A Data Mining Approach to Documenting Global Floating Building Projects: Design Trends, Material and Structural Systems

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ABSTRACT

Floating architecture has emerged as a viable response to urbanisation, climate change, and increasing sea levels. The absence of a centralised database cataloguing constructed floating buildings globally impedes thorough research and practical implementation. This paper aims to systematically gather, analyse, and categorise data on floating building globally using the method of web mining and data mining techniques to collect data. The Archdaily website was the primary source for web mining, employing 'floating architecture' as the main term for the extraction process in 143 countries globally, focusing on the construction of floating buildings from 2000 to 2025. The item studied include and classify into Continent, Nation, year of project completion, building Category, average floor area, structure and materials. Key statistics reveal that Europe leads in floating construction, accounting for 53.1% (34 structures) of the worldwide total. The Netherlands is the most engaged nation, donating 15% (9 buildings), followed by the United States (10%, 6 buildings) and Germany, Thailand, and Ecuador (6.7% each, 4 buildings). Completion records reveal a peak in 2021, with eight structures erected. Small residences constitute 53.3% (16 units), whereas places of assembly account for 36.7% (11 units). All constructions use pontoons as their foundational supports. Plastic (48%) and concrete (33%) are the primary materials, together comprising 81% of occurrences. This study establishes a foundational dataset for future research, providing essential information regarding the development, regional patterns, and technological inclinations of floating architecture. The findings underscore the potential of pontoon-supported structures and highlight material enhancements as a vital area for future development in this emerging field.

Keywords: Floating architecture, Floating Building, Climate Change, Web Mining, Content Mining

INTRODUCTION

Floating architecture, defined by structures that sustain buoyancy on water surfaces either temporarily or permanently, is increasingly considered a technological innovation and an ecological necessity. Driven by escalating urbanization in flood-prone and coastal areas, coupled with the climate crisis, architects and urban planners are reevaluating living conditions in aquatic environments. Elrayies (2025) asserts that floating spaces present a new paradigm of urbanism, integrating ecological resilience, energy independence, and spatial flexibility. The concept is not solely futuristic; it is grounded in centuries-old methods of aquatic living, augmented by modern technologies, materials, and infrastructure. Accelerated sea-level rise and heightened storm surges have made many urban coastal regions inappropriate for conventional construction methods (Calcagni et al., 2025). Floating structures offer an efficient approach by accommodating fluctuating hydrological conditions instead of resisting them. Floating architecture represents a convergence of design, sustainability, climate adaptation, and human geography (Kuyper, 2025). It encompasses dwellings, educational institutions, energy infrastructure, agricultural lands, and entire towns designed to float, relocate, and adapt.

LITERATURE REVIEW

Floating Architecture as Climate Adaptation Strategy

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Floating architecture, characterised by structures that maintain buoyancy on water surfaces either permanently or temporarily, is increasingly regarded as an ecological imperative and a technological innovation. Architects and urban planners are reevaluating habitation in aquatic environments in light of increasing urbanisation in coastal and flood-prone regions, alongside the climate issue. Elrayies (2025) asserts that floating environments provide an innovative approach to urban development by integrating energy autonomy, ecological sustainability, and spatial flexibility. The concept is not merely futuristic; it is rooted in centuries-old aquatic living traditions that have been enhanced by contemporary infrastructure, materials, and technologies. Numerous urban coastal regions have become unsuitable for conventional construction techniques due to rapid sea-level rise and heightened storm surges (Calcagni et al., 2025). By adjusting to changing hydrological conditions rather than fighting them, floating structures offer an efficient solution. Floating architecture intersects design, sustainability, climatic adaptation, and human geography (Kuyper, 2025). It encompasses not only residential structures but also educational institutions, energy infrastructure, agricultural lands, and entire towns designed to float, relocate, and adapt.

Floating Structure Typologies

Significant insights regarding modern resilience can be derived from past examples of floating architecture. Indigenous aquatic cultures, such as the Ma'dan reed dwellings in Mesopotamia and the Uros on Lake Titicaca, exemplify how traditional knowledge systems enabled sustained habitation in wet conditions across numerous generations (Holder, 2025). These communities used early bioclimatic design principles by utilizing naturally biodegradable materials to construct floating platforms. Contemporary planners and architects have reinterpreted these systems through the utilization of modern engineering techniques and materials. Felicioni's (2024) reinterpretation of Massari's 18th-century ephemeral floating installations in Venice exemplifies the enduring allure of ceremonial and transient aquatic buildings throughout Europe. These examples demonstrate the architectural originality of employing water as a stabilizing element rather than a hazardous one. Moreover, throughout colonial expansion, maritime colonies and floating encampments, comprising naval accommodations and floating penitentiaries—established logistical and juridical frameworks for offshore habitation (Kreienbaum, 2024). Contemporary discourse around territoriality and the political status of floating cities is being shaped by these historical contexts (Baumeister, 2024). Historically, these structures symbolize both resistance and tyranny. Obaribirin et al. (2024) contend that floating architecture must be decolonized by integrating it into the lived experiences and spatial politics of the Global South.

Contemporary floating architecture encompasses a diverse range of typologies classified by their structural design, utility, and flexibility to environmental alterations. Baumeister (2024) categories three primary types: static floating structures, amphibious systems, and mobile aquatic modules.

- Static floating buildings (e.g., office buildings, homes, and schools) are permanently buoyant and secured to pilings or adaptable mooring devices. These are observed in the IJburg district of Amsterdam and the Makoko Floating School in Nigeria (Obaribirin et al., 2024).

- Amphibious architecture, the typology examined by English and Piątek (2024) is terrestrial but becomes buoyant during inundations. This typology is increasingly popular in areas such as Southeast Asia and Canada due to its ability to merge familiarity with adaptability.

- Mobile or modular floating cities, such as Oceanic Busan, integrate infrastructure, housing, and agriculture on scalable platforms. According to Carrère et al. (2024), such megastructures represent a new form of climatopia environments designed around adaptive futures.

Kuyper (2025) introduced the notion of an "urban villa", wherein floating structures are clustered to create robust, decentralized communities. The pattern language incorporates buoyancy, cost-effectiveness, and socio-cultural integration. Veloso (2024) investigates amphibious housing as a sustainable alternative for the Amazon basin, developing novel typologies for "social housing on water". The classifications also vary in technological sophistication. Raft-based structures necessitate fewer complex materials and are more economical, but pontoon-based and hull-integrated systems are technologically advanced and appropriate for urban settings (English & Piątek, 2024; Sandbhor et al., 2025).

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Gaps in Studies

Despite these demonstrated benefits, the Global Floating Cities Initiative (2023) identifies a critical research gap: no centralized database exists that documents floating buildings worldwide using standardized metrics. Current knowledge remains fragmented across. The main focus of this journal is to identify the building groups that apply floating architectural designs in the construction industry. This building group refers to the 'Fifth Schedule' of the Uniform Building By-Laws 1984 (UBBL). In addition, this study also aims to investigate the flexibility of floating architectural designs. The construction pattern of floating buildings is investigated according to current trends by focusing on the relationship between the building group and the year it was completed. This aims to limit the scope of the study where the search is limited to the years 2000 to 2022 only. provide an overview for architects to obtain design strategies to achieve flexibility. The application of floating architecture in the construction industry provides many options for architects to achieve flexibility in designing buildings.

METHODOLOGY

Research Design

Quantitative methods were used in this research where all the data are extracted from popular architecture websites.

METHOD OF DATA COLLECTION

The data collected using the method of web mining and data mining techniques. The Archdaily website served as the primary source for web mining, utilising 'floating architecture' as the principal keyword for the extraction procedure from a total of 143 country worldwide and limited to the construction of floating buildings from 2000 to 2025. The item studied include and classify into Continent, Nation, year of project completion, building Category, average floor area, structure and materials.

Criteria of Data Mining

The study begins with data mining to obtain a search system for the purpose of extracting accurate data from a wide range of information sources. This data extraction process will use the Google search engine; the goal of this mining is to extract data from all websites that only specialize in architecture websites. Three criteria have been set for the purpose of this data mining. (a) List top 10 famous websites related to architecture, (b) Proof by using the site with the highest number of visitors, (c). The listed websites are updated in the near future. The search term famous architecture websites were used in the Google search engine listed several relevant and related links to floating architecture using the search term famous architecture websites. Then the list of links was checked and the results showed that there were 4 links that occupied the top position, the websites 'Similarweb' and 'Vanity Project", which met all the criteria that had been set, as shown in Table 1.

Table 1. List of famous architecture websites

Website	Number Of Visitor (Monthly)	Latest Update
Archdaily	6.5M	□
Apartment Therapy	6.4M	□
Architectural Digest	3.5M	□
Dezeen	2.3M	□
Curbed	880K	□

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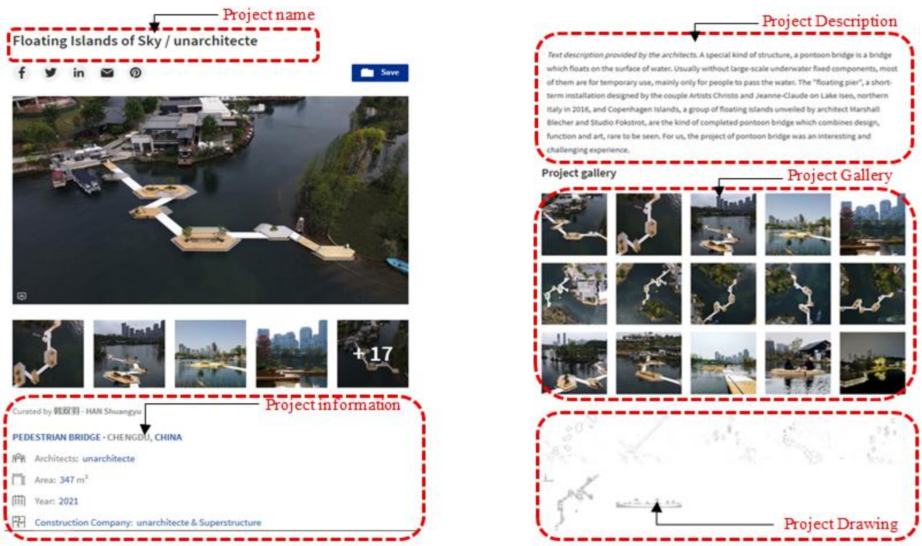
Criteria of Web Mining

Web Mining is the process of combining and extracting important information or knowledge from web pages (V. Malik. Et al, 2022). At this stage, six criteria have been set for the details of the information obtained. Only websites that meet the criteria are used for the next stage. The following are the criteria for web mining, Project Name, Region, Nation, Date of Completion, Building Category, Floor Area, Type of Pontoon Structure, Building Materials and Project Gallery.

The Archdaily website was used as the main search source because it was the only website that met the specified web mining criteria. The following is a snippet from the Archdaily website as evidence of the content preparation to meet the specified criteria. Figure 1 shows a snippet from the Archdaily website that proves the content preparation to meet the specified information criteria:

Fig 1. Screenshot image from Archdaily website



Content Mining

Content mining is the process of extracting content from a website. At this stage, the data extraction process is more detailed by investigating the number of publications of articles related to Floating architecture based on keywords. Through this keyword search, I will then focus on the most frequently found searches. Referring to Table 2, the most frequently found keyword is ‘Floating architecture’. To extract articles related to floating architecture, the extraction process will focus on the keyword search ‘floating architecture.

Table 2. Total searches based on key words

Website	Key Word	Total Searches	Access Date (2025)
Archdaily	Floating Architecture	53,201	4-Jun
	Floating Building	46,518	4-Jun
	Floating On Water	18,336	4-Jun
	Floating	7,430	4-Jun

Classification

To achieve the stated research objectives, at this stage classification will be carried out to extract the data obtained. The following classifications are divided into continents, date of completion region, building category based on the 5^{th} Schedule Uniform building by laws (UBBL), average floor area, Type of Pontoon Material, and Building material.

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Overall Mining Parameters

To facilitate the process of classifying information, a taxonomy as in Table 3 is provided to facilitate the process of extracting a large amount of data. The purpose of this taxonomy is to ensure that the information obtained can be extracted systematically and that no information is missed. Apart from that, it also makes it easier for the information to be investigated and discussed in detail according to the established classification.

Table 3. Taxonomy of Data Mining

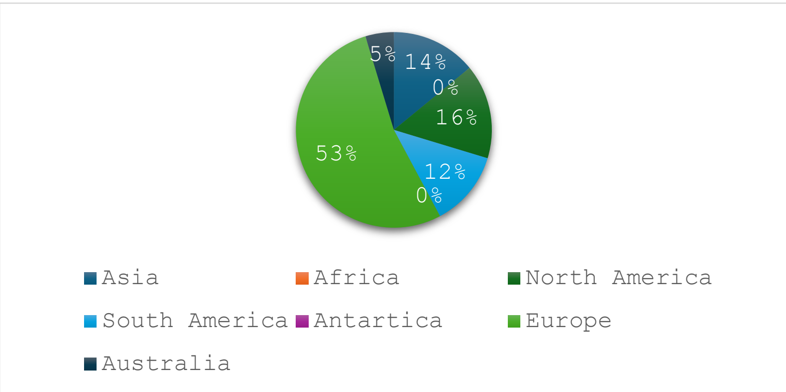
No	Project Name	Region/ Continent	Nation	Date of Completion	Category Of Building (UBBL)								Average of Floor Area (m2)	Type Of Floating Structure		Floating Stucture Materials				
					Small Residence	Institutional	Other Resident	Office	Shop	Factory	Place of Assembly	Storage & General		Pontoon	Semisubmersibles	Plastic	Foam	Fiber Glass	Steel	Concrete
1	Floating House / MOS Architects	North America	Canada	2005	/								186	/		/				
2	Floating Hotel / Sabbagh Arquitectos	Asia	Chili	2006	/								400	/						/
3	Muskoka Boathouse / Christopher Simmonds Architect	North America	Canada	2007	/								56	/		/				
4	Lake Union Floating Home / Vandeventer + Carlander Architects	North America	United States	2008	/								353	/						/
5	Float Home / Designs Northwest Architects	North America	United States	2009	/								195	/						/
6	Floating Dining Room / Goodweather Design & Loki Ocean	North America	Canada	2010					/				24	/		/				
7	Iba Dock / Architech - Architecture and Technology	Europe	Germany	2010					/				3,355	/						/
8	Tbwa Office Building / ZZDP Architecten	Europe	The Netherlands	2010				/					8,000	/						/
9	Floating Houses in IJburg / Architectenbureau Marlies Rohmer	Europe	The Netherlands	2011	/								10,652	/						/
10	The SayBoat / Milan Řídký	Europe	Czechia (Czech Repub	2012	/								63	/				/		

RESULTS AND DISCUSSION

Continent

According to the data on figure 2, there are notable differences in the distribution of finished floating structures between continents, with Europe clearly leading the way with 53.1% (34 buildings) of the total worldwide. Asia and South America exhibit moderate activity with 9 and 8 buildings, respectively, while North America trails far behind with 10 buildings (15.6%). Significantly, Africa and Antarctica report zero projects, indicating either a lack of viability, investment, or data reporting in these regions. Australia's contribution is negligible (3 buildings, 4.7%). While the lack of projects in Africa and Antarctica may be due to logistical, financial, or environmental issues, Europe's dominance may be the result of sophisticated maritime infrastructure, regulatory incentives, or climate adaptation efforts. Deeper understanding of these tendencies might be possible with more research into area regulations, consumer demand, and data-gathering techniques. Stakeholders could address possible gaps in Africa's floating infrastructure development or investigate chances in under-represented areas like Australia for results that can be put into practice.

Fig. 2: Percentage of buildings by continent



Country

The statistic shown in figure 3, indicates significant disparities in the construction of floating buildings globally. From 143 country that analyse, only 64 country that implement floating architecture. The Netherlands is the largest donor with 9 structures, accounting for 15% of the total, followed by the United States with 6 buildings (10%) and a consortium of countries comprising Germany, Thailand, and Ecuador, each with 4 buildings (6.7%).

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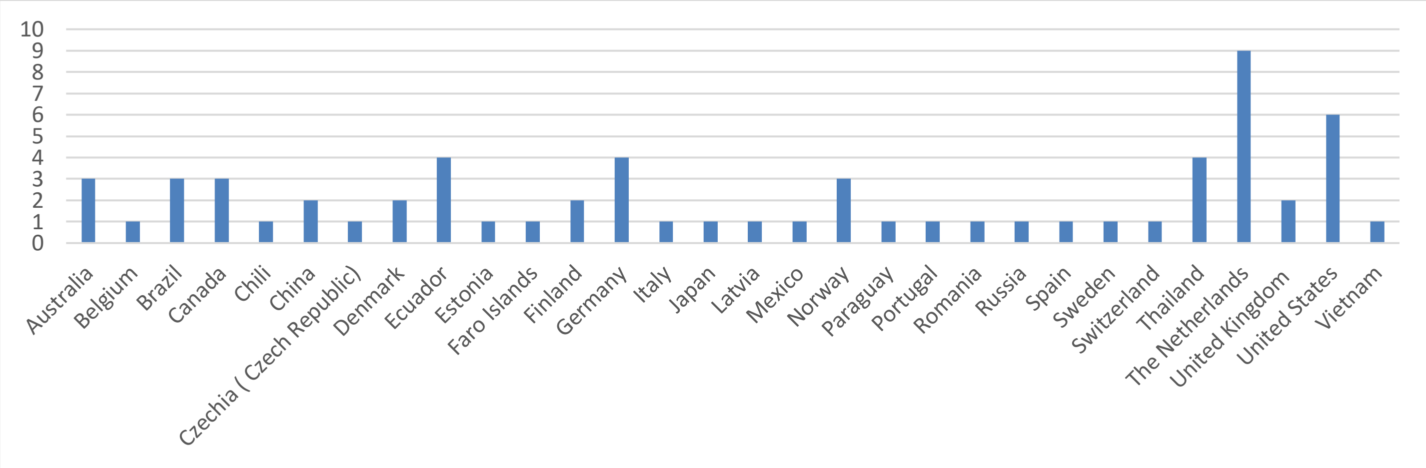
Seventeen of the twenty-nine recorded nations possess a singular floating building. The majority of these are European nations, in addition to Chile, Japan, and Vietnam. The absence of African nations and the limited participation of several Asian countries (except China, Thailand, and Vietnam) imply either inadequate infrastructure or deficiencies in reporting. Buildings in Europe, which make up approximately 50% of the total, likely result from superior methods of climate change adaptation and effective regulations for urban water system management, particularly in the Netherlands. Conversely, the limited involvement of other regions may stem from economic, topographical, or regulatory factors. Standardising country names (for instance, altering "Chilli" to "Chile") and aggregating additional data, particularly regarding building types and completion durations, will facilitate future comparisons of the global proliferation of this emerging architectural sector. By Country, The Netherlands is the largest donor with 9 structures, accounting for 15% of the total, followed by the United States with 6 buildings (10%) and a consortium of countries comprising Germany, Thailand, and Ecuador, each with 4 buildings (6.7%).

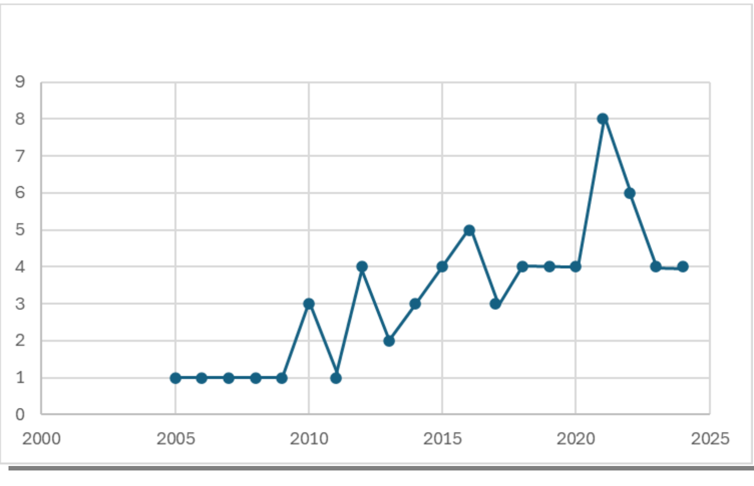
Fig. 3. Completed Floating buildings



Completed Floating Building based on Year

This dataset in figure 4 shown a distinct evolutionary progression in floating building completions from 2005 to 2024, transitioning from negligible activity (1-3 annual completions from 2005 to 2010) to moderate expansion (averaging 3.2 completions annually from 2011 to 2020, with peaks of 4-5 buildings) and culminating in a substantial increase in recent years (averaging 5.5 completions since 2021). In 2021, there was a significant peak of 8 completions, which is 60% greater than the prior high of 5 in 2016 and twice the long-term average. This event may signify a pivotal moment in the adoption of floating architecture, followed by a stabilisation of 4-6 annual completions through 2024, indicating a potential shift from experimental to mainstream status in aquatic construction. By the year of completion, delineates a distinct evolutionary progression in floating building completions from 2005 to 2024 the most constructed floating buildings are in the year of 2021 which are 8 units.

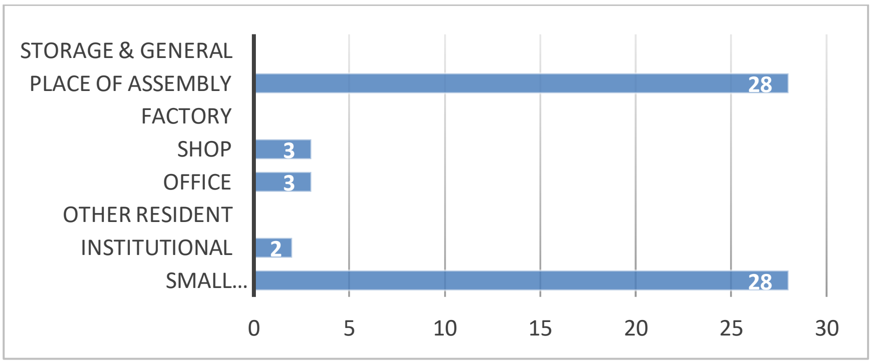
Fig. 4: Completed buildings based on year



Building Category

The dataset in figure 5 indicates a significant speciality in floating building types, with small residences (16 units) comprising 53.3% of the total reported constructions. Places of Assembly (11 units) constitute the second-largest category, at 36.7%, indicating that floating infrastructure predominantly fulfils residential and community roles. The remaining 10% is allocated to institutional (1 unit), office (2 units), and unspecified "Other Resident" (0 units) categories, whereas commercial/industrial kinds (Shop, Factory, Storage) have no representation (0 units). This distribution indicates that contemporary floating architecture primarily fulfils residential and community space requirements rather than commercial or industrial functions. The total lack of retail, industrial, and storage facilities may indicate either technology limitations for these functions or market preferences in nascent floating development. The evidence necessitates additional inquiry into whether this typological concentration arises from (1) regulatory constraints, (2) the cost-efficiency of residential compared to commercial floating structures, or (3) demand trends in aquatic urbanisation. The existence of institutional and office spaces, however limited, suggests emerging diversification beyond solely residential uses. By buildings category, small residences (16 units) comprising 53.3% of the total reported constructions. Places of Assembly (11 units) constitute the second-largest category, at 36.7%,

Fig. 5: Building Category



Average floor area

The floor area distribution in floating buildings in table 4 shown a distinct inverse correlation between dimensions and frequency. Structures within the 1-1000 m² range predominate, accounting for 93.3% of buildings (28 small dwellings and 28 assembly venues, totalling 56 out of 60 structures). The medium group of 1001-3000 m² constitutes just 5% (3 shops), whilst the largest category of 3001-8000 m² buildings comprises a measly 1.7% (3 offices). The 93-5-2% distribution indicates that floating architecture is predominantly limited to tiny designs, with almost all successful implementations (98.3% combined) occupying less than 3000 m². The extreme scarcity of mid-to-large floating structures indicates either (1) technological scalability issues, (2) disproportionate cost escalations with size, or (3) market demand focused on small-footprint applications. The total lack of structures over 8000 m² further underscores these dimensional constraints in contemporary floating construction methodologies. By average of floor area, Structures within the 1-1000 m² range predominate, accounting for 93.3% of buildings (28 small dwellings and 28 assembly venues, totalling 56 out of 60 structures).

Table 4: List of building groups and the number of floating buildings that have been built

Gap	Group	Number of Buildings (%)	Average Floor Area (m²)
Highest	Small Residence Assembly Place	28 28	1-1000
	Institution	2	
Medium	Other Residence	0	1001-3000

	Shop	3	
Lowest	Office	3	3001-8000
	Storage and General	0	

Material

The data on the figure 6 of the materials used for floating structures shows that plastic is the most common material, making up 48% of the cases, while concrete accounts for 33%, together representing 81% of all cases. This suggests that these materials are popular because they are lightweight and strong. Fibreglass constitutes a modest yet significant portion (8 instances, 13%), presumably esteemed for its corrosion resistance and durability in marine settings, whereas steel (3 instances, 5%) and foam (1 instance, 2%) exhibit minimal utilisation, likely attributable to issues related to corrosion and buoyancy constraints. This distribution reveals a distinct industry trend favouring plastic-based solutions for economical, versatile floating structures, supplemented by concrete for more durable permanent installations with fibreglass utilised for specialised applications. The limited use of steel and foam implies either technological limitations or niche applications that necessitate further exploration of their performance and economic viability in aquatic construction scenarios. By materials, floating structures show that plastic is the most common material, making up 48% of the cases, while concrete accounts for 33%, together representing 81% of all cases.

According to the research, floating structures are clearly preferred to be made of plastic (48%) and concrete (33%), which together account for 81% of the market. Steel (5%) and foam (2%) are noticeably underutilised, whilst fibreglass occupies a sizable niche (13%). Key industrial drivers are highlighted in this distribution: concrete's durability and permanence; fibreglass's corrosion resistance for specialised maritime applications; and plastic's lightweight strength, affordability, and adaptability.

Resolving Lifecycle Costs and Underutilisation:

1. Steel (5% underutilised): The main reason for its restricted application is the difficulties with corrosion in maritime settings. Steel is naturally strong, but to prevent saltwater deterioration, it needs a large, continuous investment in protective coatings and cathodic protection. Over the course of the structure's existence, such investment significantly raises maintenance expenses and complexity. Steel provides excellent long-term structural integrity if it is protected, but for many floating applications, its higher initial cost, ongoing maintenance costs, and failure risk make it less economically viable than materials that are naturally resistant to corrosion, such as fibreglass or plastic. In comparison to lesser alternatives, its weight may potentially provide handling and buoyancy issues.

2. Foam (underutilised: 2%): Durability and lifetime issues are probably the main causes of foam's low usage. Foam materials, such as expanded polystyrene (EPS), provide excellent buoyancy and low initial costs, but over time, their structural integrity and buoyancy may be compromised due to physical damage (impact, puncture), environmental degradation (UV, hydrocarbons), and possible water absorption. Despite the low initial cost, this results in a shorter service life and a higher frequency of replacements, raising long-term lifecycle costs. Rather than being the main structural element of bigger systems, foam is frequently restricted to highly particular, frequently transient buoyancy features.

3. Lifecycle Cost Factors for All Materials:

a. Plastic can provide good durability, low initial cost, and little maintenance (strong corrosion resistance). Although long-term UV degradation and other environmental issues (recycling) need to be managed, lifecycle costs are often favourable, particularly for non-permanent or modular constructions.

b. Although the initial cost of concrete, including material, shaping, and placement, is high, it has a long lifespan and requires minimal maintenance in maritime environments. For big, permanent installations when its durability and strength outweigh the original outlay, its lifespan cost becomes extremely competitive.

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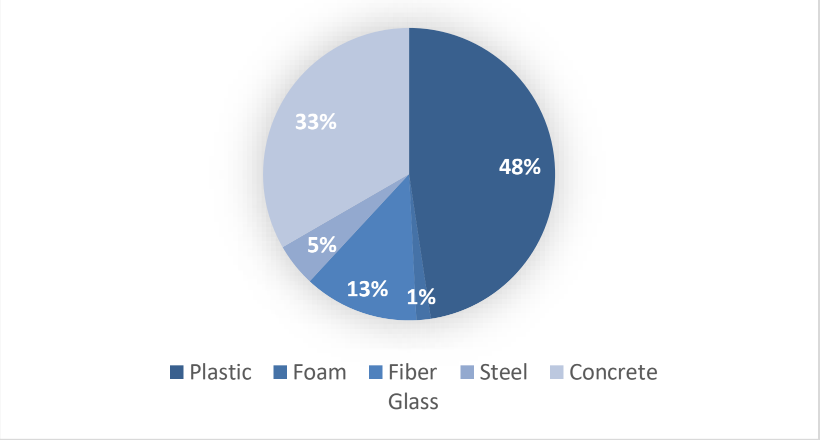
c. Fibreglass material has a moderate to high initial cost, but it offers exceptional durability and corrosion resistance, which results in minimal maintenance costs and a long service life. Although repair can be specialised, lifecycle costs are frequently advantageous for specialised applications that require high performance.

d. Steel has a moderate starting cost but a high maintenance cost (for corrosion protection) and a high failure rate. Unless the application requires its unique structural features and supports the protection regime, lifecycle costs are frequently the highest.

Foam is extremely inexpensive initially, but there is a significant risk that it will break down and require replacement sooner than expected. Because of the short service life and possible need for environmental remediation, lifecycle costs can be substantial.

Fig. 6: Building Category



CONCLUSION

An examination of worldwide floating structures indicates considerable disparities in adoption driven by technological, economic, and geographical influences. Europe dominates the business with 53.1% of constructed floating structures, propelled by sophisticated maritime infrastructure, governmental assistance, and climate adaptation initiatives. Australia and certain regions of Asia and South America have moderate activity, whereas Africa and Antarctica lack projects, likely due to financial, logistical, or environmental limitations. The Netherlands holds a global leadership position, possessing 15% of all floating constructions. The United States ranks second with 10%, succeeded by Germany, Thailand, and Ecuador, each with 6.7%. The restricted involvement of Asian countries and the lack of African nations indicate deficiencies in reporting or infrastructure. From minimal activity (2005–2010) to consistent increase (2011–2020) and eight completions in 2021, floating architecture has evolved, indicating a transition towards wider adoption. Building types are primarily comprised of tiny dwellings (53.3%) and assembly places (36.7%), while commercial and industrial applications are rare, reflecting an emphasis on communal and domestic requirements. The predominance of small-scale structures (93.3% $\leq$ 1,000 m^2) indicates that scaling floating construction presents significant challenges. The material selection indicates a preference for concrete (33%) and plastic (48%) because of their durability and buoyancy, but fibreglass (13%) fulfils specific requirements. The restricted utilisation of steel and foam indicates possible limitations in maritime applications.

Future Research

1. **Expand research** into underdeveloped regions (Africa, Australia) to identify barriers and opportunities.
2. **Investigate scalability** to enable larger floating structures for commercial and industrial use.
3. **Improve data collection** to better assess global trends and material performance.
4. **Encourage policy incentives** in underrepresented regions to foster floating infrastructure development

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