Towards a Framework for Using Floating Buildings in New Mansoura City for Sustainable Urban Development.

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Abstract:
Floating buildings have gained significant attention widely as a potential solution for coastal communities to have an urban expansion on water. They proved they are capable promoting sustainable living by utilizing renewable energy sources such as solar power or hydroelectricity, which reduces the impact of human footprint and developments on the natural environment. In addition, floating buildings also offer a unique living experience, which can be attractive to those seeking an alternative lifestyle as it can serve as tourist attractions and offer new opportunities for commercial and entertainment activities in coastal cities, taking the New Mansoura city as a case study due to its special characteristics being one of the new coastal cities in Egypt. However, challenges such as cost, infrastructure, and regulatory frameworks must be addressed to enable their widespread adoption. This research has discussed and analyzed couple of existing local and international examples of floating architecture from different design aspects that makes these buildings process, thus theoretical data can be converted into strategies and criteria to be applicable on the research's study case. The research also explores the feasibility and benefits of floating buildings to be used for different purposes according to their location, as it evaluates the environmental, economic, and social benefits of this type of architecture aiming to promote sustainable development and enhance the quality of life for the city's residents. Moreover, it affords valuable insights and recommendations for policymakers, urban planners, and developers to encourage the potential of floating buildings as a sustainable development strategy and to bring them into real practice.

Keywords:
Floating buildings – houseboats – sustainable architecture – water efficiency – new urban community – Rotterdam Floating Pavilion – New Mansoura City.

ملخص البحث:
اكتسبت المنازل العائمة اهتمامًا واسعًا كحل فعال للتوسعات العمرانية الساحلية. فكانت إحدى وسائل تعزيز المعيشة المستدامة من خلال استخدام مصادر الطاقة المتجددة مثل الطاقة الشمسية أو الطاقة الكهرومائية، مما يقلل من تأثير العنصر البشري على البيئة المحيطة. علاوة على ذلك، توفر المنازل العائمة تجربة عيش فريدة غير مألوفة مقارنة بالمباني المحلية في المدن الساحلية المصرية، مما يمكنها بأن تكون مقصداً جذابًا لأولئك الذين يبحثون عن نمط حياة مختلف وأنشطة تجارية وترفيهية استثنائية في تلك المدن. تناولت هذه الدراسة عددًا من الأمثلة المحلية والعالمية للمباني العائمة، حيث تم دراستها من جوانب التصميم المختلفة التي ساعدت تلك المباني على الطفو، وذلك لتحويل الخبرات النظرية للتصميم إلى استراتيجيات ومعايير يمكن تطبيقها على دراسة الحالة المقترحة. يتخذ هذا البحث مدينة المنصورة الجديدة كدراسة حالة نظرًا لخصائصها المتميزة

من حيث الموقع والإمكانيات، وأيضاً كونها واحدة من المدن الساحلية المصرية الجديدة. وافتقار المدينة لبعض الخدمات الترفيهية والتجارية والخدمية في المرحلة الحالية من إنشائها يجعلها الإختيار الأمثل لإحتضان مثل تلك المشاريع والتي يمكن بدورها أن تكون مباني عائمة مؤقتة الإستخدام، بحيث يمكن إعادة استخدامها في أنواع مشاريع وأماكن مختلفة. تتناول هذه الدراسة تقييم العائد البيئي والاقتصادي والاجتماعي لهذا النوع من المنشآت العائمة بهدف تعزيز التنمية المستدامة وتحسين جودة الحياة لسكان المدينة، ولإمكانية إعتماد المباني العائمة على نطاق شامل في المدينة، يتوجب على الجهات المعنية دراسة التحديات التي تواجه تلك المباني مثل تكلفة المبنى والبنية التحتية والتشريعات واشتراطات البناء التي تخضع لها المباني. تناقش هذه الدراسة فوائد المباني العائمة لإستخدامها لأغراض مختلفة تبعاً لموقعها، كما توصل البحث الى مجموعه من التوصيات واقتراح إطار عمل يمكن من خلاله صانعي القرار ومخططي المدن والمطورين للاستفادة من إمكانيات المباني العائمة وتنفيذها في أرض الواقع.

الكلمات المفتاحية:

المباني العائمة – العوامات – العمارة المستدامة – كفاءة استخدام الماء – المجتمعات العمرانية الجديدة – مبنى روتردام العائم – مدينة المنصورة الجديدة.

1. Introduction:

Through years, floating buildings has its dominant role as a potential solution for urban expansion in places which has special nature such as coastal cities like Amsterdam, Hamburg, Seattle, and others. These floating constructions proved it can withstand harsh weather conditions and the change in water levels that can cause distortion of buildings constructed on soil near water bodies. Its design's concept is buoyancy. "The buoyant force acting on a body immersed in a fluid is equal to the weight of the fluid displaced by the body, and it acts upward through the centroid of the displaced volume." Archimedes principle[1].

<u>The research problem</u> of this study is to explore the feasibility and potential benefits of using floating architecture as a means of promoting sustainable urban development in New Mansoura City addressing questions regarding the feasibility, benefits, and limitations of floating architecture as a sustainable solution for urban development.

<u>The main aim of this research</u> is proposing a framework for using floating buildings in New Mansoura City as a sustainable solution for urban development, and to provide recommendations for its effective implementation.

<u>The methodology of this paper</u> was structured as three main sections: First is the literature review that is by assessing the possibility and advantages of floating buildings, evaluating the technical, economic, social, and environmental aspects of floating architecture. Second is the analytical study, by analyzing a case study of a floating community center, and analyzing their economic, social, and environmental impacts. Finally, the framework development which synthesize the findings from the literature review, case studies, and design analysis to develop a framework for implementing floating buildings in New Mansoura City, and providing recommendations for policymakers, developers, and designers.

<u>The research question</u> can be concluded as: How can a floating community center serve as a demonstration of the potential of floating architecture as a sustainable solution for urban development in New Mansoura City?

2. Floating buildings

"Floating buildings is a living building concept using floating structure media. The concept of floating structures is used as a substitute for land in the construction of a building because its structure can float overwater".[2] These specifications are meant to lead to equalize the load of the floating structure to the amount of water displaced. This structure platform is used when the soil beneath the footing does not experience any extra load, as the load of the structure is equal or less than the soil displaced.[3]

2.1. History of Floating buildings

Although the concept of floating buildings was known by the ancient civilizations. In the twentieth century in Western Europe and North America, new construction technology allowed traditional rafts and ship hulls to be replaced with floating systems built of waterproof concrete and extruded polystyrene.[4] Each of these cities were using the concept of floating buildings for different purposes, whether it's for preventing the buildings from drainage because of the sea level rise such as the buildings in the city of Amsterdam, or even from other natural disaster like hurricanes.

2.2. Evolution of floating buildings

The evolution of floating buildings has been shaped by the changing needs and technological advancements of each era, making floating homes an enduring concept with a long and varied history. Floating buildings have evolved through the years in response to changing needs, technology, and innovations. The evolution of floating buildings can be grouped into the following key stages:

a. Early floating buildings:

These were basic structures that were primarily used as temporary or seasonal housing, such as houseboats, barges, and rafts.

b. Modern floating homes:

These are more sophisticated structures that incorporate features like plumbing, electricity, and heating, making them suitable for year-round use.

c. Sustainable floating homes:

These are designed to be environmentally friendly and incorporate features such as renewable energy systems and eco-friendly materials**.**

d. Luxury floating homes:

These are high-end floating homes with elaborate amenities, such as private docks, pools, and rooftop gardens.

e. Floating communities/island:

“Floating island is an artificially created floater, or set of connected floaters, moored to the seabed of which the topside can be used for activities similar to activities on land, as it can either be moored far offshore or connected to shore as an urban extension.” [5]

Throughout the years, floating buildings have become more livable, sustainable, and luxurious, reflecting the changing demands and expectations of their occupants.

2.3. Types of Floating buildings

Floating buildings as a concept were founded in various forms that depend on the purpose of floating constructions and the different uses of such like these buildings. They may be constructed on boats, hollow pipes, light weight pads and similar materials that helps with both buoyancy and uplift load.[3] Floating buildings can be founded in the form of the following constructions:

a. Houseboats:

They are small watercraft designed with no concessions to quality of living aboard which usually hampers the nautical and the aesthetical value of the craft.[6] In other words, they are livable, industrial designed dwellings that can cruise in water.

b. Permanent Floating buildings:

Floating buildings differ from houseboats in its permanent connectivity with a sewer and electrical system. It is also more stable in its position than the houseboats as it is built and moved to their final position on water once.[7]

c. Amphibious Buildings:

Amphibious buildings are buildings located out of a water basin and set on the ground but capable of floating on the rising flood water due to its low mass and structural elements like the buoyant foundation. They differ from the floating buildings as they can take both soil or water to work as a base for the building structure to lay on.[6] They are usually fastened to flexible mooring posts and rest on concrete foundations. If the water level rises, they can move upwards and float. The fastenings to the mooring posts limit the motion caused by the water.[7]

2.4. Benefits of using Floating Buildings

Floating buildings, when their concept of construction was firstly used, showed as an innovative solution of challenges that actually exists. Various purposes lead people design the construction that adapts the situation which varies from place to another, these purposes can be habitational, entertainment, industrial, or even commercial. [8] Some of the floating buildings targets can be summarized as follow:

a. Adaptation:

Floating buildings can rise and fall with changing water levels, providing protection against floods and reducing the risk of damage to the structure.

b. Flexibility:

Floating buildings can be moved to different locations, which is useful in areas prone to natural disasters or in areas with changing water levels.

c. Increased waterfront access:

By building on the water, floating buildings can provide access to waterfront property in areas where it is scarce or expensive.

d. Sustainable development:

Floating buildings can have a minimal impact on the environment as they do not require the removal of vegetation or the alteration of shorelines using alternative resources of renewable energy sources such as solar, wind, and tidal power.

e. Unique architectural opportunities:

The unique nature of floating buildings provides opportunities for innovative and creative architecture, adding to the aesthetic appeal of the surrounding area.

2.5. Restrictions of using Floating Buildings

While floating buildings can provide innovative solutions for housing and development, there may be restrictions on their use in certain places due to some factors that may include:

a. Infrastructure limitations:

The infrastructure of the area may not be able to support floating buildings, particularly if they require access to utilities such as water and electricity. It is important to conduct a feasibility study to determine if the infrastructure can accommodate the needs of the floating buildings.

b. Cost consideration:

The cost of constructing floating buildings may be higher than traditional buildings because of its unique design and materials required, so that the cost plan should be studied well to be arranged with the projects budget.

3. Analytical Examples for Floating Buildings:

There are several criteria to be considered in order to choose the most fit case study to the desired study application. In this context, the points below were pointed as guide lines for the study case selection.

1. <u>Diversity,</u>

Floating buildings may vary one from the other in several aspects such as the construction materials and whether they are local or world shipped ones, the different building use that can be commercial, residential, entertainment, exhibition, …etc. Moreover, the fixation techniques and the moving plan of the floating structure.

2. <u>Exceptional,</u>

Iconic floating projects that are one of a kind are scooped in this paper as study cases because they are more likely to have unique characteristics which specialize one building from another. They can be the certified projects that achieved awards from different authorized organizations.

3. <u>Modernism,</u>

Recently planned and constructed projects are more likely to be chosen because of its new technologies installed and clean sources of energy that are likely to be used in such like these projects that make the sustainable ones.

By carefully considering these criteria, the following case studies were chosen and analyzed in the upcoming paragraphs.

3.1. Schoonschip (Amsterdam, Netherlands)

Project Overview:

Schoonschip, also called a private Smart-Grid, is a housing project aimed to establish a city-embedded urban ecosystem. The project began in 2010 and took 11 years until it is fully completed in 2021.[9] The prospective floating residential community is located in Amsterdam, Netherlands consisted of 30 houseboats (a total of 48 households). This water-based site is built surrounding five piers, each of which will have 5 - 6 buildings, most of which will be shared by multiple households, as shown in the figure below.[10] It will utilize ambient water and energy, recycle nutrients locally, and promote biodiversity and human health.

Schoonschips' urban masterplan was designed by Space &Matter design studio based in Amsterdam and developed by the future residents to have a sustainable water-based community that became home for total of 144 residents, that works on lowering energy consumption as possible through whether generating or saving power from various aspects as the project has total of 516 solar panels, 30 heat pumps, 60 thermal panels, …, etc.[11] The diversity in the design of the dwellings in a project is due to the involvement of different architectural firms. The smart jetty connects all houses with each other and with the necessary technical infrastructures and was designed to facilitate casual encounters between members of the community.[9]

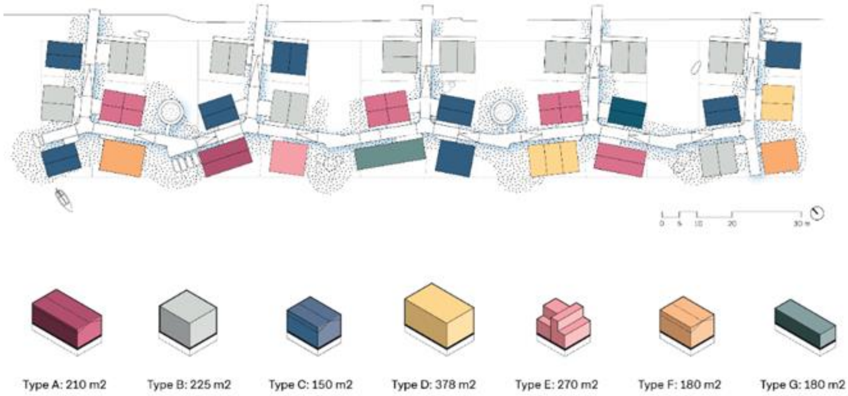


figure 1 schoonschip masterplan [9]

3.2. Rotterdam Floating Pavilion (Rotterdam, Netherlands)

Project Overview:

It’s a moving floating structure designed mainly for conferences and exhibitions. It is located in Rotterdam, Netherlands as it is one of the most sustainable ports in the city to be situated in because of its calm waves and easy accessibility. It is the main office of the Dutch National Water center. It was finished in June 2010.[12] The Rotterdam floating pavilion was constructed and developed by the architect groups Deltasync and Public Domain Architects.[13]

The floating Pavilion consists of three components: The floating foundation, the facade system and technical installations. It is formed by 3 interlinked domes of diameters 18.1m, 24m, and 19.7m in a row, shown in figure 2, covering about 1000 square meters [12], as shown in the figure below. The largest two domes house the lobby and exhibition area, while the smaller dome has an auditorium capable of accommodating group of 150 or 300 people. [13]

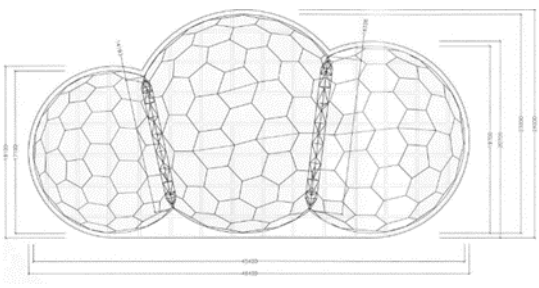


figure 2 rotterdam floating pavilion's topview [12]

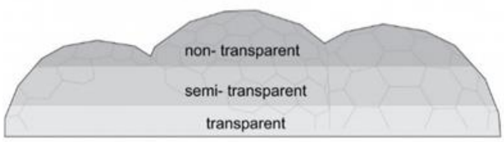
Figure 1 Rotterdam Floating Pavilion transportation [12]

The Rotterdam floating pavilion is flexible to be transported from one place to another as it was constructed at the Heijsehaven harbor before it was moved to Rijnhaven dock in Rotterdam, in July 2021, the building was relocated to Schiehaven, which is the second last final stop as it is going to be transported to its final destination to be repurposed as an energy hub aimed to encourage future innovations. [12] Figure 3 shows one of the three moves of the pavilion.

3.3.Comparative analytical study:

The table below shows a Comparative analytical study between the two examples according to design factors as shown:

Design factors	Schoonschip	Rotterdam Floating Pavilion
Material properties	- Using high insulating building material, most of them are bio-composite materials such as wood fiber, burlap and straw. - Using FSC-certified wood, figure 4, this certification provides independent assurance that the wood used supports forests managed to the highest standards. [14] - Using Hempcrete to isolate the recycled concrete basin.  **figure 4 houses exterior materials [9]**	- Using polystyrene EPS waterproof, lightweight, fire resistance platform as a structural foundation. - The facade of the structure is comprised of modular hexagonal forms, as in figure 5, constructed of steel and covered with ETFE foil, which is a hundred times lighter than glass. [15]  **figure 5 pavilion's structure [12]**
Economical aspect	- Generating clean source energy through solar and wind power and sell the excess. - The total collective costs were initially estimated at €47.000 per household, but due to the several delays and legal issues, at the end it was to adjust the amount to €70.000 per household. [16]	- It has gained worldwide recognition for its environmentally conscious and sustainable design principles, making it a model for others to follow. - "By using local sources of water and energy, the Floating Pavilion uses 60% less energy than a comparable building with the same function and volume. As such, it responds to the collective climate objectives of Rotterdam to reduce CO2 emissions by 50% in 2030." [12]
Ecological adaptation	- All buildings have at least one third of roof surface sedum roof. - Planting floating gardens using local materials. - Riverbanks have been planted with various landscape plants. - Creating a coarser surface on the steel bollards by wrapping them in coir, which should accelerate the growth of algae and mussels. [16]	- Using vegetation walls on the top of the shell as plants help to control humidity, enhance air purity, and can be utilized for soundproofing.

Accessibility	- The neighborhood is connected with smart jetty, all plots together. - Shared mobility system is available in the project allowing Schoonschip residents to share cars, electrical bikes, electrical cargo-bikes, and soon smart-grid will include the connection of electrical boats.	- As the pavilion is transporting from a port to another, it has a flexible connection with quays.  **figure 6 pavilion's accessiblity [12]**
Architectural design	- Sedum roof works as a good sound insulation. - Using solar panel façade with frame-free for fine finishes. - Every floating house has its own innovative architecture design most are from recycled materials, as shown in the figure below.  **figure 7 diversity in architecture styles [9]**	- Bright interior spaces except for the auditorium because of the transparent shell material. - Façade openings provide natural ventilation. Horizontal louvers are shown in figure 8.  **figure 8 facade openings [12]**
Flexibility	- Schoonschip is considered to be unmovable property but still flexible as the house's construction was offshore in manufacturing plants then collected onsite.	- Transportable, originally constructed at the Heijsehaven harbor, then moved to Rijnhaven dock, then to Schiehaven before its final destination.
Infrastructure	- The central jetty connecting the housing plots are designed to be smart jetty as it contains the technical infrastructure such as the smart grid system as well as the water system and the sewage system.	- The structure's floating foundation allows it to be constructed on water and later transported to its designated location.
Building Efficiency	- Smart-Grid system, which is an energy management system, is working on saving wind and solar energy whenever its excessed. - All sustainable energy sources are connected to a smart-grids can save 9 - 15% of energy consumption and CO_2 emissions compared to the more traditional systems. - Water used in bathrooms heated using solar boilers and heat bumps that extract heat from water in the canal.	- To mitigate excessive exposure to sunlight, the facade cushions vary in their level of transparency, with higher layers being less transparent and lower layers being more transparent, illustrated in figure 9.  **figure 9 transparency levels in the pavilion [15]**

- Transporting, transforming and distributing electricity comes at a loss, somewhere around 10%, but the losses are higher during peak hours. [16]

Technical Installation:

a. Heat pumps

- The water heating pumps is using water as a source and storage for heat with high capacity that is enough to be distributed to floor heating, washing machine, shower tabs, …, etc.…

b. Smart battery system

- It's a smart battery system consisted of Li-ion battery, convertor, and Energy Management System. The EMS receives data from various sensors and processes it to make forecasts of future electricity consumption and production, ensuring minimal waste of energy through equipment management.

c. Solar panel facades

- placing the solar panels on both the south-west and south-east facades, the power production spreads as evenly as possible over the day; in the morning, the southeast facade produces relatively more electricity, and in the evening, the southwest façade.

d. Smart Jetty

- At the bio-refinery, grey and black water will be separated and transformed into energy through fermentation.

e. Under floor heating

- Ensures an even distribution of heat over a large surface with a long-lasting release.

f. Solar Collectors

- Uses solar radiation to produce heat for central heating or hot water.

[16]

figure 12 roof-top solar collectors [9]

Technical Installation:

a. Heat pumps

b. Vacuum-tube solar collectors

- The auditorium uses the collectors for adiabatic evaporative cooling via an intelligent air-treatment cabinet.

c. Under- floor heating and FiWiHex-units

- The sustainability of this heating system is due to its it is a low- temperature heating as well as its use of radiation instead of convection of heat and cold. The mechanism showed in figure 10.

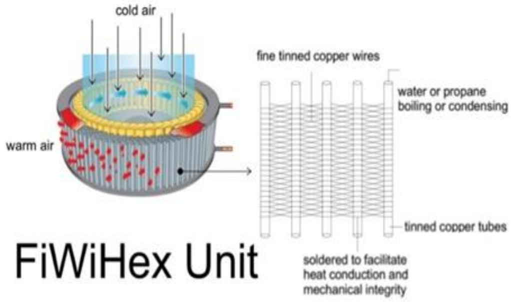


figure 10 fiwihex unit mechanism [15]

d. Solar panels

- Using solar panel placed on the shell structure for a sustainable source of energy.

e. Double layered ETFE foil

- It works also as thermal insulator as the double layers are filled with air.[15]

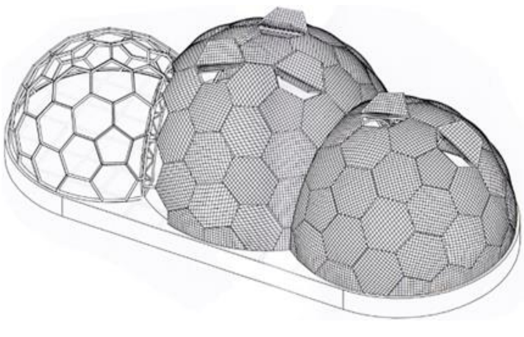


Figure 3 Rotterdam floating pavilion's shell structure [12]

Water efficiency	- Planting sedum roof make use of rainwater in the vegetation process as it delays the drainage of it. - Some houseboats collect rainwater and use them for planting and toilet flushes. - Installing shower recirculation system that saves up to 90% of water used in showers by the ingenious and hygienic systems of wastewater. - All buildings use vacuum toilets that uses 1.5 liters of water per flush. - Black water drained to a floating processor that extract biogases from black water and use them to generate electricity. [16]	- The Pavilion purifies its own toilet water and drinking water, with a focus on reusing rinse water as much as possible. - The pavilion utilizes a three-tank IBA system for purifying its own toilet water, which comprises of three distinct purification stages occurring in separate tanks for physical, chemical, and biological purification.

4. Floating buildings in Egypt:

While floating architecture is not a common type of architecture in modern Egypt, there are some examples of floating buildings that have been built in recent years, some of them are in response to the growing issue of urbanization and overcrowding in some of the country's major cities, so informal houseboats were built along the banks of the Nile River in Cairo, as shown in figure13 (a).

Other forms of floating architecture in Egypt are purposed for luxurious and unique experience. Figure 13 (b) shows the Anakob Houseboat, which is the newest and first boutique floating hotel in Aswan, reflecting the Nubian arts & culture with a trendy and modern comfortable setup, located in the Nile River in Aswan city. Gleem Bay, in figure 13 (c) is an artificial island on the Mediterranean Sea in Alexandria city. It is about 300 meters long in the sea including a big number of restaurants that are positioned on Gleem Bay, which is in the middle of the sea.

figure 13 (a) zamalek houseboats [19], cairo, (b) anakob houseboat, aswan [20], (c) gleem bay, alexandria [21]

4.1. The new fourth-generation cities in Egypt:

Egypt’s fourth-generation cities feature the newest architecture, built through sustainable and green infrastructure, powered by renewable energy and smart technology, and connected through multi-modal transport networks. Within the next 30–40 years, Egypt’s population is expected to grow from 100 million to as much as 180 million, so the new cities are essential in order to provide adequate amenities, employment, housing and infrastructure. The new cities will span some 580,000 acres and accommodate 30 million inhabitants. New cities will be located in the provinces of Alamein, Assiut, Aswan, Beheira, Beni Suef, Cairo, Dakahlia, Giza, Luxor, Marsa Matrouh, Minya, North Sinai, Port Said, Qalyubia and Qena, while the largest new city is the New Administrative Capital, located east of Cairo.[17]

4.2.New Mansoura City:

New Mansoura city is one of the New Smart Cities the state has embarked on establishing across the republic and is considered one of the major arteries of development in Egypt's northern coast. The city is planned to be stretching over a total area of approximately 4,000 feddans for about 15 Km on the Mediterranean coast. The city is being implemented in four consecutive phases.[18]

The first phase represents 40% of the total area (25,000 housing units) that is totally accomplished. Although the city goes over and above in having all the needed facilities and services building to make the lives of its residents far easier, yet most of these services buildings are not planned to be completed in the initial phases in the present time. After the site visit and by discussing this issue with the municipal officials, it's been cleared that it is an over-budget plan for the current time as they are facing difficulties in processing this plan. Thus, here comes the importance of using floating buildings in new Mansoura city.

Developments of multi-use floating islands are accelerated by an increase in offshore activities and pressing needs to create extra space in coastal regions for the surging population. The artificial island proposed in the masterplan of the new city shown in figure 14 is not planned to be accomplished in the initial phases makes the city one of the best study cases to have such an interesting project like a floating building. These kind of architecture in this case makes the use of the advantages of having a movable building that serves the first phase, in figure15, that has been totally accomplished in the city which is mostly housing projects with lack of entertainment activities.

figure 14 new mansoura city's proposed masterplan

Figure 15 New Mansoura city's current situation, source: google maps

5. Proposed Framework for using floating buildings in New Mansoura city:

Designing floating buildings requires a strategic approach to ensure that the building is safe, functional, and sustainable in its aquatic environment. Below are some strategies that can be considered when designing floating buildings:

Site Selection

Site Analysis:

Two main factors should be taken into consideration in the site selection phase:

- Water depth, considering size and weight of the floating architecture.
- Tides and waves that may affect the buildings stability.

After exploring the masterplan of the New Mansoura city, it's been determined that the purposed floating building will work as functional project like exhibition, aqua park, ceremony hall, or restaurant. It is proposed to locate the proposed floating buildings as shown in the figure below:

Figure 16 The first proposal of New Mansoura City's floating buildings, source: author

1. Floating buildings are suggested to be placed along the extension line of the city's 3 functional cores.

Figure 17 The second proposal of New Mansoura City's floating buildings, source: author

2. The picture above shows the proposed spot of the floating buildings as the yacht marine is excluded from the current construction plan.

Stakeholder

Participatory design:

Engage with stakeholders, including government officials like New Urban Communities Authorities and Ministry of Housing, Utilities, and Urban Communities, experts like The Arab Contractors and City Edge Developments, and community members, to gain insight into local needs, priorities, and concerns related to urban development and sustainability.

Communication plan:

Develop a plan for how stakeholders will be kept informed about the project and how they can provide feedback.

Architecture Design

Building Type:

The shortage of entertainment facilities and commercial projects in the current phase in New Mansoura city makes these kinds of activities more preferable to take place in the form of temporary use floating building.

Architecture Style:

Reflecting surrounded architectural style in the New Mansoura city to the exterior and interior design of the floating buildings using the key characteristics shown in figure 18.

Figure 18 New Mansoura city architecture characteristics [19]

	Accessibility: The Type and count of the floating building accesses will be determined according to the site selection and building use as well. These accessible connections can come in the form of gangway, wooden bridge, of similar structure. For the New Mansoura city, the wooden bridges shown in figure 19 will fit the most to make the floating buildings accessible from the shore by the pedestrian.  **Figure 19 pedestrian wooden bridge [20]**
	Flexibility: There are two essential concepts for building floating buildings in general to maintain an acceptable level of stability appropriate to the use: - The pontoon principle, which creates a solid platform that is lighter than water. - The ship principle, which creates a hollow concrete box with an open top. In this case of the New Mansoura City, the proposed floating structure is movable in order to be transported from place to another along the shoreline and to be used for different functional purposes according to every construction phase needs.
Sustainability	**Building Efficiency:** Examining building performance and study the building orientation, envelope, and how shading can affect energy consumption. This can be done in the New Mansoura city by implementing different energy-saving strategies such as: - Implementing solar cells on the roof top of the floating building. - Make a use of the wind power as the city's coastal location makes it an ideal selection of wind turbines to be one of the main sources of clean energy that can be supplied to the project.
	Infrastructure: Incorporating waste management system and water treatment processes through floating processors and purification systems.
	Material Selection: - Optimizing building materials and use light weight ones like wood and steel in the interior and exterior construction in order to create a light-weight construction. - Increase building's buoyancy as well as choosing durable materials that withstands harsh marine environment. - Use local materials located near the site of the New Mansoura city such as wood, straw-cement blocks, and solid rice-straw based blocks [24].

Implementation & Monitoring	**Cost Benefit:** Determine the local and economical materials in the Nile delta area that can be used in construction and workability.
	Water Management: Install water systems in the floating building to monitor water levels, wastewater, stormwater runoff and water consumption by establishing water management plan.

6. Conclusion and Recommendations:

This paper discussed a brief description of the different forms and characteristics of floating architecture as it suggests a strategy to follow for achieving the most efficient design of such like these buildings. Here, the aim was to analyze the smart design features of the floating and amphibious architecture based on existing international examples in Netherlands and local examples in Egypt. This uncommon type of architecture will work the best to fill the gap of having shortage in some kind of projects that is required to be existed at just a particular period of time then to be relocated or reused to be another planning solution as another gap-filling.

Based on the analysis and findings, several follow up studies are recommended to make this research more valuable:

1. For developing floating buildings, extensive local researches and studies should take place in all relevant fields of science and technology that are related to the structure, architecture and materials of floating buildings.
2. Reconsidering the Egyptian Building Code articles with the regard to floating buildings legal specifications.
3. Taking into account these types of buildings in the early stages of the city's urban developments.

7. References:

[1] Alciatore and Anderson :, "McGRAW-HILL SERIES IN MECHANICAL ENGINEERING Anderson: Computational Fluid Dynamics: The Basics with Applications, book, McGraw-Hill, New York, ©1995"

[2] H. P. Adi, S. I. Wahyudi, M. F. Ni'Am, and S. Haji, "An Analysis of Plastic Barrels as a Platforms Material of Floating House in Coastal Areas," *IOP Conf Ser Earth Environ Sci*, vol. 498, no. 1, 2020, doi: 10.1088/1755-1315/498/1/012066.

[3] "Floating and Moving Houses: A Need of Tomorrow." https://www.mgsarchitecture.in/architecture-design/projects/380-floating-and-moving-houses-a-need-of-tomorrow.html (accessed Feb. 18, 2023).

[4] A. Karczewski and Ł. Piatek, "The influence of the cuboid float's parameters on the stability of a floating building," *Polish Maritime Research*, vol. 27, no. 3, pp. 16–21, Sep. 2020, doi: 10.2478/pomr-2020-0042.

[5] M. M. B. Flikkema, F. Y. Lin, P. P. J. van der Plank, J. Koning, and O. Waals, "Legal Issues for Artificial Floating Islands," *Front Mar Sci*, vol. 8, Aug. 2021, doi: 10.3389/fmars.2021.619462.

[6] Ł. Piatek, "Displacing Architecture? From Floating Houses to Ocean Habitats? Expanding the Building Typology," *Education for Research, Research for Creativity*, vol. 1, no. May 2016, pp. 273–280, 2016.
[7] "Floating and amphibious housing — English." https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/floating-and-amphibious-housing (accessed Feb. 18, 2023).
[8] Y.-H. Lin, Y. Chih Lin, and H.-S. Tan, "Design and functions of floating architecture – a review," *Marine Georesources & Geotechnology*, vol. 37, no. 7, pp. 880–889, Aug. 2019, doi: 10.1080/1064119X.2018.1503761.
[9] "Schoonschip — Space &Matter." https://www.spaceandmatter.nl/work/schoonschip (accessed Feb. 19, 2023).
[10] Metabolic Lab, "Cleantech Playground: A cleantech utility in Amsterdam North," no. February, 2013, [Online]. Available: http://www.metabolic.nl/docs/cleantechplayground.pdf
[11] "Schoonschip – Amsterdam." https://schoonschipamsterdam.org/en/#site_header (accessed Feb. 19, 2023).
[12] "FLOATING PAVILION ROTTERDAM | Blue21." https://www.blue21.nl/portfolio/floating-pavillion/ (accessed Feb. 19, 2023).
[13] "Floating pavilion, Rijnhaven, Rotterdam - Public Domain Architects." https://publicdomainarchitects.com/floating-pavilion-rijnhaven-rotterdam/ (accessed Feb. 19, 2023).
[14] "WHY FSC | Build with FSC." https://www.buildwithfsc.org/why-fsc (accessed Feb. 19, 2023).
[15] "Rotterdam Floating Pavilion | INSIDE flows." https://www.insideflows.org/project/rotterdam-floating-pavilion/ (accessed Feb. 19, 2023).
[16] "Greenprint." https://greenprint.schoonschipamsterdam.org/ (accessed Feb. 19, 2023).
[17] "MIPIM 2022: Egypt's new cities create an array of investment opportunities." https://www.investmentmonitor.ai/sponsored/mipim-2022-egypts-new-cities-create-an-array-of-investment-opportunities/ (accessed Feb. 25, 2023).
[18] "الصفحة الرئيسية -المنصورة الجديدة ."
http://www.newcities.gov.eg/know_cities/newmansoura/default.aspx (accessed Mar. 13, 2023).
[19] "الكاتب عصام نبيل :تاريخ العوامات على نيل المحروسة ."
http://essam2020.blogspot.com/2010/04/blog-post_15.html (accessed May 01, 2023).
[20] "Anakob – Aswan." https://anakob.com/ (accessed Apr. 29, 2023).
[21] "Gleem Bay - الإسكندرية: Working hours, Activities, Visitor reviews, - Safarway 2023." https://www.safarway.com/en/property/gleem-bay (accessed Apr. 29, 2023).
[22] "New Mansoura Projects | The Arab Contractors." https://www.arabcont.com/english/project-747 (accessed May 01, 2023).
[23] "York Bridge Concepts: U.S. Timber Bridge Builders and Design." https://www.ybc.com/ (accessed May 01, 2023).
[24] Salah Mohamed, Awad Mona, and Kamel Yara, "Sustainable Building Material Technology as an Approach to Thermal Comfort in Low Income Housing in Hot Regions"2018.