BRNO UNIVERSITY OF TECHNOLOGY

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION

FAKULTA ELEKTROTECHNIKY

A KOMUNIKAČNÍCH TECHNOLOGIÍ

DEPARTMENT OF FOREIGN LANGUAGES

ÚSTAV JAZYKŮ

FLOATING CITIES - INTRIGUING CONCEPT OR UTOPIA (LITERARY AND INFORMATION SEARCH STUDY)

PLOVOUCÍ MĚSTA - VZRUŠUJÍCÍ KONCEPT NEBO UTOPIE (REŠERŠE)

BACHELOR´S THESIS

SEMESTRÁLNÍ PRÁCE

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SUPERVISOR — **Mgr. Pavel Sedláček**

VEDOUCÍ PRÁCE

BRNO 2023

BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION

Bachelor´s Thesis

Bachelor's study field English in Electrical Engineering and Informatics

Department of Foreign Languages

Student: Dávid Kunzo *ID:* 221475

Year of study : 3

Academic year: 2022/23

TITLE OF THESIS:

Floating cities - intriguing concept or utopia (literary and information search study)

INSTRUCTION:

Conduct a literature and information search on the topic of the floating cities. Include the history, technical concepts and approaches, the current state, assess why there has not been a real-life deployment yet and outline the possible future development.

RECOMMENDED LITERATURE:

WANG, Gil, Yiska GOLDFELD a Nitai DRIMER. Expanding coastal cities – Proof of feasibility for modular floating structures (MFS). _Journal of cleaner production_ [online]. Elsevier, 2019, **222**, 520-538 [cit. 2022-09-16]. ISSN 0959-6526. Dostupné z: doi:10.1016/j.jclepro.2019.03.007

KIRIMTAT, Ayca a Ondrej KREJCAR. Development of Self-sufficient Floating Cities with Renewable Resources. In: _Computational Collective Intelligence_ [online]. Cham: Springer International Publishing, 2018, s. 437-446 [cit. 2022-09-16]. ISBN 3319984454. ISSN 0302-9743. Dostupné z: doi:10.1007/978-3-319-98446-9_41

LIN, Fen Yu, Otto SPIJKERS, Pernille VAN DER PLANK, Lukasz PIATEK, Soon Heng LIM, Chien Ming WANG, Rutger de Graaf-van DINTHER a Notarieel GOEDERENRECHT. Legal Framework for Sustainable Floating City Development: A Case Study of the Netherlands. 158. In: _WCFS2020_. 2022, s. 433. ISSN 2366-2557.

SS, Kaviani. Floating Cities and How to Supply the Energy and Welfare in Them. _Journal of architectural engineering technology_ [online]. 2016, **5**(2) [cit. 2022-09-16]. ISSN 2168-9717. Dostupné z: doi:10.4172/2168-9717.1000165

Date of project specification: 9.2.2023

Deadline for submission: 30.5.2023

Supervisor: Mgr. Pavel Sedláček

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Subject Council chairman

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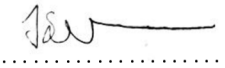
Acknowledgements

I would like to thank my supervisor, Mgr. Pavel Sedláček, for his guidance, patience, assistance, and general helpfulness in writing this thesis.

Declaration

I hereby declare that this thesis represents my own work, using the listed literature, under the professional guidance of my supervisor.

Brno, 30.5. 2023



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Student´s signature

Abstract

This thesis presents and explains the technologies associated with the construction and usage of floating cities, and related projects in South Korea, Singapore, and Japan. The next goal is to understand the potential impact of floating cities and coastal defences on the surrounding environment, and vice versa. With multiple projects such as Oceanix city and Green Float still in their early phase, it is necessary to consider whether the problems of coastal communities can be solved by such technologies, and if it is achievable at all, considering the financial circumstances, and possible limitations by used materials. Finally, by summing up the accessible information, the conclusion determines the reasons such structures are not a widely popular solution yet.

Keywords: Floating cities, coastal protection, environmental engineering, future technology, land reclamation

Abstrakt

Tato práce představuje a vysvětluje technologie spojené s výstavbou a využitím plovoucích měst a související projekty v Jižní Koreji, Singapuru a Japonsku. Dalším cílem je pochopit potenciální dopad plovoucích měst a pobřežních obranných opatření na okolní životní prostředí a naopak. Vzhledem k tomu, že řada projektů, jako je Oceanix city a Green Float, je stále v počáteční fázi, je třeba zvážit, zda lze problémy pobřežních komunit těmito technologiemi vyřešit a zda je to vůbec dosažitelné s ohledem na finanční okolnosti a možná omezení ze strany použitých materiálů. Nakonec práce poskytne shrnutí dostupných informací a určení důvodů, důvody, proč tyto stavby zatím nejsou široce rozšířeným řešením.

Klíčová slova: Plovoucí města, ochrana pobřeží, environmentální inženýrství, technologie budoucnosti, budování umělých ostrovů

Introduction

Floating cities may seem as a very unusual concept, mainly because the majority of population are born and live their whole lives on land. As one of the proposed solutions for the coastal communities, these projects are concerned with the rising sea level, as well as overcrowding.

They can be simply described as vessels, with buildings along with other usual infrastructure of a city on top of them. The way they work is building real estate off land, which should be able to produce food, energy, and manage its own waste and emissions, and even provide support for growth of corals and mangroves.

The main goal of this thesis was to search the materials that are currently accessible on floating cities. Explain the background, technological principles and methods, the current state of the art, evaluate the reasons these have not been used in practise yet, and present potential directions for future research and development.

There is currently no working prototype, although this fact is set to change with at least two big projects by Dutch Oceanix and Japanese Shimizu respectively, set to start construction in the next three years. The intention is to describe both concepts, and explain how these designs will work, to demonstrate that there is more than one concept to be put to use, and that there is not a perfect floating city formula thus far.

After analysing technologies that are planned to be implemented at both constructions, their impact on both the environment and the communities which will live there, it is explained that investing in these technologies should be done in the interests of long-term benefits rather than short-term allowances. Many quick fixes and solutions can actually be dangerous to both fauna and flora in the future, and in the end, do more harm than good.

1. What are floating cities?

1.1. History

For a long time now, humankind has been challenged to find ways to fit more and more people into small spaces, or at least, using less land to house more population. One way to do it in large cities and metropolitan areas, is using vertical space. Skyscrapers have been around for more than 130 years now, and since then, they became the standard in the most populated cities in the world. Whether used for housing or commercial space, you can see high-rise buildings becoming more regular even in smaller cities, not just the biggest metropolises.

Nevertheless, people in densely populated areas near the coast could be running out of space in the next few years. This is a major problem, because building more housing and finding space for it, is one thing, but in the 21st century, we need more than that to live a comfortable life. People need food, electricity, drinkable water, sewage systems, etc. All these things have to be provided or produced somewhere, and then supplied to hundreds of thousands of citizens at all times. The word "somewhere" is a bit too vague here; infrastructure planners and cannot just pick a place and build a power plant there. Same with food and groceries, you would have to build a farm first, then transport the harvested resources to a production site, then move the finished product to a store…That is a complex process, all of this is done to ensure the level of convenience we got used to over the last few years. A technique that helps congesting these processes is called vertical farming. With its ability to grow a lot of crops in a short space and effective space usage, vertical farming is an excellent option for urban regions with limited land resources. Additionally, it offers constant agricultural production and defence against unfavourable weather. The drawbacks, however, are high starting expenses, high maintenance costs, substantial energy expenditures, high labour costs, and a lack of technological maturity. (Miller, 2022)

Numerous countries with sea access, such as the Netherlands, the United States (mainly Florida) and Japan have also had sea level related problems, all of which had to be dealt with, whether by a fix or a solution in advance. The Netherlands, for example, have "embraced the sea" instead of pushing it away and protecting themselves from it. Houseboats, modern aqueducts, streets with just as many water canals as roads – they work with it, instead of trying to get rid of it. The Netherlands, along with United Arab

Emirates and even Nigeria, have been utilizing what is called “land reclamation”. (De Mulder et al., 1994) (Alqahtany et al., 2022)

Floating cities are somewhat different. Artificially created, reclaimed land, houseboats and floating villages are connected to the shore, at least by a bridge that you can cross, but the concept of a floating city is that it should be fully functional without any outside help or resources once it has been built – in other words, self-sustainable. All of the aforementioned conditions for a comfortable life should be well accounted for on these floating islands, with no need to go back to shore. The second difference between land reclamation and floating cities is that the city´s platforms allow for flowing water underneath.

1.2 State of the art

One of the principles that planned floating city concepts seem to work on, is this: Multiple dozen platforms, usually the size of few hundred square meters, resting on top of the sea, all of them inter-connected by small bridges, forming a flexible, puzzle-like structure, able to deal with water level changes. Another idea is building one large, flexible structure from many smaller parts, but as of right now, most of these projects are in the process of securing funds and resources to begin construction, while some have not even reached this stage yet.

One of the countries profoundly known for its solutions for high/rising water levels is The Netherlands. After 1953, as a consequence of one of the most devastating storms in their history, the Dutch began putting together a very complex and ambitious long-term strategy. One of the most important parts of this plan is the Delta Works programme. This system of dams and adjustable water gates was completed in 1997 and proves that heavy investment in coastal flood defences was a great step forward in a country where roughly 60% of the land is at risk from severe floods. (Huisman et al., 1998) Nonetheless, it is not only about investing big sums into large-scale projects. The Dutch people proved that their strategy is not about throwing money at a problem. Culture and the way of thinking proved to be a crucial element for the population for dealing with their situation at hand and improving their standing into the future. Now they are known as one of the most technologically advanced countries in terms of water related problems and usage. The Netherlands have even executed a program that was responsible for trying out a cow farm on a **floating platform** connected to the shore**.** This is very important, for the argument

of the floating city concept, because it shows that not only housing can be moved offshore. Farms, storage rooms, or even data centres and server rooms could be potentially moved onto water as part of saving space on the mainland, even without people, should it be decided that housing offshore is too complicated, pricy, or simply not suitable for humans.

2. Parts and infrastructure of floating cities

The idea of floating cities has been circulating for some time now. They are intended to be resilient, self-sufficient communities that can last through natural calamities like hurricanes and floods. One such project is Oceanix City. The Oceanix City is designed to be built using modular hexagonal platforms that can be arranged in different configurations depending on the needs of the community. How it is intended to be ,up to 12,000 people could live in this floating metropolis, with great potential for expansion. A comparable idea, the Shimizu Green Float, has also been put out by the Shimizu Corporation. This self-sufficient city could accommodate up to 40,000 people in one "cell". Both of these plans employ ecologically friendly energy sources like solar and wind power and are also built to be efficient with regards to the usage of energy. (Whiting, 2022)

2.1. Busan Oceanix City

According to their official website, the Oceanix project in Busan is supposed to have to build various kinds of platform, each dedicated to a purpose. All of them should form a totally self-sustainable, carbon-neutral community. Oceanix presented the public with three main types of platforms: a Lodging platform, a Research platform, and a Living platform.

2.1.1. Busan Oceanix city – Platforms

A lodging platform (see Pic.1) will serve as a visitor hub of sorts. As a visitor then, you can expect guestrooms, terraces with relaxing views, and some locally produced food in restaurants. Kind of like a city centre for entertainment, except all its needs would have to be taken care of on surrounding platforms. Of the three platforms, the lodging platform has the lowest ratio of building footprint to the total area, at just 6,500 m^2 to

30,000 m^2, or 21% in percentage. Of course, the aim for this design was not to maximize building space, but to provide an entertaining, dining, or just walking space for visitors and citizens alike. (Whiting, 2022) (OCEANIX, 2022)

Figure 1-Lodging platform (OCEANIX/BIG-Bjarke Ingels Group)

The Busan Oceanix city is going to be a prototype. Therefore, the research done, and knowledge gained after construction will be one of the most crucial assets to use in order to advance the concept of floating cities. However, the Research platform´s job is not just research. Plans describe a shared garden, that should take place at the ground level, and along with hydroponics and large greenhouses, is supposed to provide food even in winter. This platform has the highest ratio of building footprints to the total area, but the platform itself is somewhat larger too. If we count the winter garden´s area (3,500m^2) into the building footprint, that takes us to 14,000 m^2 of assets which sit on the 37,000m^2 large platform, so nearly 38% of "land" on this type of platform is going to be used for buildings. Therefore, at least in the beginning stages, it can be expected that a big part of the population of the city will find work in these facilities. (OCEANIX, 2022)

Figure 2-The research platform (OCEANIX/BIG-Bjarke Ingels Group)

Figure 3-Communal backyard (OCEANIX/BIG-Bjarke Ingels Group)

The living platform (see fig.3) system provides comfortable places for residents to sleep and rest. The community backyard in the centre of the platform supports residential structures and the local culture, promoting interaction and socializing among people. The topside built area is stated to be 34,000m^2, and Oceanix plans to use building 4 to 5 stories tall, similarly to the research platform.

Cleverly combining these types of platforms is going to be absolutely crucial for the efficiency of the city and quality of life of the citizens. The planners and developers can employ multiple strategies in the early stages, and later on decide which is best. Whether creating large, intertwined patterns which coexist to create one large complex system, or having smaller varying patterns, is not clear yet. It is important to determine whether designers will be unrestricted in terms of placing individual platforms where they please. On one side, they should have no problems creating an infrastructure that is the best possible option on paper. (See fig.4) On the other hand, despite Oceanix declaring that this city should withstand most of the threats created by inhabiting a structure floating on top of the sea, the planners should account for the fact that the platforms on the outer edge will be facing harsher conditions than the ones in the centre. It would be advisable to move more crucial objects of infrastructure further from the outer perimeter, despite the fact that the project counts on a material called "Biorock" to support growth of corals and mangroves in close vicinity.

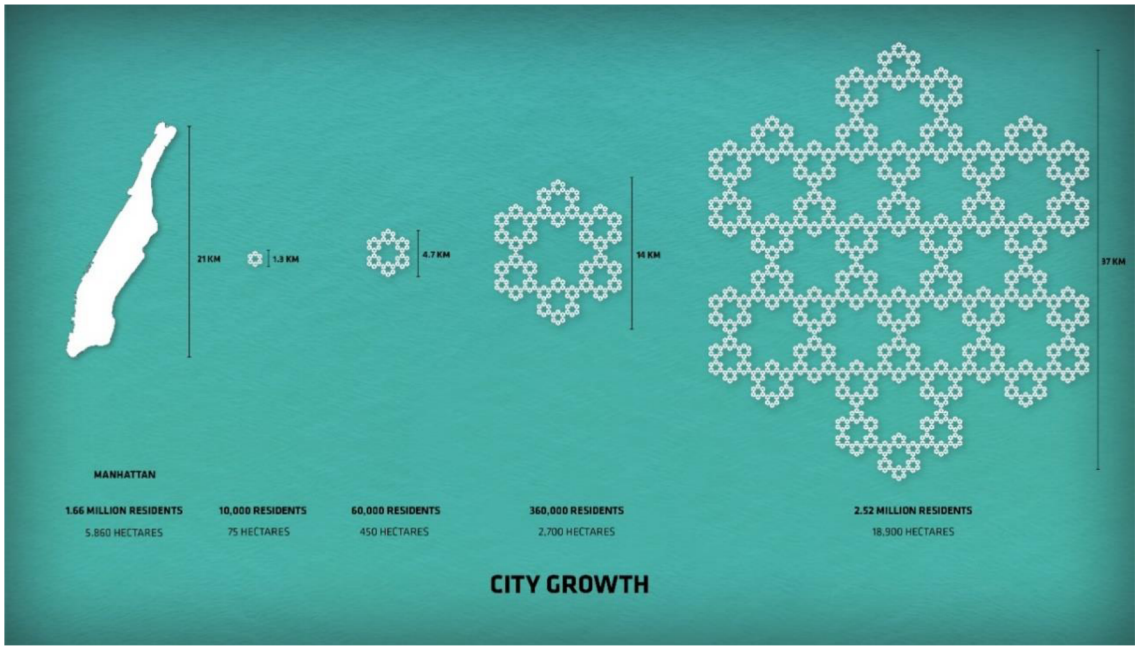

Figure 4-Projected City Growth (OCEANIX/BIG - Bjarke Ingels Group)

2.1.2. Busan Oceanix - Carbon neutrality and self-sustainability

Establishing carbon neutral areas at sea is an important concern in a world where carbon dioxide emissions are contributing to global climate change, population increase is generating local land shortages, and rising sea level is endangering coastal city development. Busan itself is a big part of this, being a major emitter of carbon emissions itself. (Yang et al., 2022)

An important part of this concept is having a renewable power source-and having it close to consumers. Another problem that must be solved in order to achieve zero carbon status is managing the city´s waste. It was established that Oceanix came up with a zero-waste system, which means that the floating colony will be able to take care of disposing waste and recycling on its own. (See fig.6) If it works, all inhabitants should be able to dispose of their daily waste, laundry etc. in a dedicated sub level of the platform. (Whiting, 2022)

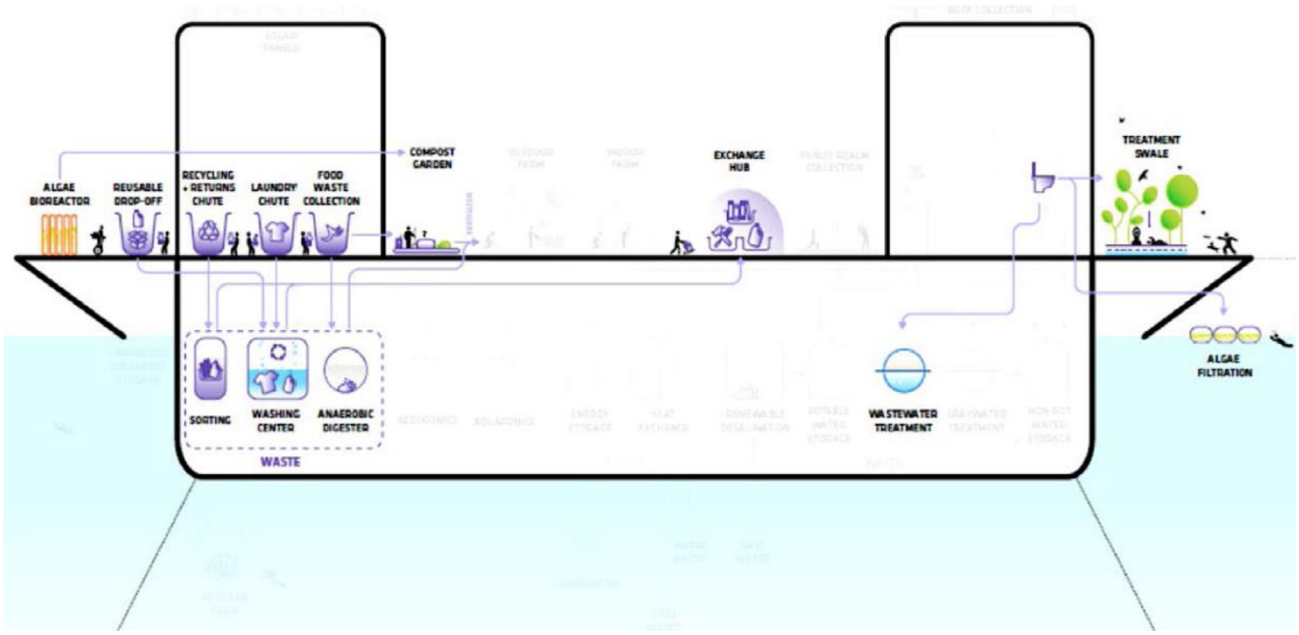

Figure 5-Zero waste system design (OCEANIX/BIG-Bjarke Ingels Group)

2.1.3. Busan Oceanix- Supporting the surrounding environment

As it often is, new technological concepts such, as building a whole city on water, leads to the need of development of new technologies, improving techniques, and new special materials.

Biorock is one such example. Biorock was protected by a trademark in the time space of 2000-2010 and is now free to use. (Justia, 2022) A re-discovered material, specifically dedicated to solving one of the not-so-obvious problems of the platforms of the floating cities, for example: what happens directly under the platforms, and how to prevent negative influence on sea life caused by blocking the sunlight. Interestingly, this can be partially solved with the help of electricity. Biorock works on a principle documented and patented by Wolf Hilbertz, coming from his research in the 1970´s. He found out that upon introduction of an electric current in salt water, a solid formation begins to form around the surface of the conductor. (Hilbertz et al, 1979). As one might have guessed, this solid rock formation is responsible for helping coral reefs grow and sustain themselves. (See Fig.7 below) Although not only coral reefs. Biorock should even help vegetation such as mangroves to grow in close vicinity, and therefore help stabilizing and reinforcing the soil (specifically the seabed close to shore) against the sea waves and currents. (Goreau, 2022)

This is important because erosion of the seabed creates ideal conditions for flooding coastal aeras, which is a problem for many coastal communities nowadays. The treatment of former Floridian swamp systems is a striking example of how to not act in terms of working with the local aquatic flora: they are currently experiencing massive drawbacks in the form of floods and coastal land erosion and destabilisation. (Florida Department of Environmental Protection, 2022)

Figure 6-Biorock artificial reef off the Gili Islands, Indonesia (sonurai.com)

2.2. Shimizu Green Float

The Japanese company Shimizu Corporation has developed the floating metropolis concept known as Green Float, often referred to as Botanical City. The future idea calls for the creation of an eco-friendly island floating in the Pacific Ocean near the equator. The city will have residences, greenhouses, and commercial and business space, and is designed around a vision to provide residents a possibility to integrate into a natural environment which is resembling a single gigantic plant. Green Float's construction is expected to start in 2025.

Unlike Oceanix, Shimizu intends to build one solid structure for each city instead of an interconnected pattern of platforms. The company plans to build a mega-structure of outstanding dimensions, measuring one to three kilometres in width and up to one kilometre in height. (Kizilova, 2019)

2.2.1. Bonded Honeycomb Structure

Hexagonal cells are the main part of the honeycomb structure. This structure is made of more than 90% air, making it both strong and lightweight, and is frequently utilised in the construction and cutting-edge aerospace industries. These honeycombs will be connected to create an artificial offshore ground structure. Shimizu has created a three-step plan for building the whole structure:

Individual "honeycombs" are created as the initial phase aboard special wave-resistant barges outfitted with concrete plants. They are turned and propelled forward by machinery at the sides of the barges. They are around 20 metres wide, 50 metres tall, and weigh between 5 thousand and 7 thousand tonnes.

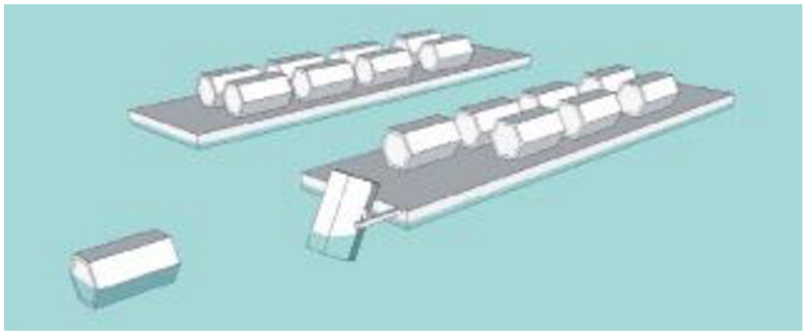

Figure 7– Honeycomb shaped cylinders are made and propelled towards their destination (provided by Shimizu)

Then, in the second step, to get the honeycomb components into a balanced state, water is pumped into them, and with the help of rubber gaskets on the bonding surfaces, units are connected into square groupings with the other honeycombs, using water pressure to squeeze the interstitial water out. In order to create tight coupling, high-strength concrete and bolts are also employed as secondary bonding.

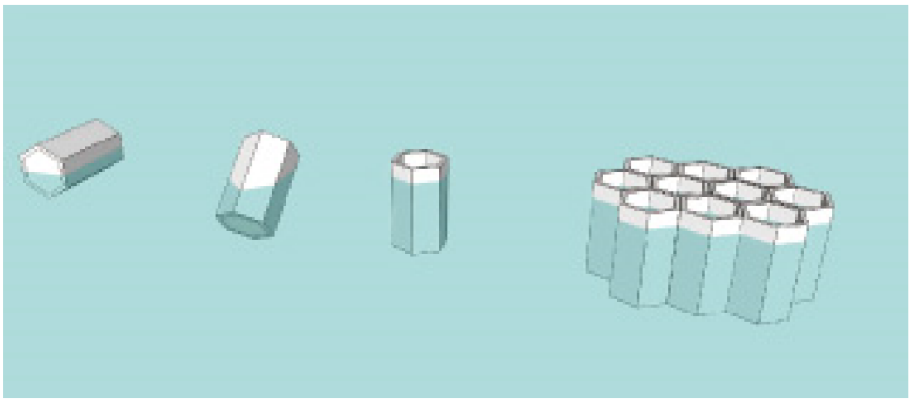

Figure 8-Stabilized honeycomb cylinders connecting to create a floating surface (provided by Shimizu)

Finally, groundwork will start when the substructure is connected and enlarged to form an artificial ground structure. (Shimizu Corp, 2008)

Much like the Busan Oceanix City, this project accounts for more than one city being completed. So, to give a clearer understanding of the scale of the project, Shimizu shows the growth and the approximate area of the districts, modules and even "countries". (See fig.9)

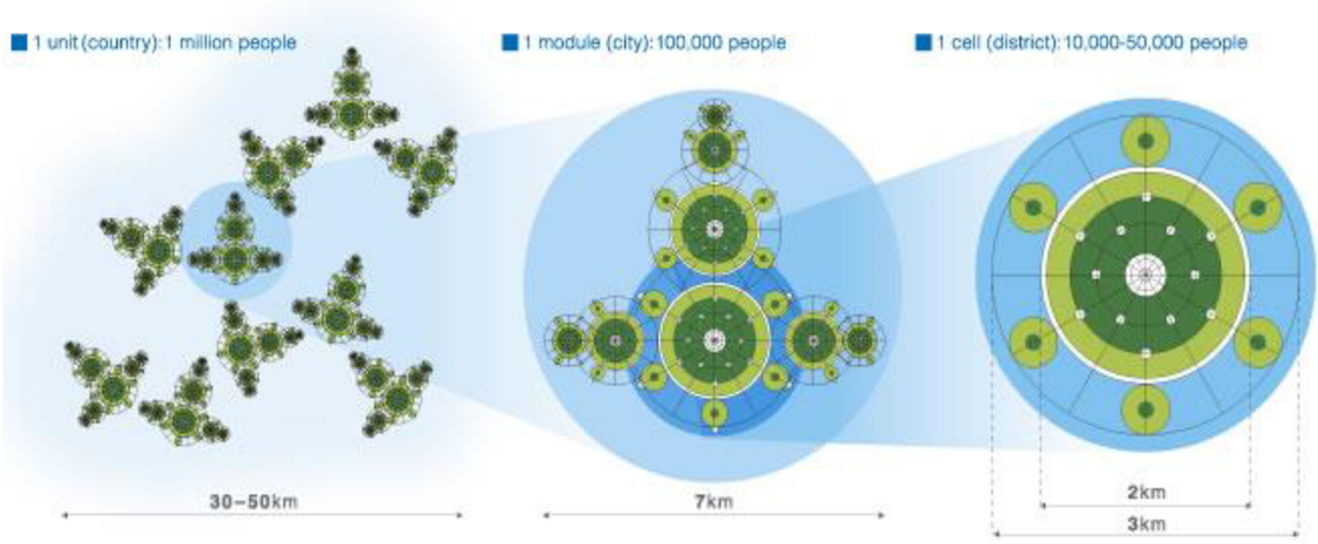

Figure 9-The size of Green Float´s cells, modules, and countries (Shimizu Corp.)

A **cell** is defined as a small community with a 1 km walking radius. Adding cells creates **modules**, which come together to create **units**.

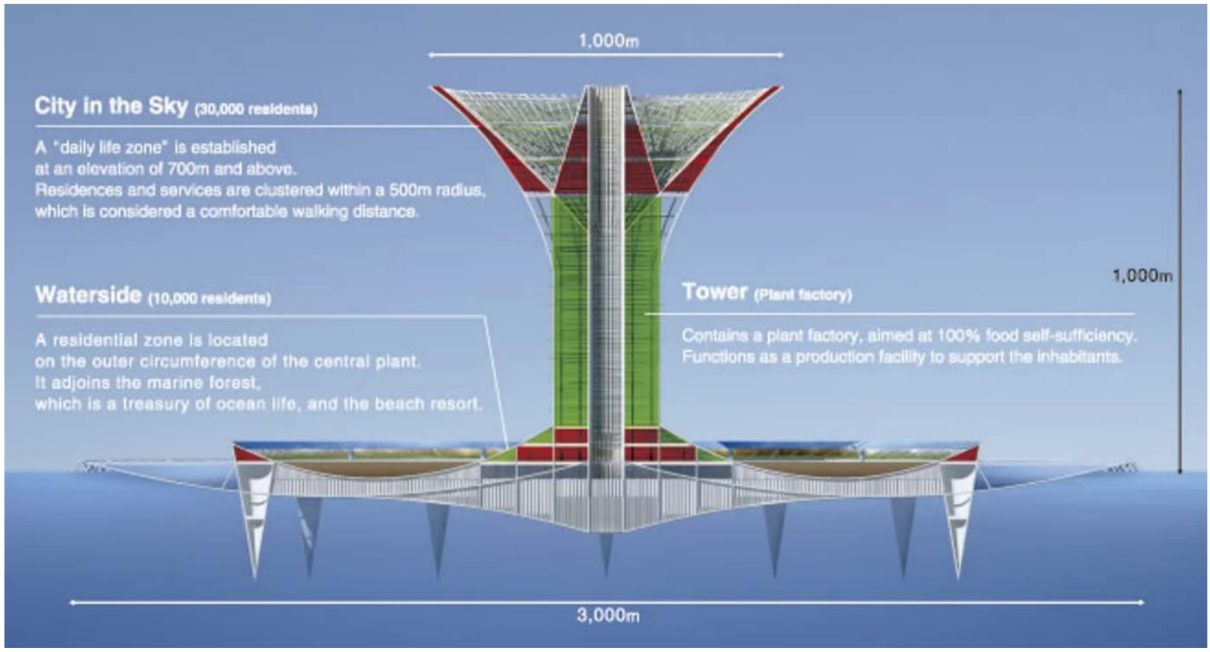

Figure 10- Green float concept dimensions (provided by Shimizu)

2.2.2. Carbon neutrality/negativity

While most floating city projects and renewable power source development programs talk about lowering their carbon emissions number to zero, Shimizu says they are able to go even lower. This does raise a very interesting point though, because to actually stand a chance in reverting the damage done by carbon emissions, achieving carbon neutrality, although being a very difficult task to manage, might not be enough. Thus, Shimizu brought forth multiple ways to reduce the amount of carbon emissions being released into the air. As presented by the company, the first of many steps is switching to more efficient transportation, and making the city compact, minimizing the traveling distances. This is said to reduce the emissions by about 40%. Another step is conserving energy that would be otherwise used for heating the residential zones. At the equator, the average temperatures equal to roughly 26 degrees Celsius at 1000 metres above the water level. This is the reason for which the structure is planned to be so tall in the first place. A part of this step is improving the efficiency of the thermal insulation that will be used and minimizing fossil fuel use. The CO_2 Emissions reduction thanks to this is estimated to be about 30%, according to Shimizu. A part of switching from fossil fuels will be building devices for harvesting various natural energy sources, such as solar power, thermal energy conversion, wind, and ocean waves. These technologies are predicted to reduce the emissions by another 30%. Finally, another 30% of reduction in CO_2 emissions will come from the ocean itself, as it is much more capable of absorbing CO_2 than forests on land. Furthermore, these structures are expected to implement a system even for generating energy from its own waste by a multi-functional recycling plant. (Quick, 2015)

2.2.3. Adapting to surrounding environment

As mentioned above, the project is counting on the ocean´s ability to absorb CO_2 to help them minimising their carbon footprint, eventually achieving a negative value. The program plans to use magnesium extracted from ocean water, in alloys used in the structure. Magnesium alloys hold immense potential as structural components for the electronics, aerospace, and automotive sectors. Particularly in the automotive industry - A magnesium engine block may drastically lower an automobile's weight in the front and, as a result, its fuel consumption, and weight distribution.(see fig below)

Material	Weight Reduction vs. Low-Carbon Steel
High-strength steel	15-25%
Glass-fiber composite	25-35%
Aluminum	40-50%
Magnesium	55-60%
Carbon-fiber composite	55-60%

Figure 11--Automotive part weight reduction versus low carbon steel. (General Motors)

One of the reasons to use magnesium is the sheer abundancy of the material. If there would be no ore left to mine to extract magnesium from, it can be obtained from sea water. It is estimated that every 770 tons of sea water contains around one ton of magnesium. (0.13%) Additionally, because it can be melted down and recycled, it has drawn attention as an ecologically benign material especially when compared to other lightweight structural materials like fibre-reinforced plastic or aluminium. (McCoy, 2018) Another advantage of magnesium is that it has a higher specific strength than steel due to its lower specific gravity (1.74g/cm^3). The main characteristics making magnesium alloys adaptable include their low density, which is only one-third of that of aluminium. Further compared to aluminium, magnesium alloys have various drawbacks, such as higher cost when compared to aluminium alloys, lesser strength, lower density, more susceptibility to corrosion, and restricted availability. (Gaikwad, 2022) (Hussein & Northwood, 2014) However, compared to other metal alloys they have superior corrosion resistance, can endure high temperatures, and are lightweight when. (Tech Steel & Materials, 2022)

Since the climate is steady and there are no frequent typhoons, the islands would be situated near the equator. Despite that, the structures are planned to be equipped with various countermeasures to withstand the outside influences of the environment, and/or potentially dangerous situations caused by the city itself. Active control vibration dampers will lessen the impacts in the event of severe winds by employing sensors already used at airports to gauge the wind's power and calculate its impact on the structure. To neutralize the effect of sea waves, the shallows above the membranes are

about 10 metres above sea level, and very strong elastic membranes are joined to the outside perimeter. The membranes can only move a limited amount because of the difference in water pressure, which reduces the force of the waves in the open sea. Additionally, seawalls 20 to 30 metres high are built to further improve the defences. Tsunamis do not pose a threat to safety because of how differently they operate in the open ocean than they do in coastal environments. Tsunamis that do not hit the coast go gently up and down, and inhabitants might not even notice one passing underneath them. (National Oceanic and Atmospheric Administration, 2018)

2.3. Atlantis Sea Colony

Atlantis Sea Colony (ASC) is planning to build modular underwater structures to be used as lodging, residences, and commercial spaces. The first phase will take place in a depth of roughly 10 meters. In this phase, the build will be reachable by scuba diving but is not meant for a broad audience. The finished product will enable entry and exit without becoming wet or without any prior training. Later builds could be placed deeper depending on the location, function, and request of the client. As of yet, no location has been chosen. The places being considered by the planners range from Florida in the United States to Central America on the Atlantic side. (ASC, 2022) These kinds of structures could also serve a purpose as auxiliaries (energy storage, data centres, etc.) in floating city projects, should the designs be fitting.

2.3.1. Private and personal accommodations

According to their website, after construction visitors will be able to spend the night at a dive shop nearby, in an Airbnb, or at their own private site where they can live beneath the waves and wake up to a sunlit underwater landscape.

The ultimate goal is to eventually make traveling to and from any undersea residence as straightforward, secure, and dry as going anywhere else in the earth.

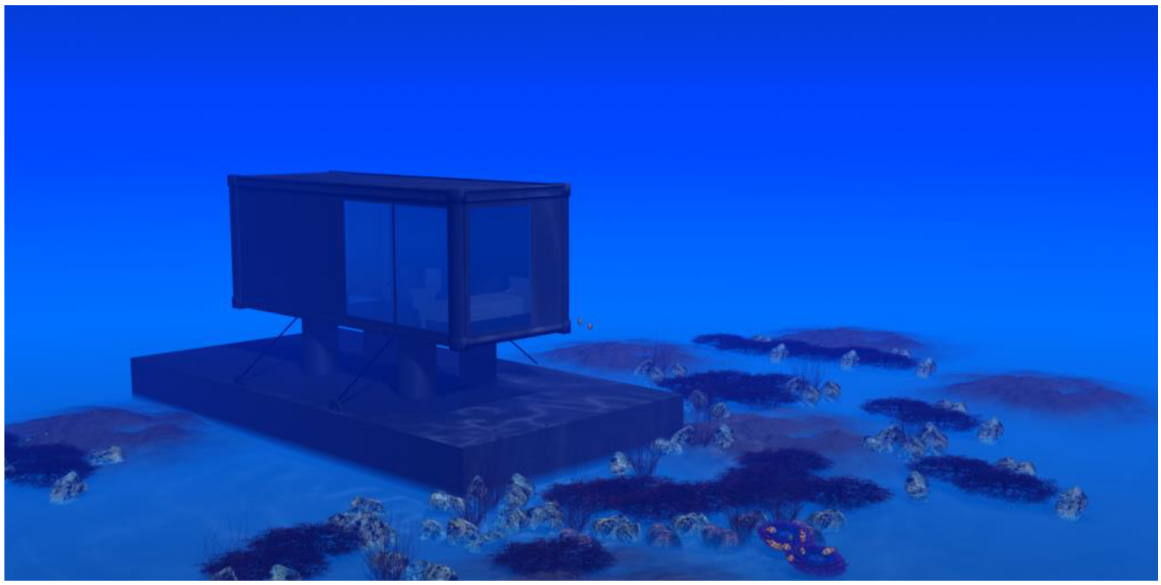

Figure 12- Potential look of private accommodations (Atlantis Sea Colony)

2.3.2. Business oriented accommodations

The Atlantis Sea colony program claims that data centres, greenhouses, survival bunkers, scientific research, energy storage, or even hotels and Bnb´s can be moved underwater. This would not be the first attempt to do so (ASC, 2022), as a datacentre the size of a shipping container was safely recovered from the seabed off Scotland's Orkney Islands by Microsoft´s Project Natick team. It was the resolution of a multi-year project whose goal it was to demonstrate that the idea of underwater datacentres is viable from a logistical, environmental, and fiscal standpoint. After retrieval, the computers from the datacentre were evaluated and kept under close observation for the following two years by the team. Corrosion from oxygen, humidity and temperature changes can all contribute to equipment failure - the team proved that a sealed container on the ocean floor could offer ways to improve the overall reliability of datacentres. (Roach, 2023)

Figure 13- A graphic depicting placement among the surrounding environment (Atlantis Sea Colony)

2.4. Arktide Seastead Dome

Arktide is a company that has designed a dome seastead that is 250ft in diameter and has a total of 5 floors with a height of 50ft from base to dome top. The building material for the dome will be a variation of Ultra High-Performance concrete (UHPC) which has a projected 100-year life span with exceptional strength, durability, flexibility, and longevity.

The dome is intended to include housing, amenities, communal office spaces, and markets for locally produced and imported goods. The community will be fully sustainable through the incorporation of Ocean Thermal Energy Conversion (OTEC), Sea Water Air Conditioning (SWAC), water desalination, solar energy, and aquaculture farming. (Jackson, 2023)

According to Arktide's website, they plan to begin construction of the dome seastead design prototype in the next couple of weeks and a full-size dome (see in fig. below) in late 2023/early 2024.

Arktide has recently obtained a property in Puerto Rico about thirty minutes east of Mayaguez, from which they plan to begin their operations of construction. The plan is to construct floating platforms from which to construct the dome on the coast of Mayaguez.

Initially, these domes will be located near shore as part of land-based communities, marinas, or hotels. This will help them establish an initial market. They eventually plan to expand out into the ocean. (Silone, 2023)

Figure 14-Arktide Dome design (BIM group)

2.5. Land reclamation in Singapore

Since the early 19th century, Singapore has made great use of land reclamation to increase its area and accommodate its expanding people and industry. This chapter discusses some of the major land reclamation projects in Singapore, such as the Marina Bay, Jurong island, etc.

In 1822, work on Singapore's first land reclamation project began on the river's southern bank, in order to establish Boat Quay and Commercial Square (now Raffles Place). Up to 1937, the colonial administration undertook a number of reclamation projects along the Kallang Basin, Collyer Quay, Singapore River, and Telok Ayer Basin.

The colonial government reclaimed more than 13 800 hectares of land between 1965 and 2015, primarily along the east coast, Marina Bay, Jurong Island, and Changi. These land reclamation initiatives offered much-needed space for industrial, commercial, and residential uses, which was crucial for Singapore's economic growth and development. The development of Jurong Island into a petrochemical hub and Marina Bay's transition from a dirty bay to a busy financial district serve as examples of these projects' success. However, it has resulted in the destruction of natural habitats and the disturbance of marine ecosystems - land reclamation has an adverse effect on the environment that

cannot be ignored. It is critical to strike a balance between growth and sustainability as Singapore expands. (Seng, 2017)

Figure 15- Singapore's first reclamation in 1882 - Lieutenant Edwin Augustus (National Museum of Singapore, National Heritage Board)

In summary, land reclamation has played a crucial role in Singapore's growth and development since the colonial era, allowing for the expansion of physical size, creation of new land for development, and addressing land scarcity issues. However, it has also raised concerns about environmental impact and sustainability, which the government has addressed through eco-friendly reclamation methods, promoting biodiversity, and preserving coastal habitats, and investing in research and development to mitigate the effects of climate change. While Singapore has been recognized as one of the most sustainable cities in the world. (Seng, 2017)

2.5.1. Approaches and goals

Building containment dykes around the area to be reclaimed and filling it with materials like soil, sand, and clay are both steps in the modern land reclamation process. Imported materials from inland hills, nearby seabeds, or from neighbouring nations were used as filler. Singapore recently came up with a more environmentally friendly technique called "empoldering" that has cut down on the quantity of sand required for reclamation projects.

Figure 16-Seven phases of the East Coast Reclamation, which started in 1966 and lasted for around 30 years, resulted into the creation of Marina Bay in the early 2000´s. (© Urban Redevelopment Authority. All rights reserved.)

In 1822, work on Singapore's aforementioned first land reclamation project began on the river's southern bank. Raffles initially planned to locate the commercial zone north of Singapore River, along the beachfront of the Esplanade and the Rochor River. Raffles modified his town plan to reflect the fact that the location was unsuitable for maritime activities owing to the shallow waterways and waves. A hilltop close to where Battery Road is now, was levelled to give soil to cover the marshes as the south bank had a low-lying marsh that was prone to flooding. To complete the construction and create an embankment along the river's edge to stop water from pouring into the land, some 300 coolies were employed. About four months later, a crescent-shaped area presently known as Boat Quay was created as a result of the operation. (SG101, 2022)

Figure 17- Marina Bay at night (iiconsortium.org)

2.5.2. Environmental concerns

A large-scale loss of marine ecosystems has been caused by Singapore's industrialization, notably in terms of coastal development and land reclamation projects. Large portions of Singapore's north-eastern shore, as well as the majority of its southern coast, have undergone various land reclamation realizations. Many offshore islands have been altered, frequently by filling up the spaces between tiny islands to form solid landmasses.

95% of Singapore's mangroves have disappeared as a result of this development. The benefits of mangroves, such as protection against erosion and a decrease in organic pollutants, which both improve the quality of coastal waters, have been significantly reduced as a result of this loss. (Wong et al., 2008)

Despite the extensive industrialization and land reclamation operations that have harmed Singapore's aquatic habitats, greater effort has been made in recent years to tolerate and repair the impact. Environmental impact assessments (EIAs), which analyse the potential ecological effects of a specific developmental initiative as well as viable solutions to decrease the environmental harm, have received increased attention since the mid-1990s. For instance, once the project was commissioned in 1999, a thorough EIA was conducted for the construction of the Semakau Landfill.

According to the assessment, the 350 ha (860 acres) project's allotted coral reefs and mangroves were to be damaged. As a result, plans were made to replant the mangroves somewhere else and sediment screens were installed to keep silt from reaching the reefs that would otherwise be negatively impacted. And while these EIA rules are not mandated by any legislation, and they are not necessary for the official approval of land reclamation projects, the Singaporean government has been more receptive to suggestions from the general people for improved sustainability in future land developments. (Wong et al., 2008)

2.5.3. Political concerns - in the history and nowadays

Singaporean land reclamation around the turn of the century (especially between 1919 and 1923) was largely caused by a desire for more public amenities (such roads and railroads) and military coastal security. During World War II, when Singapore was controlled by the Japanese, attention was diverted from improving Singapore to extending Japanese culture. Thus, there was a pause in Singapore's industrialisation during this time, which persisted through the 1950s and the early 1960s (during which Singapore saw significant political transition) until the city-state's involvement in the formation of Malaysia in 1963. Singapore benefited from economic development schemes when it was a part of Malaysia and after it gained independence in 1965, which necessitated large-scale land reclamation operations. (Glaser et al., 1991)

In the 21st century, land reclamation has become a global sensation, including 106 out of 135 major coastal cities. Ports, businesses associated to ports, and residential and commercial uses make up the majority of the land uses on reclaimed land so far. (Chen et al., 2023)

One of the potential problems with expansion of countries and city-states, much like Singapore, is that neighbouring countries might not be very enthusiastic about their next-door neighbours expanding their influence over the surrounding area. While for Singapore, land reclamation is an important part of their economic growth, Malaysia may view as land grabbing.

Malaysia complained to Singapore in 2003 over land reclamation initiatives at each end of the Straits of Johore, which divide the two nations. Malaysia formally challenged Singapore under the UN Convention on the Law of the Sea on the grounds that Singapore's intentions infringed on Malaysian territory and were harmful to the environment and the lives of local fishermen. Arbitration was used to resolve the disagreement. (The Economist, 2015)

More recently, accusations against Malaysia about the latter's two land reclamation projects in the Straits of Johore were made by Singapore. In one proposal, four islands in the strait would be created and connected, resulting in Forest City, a new city that Malaysia hopes to market as a horticultural oasis with buildings covered in vegetation and an astonishing stretch of public transportation. After Singapore complained against

the project's development in 2014, work on it allegedly came to a standstill. However, the Malaysian government reportedly authorized a scaled-down version of the project in January 2015. (The Economist, 2015)

Regarding land reclamation projects, there are also territorial disputes in the South China Sea. (Center for Preventive Action, 2023)

2.5.4. Land usage planning

In the near future, it is highly likely that land-scarce Singapore will continue to consider reclamation as a means to address the needs of its expanding population. The Ministry of National Development strongly emphasized in the 2013 Land Use Plan that an additional 5,600 hectares of land ought to be made available by 2030, which could potentially be one of suitable solutions, considering the estimated population growth – Singapore is expected to reach anywhere between 6.5 and 6.9 million in the meantime, although precise figures may vary. (Ministry of National Development, 2013)

However, it is important to acknowledge that there are numerous limitations and matters to consider when it comes to land reclamation. These include the aforementioned escalating costs associated with importing sand, potential environmental repercussions, as well as the impact on shipping routes, and territorial constraints. Recognizing these challenges, Singapore is actively exploring alternative approaches to maximize its land capacity, aiming to move beyond solely relying on aggressive land reclamation. These alternatives encompass various strategies such as the development of reserve land, intensifying land usage in emerging developments, as well as repurposing and rezoning former industrial areas and leisure zones for more practical and beneficial purposes. (Ministry of National Development, 2013)

2.5.5. The Float – World's largest floating stadium

The largest floating stage and football stadium in the world is The Float in Marina Bay. It was constructed in 2007 to serve as a temporary location for events typically held at the National Stadium in Kallang while it was being rebuilt as part of the Singapore Sports Hub project. These events included football games, concerts, art exhibitions, and celebrations like the National Day Parade (NDP). The floating platform, which can accommodate up to 9,000 people, is secured to the ocean floor by six pylons so it is not really floating, however it does allow for water to flow under it. An estimated 27,000 spectators may fit in the separate stand, which is placed on the coast right next to the field itself. For reference, the biggest stadium in Slovakia, Tehelné pole, can accommodate 22,500 people, 4,500 less than the Float´s grandstand. (ŠK Slovan Bratislava, 2022) , (Marina Bay Sands, 2023), (Goh, 2007)

Figure 18- The Float and it´s grandstand (stadiumguide.com)

Although the platform is the size of a football pitch, it has not ever hosted a match the Singapore national team and has rarely been used for football matches. (For instance, the platform was the playing ground of one of the matches of the ASEAN Football championship in 2014.) (E1looditor-Interpcan 2020) The stadium has mostly been utilized for live show performances, celebrations, and neighbourhood gatherings. The Float in Marina Bay was only supposed to hold events for five years, but because of

delays in the new Singapore National Stadium's development, it has been in use for longer.

The Float will be demolished, rebuilt, and renamed to a permanent venue known as NS Square—which will expand upon The Float with a capacity for 30,000 and include a multi-purpose space for community activities as well as a museum dedicated to the national service of the country. The Float will continue to serve as the primary venue for the NDP (outside of those held at the Padang every five years). Deconstruction of The Float, which was created by local architects WOHA, started in 2023, and NS Square should be finished in 2026. (Min, 2020) , (Lee, 2023) , (Zhang, 2019)

Figure 19-- a Depiction of the potential look of NS Square (channelnewsasia.com)

2.6 Various land reclamation projects

In coastal countries like the Netherlands, where around 17% of the present country's territory has been reclaimed from the sea or lakes, land reclamation has been taking place for centuries. Massive land reclamation initiatives are a relatively recent development that have gained popularity in regions with an abundance of shoreline but insufficient mainland to meet their demands. (Rosenberg, 2019)

For a variety of purposes, including the construction of ultra-modern housing developments and an entertainment archipelago complete with hotels, restaurants, theatres, and retail establishments, these projects can produce land where there was previously sea. A few instances of worldwide land reclamation are provided in this chapter.

2.6.1. The Palm Jumeirah, Dubai

The Palm, which resembles a massive palm tree extending into the Persian Gulf (see fig. 19 below), is on of the most recognizable land reclamation sights in the world. It has an 11-kilometer breakwater surrounding it, is visible from space, and has a dedicated train for getting about the artificial archipelago. On the Palm, however, do not expect to find inexpensive homes as it is proved to be more of a millionaire's haven. Ten nautical miles from the islands, around 120 million cubic meters of sand had to be excavated and transported across from the Persian Gulf's bottom. The Hajar mountains in the northern UAE were mined for more than seven million tons of stone. (Hosseini, 2021)

A larger land reclamation project nearby named The World is constructed like a map of the world, with individual islands standing in for each nation. Dredging operations started in 2003, and while construction was put on hold during the 2008 global financial crisis, several of these islands are now privately held. Due to its distinctive shape, Palm Jumeirah is one of the most well-liked tourist sites in the Middle East. (Elliott, 2021)

Figure 20-The Palm (traveldigg.com)

2.6.2 Lantau Tomorrow Vision, Hong Kong

One of the world's most densely populated nations, Hong Kong requires additional room to accommodate its expanding population. A major land reclamation project called Lantau Tomorrow Vision would build man-made islands off the coast of Lantau Island.

40% of Hong Kong people oppose the proposals due to the project's outrageous cost of HK$624 billion, despite the CEO of Hong Kong Carrie Lam's assertion that it might provide up to 1.1 million additional residences. A local journalist recently requested an administrative review of the proposal, but the Hong Kong High Court denied the request. (The Economist, 2020)

The first residents of Lantau Tomorrow Vision will not begin to occupy the area until 2034, therefore there is still much work to be done. (J. Ng, 2020) , (The Economist, 2020)

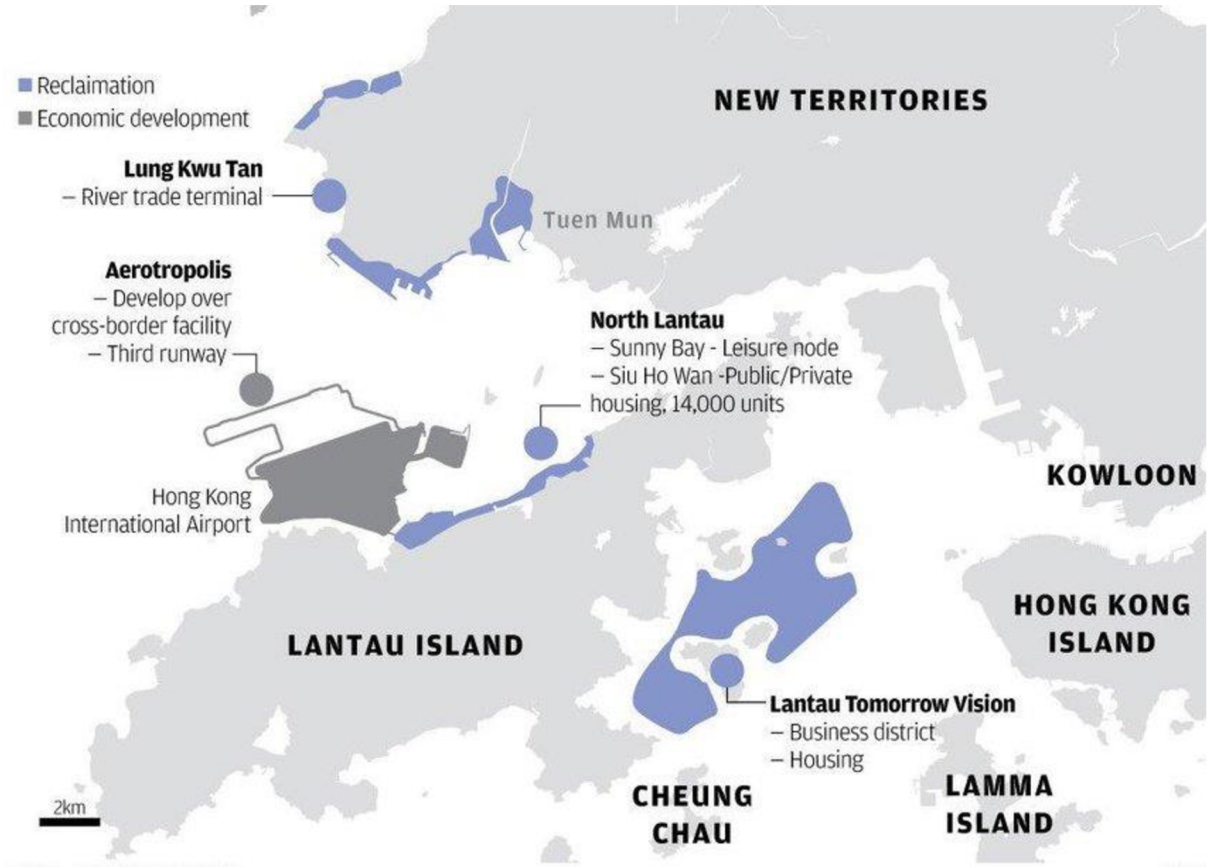

Figure 21- a map of the planned expansion (researchgate.net)

2.6.3. The Great Garuda, Indonesia

The city of Jakarta is sinking at the fastest pace in the world, at up to 10 centimetres every year. The soil has sunk 2.5 meters in North Jakarta, an area that over the past 10 years, has been particularly prone to floods.

This is mostly caused by the overuse of groundwater for industrial and commercial purposes: The land atop a subterranean well dips when water is pumped out of it. 40% of Jakartans do not currently have access to piped water. The majority of them eventually turn to performing their own groundwater extractions. The quickest and least expensive method of extracting water, according to Isnu Sulistyawan, director of the Groundwater Conservation Center for the Ministry of Energy and Mineral Resources. (Ng & Rivai, 2022)

But groundwater extraction is not the only cause for the problem at hand. The lowland plain on which Jakarta is built is low and flat, with historically sizable muddy sections. The city's interior areas are placed a little bit higher. In the wet season, it is frequently flooded. The threat of floods has grown as a result of the draining of marshes for construction and the ongoing decline in upland forest cover (Waworoentoe, 1998). What this means is that a large portion of North Jakarta was once swampland but has since been developed into housing developments, shopping malls, and factories. In reality, due to the increasing demand for residential and commercial space, every corner of the city is now occupied by residential structures or shopping malls, and the skyline is dotted by a rising number of buildings, which puts an enormous strain on the soil underneath. (Ng & Rivai, 2022)

One of the plans to save Jakarta was a land reclamation project called The Great Garuda.(see fig. 21) Originally, the project was a component of the National Capital Integrated Coastal Development (NCICD) plan, which aimed to construct a bulwark to keep water out of the city and to reduce sinking and erosion. The Great Garuda project, named after the mythological bird on Indonesia's coat of arms, intended for the construction of 17 man-made islands off the island's northern shore.

The construction of four of the islands has already stopped due to project resistance. Communities who depended on fishing for a living were also opposed to the land reclamation project due to the pollution it caused. (Heriyanto, 2016), (Yucel, M. et al., 2016)

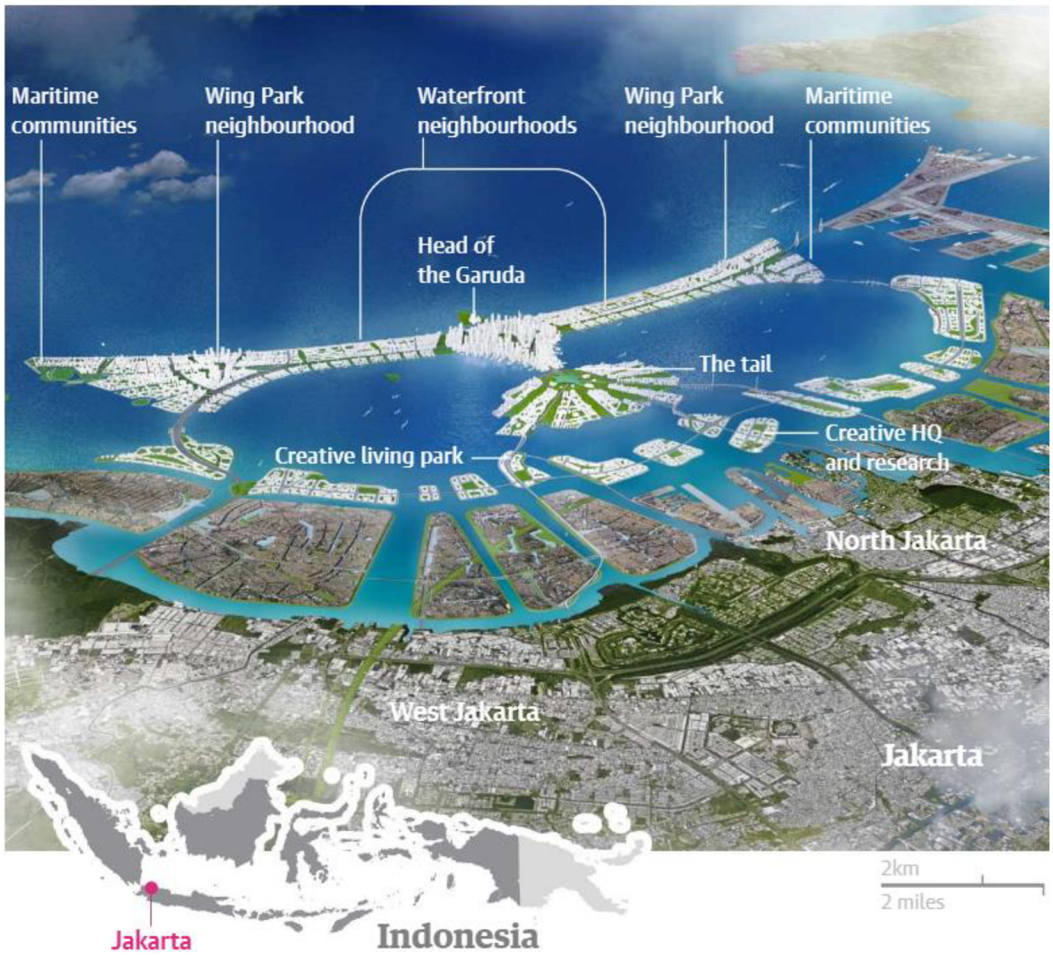

Figure 22-- A graphic depicting the plan of the Garuda (NCICD)

2.6.4. Eko Atlantic City, Lagos, Nigeria

Eko Atlantic City is a planned community being built in Lagos State, Nigeria, on land that was once part of the Atlantic Ocean. When finished, it will be able to hold at least 250,000 inhabitants and 150,000 commuters per day. The construction site is situated on Bar Beach in Lagos. The city is being constructed as a response to the persistent real estate shortage in Nigeria's most populated metropolis. About ten districts, including a central business centre, neighbourhoods, a marina, and an artificially created island are anticipated to be built inside the city. Additionally, the city will have autonomous water and electricity delivery systems. Construction on the project started in 2008 after it was initially proposed in 2003. The project's initial phase was finished in 2013. In 2019, the first residential tower in Eko Atlantic City was completed and opened for use. (Mongalvy et al., 2018)

A company called South Energyx Nigeria Limited, a division of the Chagoury Group, is building the Eko Atlantic City. (Eko Atlantic City | DEME Group, 2009) The project is expected to cost $6 billion, according to a 2021 article on Construction Review Online. (Mwenda, 2022)

Figure 23- Eko Atlantic city construction (ekoatlantic.com)

In the year 2020, @AfricaFactsZone on Twitter published photos of an Eko Atlantis City project property that was put up to sale for 2.5 million dollars. This has caused a wave of backlash on social media, as people criticised the pricing of the apartment as well as the rather unappealing visuals. Since then, the pictures were deleted from the tweet. In the same year, a YouTube content creator under the name Tayo Aina published a video about the apartment, and the criticism from viewers revolved pretty much around the same topic. On the picture below, is the view from the balcony in 2020. (Tayo Aina, 2019) Of course, what needs to be taken into account is that while the futuristic metropolis of Eko Atlantic continues to expand, it is probable that more (and more favourably looking) footage will come from their marketing team.

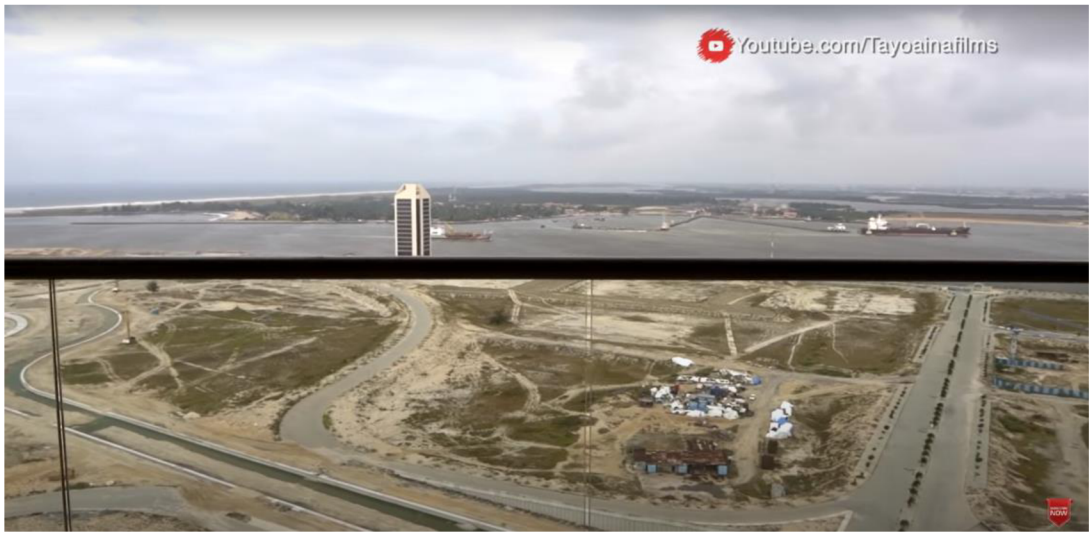

Figure 24- The view from the Eko Atlantis apartment in 2020 (YouTube – Tayo Aina)

3. Awareness and knowledge

As mentioned, Florida is one of the areas suffering from floods and similar problems, and it is predicted to only get worse. However, not everyone knows about that, and the more people are engaged, the more likely it is to get a bigger group of people actually look for solutions. Some people were a bit taken aback by what a Formula 1 racer Sebastian Vettel did at the inaugural Miami Grand Prix Last season: Sebastian chose to wear a t-shirt somewhat sarcastically captioned: "Miami Grand Prix, The first Grand Prix under water – act now or swim later! ", (see Fig.12) thus, spreading awareness about the problem of the rising sea level. And so, the 4-time world champion of the sport kept up his reputation of pointing out the uncomfortable truth, even though the sponsors and other people in power might not support such behaviour.

Figure 25– Sebastian Vettel wearing his Miami 2060 t-shirt. (Sky Sports F1)

3.1 Dangers of quick solutions

What needs to be understood here, that being informed and educated could be the difference between making it through and failing to stay un-submerged. It is very important not to fall for quick solutions and keep one's mind open about possible ways to deal with these issues. Japan for example, as an island country, demonstrated willingness to invest and engage in development of technology needed to position itself better against not only the rising water level, but phenomena such as tsunami and land erosion as well.

However, after Japan´s government invested heavily in concrete barriers in the last 10 years, many drawbacks began to appear. Firstly, after a tsunami hit, a more or less natural recovery takes place, if one does not account for damages in artificial infrastructure. This

natural recuperation is under danger due to these walls in a variety of ways. Seawalls, some of which are 45 feet in height and over 150 feet wide, can obstruct the circulation of water, sand, and natural organisms between land and sea depending on their layout and position. They, together with coastal highways and earthen embankments, have the ability to physically destroy tidal flats, dunes, and other crucial ecosystems. Therefore, the building of these structures may significantly damage natural environments. (Bird, 2013) Secondly, and this is much more related to the issue at hand, is land erosion.

As mentioned before, vegetation such as mangrove prevents land erosion by breaking down sea waves and easing up the impact of those waves on the shore directly. Without this natural buffer zone, the current hits the shore with full force, over time damaging and washing away the soil. Substitutes such as tetrapods (See fig.13), pointy concrete structures which were thought to have similar effect such as mangroves, have proved less efficient than desired.

Figure 26–– Japanese sea barrier with tetrapods (arstechnica.com)

While sea barriers and tetrapods help Japan in the short term by reducing the effect tsunamis have on the human coastal communities, they do not help the situation from the long-term point of view, by obstructing the local fauna, and accelerating land erosion. (Baird, 2016) The nation's tidal flats covered roughly 84 thousand hectares in 1945; by 2001, reclamation for agriculture, industry, and housing had brought the total down to fewer than 50 thousand hectares. According to the Ministry of Agriculture, Forestry, and Fisheries, between 1988 and 2001, seagrass beds were destroyed on almost 55 thousand hectares. Another significant issue is beach erosion. Additionally, less and less beach is left for endangered species to flourish or for sea turtles to lay their eggs due to waves smashing right on seawalls in numerous locations. (Bird, 2013)

4. Inspiration in science fiction

It would be fair to say that the designs for floating cities undeniably look very sci-fi inspired. Until the first floating city will be floating, the image of people living on water will almost seem like science fiction. Similar themes have occurred in pop culture numerous times. For example, the post-apocalyptic movie “Waterworld” represents an artistic interpretation of people forcibly moving off-land, scattering all over one giant ocean that was once the Earth´s surface. In this movie, people live on wooden and metal vessels, or sometimes on more of them connected to each other – a bit like the Oceanix floating city will work. Let us only hope that our landscape will look different to that of Waterworld´s by the time the Oceanix floating city will come to fruition.

The Shimizu TRY 2004 (See fig.8) was inspired by the now classic 1982 science fiction movie “Blade Runner”. Originally appearing as the Tyrell Corporation headquarters in the picture, the story is that one of Shimizu engineers decided to see this movie after a day of work, liked the design and told his co-workers about it later. Ten years later, the company found itself applying for a patent in London.

5. Plans and ideas for the future

5.1. Shimizu TRY 2004 Mega-City Pyramid

The projects planned for fighting the sea level rise, and create more land for people to exist on, are drafted more and more by the day. By far, the most outlandish and enormously spacious is the concept proposed by the aforementioned renowned Japanese corporation – Shimizu. The same corporation that built Japan´s first bank, first nuclear reactor, and much else, came up with yet another idea, only this time far more ambitious. The TRY 2004 mega-city pyramid would be over two kilometres in height, could accommodate 750,000 people (potentially even 1 million), making it the biggest and most populous man-made structure in the world. (Shimizu Corp., 1996) In reality, the size of the pyramid is such that the weight of the materials needed to construct it would be impossible. Future availability of robust, lightweight **carbon nanotube** technology is a requirement for the design.

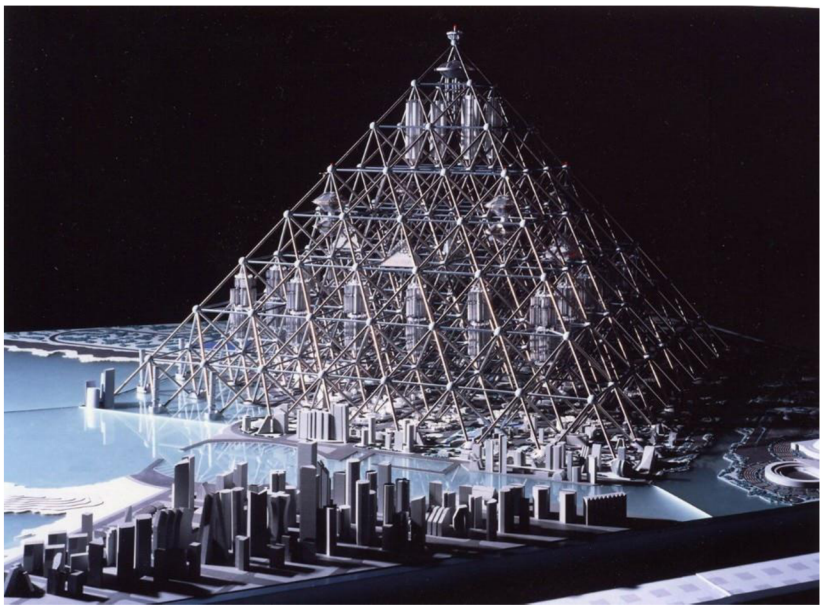

Figure 27- Shimizu Mega City Pyramid Concept

To ensure smooth and efficient transportation for the residents, People will employ a continuous circulation transit system that includes elevators in diagonal shafts to go vertically around the city. For lateral movement, residents will make use of a brand-new linear-motor transportation system installed inside the horizontal shafts. People will utilise moving walkways, escalators, or corridors to get from a node to a building.

Elevators will be used by people within buildings. For vertical conveyance, the city's distribution system will rely on a continuous circulatory transit system. The automatic transfer loader will then load items onto a container carriage or conveyor belt at each node for automatic horizontal delivery. The structure itself would be placed over the Tokyo Bay. But seeing as Shimizu patented this concept in multiple countries across the world, they planned for exporting this idea too. (Bento, 2018)

5.2. Pangeos Yacht (Saudi Arabia)

Pangeos is a proposed turtle-shaped yacht that would become the biggest sea vessel ever built and would effectively serve a huge floating metropolis. The Lazzarini Design Studio created and put out the project. The firm, which is located in Rome, uses 3D technology to depict designs and concepts. Pangeos' planned dimensions are enormous. If it were built, it would be the biggest moving vessel ever built. Its projected measurements are 610 meters in width and 550 meters in length. According to Lazzarini,

Pangeos can hold 60,000 people in addition to an undefined number of crew and personnel. (Buckley, 2022) There would be enough room for 69 apartments and 19 villas on each side wing of Pangeos. (See fig. below for visualization) On the rooftop shell, there will be 72 terraces. Some will overlook the central port area of the ship, while others will offer sea views.

Figure 28- Inner space of the yacht architecturaldigest.com (Lazzarini studio)

The Pangeos is anticipated to have a peak speed of just five knots (5.7 miles per hour/9.2 kilometres per hour), powered by nine 16,800 horsepower electric engines. Boats rarely deviate from the typical sharp “V” shape since the objective is often to reduce drag, and

they even less regularly take the appearance of marine life, but Pangeos's flippers represent more than simply a strange sight. The business claims that the outside edges will absorb kinetic energy from the waves, enabling the boat to continuously sail without emitting any pollutants. If more electricity was required, solar panels would also be installed on the roof; electric engines are also incorporated into the design.

Visitors can choose between using a different maritime vessel or an airplane to get from the Pangeos to other areas. On board, a port for other vessels will be built, and an "upper shell area" will provide access for flying objects.

A huge floating metropolis is not going to be inexpensive to build. According to Lazzarini, the development of Pangeos will require an investment of $8 billion. In order to raise money, there is an NFT crowdfunding project in the works - cryptocurrency could be used by backers to purchase virtual space on Pangeos within the metaverse.

Pangeos is still in the conceptual stage right now. However, the futuristic floating city's development is expected to start in 2033, with an estimated build time of around 8 years. To start construction, a seabed area of around one square kilometre would need to be dredged. Water levels would be managed at the building site using a circular dam. (McLaughlin, 2022) (Cormack, 2022) (Buckley, 2022)

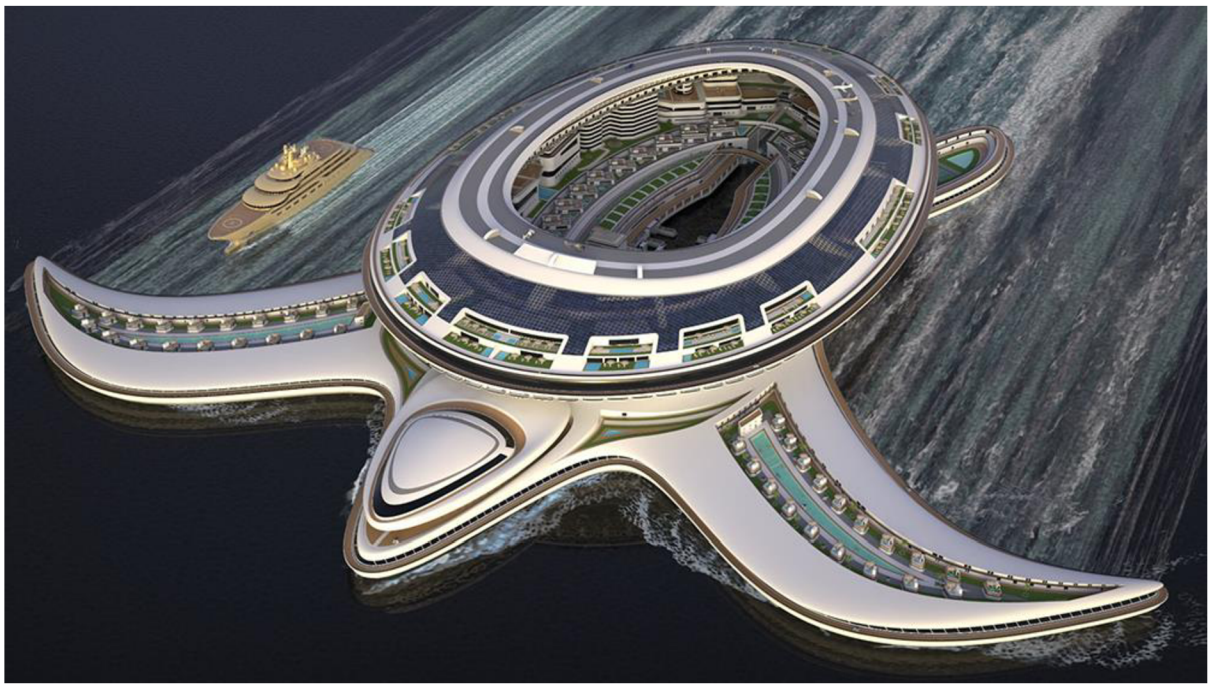

Figure 29- Pangeos yacht from the outside.- architecturaldigest.com (Lazzarini studio)

5.3. Ishikari Bay New Port offshore windfarm

Shimizu are no strangers to building parts of infrastructure offshore. The plans for their currently ongoing project, The Ishikari Bay New Port offshore windfarm (See fig.15), are currently being realized by Shimizu Corporation along with Nippon Steel Engineering Co., Ltd. Placed in between the Ishikari City and Otaru City, located on the Hokkaidō Island. The new windfarm is going to be the largest of its kind in Japan, occupying an area of approx. 500 hectares, placed 1,600 meters from the shore. Assuming the turbines will need maintenance and repairs regularly, this is one of the key advancements in building parts of infrastructure offshore, seeing as the turbines will require access by boat, as a consequence of not being connected to the shore, just like floating cities. Of course, the components need to be carefully transported to the site before the assembly can begin. The highest point of the blade on the 8 MW wind turbines, is 190 metres high, making them the tallest offshore wind turbines in Japan when they are finished. The wind turbines are made up of a 90-meter tower, an installed motor unit, and three blades that each measure 80 metres in length. (Offshore, 2022) This of course makes the transportation to the construction site much more difficult. That is why Shimizu plans to use special “SEP”(Self-elevation platform) vessels, may move them while still having their whole tower for quick installation. With other SEP boats, the tower could be split into two pieces and erected offshore depending on the main crane's capability and the loading capacity of the vessel. Due to the numerous planned journeys between the base port and the building location, it is predicted that construction would take around four months. Shimizu claims that the work can be finished in two months using its specially designed vessel. By reducing the SEP vessel building time and costs, it is possible to increase the profitability of the power generation industry.

Additionally, as wind farms and turbines grow in size, the efficiency of this technology used in construction will have a considerable influence on the time and expense of the project. Developers of offshore wind farms both in Japan and elsewhere may find their SEP vessel usable on their projects because of this. In the future, it is likely that floating city developers will resort to similar methods of transportation of materials and components, due to the expected increase in scale of operations.

Demand for energy is rising as a result of the Japanese government's goal to reduce greenhouse gas emissions to zero by 2050 and an impending energy crisis brought on by Russia's invasion of Ukraine. One of the most promising renewable energy sources offshore is wind, so building projects of this kind are becoming important both domestically and abroad. Shimizu indicates that they want to increase contracts and take on more responsibility for the development of offshore wind farms. (Shimizu Corp., 2022)

Figure 30– A computer graphic depicting the Ishikari Bay New Port offshore windfarm upon completion (image provided by Green Power Investment Corporation)

Conclusion

Through research and presentation of the information on multiple floating city projects, an understanding of how floating cities work was formed. Based on this understanding, the impacts on environment surrounding the structures should prove positive, provided the presented technologies and techniques such as Biorock and magnesium extraction presented by Shimiz, will be implemented as planned, and resources will be provided in a sufficient manner, so that the designers of these constructions will not need to switch to cheaper, or less environmentally responsible counterparts. The lack of floating cites already built comes from the fact that construction and development of these projects and materials for building them are both time-consuming and financially demanding, plus in some cases, like the they plan to be independent and separated from any government on land.

What has been explored to a larger extent is land reclamation, most famously in the Netherlands, Singapore, and Saudi Arabia. Unlike the Floating city projects, these parts are connected to the mainland by the soil on which they sit on or extend from the shore itself. Nevertheless, rapid progress can be seen on multiple fronts regarding the advancement of technology for building, powering, and supplying such structures, which does encourage the possibility that floating cities could be one of the solutions for overcrowding in coastal areas, and rising water level, provided the properties will be affordable for the average citizen previously living by the nearest coast, not just wealthy individuals seeking a residence outside the influence of governments, or simply seeking a vacation home.

Rozšířený abstrakt

Protože většina lidí je zvyklá žít především na souši, může se koncept plovoucích měst zdát zpočátku neobvyklý a neznámý. Tyto ambiciózní projekty byly navrženy jako potenciální řešení problémů, které představuje stoupající hladina moře a přetížení pobřežních oblastí obyvatelstvem. V podstatě se jedná o výstavbu městské infrastruktury na speciálně navržených platformách, které se promění v plovoucí městské prostředí. Smyslem těchto projektů je vytvořit další obytný prostor nad rámec tradiční pevniny s cílem obstarat různé důležité funkce, jako je produkce potravin, výroba energie, zpracování odpadu, kontrola množství uhlíkových emisí, a dokonce i podpora růstu korálů a mangrovníků.

Hlavním cílem této práce bylo prozkoumat existující prameny týkající se plovoucích měst. To zahrnuje zkoumání historických souvislostí, technologických koncepcí a postupů, současného stavu techniky, posouzení důvodů, proč tyto myšlenky dosud nebyly realizovány, a možných budoucích směrů výzkumu a vývoje. Je důležité poznamenat, že ačkoli v současné době neexistují žádné plně funkční prototypy, očekává se, že se tato situace v blízké budoucnosti změní, neboť se předpokládá, že dva významné projekty - vedené společností Oceanix a japonskou společností Shimizu - budou zahájeny během příštích tří let. Cílem tohoto materiálu je prostřednictvím diskuse o několika konceptech a vysvětlení jejich funkcí poukázat na absenci jednoznačného plánu pro plovoucí města a představit některé alternativní možnosti konstrukce.

S důrazem na potřebu zvážit spíše dlouhodobé přínosy, než krátkodobé úlevy se argumentuje, že k investicím do těchto technologií by se mělo přistupovat s pečlivou analýzou jejich dopadu na životní prostředí a jejich vlivu na komunity, které budou tato plovoucí města obývat. Je důležité postupovat obezřetně, neboť ukvapené a impulzivní zásahy mohou v konečném důsledku vést k větší škodě než užitku v dlouhodobém horizontu, což se může projevit jak na flóře, tak na fauně.

Poznatky o fungování plovoucích měst byly získány na základě komplexních studií a zkoumání různých iniciativ v oblasti plovoucích měst. Na základě těchto poznatků se předpokládá, že dopad na okolní životní prostředí může být příznivý za předpokladu, že navrhované technologie a techniky, jako je Biorock nebo metoda extrakce hořčíku navržená firmou Shimizu, budou realizovány podle zamýšleného záměru a budou

vyčleněny dostatečné prostředky, aby se projektanti neuchýlili k levnějším nebo životnímu prostředí škodlivým alternativám.

Omezený počet existujících plovoucích měst lze přičíst rozsáhlému plánování a nákladné povaze těchto projektů, včetně specifických materiálů potřebných pro jejich výstavbu. V některých případech se navíc předpokládá, že tato města budou mít vlastní nezávislé řídící struktury, což dále zvyšuje složitost jejich realizace.

Budování umělých ostrovů si získalo značnou pozornost zejména v Nizozemsku, Singapuru a Saúdské Arábii, kde se usiluje o rozšíření půdy připojením ke stávajícímu terénu nebo pobřeží. Naproti tomu koncept plovoucích měst nabízí alternativní přístup, který není přímo závislý na existujících pozemních strukturách.

Plovoucí města sice mají potenciál řešit problémy přelidnění pobřeží a stoupající hladiny moří, je však důležité poznamenat, že jejich funkčnost závisí na neustálém technologickém pokroku v oblasti výstavby, zajišťování zdrojů a dodávek energie. Aby plovoucí města skutečně sloužila jako řešení, je navíc nezbytné, aby byla dostupná a cenově přijatelná pro běžné občany žijící v pobřežních oblastech, a ne aby byla exkluzivními možnostmi pro bohaté, kteří se chtějí distancovat od vlivu svých předchozích vlád, nebo jen hledají prázdninové sídlo.

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