements are advocating for its revival. By embracing the city's historical connection to its rivers, river manager and operational can gain a deeper understanding of its current resurgence. This historical perspective could serve as a valuable guide in the planning, development, and management of future bathing infrastructure (e.g., location, design, safety measures). To support this dynamic, scientists could investigate the evolving relationships between rivers and cities through comparative and context-specific studies. This includes analysing the spatial and temporal dynamics of historical bathing sites and observing the contemporary revival of river bathing in Europe. Such research can provide insights into how these practices may help restore connections between citizens and rivers.

Moreover, reviving a river bathing culture requires social innovation. Social scientists – e.g., anthropologists and historians – can support this process by documenting traditional bathing practices and helping communities reconnect with their river heritage. Community practitioners, including swim clubs and environmental NGOs, can organize river-centric cultural events (e.g., river festivals, art exhibitions, clean-up activities, and aquatic heritage celebrations) that foster a sense of stewardship and actively engage civil society in promoting sustainable urban river governance.

4.2. Regulation and laws

EU BWD provides a unified framework for managing bathing sites in EU. However, national laws and local regulations can either facilitate or obstruct the development of urban river bathing. Operational issues will focus on balancing public safety requirements, regulatory constraints and society's growing demand for access to rivers. The challenges posed by illegal bathing should also be addressed. Strategies must be found to anticipate and mitigate potential conflicts linked to the multiple use of rivers. A first scientific perspective could be to explore how legal frameworks influence transgressive behaviours related to river bathing, shedding light on the ways regulations shape social and individual practices. A comparative analysis of river-bathing practices in different regulatory contexts could reveal how legal and cultural factors influence the enabling of bathing activities. For instance, in Switzerland, individuals

bear responsibility for their safety when engaging in river bathing, while in France, mayors face potential legal liability when drowning incidents occur in their jurisdictions. Understanding how these contrasting liability frameworks – e.g., individual versus municipal responsibility – affect bathing practices and safety outcomes could inform more effective regulatory approaches. Examining the historical evolution of river bathing legislation across various European countries could help identify recurring patterns, regulatory trends, and significant divergences. Researchers could also explore the role of social movements in influencing – or resisting – changes within legal frameworks. Beyond analysis, they can support and collaborate with civil society to advance governance reform. For instance, by partnering with local 'swimmable river' advocacy groups, researchers can help develop evidence-based safety guidelines that inform new municipal ordinances. This co-production of governance innovations – blending scientific expertise with grassroots initiative – can further contribute to the evolution of laws toward enabling safe and sustainable urban bathing.

4.3. Water quality and health risks

Bathing in rivers contaminated with microbial pollutants poses health risks, a concern likely to grow as climate change impacts reduce the general dilution capacity of European rivers (Abily et al. 2021). While the BWD relies on two FIB indicators and mandates regular monitoring, it does not fully capture the complexity of urban river contamination. Currently, sampling locations, monitoring frequency, and measured parameters vary across European countries. Urban-specific factors like sewer overflows, surface runoff, droughts, and cyanobacteria are expected to worsen with climate change. To improve safety, key operational recommendations should include (1) limiting contamination sources through integrated management of CSOs, reduction of surface sealing, and wastewater discharges, (2) conducting standardized, comprehensive monitoring of bathing water quality, and (3) developing early warning systems to prevent exposure to microbial pollution. Additionally, raising public awareness about health risks and implementing targeted communication strategies for different bather groups will be essential. The Lyon experience reveals research priorities for post-industrial urban rivers undergoing recreational transformation – a trend mirrored in many European cities. Situated at the confluence of the Rhône and Saône, Lyon presents unique challenges arising from the interaction of multiple river systems and the spatial heterogeneity of microbial communities across different sections of the rivers. First, advancing models of contaminant transport and behavior—especially those integrating microbial ecology—is essential. This includes exploring the relationships between microbial diversity, river ecological quality, and the emergence of

pathogens. Second, characterizing aquatic microbiota helps assess the effectiveness of pollution control measures. Third, develop new indicators and methodologies specifically adapted to the complexities of urban rivers to improve water management. Finally, fostering interdisciplinary collaboration under a One Health framework is crucial. Water quality management underpins both human health and ecological integrity and is therefore a key determinant of the viability of urban river bathing. For instance, monitoring programs should be designed to detect not only human pathogens but also early signals of ecological degradation, enabling a proactive, integrated approach to safeguarding the health of people and ecosystems.

4.4. River drowning and safety

Unintentional drowning is a major safety concern in urban rivers. Epidemiological studies show that young men are the primary victims, often involved in riverside recreational activities or high-risk behaviors. Prevention measures are often inadequate or poorly adapted to local contexts. To enhance urban river bathing safety, prevention efforts should focus on identifying high-risk areas, periods, and behaviors to target interventions more effectively. The efficiency of rescue operations in complex urban river environments should be improved. These efforts extend beyond rescue techniques to include the surveillance of bathing areas to enable faster emergency responses. Effective communication and coordination between prevention organisations, rescue teams and forensic medicine institutions should be strengthened to support the continuous improvement of rescue and resuscitation techniques through the sharing of best practice. From a scientific perspective, key priorities include studying the local epidemiology of river drownings to identify spatio-temporal risk patterns and vulnerable groups, providing a basis for targeted prevention strategies. Developing risk models through multivariable analyses can help quantify contributing factors and inform evidence-based safety measures. Additionally, modeling underwater trajectories of drowning victims, tailored to specific river conditions, could improve rescue operations. Finally, standardized protocols for assessing bathing site usage – who bathes, where, and when – are essential for optimizing prevention and emergency responses.

Another safety issue involves injuries such as cuts or sprains, which can occur if bathers encounter broken glass, metal scraps, or slippery rocks in the riverbed. In some urban rivers, bathers may also experience leech bites or skin irritations from contact with certain aquatic plants or algae. Therefore, a comprehensive safety strategy should include regular riverbed surveys and clean-ups to remove hazardous debris, as well as public education efforts – in collaboration with community NGOs or swim clubs – about local wildlife (e.g., avoiding areas

known for biting catfish or water snakes). Ensuring the presence of first-aid kits and trained personnel (e.g., lifeguards) at official bathing sites is equally important. By proactively managing these non-fatal risks, city authorities can significantly enhance overall safety for river bathers.

4.5. River ecosystems

River bathing can have both positive and negative effects on aquatic ecosystems. While it may contribute to improved water quality, it can also disturb terrestrial and aquatic flora and fauna. These ecological impacts often extend beyond urban boundaries due to the increased use of surrounding natural areas by city dwellers. However, such processes are not yet sufficiently considered by urban policies, river managers, and scientists. To address these challenges, several operational recommendations can be proposed. First, ecosystem conservation and restoration should be prioritized through spatial zoning strategies that identify areas of varying ecological sensitivity to human disturbance, i.e., bathing. High-intensity recreational use should be directed toward easily accessible sites with lower ecological sensitivity, while access to sensitive areas such as fish spawning grounds or bird nesting sites should be restricted through reduced infrastructure and clear guidance against trespassing. This approach requires detailed habitat mapping combined with social impact modelling to optimize the spatial distribution of recreational activities. Second, environmental education programs must accompany this zoning approach, helping users understand why certain areas require protection and how their behavior affects aquatic ecosystems. From a scientific perspective, it is essential to quantify the ecological impacts of river bathing, including chemical pollution, physical disturbances to riparian and aquatic habitats, and noise pollution. Identifying key processes and impact factors by bathing type would guide the development of targeted mitigation strategies. Finally, adopting a One Health approach – which recognizes the interconnectedness of human, nonhuman species, and environmental health – is crucial for urban river management. Ecological integrity constrains certain human activities while offering opportunities to benefit from preserved biodiversity for social-cultural benefits related to bathing. Balancing recreational use with ecosystem conservation thus becomes a public health strategy, helping to safeguard humans through improved water quality, reduced disease transmission, and enhanced climate resilience.

4.6. Social perspective

Rivers are dynamic social-ecological systems that shape how urban residents perceive and interact with nature. Different population groups hold diverse perceptions, values, and

preferences regarding river bathing, that can be influenced by cultural, historical, and social contexts (Meyerhoff et al. 2010; Maghakian et al. 2024). To promote sustainable management of urban river bathing, it is crucial to integrate citizens' perceptions and cultural values into decision-making processes. Inclusive planning is essential to ensure equitable access to river bathing. In Lyon, as in many cities, those most affected by heatwaves and with limited vacation opportunities – often residents of low-income neighborhoods – should have the most to gain from inclusive urban blue spaces. This requires addressing the barriers faced by vulnerable groups. For example, designated bathing sites should be easily accessible by public transportation and designed to accommodate the needs of the elderly, persons with disabilities, and others with specific requirements. Access to these natural bathing areas should remain low-cost or free, allowing people from all socioeconomic backgrounds to benefit.

Actively engaging local communities in governance enhances the inclusivity and effectiveness of urban river management. Involving residents, stakeholders, and interest groups fosters democratic participation, a sense of ownership, and shared responsibility for the protection and sustainable use of urban rivers. From a scientific point of view, identifying social needs through participatory research or citizen science is a priority to actively involve various stakeholders in co-defining urban river bathing project. By contributing to data collection and environmental monitoring, citizens can evaluate the ecological impact of river bathing and build stronger connections with urban ecosystems. Finally, conducting comparative case studies across different socio-eco-cultural contexts would provide insights into how cultural factors shape river-related practices, helping to identify adaptable governance models for diverse urban settings.

4.7. Urban planning

Urban rivers serve multiple purposes, including navigation, tourism, wastewater dilution, hydroelectricity. Introducing urban river bathing can create conflicts among stakeholders, altering power dynamics and requiring a redistribution of roles in river management. To ensure sustainable development, fostering multi-stakeholder dialogue and collaboration through integrated urban planning is thus essential. Urban river bathing should be fully embedded in territorial planning as a climate mitigation and sustainable transformation strategy. By incorporating it into broader urban development frameworks, cities can align recreational activities with environmental conservation, public health, and sustainability goals, such as climate change mitigation. Future research should explore how urban river bathing reshapes institutions and redefines stakeholder roles in negotiation and collaboration processes.

Furthermore, developing a multi-criteria, science-based decision-making tool is crucial. This tool must consider water quality, ecological impacts, and social acceptance to support evidence-based decisions. Continuous refinement of this tool, informed by new data, feedback, and evolving scientific knowledge, would be essential. Evaluating related policies and pilot projects will further enhance its effectiveness. This iterative process will ensure the tool remains adaptable and relevant, guiding informed, sustainable urban river bathing initiatives responsive to emerging challenges.

5. Limitations

While our framework offers a comprehensive approach to understanding urban river bathing, several limitations should be acknowledged. First, economic dimensions were not explicitly included as a standalone theme. This is because we focus on public river bathing spaces that are not profit-oriented. Nonetheless, factors like tourism potential, infrastructure costs, maintenance expenses, and funding mechanisms inevitably influence the feasibility of such projects. On the other hand, the costs associated with water quality improvements and safety infrastructure can pose economic challenges that must be carefully weighed against anticipated benefits. Further studies could also examine how urban river bathing initiatives stimulate local economies by attracting both residents and tourists, potentially generating new business opportunities. Second, our case study in Lyon reflects a specific socio-cultural and environmental context that may not be fully generalizable to other European cities with different river types, climatic conditions, or bathing traditions. Therefore, our recommendations should be adapted with caution. Finally, we acknowledge that our team's disciplinary strengths lie primarily in the environmental sciences. As a result, socio-cultural aspects were discussed in qualitative terms. Future research should explore these dimensions in greater depth – particularly through dedicated social science methodologies. Despite these limitations, we believe our interdisciplinary approach provides a valuable starting point for guiding inclusive, sustainable urban river bathing strategies.

6. Conclusion

River bathing in Europe is a culturally rich tradition, deeply connected to the history of swimming and urban development. With access to natural waters, urban river bathing requires

minimal infrastructure and appears as an economic and ecological alternative to artificial swimming pools. Today, a growing societal demand to reclaim urban rivers has driven initiatives and policies promoting river bathing. Such new river practices could serve as a leverage point to improve water and ecosystem quality, further generating co-benefits within a One Health perspective. However, they may also conflict with existing uses such as wastewater dilution, energy production, navigation, or river restoration. Moreover, unregulated intensive recreation has potential to disrupt ecosystems, and drowning risks highlight the need for safety measures.

From an initial kernel comprising a rescue service and three laboratories, an interdisciplinary group has been developing since 2019 in the frame of Université de Lyon, gathering researchers, from Lyon, Rennes and Liège and a wide range of stakeholders. Considering the inherently multidisciplinary nature of urban river bathing, this article intended to study the topic holistically. It aimed to propose a framework for future practices and research in the European context, by capitalizing on the activities of the group as a think tank. Drawing on the experience of Lyon, the paper organized its main findings through seven key aspects: history, law, water quality, drowning, river ecosystems, social perspectives, and urban planning. We proposed recommendations, about the operational issues linked to build a sustainable urban river bathing in European cities, and about the corresponding scientific perspectives they suggest. In the context of climate change and the growing urban population in large cities, the development of urban river bathing likely presents an opportunity to enhance the well-being of populations, particularly the most vulnerable, who cannot find relief from the heat outside the city during heatwaves. A key challenge will be to support and regulate river bathing and the increasing use of riverbanks, in compliance with local laws and regulations, while minimizing risks related to drowning and water/ecosystem quality. We hope that this feedback from the Lyon consortium on this topic will contribute valuable insights to this emerging area of research.

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