Literature Review: Floating Architecture

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***Abstract*—Floating architecture is emerging as a viable response to flooding, land scarcity, and rising water levels, but its performance depends on decisions far beyond conventional architecture. This research evaluates floating buildings through four architectural parameters: buoyant structural systems, material behavior, MEP adaptation, and construction methodology. Using literature review, system classification, case studies, and interviews, the study compares pontoon, modular grid, amphibious, VLFS, and hybrid systems in relation to stability, massing, environmental context, and service integration. Material analysis highlights the trade-offs between concrete stability, steel precision, composite modularity, and hybrid durability. Case studies-from small floating houses to large districts-reveal that mass distribution, prefabrication, flexible utility routing, and context-specific mooring fundamentally shape architectural form and usability. Interview insights further emphasize that height, weight, and layout are dictated by hydrostatics, not aesthetics. The study concludes that architectural success on water requires early interdisciplinary coordination and system-led design thinking.**

***Index Terms*—Floating Architecture; Buoyancy Systems; Materials; MEP Integration; Architectural Design**

I. AIM

To evaluate how buoyant systems, materials, MEP, and construction directly shape floating architecture.

II. OBJECTIVES

- To analyze how structural, material, and service systems influence the form, stability, and performance of floating buildings.
- To identify architectural principles derived from global case studies, assessing feasibility across different water environments.

III. SCOPE

This study reviews permanent and semi-permanent floating buildings such as houses, public buildings, mixed-use platforms, and floating districts. It evaluates buoyant structural systems, material suitability, MEP adaptations, and construction strategies that influence architectural design. The scope includes lakes, rivers, sheltered coastal zones, and flood-prone landscapes, excluding offshore industrial structures and naval engineering platforms.

IV. LIMITATION

The study excludes hydrodynamic simulations, naval-architecture-level calculations, offshore industrial platforms, and detailed cost modelling. Case-study data is limited to available documentation and interviews.

V. INTRODUCTION

Floating buildings challenge conventional architectural assumptions because buoyancy, stability, and mass distribution define form, height, and spatial organization. As rising water levels affect urban and riverine settlements, floating systems-from pontoons to modular grids and amphibious foundations-offer alternatives that merge architectural intent with marine engineering. However, architecture on water is constrained by materials, movement, utilities, and long-term maintenance. This study addresses these gaps by classifying floating systems, analyzing materials, comparing built precedents, and incorporating professional insights to identify how architectural design must adapt when the ground itself is no longer fixed. (Rabin Chakrabortty 1, 2025) (Tejonmayam, 2024) (Anushiya J, 2024)

VI. METHODOLOGY

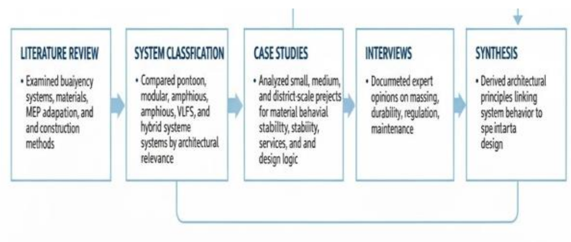

Figure 1: Methodology (Source – Author)

The methodology combines a structured literature review with system-based analysis and case-study evaluation. It first examines buoyancy systems, material choices, MEP adaptations, and construction methods, followed by a classification of pontoon, modular, amphibious, VLFS, and hybrid systems based on their architectural relevance. Medium- and district-scale projects were then studied to understand how materials, stability, and service strategies shape spatial and structural decisions. Expert interviews provided additional insight into massing, durability, regulation, and long-term maintenance considerations. These layers of analysis were finally synthesized to derive architectural principles that link system behavior to spatial design.

VII. HISTORY OF FLOATING ARCHITECTURE

Floating architecture has progressed through distinct phases. In prehistoric and ancient periods, communities created stilt houses and reed platforms as basic responses to wetland ecosystems. From 1000-1800, organized floating villages emerged in regions like Lake Titicaca and Tonlé Sap, developing communal layouts and water-based circulation. The 19th century introduced industrial materials such as steel and engineered timber, enabling larger pontoons and early engineered buoyancy systems. Between 1900–1970, houseboats and naval research improved mooring and hydrostatics but remained vessel-driven. By the late 20th century, reinforced concrete pontoons and modular utilities allowed purpose-built floating neighborhoods, particularly in the Netherlands and Japan. From 2000–2015, floating architecture shifted toward climate-responsive design with modular platforms and amphibious systems. Since 2015, advancements in hybrid materials, scalable modules, and VLFS technologies have supported the rise of floating districts like Schoonschip, positioning water-based urbanism as a credible response to climate risk and land scarcity.(Moon1, 2018) (Wang C. M., 2011) (Guimaraes, 2014)

VIII. PROFESSIONAL ROLES IN FLOATING BUILDING PROJECTS

Floating architecture requires a coordinated team because every design choice affects buoyancy, stability, and safety. Architects, naval and structural engineers, MEP specialists, and regulatory bodies must work together to avoid technical or legal failure. (Gupta, 2025) (Dhanuskar, 2025)
Architects shape space on buoyant foundations, while engineers manage load paths, movement, and resilience. These projects only succeed when all disciplines operate as one system.(Preamble, 2025) (About civil engineering, n.d.)

IX. TYPOLOGY AND ARCHITECTURAL

Classification of Floating Structural Systems

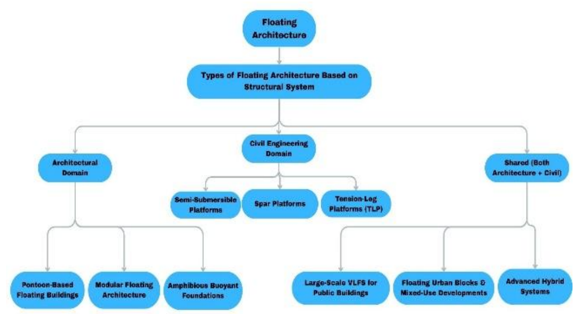

Figure 2: Typology and architectural classification of floating (Source – Author)

1. Architecturally Dominant Systems
1.1. Pontoon-System

Figure 3: Professional Roles and What They Contribute (Source – Ruukki)

Pontoon systems use wide, shallow concrete, steel, or HDPE pontoons that directly support architectural loads. Built through precast caissons or welded modules, they work best in lakes, canals, reservoirs, estuaries, and other sheltered waters at depths of roughly 1.5–20 m. They remain the most economical option for small- to medium-scale buildings and offer moderate design freedom, though the footprint is fixed. Services typically run through under-deck corridors with articulated joints. Key forces include hydrostatic buoyancy, wave uplift, and wind or current loads. (Icho SEIMOKOMOH Igwe, 2020) (El-Shihy, 2019) (Chayka, 2024)

1.1. Modular Floating System

Figure 4: Modular floating building (Source- adsttc)

These systems link concrete, steel, or HDPE units into interconnected grids that allow expandable and reconfigurable layouts. Factory-made modules are joined with engineered connectors and perform well in lakes, calm rivers, and protected coastal bays, generally between 2–30 m depth. Costs fall in the medium range and rise with module count, but they offer high design liberty and urban-scale adaptability. Services plug in across modules, and forces are governed by connector shear, torsion, and wave-induced modular motion.(Huimin Yang, Analysis of floating city design solutions in the context of carbon neutrality-focus on Busan Oceanix City, 2002) (EL-Shihy, 2024) (Wang S. , Analytical solutions for the dynamic analysis of a modular floating structure for urban expansion, 2022)

1.1. Amphibious / Buoyant Foundation Systems

Figure 5: Amphibious floating building (Source-ResearchGate)

Amphibious systems keep buildings on land under normal conditions but lift them during floods using buoyant bases made from timber composites, HDPE blocks, or concrete tubs, guided by steel posts. They suit floodplains, wetlands, and river edges where water may rise up to about 10 m. This is one of the most economical strategies for flood adaptation, though architectural freedom stays close to standard land-based forms. Services rely on flexible loops and elevated risers. Forces stem from vertical buoyancy, guidepost friction, and flood hydrodynamics.(Nopia, 2021) (Hope Ameh *ORCID, 2024)

2. Engineering-Dominant Systems

2.1. Semi-Submersible System

Figure 6: Amphibious floating building (Source-Wikimedia)

Semi-submersible platforms use submerged columns to reduce wave impact, adapted from offshore engineering. Their deep draft and complex mechanics make them hard to use in shallow bays and complicate access and services, leaving architects with limited design freedom.

(Semisubmersibles, 2021) (Kabir Sadeghi, 2019)

2.2. Span System

Figure 7: spar platforms (Source- Wikimedia)

Spar systems use deep-draft cylindrical floats tethered vertically in the water. Built for offshore energy, they offer very little usable area and difficult service access, making them impractical for almost any architectural program and giving architects minimal design flexibility.(Spar Platforms, 2018) (Kim)

2.3. Tension Leg Platforms (Tlp) System

Figure 8: Tension Leg Platforms (TLP) System (Source- Marine insight)

Tension Leg Platforms (TLPs) use buoyant decks anchored to the seabed with vertical tensioned tendons, creating a stiff platform with very limited vertical movement. Although stable, they are costly, require deep-water moorings, and demand constant tendon maintenance. These technical and financial constraints make TLPs difficult for most architectural applications.
(M. Jameel) (Yipin Wang, 2025)

3. Shared Systems (Architecture + Engineering)

3.1. Large Public Buildings On VLFS

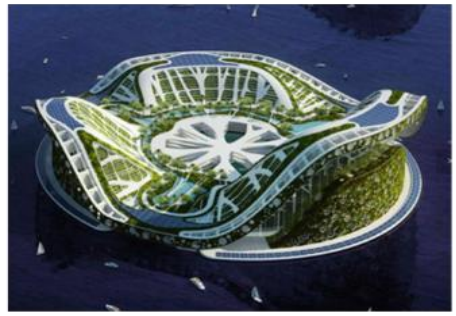

Figure 9: Large public buildings on VLFS (Source- Springer nature)

VLFS are mega-scale platforms such as runways, terminals, or stadiums that behave as hydroelasticity slabs. Built from prestressed concrete, steel mega-pontoons, or composite caissons, they rely on post-tensioned decks, precast mega-modules, and engineered mooring grids. They perform best in sheltered seas, deep bays, and calm coastal zones at depths of roughly 10–60 m. Although expensive, they are still cheaper than land reclamation and offer very high design freedom, including large uninterrupted floorplates. Services run through central spines and integrated caisson networks. Key forces involve hydroelasticity bending, long-period waves, and mooring tension.(Amouzadrad, 2024) (C.M. Wang) (Miguel Lamas-Pardo)

3.2. Floating Districts and Urban Modules

Figure 10: Floating districts and urban modules (Source- Bluebeam)

These systems use interconnected concrete, steel, or composite caissons to create neighborhood-scale floating urban blocks. Mass-produced modules are assembled on water, enabling scalable and adaptable layouts. They suit lakes, estuaries, harbors, and sheltered seas at depths of around 5–50 m. Costs sit in the moderate-to-high range but become efficient for long-term urban expansion. They offer high design liberty and flexible planning. Services move through shared MEP corridors, hubs, and bridges. Structural behavior is shaped by coupled hydrodynamics, mooring stresses, and wind loads.(Huimin Yang, Analysis of floating city design solutions in the context of carbon neutrality-focus on Busan Oceanix City, 2022) (Wang S. , Analytical solutions for the dynamic analysis of a modular floating structure for urban expansion, 2022) (Dr. Swati Agrawal, 2025)

3.3. Hybrid Marine Architectural Systems

Figure 11: Hybrid marine-architectural systems (Source- Architectural digest)

Hybrid systems combine vessel engineering with architectural programming to create floating eco-piers, mixed-use decks, and landscape interfaces. They use steel hulls, concrete platforms, composites, and marine-grade timber, built through shipbuilding techniques topped with architectural superstructures. They perform well in harbors, estuaries, and protected coastlines at depths of roughly 5–40 m. Costs fall in the mid-to-high range due to ecological and technical complexity but offer extremely high design flexibility. Services are delivered through a mix of marine piping and architectural utility grids. Forces include vessel-like motion, buoyancy variation, and torsion between hybrid elements.(Adnan, 2020) (Amouzadrad, 2024) (Miguel Lamas-Pardo)

X. MATERIAL-BASED TYPOLOGY + ARCHITECTURAL SUITABILITY

1. Concrete - Heaviness, Stability, Long Life

Concrete platforms feel closest to land because their weight reduces motion, making them suitable for public buildings and heavy programs. Their main drawback is corrosion, so marine-grade mixes and regular inspections are essential. Use when: permanence, stability, heavy programs matter. (VSL INTERNATIONAL LTD.) (D.L. (Dil) Tirimanna)

2. Steel - Precision, Speed, Corrosion Management

Steel offers slim profiles, clean detailing, and fast prefabrication, which benefits modular and expressive designs. However, in saline environments it needs strict corrosion protection and ongoing maintenance. Use when: speed, slenderness and modularity matter more than low-maintenance longevity. (Abunassar, 2022)

3. Hdpe / Composite - Light, Modular, Corrosion-Free

HDPE and composite pontoons are light, modular, and resistant to harsh water chemistry. They work well for quick-build neighborhoods and small public decks, though long-term UV performance depends on fabrication quality. Use when: modularity, low maintenance and rapid deployment matter most. (HDPE Floating Pontoon – 5 Practical Applications and Benefits You Should Know, 2025)

4. Timber / Bamboo - Sustainable But Scale-Limited

Timber and bamboo create warm, low-carbon architecture and suit small pavilions or community projects. Their limits are decay and load capacity unless paired with protective treatments or hybrid reinforcement. Use when: small-scale, community or culturally rooted projects are the priority. (Abdel, 2022)

5. Hybrid Material Systems - Balancing Contradictions

Hybrid platforms blend concrete, steel, and composites to achieve durability, strength, and reduced maintenance. They offer more control over form and internal space while giving engineers predictable structural behavior. Use when: the brief demands long life + controlled motion + expressive architecture. (Weikang Gong, 2025)

6. Material Selection for Superstructure

Material choice for the superstructure must balance durability, weight, and compatibility with the floating platform. Timber and engineered wood are light and warm but need proper marine treatment. Steel provides precision and long spans but requires aggressive corrosion control. Composites offer lightweight, low-maintenance construction yet must be checked for UV and fatigue performance. Off-site fabrication improves quality, and fire safety must be planned early due to platform movement and limited evacuation routes. Ultimately, the superstructure's mass must match the platform's stiffness heavier finishes demand rigid pontoons, while lighter steel or composite frames support more flexible and modular designs. (Top 10 Principles of Architectural Material Selection: Choosing the Right Surface for Every Space, 2025)
(Shoji Yoshida, n.d.) (Xiaowei Zang, 2024) (Yan-Kun Zhang, 2024)

XI. CASE STUDY

1. Floating Hotel – Sabbagh Arquitectos (Chile)

Figure 12: Floating Hotel – Sabbagh Arquitectos (Chile) (Source- Adsttc)

Architect: Sabbagh Arquitectos Location: Aysén Fjords, Chile Climate: Cold, humid, sub-polar maritime Water Body: Protected coastal fjord Area: ~2,000–3,000 m² (adjust if you have exact data) Floating System: Modular reinforced-concrete caisson platform Materials: Concrete caissons, galvanized-steel superstructure, timber interiors, marine glazing.
Built for cold maritime fjord conditions, this project uses modular concrete caissons for stability, paired with a steel-and-timber superstructure to keep the center of gravity low. Prefabricated modules were assembled off-site and floated into position, improving precision. Technical demands include strict inspection of concrete caissons, joint fatigue control, and reliable anchoring under strong regional winds.(F., n.d.)

2. Brockholes Visitor

Figure 13: Brockholes Visitor (Source- visit Preston)

Architect: Adam Khan Architects Location: Lancashire, United Kingdom Climate: Temperate maritime (cool, wet, high seasonal rainfall) Water Body: Restored wetland lake system Area: ~2,000 m² (adjust if you have exact figures) Floating System: Hybrid marine–architectural timber pontoon system Materials: Glulam timber frames, timber cladding, steel connectors, composite flotation pontoons, ecological reed-bed edges.
Adam Khan Architects developed this 2,860 m² floating cluster on a nature-reserve lake using a hybrid pontoon system with concrete/steel flotation and a lightweight glulam timber superstructure. The design reduces site impact and supports sensitive ecology, but its hybrid configuration required careful regulation, services integration, and long-term durability planning. (BROCKHOLES VISITOR CENTRE, LANCASHIRE, n.d.)

3. Maasbommel Amphibious Houses (Netherlands)

Figure 16: Maasbommel Amphibious Houses (Netherlands) (Source- encrypted-tbn0.gstatic)

Architect: Factor Architecten Location: Maasbommel, Netherlands Climate: Temperate maritime Water Body: River Maas (floodplain) Area: ~100–120 m² per unit (varies) Floating System: Amphibious system-hollow concrete buoyant base on vertical steel guide posts Primary Materials: Hollow concrete hull, lightweight timber superstructure, flexible utility connections

The Maasbommel development by Factor Architecten and Dura Vermeer is a temperate-climate housing project along the Maas River, where each 85–100 m² home is designed to float during floods. The units rest on hollow concrete hulls that rise up to 5.5 m along steel guideposts, while timber superstructures keep weight low and stability high. Although the houses follow conventional residential layouts, their buoyant foundations and flexible utility connections allow them to function as fully amphibious structures. The project remains a benchmark for practical, community-scale flood - resilient housing. (Amphibious homes, Maasbommel, The Netherlands, n.d.) (Project review: Floating Homes 'De Gouden Kust') (Amphibious housing in Maasbommel, the Netherlands, 2020)

4. Schoonschip Residential Community (Amsterdam)

Figure 18: Schoonschip Residential Community (Amsterdam) (Source- Archivibe)

Architect: Space & Matter Location: Buiksloterham, Amsterdam, Netherlands Climate: Temperate maritimeWater Body: Buiksloterham Canal BasinArea: 46 floating homes (varies per unit; overall district scale)Floating System: Concrete pontoon based floating platforms with interconnected jetties Primary Materials: Concrete pontoons, prefabricated timber superstructures, photovoltaic systems, water-source heat pumps, circular/recycled materials

Designed by Space & Matter, Schoonschip consists of 46 homes (about 100–140 m² each) built on concrete pontoon modules in a temperate maritime canal setting. The neighbourhood operates on a shared microgrid with circular water and energy systems, while strict buoyancy and weight limits shape each home’s form. Its biggest challenge is coordination - shared utilities and collective governance across multiple floating units.(Cutieru, 2021) (Schoonschip: A sustainable floating neighborhood, n.d.) (Schoonschip, 2021) (Tracy Metz, 2020)

5. Case-Study-Derived Principles

Across all case studies, several principles remain consistent:

1. Hydrostatics dictate massing - every successful project respect buoyancy and center of gravity.
2. Prefabrication is essential - on-water construction is slow, risky, and expensive.
3. Modularity equals resilience - scalable units outperform monolithic forms.
4. Environmental context shapes the form - calm lakes allow expressive architecture; tidal or river systems limit it.
5. Service integration is not secondary - waste, energy, and moisture define the usability of floating buildings.

XII. INSIGHTS FROM INTERVIEWS

Professionals repeatedly pointed to the same realities:

- Materials are dictated by durability, maintenance, and project scale-not design preference.
- Building height is not an aesthetic choice; it’s a stability calculation.
- Architects must be obsessive about proportion, center of mass, and balance.
- Still water environments (lakes, protected basins) are the safest and most feasible.
- Form freedom exists, but only when buoyancy and load distribution are respected.
- Structural stability is about balancing buoyant force with total mass distribution-not “foundation strength.”

XIII. RESULT

The study finds that architectural design on water is controlled by system choice, not stylistic preference.

Pontoons offer stability for small–medium programs; modular grids support urban expansion; amphibious systems provide flood resilience; VLFS enable large public buildings; and hybrids integrate ecological or civic programs. Material performance strongly influences durability - concrete for stability, steel for precision, composites for modularity, and hybrids for balance. Case studies show that prefabrication, flexible services, mass control, and context-driven mooring are essential. Interviews confirm that building height, weight, and form are constrained by hydrostatics, maintenance access, and environmental conditions.

XIV. CONCLUSION

Floating architecture is feasible only when architectural intentions align with buoyant behavior, materials, and service integration. Successful projects prioritize low mass, controlled centers of gravity, modular construction, and early architect engineer collaboration. Case studies and interviews show that systems, not aesthetics, determine form and limits. As water-based environments become more common, architects must adopt performance-driven design thinking rather than treating floating buildings as extensions of land-based typologies.

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