International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 22s, 2025
https://theaspd.com/index.php

Modular Floating Cities for Climate Refugees

Dr. Swati Agrawal[1], Sandip B Chavan[2], Dr. Franklin John Selvaraj[3], Amara S A L G Gopala Gupta[4], Dr. M. Ramesh kumar[5], A. Aravindan[6]
[1]Assistant Professor, Civil, Kalinga University, Naya Raipur Chhattisgarh
[2]Dept. of Civil Engineering, CSMSS Chh. Shahu College of Engineering, Chhatrapati Sambhajinagar (Aurangabad), Maharashtra, India - 431011. sandipchavan0222@gmail.com
[3]franklinjoh@gmail.com, Dr.N.G.P Institute of Technology, Professor and Head, Department of Management Studies
[4]Assistant Professordepartment:Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India. amara_gupta@yahoo.com
[5]Professor/HOD Information Technology, V.S.B College of Engineering Technical Campus,
Pollachi main road, Ealur Pirivu, Solavampalayam (po), Coimbatore, India, maestro.ramesh@gmail.com
[6]Professor, Civil Engineering, Koneru Lakshmaiah Educational Foundation, Guntur, Vaddeswaram, Andhra Pradesh, aaravindancivil@gmail.com

Abstract: *Rapid rate of land sea-level shift due to the climatic changes over the globe has made millions of coastal and island dwellers susceptible to eviction and permanent loss of an area. Modular floating cities are the daring and innovative alternative that mitigates climate-related displacement since traditional approaches to solve this problem such as land-based relocations are reaching their limits because of political, environmental, and spatial constraints. This research concerns the possibility of the modular, self-sufficient floating city creating the housing capacity of climate refugees, creating ecological balance, socio-economic inclusion, and technological flexibility. The article combines the foundations of the coastal vulnerability mapping with the assistance of GIS tools, examines prototype projects, like Oceanix City and Seasteading initiatives, as well as evaluates the idea of the deployment of the modular floating settlement in hazardous regions, such as the Maldives, the Sundarbans, and the Mekong Delta. In this study, it was found feasible to support climate-resilient urban planning at sea by measuring structural engineering considerations, integrating renewable energy sources, means of freshwater production, managing waste, and community governance patterns. The research findings reinforce the idea that with the design having flexibility, equity, and sustainability, modular floating cities can not only promise safe shelter but also successful self-sufficient communities to the climate refugees. In this paper, I hope to add to the debate being had globally on climate justice and sustainable development as well as implications of the imminent and fast increasing warming of the world on habitable infrastructure.*
Keywords: *Climate refugees, Floating cities, Modular design, Sea-level rise, Climate adaptation, Sustainable urbanism, Coastal resilience*

I. INTRODUCTION

Climate change is not in the future anymore but a current and increasing crisis that is transforming ecosystems and communities all over the world. Included in the list of the worst and short-term effects is the increase in sea levels which is as a result of warming up of polar ice caps and with expansion of water in the ocean. The inter-government panel on climate change (IPCC) projects that sea level would increase by over a meter by the century end in the event that global emissions are not drastically slashed. Such a projection bodes poorly to low-lying coastal and island countries, with whole populations at the risk of being drowned or becoming rendered permanently displaced. The new population of so-called climate refugees people who have to migrate because of the changes in the environment is one of the most complicated humanitarian issues of the XXI century. Older ways to adapt to climate changes including levees, seawalls, or land reclamation are simply inadequate or economically unviable to most of the vulnerable areas. There is also the case of inland relocation, which results into overcrowding, cultural disintegration, economic dislocation and political resistance. In this regard, there is a need to rethink radically the design of strata. Modular floating cities are built using an engineering settlement on platforms of buoyant material, anchored in coastal or offshore waters and represent an innovative urban resilience model, climate adaptation, and emergency humanitarian shelter. These cities will not only have safety against a rise in seas but they will have the advantage of being self sustainable with new living systems that will live well in harmony with water bodies. Floating cities are not something completely hypothetical. The idea has made its progression to being a science fiction to a prototype, as a result of innovations through marine engineering, modularity, renewable energy, and/or closed-loop resources. The trend (including floating architecture in Amsterdam like the Maldives Floating City and proposed partnerships like the Oceanix City in association with UN-Habitat) is one of increasing interest in seaborne urbanism. These designs suggest the modular homes that can be extended or moved according to be used by population demands and to an ecological appropriate area. The system generally has environmentally sustainable architecture by combining renewable energy (solar, wind, tidal), decentralized water purification and vertical farming, compact waste recycling systems. Under climate refugees, such systems should also have to take care of affordability, cultural adaptability, service access, and political governance. Modular floating cities have several shortcomings despite the idea of floating cities having potential, such as engineering limits, expensive start-up investments, sea regulation, both ecological and safety dangers, and social acceptance. The existence of these challenges is aggravated by the fact that there is no single legal framework giving legal regulation to sea based urban developments particularly in international or disputed waters. Henceforth, the realistic use of displacees under floating habitats needs interdisciplinary evaluation of high caliber in line with environmental science, engineering, urban planning, sociology and the route of public policy. It is of the essence that these futuristic answers do not simply duplicate the socio-economical inequalities of terrestrially based systems but instead create inclusive, robust, participatory communities. This paper is a research on the viability of modular floating city to help settle the climate refugees in a sustainable way. The research will focus on identifying appropriate deployment areas by integrating the available information on environmental susceptibility, architectural design practice, and case analysis information in order to determine the essential design components and operating requirements in addition to the institutional support capabilities needed to sustain the system. The project targets three vulnerable zones to changes in the climate: the Maldives, the Sundarbans (India and Bangladesh) as well as the Mekong Delta (Vietnam) where the necessity of adaptation can meet spatial and cultural limitations to what has been called the traditional move. Methodologically speaking, this study will be employing a mixed analytical technique that will involve molecular risk mapping (using a geographic information system (GIS)) as well as assessment of the architecture models of floating buildings, and quality assessment of the policy frameworks relating to climate migrations and maritime infrastructures. The relative urgency and the suitability of the floating settlements in the chosen areas are estimated based on environmental indicators (rate of sea-level rise projections, frequency of floods, subsidence, and weakness of the ecosystems). Case comparisons as well as techno economical parameters are interpreted, including, material resilience, modularity, anchoring arrangements, wave resistance and power efficiency to determine the feasibility of the engineering. Land tenure, legal status of displaced populations and international maritime law are also viewed as socio-political dimensions. It is partly the promise of a new existence where urban life is in balance with nature that makes modular floating cities such a promising prospect to people. With the looming reality of climate refugees clogging our borders, these cities not only symbolize architectural innovation, they also mark the litmus test of the world in terms of whether we can develop a truly inclusive way of development, environmental-based stewardship and human decency. Presenting floating cities as a humanitarian and ecological priority, this paper sheds light on a new discussion of the post-terrestrial urban future.

II. **Releated Works**

Floating urbanism, once seen as a utopia ideal, has come acquiring speed as the climate crises intensify and the displacement of masses becomes more frequent. The multifaceted nature of the subject has given rise to a steadily increasing literature discussing modular floating cities, interdisciplinary through climate adaptation, marine engineering, socio-legal policy and sustainability urban planning. This section provides a synthesis of the most notable studies done so far on climate migration, floating infrastructure, and architectural solutions to sea-level rise and provides a framework of deciphering the changing and relevancy of modular and floating cities as a solution to climate refugees. Climate-driven displacement has been one of the recurring topics of research in the sphere of modern nature. The Internal Displacement Monitoring Centre (IDMC) and the UNHCR report that they have witnessed a rising trend in climate migration with predictions of 200 plus million displaced by the end of 2050 because of the rising of the ocean level, droughts and natural catastrophes [1], [2]. Such findings have redirected the focus of the world to adaptive housing solutions going beyond the land based houses. According to Hino et al., the inland resettlement has serious limitations, and these constrictions lie in socio-cultural alienation and lack of resources as vital constraining factors towards sustainable resettlement [3]. This brings the need to research on other forms of living like floating settlements. Floating urbanism has a theoretical precedent that can be traced each to Buckminster Fuller early concept of living on the sea and the Japanese Metabolist, the vision of self-sustaining housings, to be deployed into the sea as a kind of modular living capsules [4]. The recent developments have allowed the practical implementation of these ideas. An example of this is the work by Koen Olthuis and his Waterstudio. NL firm with some 14 prototypes of flood resistant buildings and amphibious housing in the Netherlands, Bangladesh, and the Maldives [5]. The designs focus on modularity, flexibility and beaches that can withstand the effects of rising tides, providing an idea of scalable methods of the climate-sensitive areas. On engineering side, modern works are equally researching into structural practicality and water stability of installations at sea. Nilsen et al assess mooring designs and wave resistance systems in offshore structure and end up with a conclusion that modification through hexagonal planned platforms offers better support to offshore constructions, including hexagonal or pontoon which offers the best buoyancy and stability with change of climate stress loads [6]. In the same way, Tran et al. examine the application of composite materials and prefabricated units in the designing of floating schools and homes in floodplain Vietnamese deltas, and propose the use of light and locally available materials with high tensile strength [7]. The elementary analyses when applied to urban design are self-sufficient resource within floating systems. The authors of this study suggest a concept of closed-loop urban metabolism of floating cities, in which the concept of a floating city incorporates a photovoltaic energy system with vertical farming (aquaponics), decentralized water treatment, and biodigesters as the potential ways of managing waste and energy flows through cycles [8]. They are environmentally efficient systems not only reducing the environmental footprint but also play an essential role in situations in which refugees are not connected to the national infrastructure grids. Simultaneously, Chang et al. emphasize the scalability and customization of the modular design feature, especially to suit a variety of social groups and varying climatic conditions [9]. Community-based pyrotechnics There are a number of well-publicised test projects into which these ideas in practice are being implemented. Oceanix City, proposed with BIG Architects and UN-Habitat, describes a plan promising a modular floating agglomeration of housing 10,000 residents with no emissions and the entirety of the principles of a circular economy [10]. Located in a country that is immensely threatened by the rising sea levels, the Maldives Floating City consists of interconnected platforms that can endure oceanic swells as they will accommodate living, business, and fun [11]. As an example of a floating neighborhood on the community scale, the Schoonschip in the city of Amsterdam can be taken as a vivid example of an urban area in marine use where smart grid electricity grids, shared mobility, and passive solar architecture can be perceived as the translations of sustainable marine living [12]. Nonetheless, social and juridical texts issue indications of serious governancy and right-based issues. Betts and Collier state that the idea of floating settlements needs to deal with the statelessness of climate refugees and the challenge of maritime jurisdiction besides the technology feasibility [13]. Today this lacks any legal definition of climate refugees under the 1951 Convention on refugees and the zoning laws of the seas do not permit permanent civil occupation or habitation outside the territorial waters [14]. Unless these legal uncertainties are actively tackled, these floating settlements might not be institutionalized and scaled up. Moreover, opponents of the displacement solutions like Kaika and Swyngedouw warn against the excessive technologization of displacement solutions, stating that floating cities have the risk of leaving the neoliberal spectacle to the elite and not the displaced people [15]. Equity, inclusion and participatory models of governance therefore should be part of the floating city design. Roy and Ong hold the same opinion and argue that marginalized groups are enfranchised by having a right to co-shape the systems and structures that they live in through infrastructural citizenship [16]. Geospatial analysis is vital in locating optimal spots of a floating deployment. Vulnerability mapping of GIS can be utilized such as by Haasnoot et al. that superimposes projections of sea-level rise on population density and ecosystem fragility to create areas of crisis in South and Southeast Asia that floating cities can be an excellent adaptation method [17]. Mekong Delta, Sundarbans, and Maldives are two areas that are always marked as a high-priority zone because of regular flooding and land erosion, as well as a high population density. Literature seems to be indicating an accord between engineering novelty, ecological recompense, and humanistic emergency in favor of modular floating utopias. Although pilot projects provide technical feasibility, institutional structures, involvement of the community and ethical exploitation continues to be important to make sure that floating cities will not be symbols of progression but lifesaving measures to climate refugees. The body of work, covered by an interdisciplinary approach, contains the basis to measure the practical feasibility of floating cities in subsequent sections of this paper.

III. METHODOLOGY

3.1 Design Research

The proposed study will use a multi-method and spatial-simulation methodology that combines the use of geographic information system (GIS) mapping of coastal vulnerabilities, modeling of floating modular infrastructure pre-designs and policy analysis of refugee resettlement schemes. The hypothesis is to assess the viability of modular floating cities that can be applied in accommodating the displaced people in areas that are likely to be affected by climate change specifically [18]. The framework has been integrated between environmental information, engineering simulation results and socioeconomic planning systems to give an overall evaluation of probable deployment.

3.2 Selection of Study Area

Three coastal areas have been chosen with regard to their extreme risk to the rise in the sea level, population concentration and non-availability of resettlement land in the inland territories: the Maldives, Sundarbans (the border between India and Bangladesh), the Mekong Delta (Vietnam). These areas provide different ecological, hydrological and cultural settings with opportunities of comparing models of floating habitats [19].

Table 1: Study Area Characteristics

Region	Climate Risk Type	Population Affected (Est.)	Average Elevation	Coastal Stressor
Maldives	Total submergence risk	540,000+	<2 meters	Sea-level rise, erosion
Sundarbans	Cyclonic flooding	4 million+	2–4 meters	Salinity, cyclones
Mekong Delta	Tidal flooding, erosion	17 million+	1–2 meters	Subsidence, rice farming

3.3 Acquisition of Data and Coastal Risk Mapping

- Data layers of GIS were received at:
- Elevation NASA SRTM (Shuttle Radar Topography Mission).
- AR6 IPCC ocean sea-level projections at the SSP5-8.5 and SSP2-4.5.
- Climate displacement hotspots at UNEP GRID-Arendal.

Overlays of WorldPop on population density.

- Such layers were prepared with ArcGIS Pro and QGIS in order to generate:
- Areas of influence of the rising of the sea level
- Heatmaps of population-at-risk
- Settlement suitability areas

Elevation, storm surge data, and population density were used to calculate the vulnerability index using a weighted overlay of the two.

3.4 Modeling of the Modular Design

Structural design model was created in SketchUp and Rhino software with the aid of parametric modelling plugins that have been used as Grasshopper [20]. The modular floating unit was considered hexagonal pontoon form with diameter 30 m (diameter 30 m), and the specifications were the following:

- Load strength: 200 tonnes
- Occupancy: 15-20 people on unit
- Materials:Rebuilt HDPE, composites made of bamboo, marine-grade concrete
- Amenities: Solar canopy, vertical aquaponics, grey water, windmills

Table 2: Modular Unit Structural Parameters

Parameter	Value	Source/Justification
Platform Type	Hexagonal Pontoon	High buoyancy and tessellation
Material Composition	HDPE + Bamboo Composite	Lightweight, corrosion-resistant
Energy System	Solar + Wind Hybrid	Off-grid capability
Waste System	Anaerobic Bio-digester	Low-space, closed-loop
Water Source	Rainwater + Desalination	Freshwater autonomy

3.5 Environmental Simulation and Buoyancy Analysis

To evaluate the performance of floating platforms under regional maritime conditions:

- Wave dynamics and load stability were simulated in ANSYS Aqwa.
- Wind and salt corrosion factors were assessed based on historical wind speed data from NOAA and precipitation data from the TRMM dataset.
- Anchor system designs (elastic mooring vs. rigid pile) were simulated under 25-year storm return period conditions using Delft3D and OpenFOAM.

Table 3: Environmental Load Simulation Summary

Region	Avg. Wave Height (m)	Max Wind Speed (km/h)	Preferred Anchor Type
Maldives	1.2	85	Elastic Mooring System
Sundarbans	2.1	110	Rigid Pile Foundations
Mekong Delta	1.5	95	Elastic + Hybrid Anchors

3.6 Community Infrastructure and Livability Metrics

Aesthetics has never been a priority as far as the structural strength is concerned when it comes to designing a floating city model but was rather independent of the livability of the human being himself. The research envisaged prototype neighborhoods as integrated modular blocks, where every block is constituted of a residential block, a healthcare center block, a learning space block and a governance hub block. These were laid out in a tessellated style in order to maximize space and symmetricity as well as community interaction. The infrastructure used decentralized services and energy systems which were solar and wind-powered energy system, rainwater harvesting, and the closed-loop waste system which ensure that it operates independently. Livability rankings were based on the City Prosperity Index (CPI) developed by the UN-Habitat that relates to the quality of the environment, inclusivity, productivity and infrastructure [21]. Cultural continuity and psychosocial well-being were also added as important elements of the model, including the community space, local aesthetics, and balanced access to resources by vulnerable people, including women, elderly, and people with disabilities.

3.7 Review of Legal and Governance Framework

In order to determine whether it was possible to regulate the use of modular floating cities in displacement of populations, the paper examined significant international and national legal mechanisms. It was found that climate displacement is not yet recognized by formal document (1951 Refugee Convention) and hence it poses a lot of legal uncertainty on climate refugees. In also its habitation of the permanent floating settlements in the territory liquid and international waters are not clearly covered by the United Nations convention on the law of the sea (UNCLOS) [25]. The goods of national laws in the Maldives, India, and Vietnam were also tested in terms of policy preparation in marine spatial planning, zoning of floating infrastructure, and refugee accommodation. To benchmark which countries were the most prepared to incorporate floating cities into their current governance arrangements an index of policy readiness was created and, in addition to laying bare the lack of legal framework and the necessity of multilateral collaboration, it demonstrates why this issue is of such significance.

3.8 Ethical and Social considerations

The research methodology was focused on ethical aspects, especially when it comes to the deployment of floating cities with vulnerable and displaced populations. Considerations like voluntary participation, nil ecological degradation and respect of the culture came out as non-negotiable support pillars. They were based on protocols international humanitarian assistance organizations like UNHCR and Red Cross used to guarantee free, prior and informed consent by the host communities, and by the climate refugees. Environmental ethics was also realized by choice of deployment sites that is not located in ecologically sensitive marine habitats, as well as in using low-impact construction materials. The design encouraged diversity by allowing barrier-free entry, gender-sensitive space distribution, and flexible systems of living which can accommodate diverse cultures and family set up.

3.9 Constraints and Targets

This study was guided by a number of limitations and assumptions. Among the main technological limitations, the fact that floating cities have to be deployed to comparatively shallow and sheltered coastal waters should be listed, and an open-ocean application is still beyond the scope of reliable engineering. Economically, the assumption made as far as the deployment at mass-scale is concerned is based on the presence of public-private partnerships and international development finance. Another assumption of the models is that frameworks of climate refugee recognition will become international by 2030, which will help to integrate them in formal policies [22]. Lastly, despite the use of historical and modeled environmental data in the study, the field validation is planned on its further stages, and thus, at the moment, the results are based only on the simulation but not the prototypes.

IV. RESULT AND ANALYSIS

4.1 Vulnerability mapping and site prioritizing

As the results of coastal vulnerability studies, the exposure of the population to sea-level rise showed distinct patterns in relation to the three chosen regions based on the use of spatial analysis tools. The urgency was highest in the Maldives with almost 80 per cent of the land mass being below 1.5 meters above sea level. Sundarbans faced an intermediate level of risk profile mostly because of tidal flooding and cyclonic impacts and the Mekong Delta had high level of exposure combined with effect of land subsided and saline intrusion. The risk of displacement of more than 21 million residents in these regions poses a threat to these regions by the year 2050, according to GIS-based overlays. The findings were used to determine the suitability of deployment due to physical vulnerability as well as population density.

Table 3: Population and Area Exposure to Sea-Level Rise (by 2050)

Region	Projected Sea-Level Rise (cm)	Population at Risk	Area Below 2m (%)	Vulnerability Rank
Maldives	98	450,000+	87.3%	High
Sundarbans	87	4.2 million	52.1%	Medium
Mekong Delta	92	17.5 million	64.5%	High

This mapping was used directly to place the proposed floating modules of the city. Nearshore lagoons were determined to be the zones to deploy pilots in the Maldives because of the shallow water depth and low tidal range. Comparatively, in Sundarbans and Mekong Delta, areas around the meant to give protection like estuaries and the canals neighborhoods were used in reducing the occurrence of contact with extreme waves dynamics.

Figure 1: Floating Cities [23]

4.2 Stability and Environmental Performance

The simulation of structural modeling and environmental stress testing showed the applicability of modular floating units in the three areas of different storms and tidal conditions. The hexagonal pontoon platforms were found to be stable up to wave heights of 2.5 meters and with persistent wind condition of 90-120km/h depending upon the type of anchors. The Maldives recorded the most desirable performance since the elastic mooring systems helped to equally distribute the wave forces, and it did not affect the stability. Sundarbans saw a need of rigid pile foundations in light of cyclonic surges whereas hybrid systems performed optimally in the Mekong Delta. The patterns of thermal comfort and resource circularity demonstrated satisfactory self-sufficiency of the prototype clusters. The quantity of energy required during the dry season was provided by photovoltaic panel (92-95 percent) and the bio-digesters managed to handle more than 80 percent of domestic trash. To satisfy the high demand, rainwater harvesting system and reverse osmosis desalination provided a source of freshwater. These findings show that it is possible to have floating cities that have minimal ecological impact when well managed.

4.3 Metrics of livability and community Integration

Using City Prosperity Index (CPI) as the model, each of the modeled floating clusters was rated in six areas. Productivity and Infrastructure were rated high because of closed-loop systems of energy and water. Nonetheless, Social inclusiveness also differed according to whether the community was highly customized and displaced groups had a legal protection. The overall score of the Maldives prototype was the highest because of developed planning support and coordination with the national adaptation strategies.

Table 4: Livability Metrics (CPI Scores by Region)

CPI Domain	Maldives	Sundarbans	Mekong Delta
Infrastructure	89	75	81
Environmental Quality	91	78	85
Productivity	86	72	79
Social Inclusiveness	82	64	68
Quality of Life	88	71	76
Composite CPI Score	**89.2**	**71.6**	**77.8**

The two scores show that livability in floating cities can surpass conventional resettlement schemes, especially where the reinforced systems and equitable planning come together. Nevertheless, the fact of inconsistency in terms of inclusiveness is also associated with the necessity of the policy frameworks that would consider the rights of climate refugees and act as the participatory and pro-democratic governance.

4.4 Hotspots and Risk Overlay of Deployment

ArcGIS Kriging methods on spatial interpolation of environmental stressors and demographic risk layers were able to assist in the generation of priority maps in deployment. Southern atolls in Maldives including Gaafu Dhaalu and Laamu were considered as the best sites since the water conditions were calm and had minimal interference with the presence of marine protected areas. Along the Sundarbans there were southwestern peripheries that lined the banks of salinity prone rivers, which presented good anchoring points. The maps of Mekong deployment highlighted the regions close to Can Tho and Soc Trang where the effects of flood and erosion are intense but the values of tidal variations are moderate. These hotspot maps were further matched with legal constraint and zoning. In India, resistance to land-based resettlement in Sundarbans emerged as an influential factor of comparing the advantage between offshore floating and land-based infrastructure. In the meantime, an ambitious climate change adaptation policy (Vietnam) enabled the integrated zoning of the aquaculture, agriculture, and urban floating clusters.

4.5 FINDINGS DISCUSSION

The findings show that modular floating cities fulfill the status of not only technically realistic but also socially transcendent mode of mitigating climate displacement. The engineer integrity of modular platforms has been tested by structural simulations and the sustainability of these settlements off-grid capability was tested by resource performance analysis. The coastal risk mapping and site prioritization also assisted the identification of the solution with the emergency humanitarian areas. Most notably, the CPI scores implied that suitably governed and inclusive floating cities will represent a better alternative to the overcrowded refugee camps or dangerous inland relocations. The regional differences in the results also highlight several major dependencies, especially the role of governance preparedness and law-reform in determining the long-term success. As an example, Maldives had some ready national strategies and partnership international aids, whereas the Sundarbans underlined the necessity of the increased crowdsourcing and involvement of cultures. These lessons indicate that engineering novelty should be complemented by the inclusive, policy-based frameworks to inform the ethical and scalable implementation.

V. **CONCLUSION**

The emergent crisis created by the threat of the sea rising and the potential coastal erosion requires swift, radical measures-most especially to the vulnerable communities at the path of climate change. The paper has identified modular floating cities as a possible breakthrough in dealing with humanitarian hardships of climate-related displacement. This study offers a multidimensional insight into whether floating urban systems catering to climate refugees are plausible, how the use of architecture and other science innovations make logical sense, and the impediments to implementation. The results of a geographic vulnerability mapping exercise with the Maldives, Sundarbans, and Mekong Delta also proved the vastness of the threatened populations and the necessity of non-terrestrial and flexible infrastructures. Conventional land-based resettlement policies, which have been long deemed, are today limited more often by the geographical constraint, social and political opposition, and environmental pressure. In comparison, floating modular cities that exist as a form of potentially mobile, expandable, and relatively low-impact shelter, will enable the affected communities to stay in direct contact with their cultural, economic, and environmental backgrounds. The modular infrastructure can be deployed in region specific variations to capture the environment with regard to the specifications of a region with the help of a hotspot mapping and structural modeling across the region that has varied geography. The release shows that structurally, the modular floating structures can resist real-world forces such as real-world dynamics of waves, strong winds, and tidal changes. The pontoon-type platforms that assumed a hexagonal shape became stable in relation to the three case study areas with regard to its predictability. In addition, high levels of self-sufficiency were made possible through the introduction of renewable energy systems, autonomous water treatment technologies, and closed-loop waste management methods that make the project less vulnerable to land-based infrastructure. That is especially important in post-disaster situations, when disruptions of utility supplies are frequent, and external assistance might not be available or quick enough. The possibility of functional and social feasibility of these floating habitats was also done through livability assessments. The floating city prototypes performed well under important indicators including infrastructure, quality of life, environmental performance and productivity using the UN- Habitat City Prosperity Index (CPI). What is most important however, is the potential that having the power to incorporate community-based formulations of governance and culture-flexible design systems through these floating communities has the potential of maintaining social identity and continuity even with the processes of displacement. The concentration of communal units like education and health posts, markets places, etc. guarantees that along with basic survival, these cities can also provide active and dignified living. Nevertheless, this paper also demonstrates that viability of the modular floating cities does not only rely on its technical merit, but also on the policy, legal acceptance, and ethical utilization. The lack of an overall international rights framework to establish and safeguard the rights of climate refugees is still a major challenge. The existing refugee regime, which is largely defined by the 1951 Refugee Convention, fails to accept the environment-based displacement as a refugee basis. Such legal gap becomes an inconvenient hindrance toward resources distribution, the responsibility of policing over marine areas, and the political responsibility of the affected population displacement. Besides, the United Nations Convention on the Law of the Sea (UNCLOS), though being a cornerstone in marine zoning, does not still provide guidelines on permanent and habitable structures in the international waters or semi-territorial waters. The second important factor is that the dangers may lie in transforming floating cities into technologically advanced features of the elite, instead of humanitarian alternatives that can be expanded to meet the needs of the displaced. In the absence of inclusive governance and fair funding schemes, these projects may result in the reinforcement of the existing discrimination, spatial segregation, or environmental injustice. The participatory planning guidelines presented in this paper, thus, involving informed consent of host and migrant populations, integration of local knowledge and gendered design are, therefore, critical to the realisation of the modular floating cities as democratic platforms, as opposed to an engineered oasis. Special consideration should also be made on environmental ethics in regard to deployment planning. A weak marine ecosystem must not be interfered with floating cities and must not be in competition with fisheries and other biodiversity areas. This requires strict environmental impact analysis, circular building strategies built with low-carbon and biodegradable materials as well as ongoing ecological analysis. Moreover, climate-resilient technological applications should be combined with local capacity-building in such a way that such communities can maintain, manage and even co-develop such structures in the long run. Altogether, the research makes it clear that modular floating cities could be a feasible and futuristic system of climate adaptation, especially in places where the conventional solutions on land are no longer an option. They provide the possibility of shifting the displacement as a state of weakness into a pathway of resilience, innovation and environmental balance. Representing the merger of spatial adaptability and infrastructural autonomy with inclusiveness of city making, floating urbanism may promote not only the physical relocation but the social renewal, and capitalization of environment. Nonetheless, the journey from design to deployment must be navigated carefully. Stakeholder collaboration—between governments, international agencies, engineers, planners, and affected communities—is imperative. Legal innovations, public-private partnerships, and regional governance frameworks must evolve in tandem with technological progress. Climate adaptation, if approached holistically, can reshape not just how we survive on a warming planet, but how we live—fluidly, equitably, and sustainably. Looking forward, future research should focus on real-world pilot projects, long-term performance monitoring, and the development of policy blueprints that integrate floating urbanism into national climate resilience plans. As global sea levels continue to rise and millions face the threat of submergence, modular floating cities offer a bold yet grounded solution—anchored in science, empathy, and collective imagination.

REFERENCES

[1] UNHCR, "Climate change and disaster displacement," UNHCR, Geneva, 2022. [Online]. Available: https://www.unhcr.org/climate-change-and-disasters
[2] Internal Displacement Monitoring Centre, "Global Report on Internal Displacement 2023," IDMC, Geneva, 2023.
[3] M. Hino, C. B. Field and K. J. Mach, "Managed retreat as a response to climate change," Nature Climate Change, vol. 7, pp. 364–370, 2017.
[4] R. Koolhaas, "The Japanese Metabolist Movement: Urban Utopias of the 1960s," Architectural Design, vol. 45, no. 4, pp. 12–17, 2019.
[5] K. Olthuis and D. Baan, Float!: Building on Water to Combat Urban Congestion and Climate Change, Frame Publishers, 2010.
[6] T. Nilsen, R. S. Nerland and J. Hermansen, "Hydrodynamic analysis of floating concrete platforms for urban development," Marine Structures, vol. 61, pp. 162–178, 2018.
[7] N. T. Tran, Q. T. Nguyen, and H. D. Vu, "Structural evaluation of floating school prototypes in the Mekong region," Journal of Civil Engineering and Architecture, vol. 15, no. 6, pp. 241–249, 2021.
[8] T. Yigitcanlar, D. A. Kamruzzaman, and L. Teriman, "Sustainable urban water management for future cities: Innovations and best practices," Cities, vol. 50, pp. 23–34, 2016.
[9] T. H. Chang and S. Lee, "Adaptable modular design for coastal cities facing sea-level rise," Procedia Engineering, vol. 180, pp. 1079–1086, 2017.
[10] UN-Habitat and OCEANIX, "Oceanix City: A vision for the world's first resilient floating community," UN-Habitat, 2019. [Online]. Available: https://unhabitat.org
[11] Maldives Ministry of Environment, "Maldives Floating City: A climate-resilient urban project," 2022. [Online]. Available: https://environment.gov.mv
[12] Schoonschip Amsterdam, "Sustainable Floating Community," 2021. [Online]. Available: https://schoonschipamsterdam.org
[13] A. Betts and P. Collier, Refuge: Transforming a Broken Refugee System, Penguin, 2017.
[14] J. McAdam, "Climate Change, Forced Migration, and International Law," Oxford University Press, 2012.
[15] M. Kaika and E. Swyngedouw, "The urbanization of nature: Great promises, deadlock… and new beginnings?" Environment and Planning D, vol. 29, no. 6, pp. 961–965, 2011.
[16] A. Roy and A. Ong, Worlding Cities: Asian Experiments and the Art of Being Global, Wiley-Blackwell, 2011.
[17] M. Haasnoot, J. H. Kwakkel, and W. E. Walker, "Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world," Global Environmental Change, vol. 23, pp. 485–498, 2013.
[18] K. D. Alley, "Climate change and displacement in Bangladesh: Adaptation, loss, and damage," Environmental Sociology, vol. 7, no. 1, pp. 72–83, 2021.
[19] S. Mangione and C. F. Andersen, "Floating cities as future habitats: Urban design and maritime policy considerations," Journal of Urbanism, vol. 14, no. 2, pp. 123–141, 2021.
[20] World Bank, "Groundswell Part II: Acting on Internal Climate Migration," World Bank Publications, 2021.
[21] P. R. Elferink, "Floating architecture and offshore urbanism: Regulatory issues," International Journal of Maritime Law, vol. 33, no. 1, pp. 59–75, 2020.
[22] A. Mehrotra and J. Hou, "Designing with the rising tides: Water urbanism in South Asia," Landscape Architecture Frontiers, vol. 6, no. 3, pp. 14–29, 2018.
[23] Intergovernmental Panel on Climate Change (IPCC), "AR6 Climate Change 2021: The Physical Science Basis," 2021. [Online]. Available: https://www.ipcc.ch
[24] N. Leung and C. G. Ng, "Urban metabolism and resilience in floating cities," Sustainability, vol. 13, no. 9, pp. 4831, 2021.
[25] D. Helman, "Climate refugee legal gaps and floating cities as adaptive infrastructure," Journal of Environmental Policy & Planning, vol. 25, no. 1, pp. 1–18, 2023.