

FLOATING BUILDINGS AS A CATALYST FOR URBAN REGENERATION AND SUSTAINABLE ARCHITECTURE: THE CASE OF BELGRADE

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ABSTRACT

The concept of floating buildings is emerging as a transformative architectural solution in dynamic urban environments. This innovative trend leverages the untapped potential of urban rivers to create sustainable, adaptable, and resilient housing solutions that address contemporary urban challenges. Floating houses are increasingly recognized as equal to traditional housing in terms of comfort, quality, and cost, while offering distinct advantages in mobility and resource efficiency. By utilizing renewable energy sources and secondary materials, these structures contribute to sustainable urban development, aligning with the social and environmental demands of future generations.

This paper focuses on the feasibility of implementing floating buildings in Belgrade as a response to urban densification, limited land availability, and the evolving social requirements of modern cities. The study critically examines the theoretical framework of floating architecture and explores its integration into Belgrade's urban regeneration strategy. Through a comparative analysis of successful examples from Europe, the paper highlights the potential of floating buildings to activate river courses, enhance urban identity, and foster social inclusiveness.

The research provides a comprehensive analysis of the technological, social, environmental, regulatory, and economic aspects of floating buildings. Key recommendations include incorporating these structures into urban development policies, fostering public-private partnerships, and leveraging their environmental and economic benefits. The findings aim to establish a typology and technological framework for floating buildings that can be adapted to the complex urban context of Belgrade, promoting a harmonious balance between architecture, sustainability, and urban regeneration.

KEYWORDS _ *Floating buildings, urban regeneration, sustainable architecture, Belgrade, adaptive design, river activation*

INTRODUCTION

Urban areas worldwide are facing significant challenges related to land scarcity, climate change, and rapid population growth. As traditional urban expansion becomes increasingly difficult due to limited land availability, cities are seeking alternative solutions for sustainable development. Floating buildings present an opportunity to utilize underdeveloped waterfronts, transforming them into dynamic, habitable spaces that contribute to urban regeneration (UN-Habitat, 2019; Li, Cao, & Lin, 2021). These structures have been recognized for their adaptability to climate change and potential to reduce pressure on terrestrial urban infrastructure (Henriques & Louis, 2020; Kim & Bae, 2020). Belgrade, situated at the confluence of the Sava and Danube rivers, has extensive, underutilized waterfront areas. Historically, these rivers have played a crucial role in the city's economic and social development (Vuksanović-Macura, 2017). Implementing floating buildings could revitalize these spaces by providing additional residential, commercial, and cultural opportunities, aligning with contemporary urban planning trends (Maksimović, 2019; Kaplinsky & Talsma, 2017). This research aims to analyze the feasibility of integrating floating buildings into Belgrade's urban landscape. The key objectives include: investigating the architectural and structural feasibility of floating buildings, assessing the environmental and social impacts of such developments, evaluating economic viability and potential financing models, and providing policy recommendations to facilitate the implementation of floating architecture (Calcagni, 2022; Lago & Czapiewska, 2020).

METHODOLOGY

This research uses an analytical-synthetic approach, combining theoretical and empirical studies of primary and secondary sources. Primary sources include texts from the field of architecture and realized examples of floating structures, while secondary sources provide indirect insights into the researched topic. By comparing case studies from Amsterdam, Hamburg, and Copenhagen with the spatial and regulatory environment in Belgrade, the research aims to synthesize knowledge and propose adaptable typologies and policy frameworks for integrating floating buildings into the city's development strategy. The comparative approach helps bridge the gap between global best practices and local needs. The methodology also acknowledges the interdisciplinary nature of the topic, which spans architecture, environmental science, urban planning, and socio-economic studies. This holistic approach allows for a more understanding of the challenges and potentials of floating buildings as a sustainable architectural typology.

THEORETICAL FRAMEWORK

Floating architecture, though often perceived as futuristic, has deep historical precedents—from Southeast Asian water villages to Dutch amphibious homes—demonstrating humanity's long-standing adaptation to aquatic environments (Pungetti, 2006; Bertram, 2010). In contemporary discourse, floating buildings have become increasingly relevant in the context of climate change, urban densification, and land scarcity (UN-Habitat, 2019; Kim & Bae, 2020; Li, Cao, & Lin, 2021). More than engineering solutions, they are now framed as socio-spatial interventions that reshape urban boundaries and contribute to flexible, resilient city-making (Olthuis & Keuning, 2010; de Graaf, 2012). Sustainability plays a central role in floating architecture, emphasizing adaptive reuse, renewable energy, and efficient resource cycles (Lago & Czapiewska, 2020; Manzano & Santos, 2021). Projects like Schoonschip in Amsterdam and Urban Rigger in Copenhagen integrate solar power, rainwater harvesting, and low-carbon materials (Kaplinsky & Talsma, 2017; BIG, 2016). These examples act as prototypes of sustainable micro-urbanism and catalysts for reactivating riverfronts. Floating structures thus contribute to urban regeneration by reintegrating water into public space and fostering identity, inclusivity, and ecological resilience (Huebner, 2025; Jaroszynska & Wolanski, 2019). However, successful implementation requires regulatory clarity. Critical legal issues include

the absence of specific zoning for water-based development, the need to comply with navigation and ecological laws, and unresolved questions of ownership and tenure (Maksimović & Krstić-Furundžić, 2020; Urban Planning Institute of Belgrade, 2021). As strategic urban instruments, floating buildings offer Belgrade the potential to transform underutilized post-industrial riverfronts into adaptive, inclusive, and sustainable spaces.

CASE STUDIES: EUROPEAN CONTEXT

To better understand the practical applications and transformative potential of floating buildings, this section analyzes prominent European case studies that have successfully integrated floating architecture into urban regeneration strategies. These projects provide insight into diverse typologies, technological innovations, and governance models that could be adapted to the context of Belgrade.

Table 1: Case Studies

Case	Name of floating building	Method of investigation	Location	Date
1	<i>Schoonschip</i> Floating Community	Internet research, reports, image analysis	Amsterdam-Noord, Netherlands	2020
2	<i>Floating Homes</i> – HafenCity	Internet research, urban planning documents	Hamburg, Germany	2018
3	<i>Urban Rigger</i> Floating Student Housing	Internet research, architectural documentation	Copenhagen, Denmark	2016

Schoonschip, Amsterdam

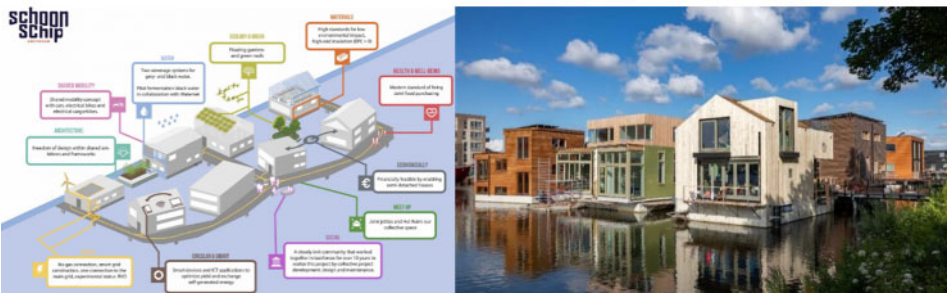


Figure 1: The Schoonschip project – overview of the floating neighborhood with clustered housing and renewable systems. - <https://schoonschipamsterdam.org/en/>

The Schoonschip project, located in the northern part of Amsterdam, is considered one of the most sustainable floating neighborhoods in Europe. It was developed through a community-led participatory process that spanned over a decade (Spectral Energy, 2018; Metabolic, 2019). This floating community consists of 46 residential units arranged in clusters, accompanied by shared spaces connected via floating docks and collective infrastructural systems (Space&Matter, 2020). On a technological level, Schoonschip operates as a micro-energy system: each unit generates its own electricity using solar panels and is connected through a smart grid that enables energy exchange among households (Spectral Energy, 2018). The entire development is gas-free, significantly reducing its carbon footprint (Metabolic, 2019). Integrated mobility is a core component of the project, including shared use of electric vehicles, bicycles, and cargo bikes, which minimizes emissions and reduces reliance on private transportation (Schoonschip, 2022). Water management strategies include separate greywater and blackwater systems, with a pilot fermentation project implemented in cooperation with Waternet (Spectral Energy, 2018). Green roofs and floating gardens enhance biodiversity, provide passive climate control, and contribute to the ecological functionality of the neighborhood. Building materials

were selected for low environmental impact, and all housing units meet the highest energy standards, aiming for near-zero or zero energy use (Space&Matter, 2020). Socially, Schoonschip is defined by its collective spirit: residents co-created the neighborhood, organizing into thematic working groups to define principles for architecture, sustainability, and community life. Communal spaces like Het Ruim host meetings, workshops, and shared events, reinforcing the social and participatory nature of the project (Schoonschip, 2022). By combining ecological, technological, social, and spatial innovations, Schoonschip stands as a pioneering model of circular and climate-resilient urban living on water.

HafenCity, Hamburg



Figure 2: Masterplan of HafenCity – Baakenhafen basin with floating housing integration -<https://www.hafencity.com/en/overview/masterplan>

The HafenCity project in Hamburg represents one of the largest and most ambitious urban regeneration initiatives in Europe. Covering approximately 157 hectares of former port and industrial land along the Elbe River, HafenCity integrates floating residential units within a broader framework of sustainable and flood-resilient urban design (HafenCity Hamburg GmbH, 2021). Specific zones of the development, such as Baakenhafen basin, feature floating homes that are adapted to fluctuating water levels and are stabilized using advanced mooring systems. The flood-resilient nature of HafenCity's infrastructure is among its most significant achievements: all buildings, including floating units, are constructed above the legally defined flood protection line, while public spaces are designed to accommodate water level changes and storm surges through multifunctional quay typologies (HafenCity Hamburg GmbH, 2021). In addition, the project employs the HafenCity Environmental Sustainability Certification (HCH), a customized green building standard that is more rigorous than LEED or BREEAM, emphasizing sustainable materials, energy efficiency, and ecological integration such as green roofs and renewable energy systems (HafenCity Hamburg GmbH, 2021). Floating housing is not treated as an isolated experiment but as part of an inclusive, mixed-use environment that combines residential, educational, cultural, and recreational functions. This integration ensures active connectivity between floating units and the land-based city, fostering social inclusion and accessibility. The project is managed through a public-private governance model coordinated by HafenCity Hamburg GmbH, which oversees land-use planning, environmental requirements, and architectural coherence. HafenCity thus serves as a transferable framework for other cities seeking to incorporate floating architecture into their own sustainable waterfront regeneration strategies.

3.3 Urban Rigger, Copenhagen



Figure 3: Top-down view of modular Urban Rigger unit with solar and green roof, Construction process of Urban Rigger using upcycled containers - <https://big.dk/projects/urban-rigger-3021>

Urban Rigger, located in the port area of Copenhagen, Denmark, is an innovative modular floating housing solution designed by Bjarke Ingels Group (BIG). Developed in response to the student housing shortage in Copenhagen, the project offers a sustainable, mobile, and cost-effective alternative to traditional dormitories (BIG, 2016). The concept repurposes upcycled shipping containers, arranged in a hexagonal layout atop a floating concrete platform. Each unit includes private rooms and shared communal spaces, creating an efficient co-living environment. Technologically, Urban Rigger is designed to operate as a low-energy structure: it incorporates photovoltaic solar panels, green roofs, and seawater-based thermal systems for heating and cooling (BIG, 2016). The floating base, made from recycled materials, supports the project’s emphasis on circular design, sustainability, and minimal ecological impact. One of its distinctive features is mobility—the entire structure is relocatable, making it particularly well-suited for underused harbor zones and transitional urban areas. Environmentally, Urban Rigger exemplifies principles of material reuse and modularity, while socially, it promotes community living through shared spaces and a central floating courtyard. Its affordability, adaptability, and sustainability position Urban Rigger as a forward-thinking prototype for scalable housing solutions in dense coastal cities.

Table 2: Comparative Analysis Overview of Floating Structures

Project	Floating System	Construction Technology	Energy Efficiency	Public Utilities	Applicability to Belgrade
Schoonschip	Modular concrete pontoons; clustered layout	Prefabricated wooden modules; smart grid; participatory design	Net-zero (EPC = 0); solar, batteries, heat pumps	Independent systems; grey/black water separation; no gas	High: adaptable to riverbanks with limited land; supports bottom-up models
HafenCity	Floating units on regulated tidal platforms	Conventional + flood-resilient structures; integrated planning	Certified green building standard (HCH); green roofs	Fully connected to city grid; flood-resilient public zones	Moderate: applicable with major planning reforms
Urban Rigger	Floating containers on concrete base	Upcycled shipping containers; modular, movable; prefab systems	Energy-positive; green roofs; seawater heat exchange	Potentially off-grid; scalable for underused port areas	High: replicable in unused industrial river zones like Ada Huja

The comparative analysis of Schoonschip (Amsterdam), HafenCity (Hamburg), and Urban Rigger (Copenhagen) provides a solid foundation for assessing the feasibility of floating buildings in Belgrade. These case studies illustrate varied typologies—from community-driven to state-supported and modular student housing—offering adaptable models for local urban conditions. Technological elements such as energy-positive systems and flood-resilient designs serve as references for ecological performance. The projects also reveal how differing policy and financing frameworks

shape implementation potential. Emphasis on participatory planning, particularly in Schoonschip, highlights the role of civic engagement in successful urban integration. These examples demonstrate that floating architecture can be transferred or hybridized to suit Belgrade’s legal and riverine context. The research contributes to forming a scalable, localized framework for sustainable water-based development.

ENHANCING JOYFUL URBAN LIVING THROUGH
TECHNOLOGICAL INNOVATION IN FLOATING ARCHITECTURE

In addition to demonstrating technical and spatial feasibility, the European case studies reveal how technological innovations embedded within floating architecture can significantly contribute to shaping vibrant and socially engaged urban experiences. Projects such as Schoonschip in Amsterdam and Urban Rigger in Copenhagen exemplify how smart systems, renewable technologies, and communal spatial arrangements support not only environmental goals but also emotional, aesthetic, and participatory aspects of urban life (BIG, 2016; Space&Matter, 2020; Schoonschip, 2022). These interventions go beyond sustainability—they promote new forms of urban living that are inclusive, community-driven, and resilient to environmental challenges. Through the integration of human-centered design, circular resource use, and collective governance, floating architecture emerges as a transformative strategy for reactivating underutilized riverfronts and cultivating meaningful, adaptive public spaces (Metabolic, 2019; Spectral Energy, 2018). As such, these models offer relevant insights for the redevelopment of river-adjacent areas in cities like Belgrade, where floating structures could help reconnect people with water and foster new forms of inclusive urban identity.

Table 3: Technological Innovations and Joyful Urban Experience

Project	Smart/Digital Technologies	Modular/Construction Innovation	Sustainable Systems	Enhancing Joyful Experience
Schoonschip (Amsterdam)	Smart grid, solar panels, energy sharing, ICT systems	Prefabricated wood modules on concrete pontoons	EPC=0, green roofs, black/grey water separation	Collective energy systems, shared mobility, strong community identity
HafenCity (Hamburg)	Flood sensors, sustainable infrastructure, planning software	Hybrid floating + fixed structures, flood-resilient bases	Green roofs, HafenCity sustainability standard (HCH)	Public access waterfronts, multifunctional social spaces
Urban Rigger (Copenhagen)	Solar panels, seawater heat exchange, smart ventilation	Upcycled containers, modular floating platforms	Net-positive energy, sustainable insulation, green roofs	Youth-focused co-living, central courtyard, affordability, mobility

Floating buildings also support joyful urban living through their ability to host multifunctional public spaces—such as floating parks, educational platforms, and cultural venues—that reconnect citizens with aquatic environments and foster interactive, memorable experiences. Examples from Europe illustrate how these structures serve not only ecological or residential purposes, but also create vibrant urban interfaces that blend leisure, culture, and community life (Kaplinsky & Talsma, 2017; Huebner, 2025). Viewed through the lens of technological and spatial innovation, floating architecture thus emerges not merely as a solution to environmental constraints, but as a dynamic catalyst for inclusive, resilient, and experientially rich urban futures.

MULTIDIMENSIONAL FRAMEWORK FOR THE IMPLEMENTATION
OF FLOATING ARCHITECTURE IN BELGRADE

The integration of floating architecture into Belgrade’s urban landscape requires a multidimensional approach that encompasses technological, environmental, social, regulatory, and economic

considerations. From a technological standpoint, floating buildings depend on specialized engineering systems and modular construction techniques that enhance adaptability, durability, and sustainability. Key features include buoyant foundations made of reinforced concrete or high-density polymers, prefabricated modules for rapid assembly, and integration with renewable energy sources and smart-grid networks, as demonstrated in projects like Schoonschip and Urban Rigger (BIG, 2016; Spectral Energy, 2018). Anchoring systems must be adapted to local hydrological dynamics, while infrastructure nodes enable connection to water, energy, and communication systems (Space&Matter, 2020).

Environmentally, floating buildings can reduce land consumption and lower carbon emissions, especially when constructed using sustainable materials and designed to support circular resource use (Manzano & Santos, 2021; Metabolic, 2019). In addition to conserving terrestrial ecosystems, these structures may include greywater treatment and biodiversity-supporting elements such as green roofs or floating gardens. Nevertheless, their deployment requires thorough environmental assessments, especially in ecologically sensitive zones along the Sava and Danube rivers (Urban Planning Institute of Belgrade, 2021).

On a social level, floating housing models can promote inclusivity, especially when designed for students, cooperatives, or mixed-use communities. Projects such as Urban Rigger and Schoonschip illustrate how water-based housing can enhance affordability and social cohesion (BIG, 2016; Kaplinsky & Talsma, 2017). Publicly accessible floating spaces—such as community pavilions or cultural venues—could further reconnect Belgrade’s residents with the waterfront, helping to resist trends of riverfront privatization (Vuksanović-Macura, 2017).

The greatest challenges lie in the regulatory and institutional frameworks. Serbian planning law does not yet formally recognize floating buildings, while water surfaces remain classified as public property, governed separately from land (Law on Planning and Construction RS, 2022). This legal fragmentation complicates issues of ownership, permitting, and zoning integration. As suggested in critical urban analyses, overcoming these barriers will likely require new institutional mechanisms, such as pilot regulatory zones or specialized interdepartmental bodies (Vujosević, 2015).

Economically, although floating buildings may entail higher upfront costs, they can prove competitive over time due to reduced land acquisition expenses and lower energy consumption (Lago & Czapiewska, 2020). Moreover, they offer potential to stimulate river-based economic development, including tourism, ecological infrastructure, and innovation in green construction.

CONCLUSIONS

Floating buildings represent an emerging typology that holds transformative potential for cities grappling with spatial, environmental, and social challenges. This research has shown that, when designed and governed responsibly, floating architecture can contribute meaningfully to urban regeneration, sustainability, and climate adaptation. The case studies of Amsterdam, Hamburg, and Copenhagen offer valuable lessons on community involvement, technical feasibility, and policy innovation. In the context of Belgrade, a city rich with underutilized riverfronts and a cultural affinity for life on water, floating buildings offer a compelling strategy to revitalize degraded zones, diversify housing options, and reconnect citizens with their urban rivers. However, the realization of this potential depends on institutional willingness, interdisciplinary collaboration, and a clear regulatory framework. Floating architecture must be integrated not just physically, but strategically—embedded into the urban fabric, policy planning, and collective imagination of the city. Ultimately, floating buildings should not be seen as futuristic anomalies but as adaptable instruments for a more inclusive, resilient, and ecologically balanced urban future.

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