THE REPUBLIC OF TURKEY
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WATER-BASED ARCHITECTURE: A COMPARATIVE ANALYSIS ON CONTEMPORARY APPROACHES OF OFF-SHORE ARCHITECTURE

M.S. Thesis

BIRCE KOZANLI

ISTANBUL, 2012

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I certify that this thesis meets all the requirements as a thesis for the degree of Master of Architecture.

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Program Coordinator

This is to certify that we have read this thesis and that we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Science.

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January 6, 2012 Birce KOZANLI

ABSTRACT

WATER-BASED ARCHITECTURE: A COMPARATIVE ANALYSIS ON CONTEMPORARY APPROACHES OF OFF-SHORE ARCHITECTURE

Birce Kozanlı

Master of Architecture

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This thesis is an exploration of water-based architecture using different projects from around the world as case studies. Environmental issues like global warming and rising water levels are amongst the many reasons why humans may need to live on water. The focus of this study is the concept of water-based architecture that includes self-sustaining systems.

This study has been accomplished by doing extensive research and creating a compilation of projects that ultimately proves through the comparative analysis that self-sufficient water based architecture should become a more prominent focus of the architectural profession and needs to be seen as one of the possible solutions to address some of the present global issues, which have been introduced above.

The analysis begins with a section about water and its relation with humans, land and global warming and then goes into an explanation about the historical and contemporary approaches of water-based architecture. To finalize the off-shore water-based architecture examples that are at 'city scale' have been compared an analyzed according to selected design criteria.

The comparative analysis shows that most of the contemporary approaches to water-based off-shore city examples have self-sustaining systems and it is expected that these projects can be the key to reduce the impacts of environmental issues like global warming and rising water levels. Therefore, architects and designers should embrace the opportunity that water-based architecture offers in order to find new living environments for humanity.

Keywords: Water-Based Architecture, Self-Sustainability, Off-Shore, Global Warming, Rising Water Levels

ÖZET

SUYA DAYALI MİMARLIK: KIYIDAN UZAK MİMARİDE ÇAĞDAŞ YAKLAŞIMLARIN KARŞILAŞTIRMALI ANALİZİ

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Bu tez suya dayalı mimarlığın dünya üzerindeki çeşitli örneklerinin incelenerek araştırıldığı bir çalışmadır. Küresel ısınma ve suların yükselmesi gibi çevre sorunları insanların neden su üzerinde yaşamaları gerektiğinin nedenlerinden biridir. Bu çalışmanın odak noktası kendi kendine sürdürülebilen suya dayalı mimarlık konseptidir.

Bu çalışma, kapsamlı araştırma ve bir dizi projenin bir araya getirilmesiyle tamamlanmıştır. Yapılan karşılaştırmalı analiz ile kendi kendine yetebilen suya dayalı mimarlığın, mimarlık mesleği için daha önemli bir hale gelmesi gerektiğini ve daha önce belirtilen çevre olaylarının çözümü için bir alternatif olabileceğini öngörmektedir.

İnceleme bölümünde, su ve suyun insanla, karayla ve küresel ısınmayla olan ilişkisini açıklamakta, daha sonra tarihi ve çağdaş suya dayalı mimarlık yaklaşımlarını incelemektedir. Son olarak belirlenen kriterler ışığında kıyıdan uzak suya dayalı ve şehir ölçeğindeki mimari örneklerin karşılaştırmalı analizi yapılmıştır.

Karşılaştırmalı analizlerin sonucuna göre çağdaş suya dayalı ve kıyıdan uzakta tasarlanmış şehir örnekleri kendi kendine yetebilir özelliklere sahip olmakla beraber, projelerin küresel ısınma ve yükselen su seviyeleri gibi çevre sorunlarının etkilerini azaltmaya yönelik bir çözüm olduğu düşünülmektedir. Bu nedenle mimarlar ve de tasarımcıların suya dayalı mimarlığın insanlara sunduğu yeni yasam alanlarının getirililerini benimsemelidirler.

Anahtar Kelimeler: Suya Dayalı Mimarlık, Kendi Kendine Sürdürülebilirlik, Kıyıdan Uzakta, Küresel Isınma, Yükselen Su Seviyeleri

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

IPCC	:	Intergovernmental Panel on Climate Change
ACIA	:	Arctic Climate Impact Assessment

1. INTRODUCTION

Prologue: "Humans consist of 80 percent water, the earth consists of 80 percent water without water there is no life" (Hauser 2007).

Human civilization has blindly overlooked a crisis, a crisis which consequences have been progressively deteriorating our planet. Global warming and its impacts on rising water levels are irrefutable, and the facts have been presented extensively through scientific research. Global warming, climate change and rising water levels are issues of great consequence that can no longer be overlooked. The implications that global warming and rising water levels' pose to the future must be embraced and the devastating consequences that will impact the world's population must be acknowledged. Professions like architects/designers and engineers will play a pivotal role in this process of adaptation. They must look at how water levels will be affected by climate change and how water will be a major element shaping world's future and the way this will impact the approach to the built environment. This thesis's aim is to pose the following questions which through the research and analysis this thesis will seek to answer, how will architects/designers and engineers be impacted by these changes the planet is going through and how will the profession adapt to the changing conditions?

Realistically, architects cannot solve the issue of global warming or prevent water levels from rising, but they can try to eliminate the negative impact of the industry of architecture on the planet through sustainable design. Architects need to produce designs that adapt to the changes caused by changing climates and rising water levels. Architects must realize the opportunity that water-based architecture provides. There are numerous examples of water-based projects that have been presented which shows that architects have started to seek to understand the implications of having to design water structures.

Architects and urban planners have to understand the importance of designing more efficiently, aesthetically and environmentally so that they can consciously design water structures and embrace water as a new building site. A range of strategies are being used and proposed from designs inspired by nature to those coming from technological innovation. Problems like overcrowding cities, lack of land, lack of resources, rising water levels attributed to global warming, curiosity and prestige are only a few reasons that lead to the design of structures to accommodate an adaptive way of living on water. This thesis seeks to explore the realm of futuristic water-based projects that have been designed around the world, and compare different examples with regards to select criteria.

1.1 SCOPE OF STUDY

The focus of this exploration will be on the concept of self-sustaining water-based architecture. This will include the idea of generating water-based architectural designs that include self-sustaining systems that don't rely on natural resources or produce harmful gases. This idea can be extended to include the use of alternative energy sources such as wind generators, solar and biomass energy that would produce electricity. Other design decisions that would contribute to a self-sufficient design would be allowing for the use of natural day light and the ability to take full advantage of the sun. Architects should seek to design in harmony with nature, so that they can reduce the impacts of global warming and adapt architectural designs that help address the issue of rising water levels.

This study has been accomplished by doing extensive research and creating a compilation of projects that ultimately proves, through comparative analysis, that self-sufficient water based architecture should become a more prominent focus of the architectural profession and that it needs to be seen as one of the possible solutions to address some of the present issues caused by global warming. Solutions to the issues of overcrowding cities, climate change and rising water levels are not included in the scope of this study.

The scope of this study is focused on the exploration of water-based architecture, which can be defined as having a direct relationship with water either physically or conceptually. The water-based examples that are related to water conceptually are dependent on water but not necessarily built on water (Referred to examples of water-based architecture that are listed in Table 4.5). The study begins with a section on the relationship of water, land and humans beings. It then presents evidence into the realty of global warming and its impact on earth. Next, the study provides information about the historical approach of water-based architecture. The following chapter then moves into the contemporary approaches in two groups, as built and un-built. Then the fifth chapter looks into the projects that are in city scale and off-shore. The selected projects will be briefly discussed and then the previously provided information will have set the foundation for the next part, which will seek to formulate a definition of offshore architecture by discussing them more in depth according to the criteria derived from the examples analyzed in the previous chapter As a conclusion the study will seek to emphasize the differences between different futuristic approaches of water-based architecture from a self-sustainability standpoint as well as exemplifying the importance of each project in minimizing its impact and contribution to environmental issues.

1.2 METHOD OF STUDY

The method of the study includes choosing and organizing a selection of projects covering a broad range of time throughout history and creating various templates to be able to analyse the projects by comparing them according to the underlying design principles of the projects. The only water-based projects which will be analyzed are the ones that are designed off-shore and the ones in city scale. These projects will be analysed and compared according to the criteria created by examining the characteristics of off-shore architecture examples. This study was accomplished through the review of literature and information which was found in varying media including press, books, articles, other thesis, seminar notes and internet resources.

2. WATER AND ITS TIES TO HUMANS, LAND AND GLOBAL WARMING

Water means everything for the planet and is inevitable when it composes ¾ of the planets area. As Wylson (1987) stated “Water not only provides a basis for man’s existence and a continuous challenge to secure its use, but it is a source of metaphysical symbolism, aesthetic pleasure and therapeutic value.”
In this chapter, water and its ties to humans, land and global warming will be examined in the context of architecture. First the interaction between water and humans will be discussed, secondly water and its relation with land will be examined as rivers & canals, lakes and seas, and then global warming and its relation with water will be explained.

2.1 WATER AND ITS INTERACTION WITH HUMANS

Water is one of the most important elements for humans and other living organisms in terms of existence and sustainability of life, and it also has become one of the influential factors on humans and on their designs. Also water is an essential part of life as a chemical component. According to research and studies conducted, life on earth originated in/from water, it then lead to plant and zoological life which came about through natures processes over an extended period of time. Even though, organisms evolved and started dwelling on land, they remained dependent on water for survival. This remains a reason as to why humans preferred living in close relationship with water if not live on it. As stated by Fischer (2008, p.6): “Examples of modern plans show that light, air and sun are no longer the parameters that determine a design. Water is becoming increasingly popular, evolving into a new trend, where architecture, innovation, light and water closely interact.”

In looking into the early ages, it can be found that philosophers like Thales regarded water as one of the four basic substances and emphasized the importance of water for the people of this time and it was also reflected in the architecture.He stated that the origin of all matter (arché) is water and he also believed that the earth rests on water, like a barrel that swims in the sea (www.thebigview.com 2011).

Settlements which were founded by water depended on it to give life to its plants in their gardens, as well as serve as a source of inspiration for their designs. Water has also played a crucial part in transportation and shipping, its versatility has served in curing patients and shaping people's views towards design. Waters influences on such a broad spectrum of daily human activities and interactions have made it indispensable.

Water also has a great influence on cities. The coastline, where land and water meets is presently getting encroached upon, but in the 18th century waterfronts were undesired, unattractive and undeveloped parts of cities. Thus, coastlines used to be the unplanned landscapes that were doomed to be regarded as the suburbs in the cities, which drew people away.

However, beginning in the second half of the 18th century, coastlines gained importance gradually. With shores beginning to be built upon, people began to realize that waters resourcefulness extended beyond facilitating trade, but that it could also be used for recreation. The fact that the curiosity for seas and coastlines increased affected urban settlement plans and different art groups. Shores became used more than ever before, a trend that has continued. As Mizuno (2007) stated "Almost 40 percent of the world population lives in coastal areas, less than 60 kilometers from the shoreline." Therefore the reality of rising water levels due to global warming is a great threat for the world and especially those who live along the coastline.

However, in examining water-based settlements throughout history, it is apparent that the relationship of cities with water has gone through changes with different preferences and ideas in time. Furthermore, the use of water has acquired unimaginable dimensions with the contribution of technology. Some examples of the technological contributions include: precautions taken for floods, mobile safety systems, airports on water, generation of energy, floating islands, personal islands and oil rigs. Considering the above technological contributions the components seek to address the issue of rising water levels, which have been attributed to global warming and have become a great threat, but these components as well as others have made it possible to live on water and provide an alternative lifestyle.

When compared to other living organisms, humans are especially dependent on water. From the beginning, humans understood that they needed to be near a water source in order to be successful in the struggle for survival. Water sources, with their different and rich ecosystems that support the existence of various plants and animals, were attractive places for early hunter-gatherers. Moreover, water also served as protection against attacks. Therefore, islands, peninsulas and swamps were commonly chosen as settlement sites due to the safety they provided to their inhabitants (Tabak 2006).

So it has been notable that the gathering of humans near seas and other water sources is not a new phenomenon. There is a lot of evidence showing that human beings lived near water since the onset of human civilization. With an increasing population and developing technology early humans began to change their living areas. As a matter of fact, the redevelopment of coastlines dates back to 10,000 years ago (Ryan 2010). The reason why coastlines are extremely important is the fact that proximity to water is required to satisfy basic human needs and it also is an aesthetic element that serves as a medium for transportation that facilitates trade. So settlement sites, where chosen for vital survival/sustenance reasons and later became attractive due to their commercial/economic appeal. Consequently, cities developed as well as the transportation and trade industries along with water and many of these cities became some of today’s metropolises.

Coastal structures also became diversified in terms of architecture with developing technology. Coastlines developed as seaports and other structures were built over time. Furthermore, barriers and breakwaters began to be built in order to protect the new coastline structures built.

According to Bender (1993), the reason why people settle along the coasts is because they were the first places they reached when they came from sea. The reason why they settled on the coastlines is because strategically having the ocean on one front facilitated the protection from attacks and therefore increased the security of their houses and land. In addition, it also allowed for trade, to make use of it for shipping, and it had a nice scenery and mild climate. Taking these into consideration, it can be said that water has always been a source of life, power, comfort, pleasure and has always been a symbol of renewal and purification (Tabak 2006).

All these features of water on architecture can be perceived by humans with their senses in different ways: these are visual, auditory and tactile. One of the most important features of water is its reflective property. The reflective property of water helps to add different meanings to architecture through effects like spatial integrity, depth, luminous effects, etc.

Fischer (2008) stated that, “The smell of the sea, the sound of a roaring river and the sheer infinity of the ocean are all aspects that make places on or near water so extraordinary.”

The place of water in architecture is not only important visually, but also aurally. Water’s aural effect is used for many meditation methods as its relaxing and restful features. Water can also be used to remove or hide undesired sounds in some noisy places. One of the most important features of water is that it can be perceived by the outer world and people, thus water has visual effects also. By using this effect, the visual impression of a building can be greater depending on the designer’s thoughts and conceptual exploration (Ozmert 1997).

2.2 RELATIONSHIP OF LAND AND WATER

The relationship between land and water can be observed in various ways on earth. Some of these relationships include the following; lakes, rivers, canals and seas. The areas where land and water meet and interact are called ‘coasts’. According to Webster’s, waterfronts are defined as: “The area of a city (such as a harbour or dockyard) alongside a body of water.” (www.websters-online-dictionary.org 2011). The most substantial and basic feature of coasts is its interaction between presence of water and water itself physically. This interaction changed over time, but it has always been a highly effective factor in the determination of characteristics and structures of cities. Water has always been one of the important elements of big cities and this element created various coastal typologies in cities. Some examples are Amsterdam, Tokyo, London, Manhattan, Istanbul, etc.

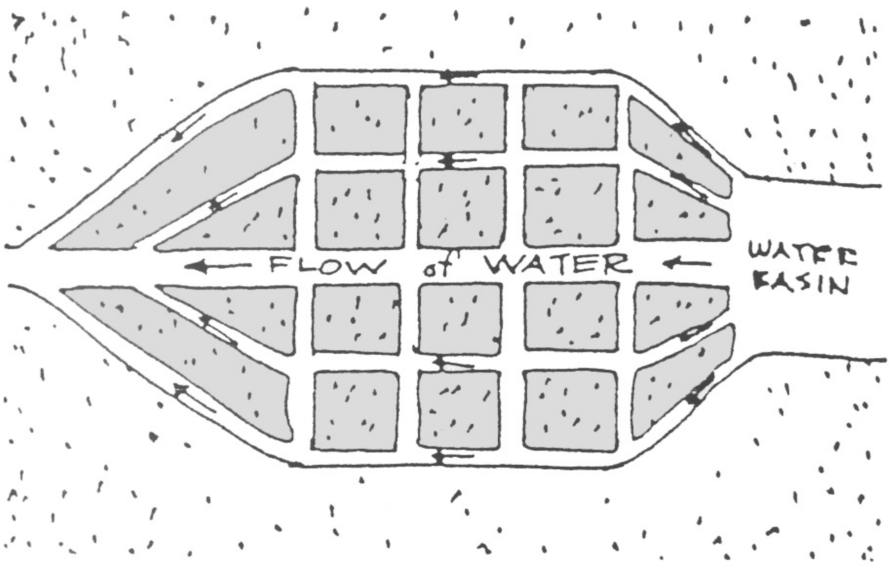
a. Rivers and Canals

According to Webster’s, a river can be defined as, “A large stream of water flowing in a bed or channel and emptying into the ocean, a sea, a lake, or another stream; a stream larger than a rivulet or brook” (www.websters-online dictionary.org 2011).

Canals and rivers typically come from a source and flow into seas or lakes. This feature is very similar to blood circulation in the human body. Water coming out from a source carries water necessary for natures systems to work much like the veins in human body, which carries blood and other necessary nutrients throughout our body. This circulation always continues just like the water in rivers and canals. It never stays the same due to the movement of water, caused by rain, drought and other circumstances. As Heraclitus said: "You cannot step into the same river twice, for other waters are ever flowing onto you." This can be interpreted as meaning that the water your step in is not the same you stepped in before, water changes, it always moves and never stays the same (www.thebigview.com 2011).

Leonardo da Vinci is one who passionately studied the movements of water. He conceived a river city sketch divided into many branches in order to find ‘the ideal city’. In this sketch, the river is divided into 6-7 branches according to the direction of the current. These branches are then combined with the river and they are used for different purposes. The undermost canal is designed for water and sewage and the middle canal is designed for canal stock and circulation functions. Finally the third and the topmost canal is the ‘gentleman’ of the city, which is designed to display the visual beauty and aesthetics of the city (Ozmert 1997).

Figure 2.1: Leonardo da Vinci’s ideal city



Source: Hattapoğlu 2004

Water has served as an essential means of transportation and shipping and it still remains commonly used, therefore cities near water sources developed through history. A perfect example for this is Egypt, which developed its trade, marketing and transportation through the use and interaction with the Nile River. Rivers, which influence cities in many ways are like a spine for the cities therefore many urban planning projects were designed considering the cities’ locations in relation to these rivers. Some examples include Manhattan and Philadelphia (Moore 1994, pp.78-79).

Rivers can also sometimes divide cities creating a parallel relationship to each other. An example of this can be seen in Manhattan, where the center of the city called ‘downtown’ is founded on a ‘grid’ based planning, which extends between the ‘East’ and ‘Hudson’ rivers. Many river cities through history were founded along one main river, an example of such being the Nile as stated above, in this case settlements occurred only on one side of the river. This decision was primarily based on where goods came from, river currents, soil fertility, safety conditions, climatic features as well as other factors (Kostof 1992, pg.40).

Figure 2.2: The Commissioners Map of the City of New York, 1807

Source: www.arkitera.com

b. Lakes

As stated in Webster's a lake is; "A body of (usually fresh) water surrounded by land." (www.websters-online-dictionary.org 2011). Lakes are landlocked water bodies which have different water characteristics, these are supplied by precipitation, rivers and underground sources and whose width and depth may vary. Lakes vary according to their formation types like, tectonic lakes, glacial lakes, mountain lakes, crater lakes, etc. They can also vary according to their size. Some lakes are formed on small plains while others, like the Caspian Sea, are big lakes considered to be inland seas.

The total surface area of lakes on earth is roughly 2.5 million km^2 and they are generally formed on river courses, and change depending on rivers' changing their beds. Lakes are common in places with abundant precipitation. Lakes may be seasonal in some places like in the Serengeti and in Tanzania where they are formed after yearly rains that continue for weeks. Much like the Crater Lake in the Southern Oregon, dead volcanoes may also become filled with water, creating a lake. Moreover, lakes may be created by building dams on rivers. So there are several ways for lakes to exist, and humans preferred areas around lakes for different reasons: defense, agriculture, fishing etc… (Moore 1994, p.122)

Lakes have been suitable sites for people to live around throughout history. It is known that humans were using the structure type and method of on-water shelters built on wood bases by penetrating piles in lakes between 4000-1000 B.C. These water-based villages were known as 'palafits'. The connections of these shelters and housing structures to land were established with wooden bridges and these bridges were removed depending on security and safety measures (Hattapoğlu 2004).

Furthermore, the settlements near Lake Ohrid, Macedonia and the housing surrounding the Lake in Urfa, which is called Balikli Gol are examples of lake based settlements. Examples of this project typology can be seen around the world. For example, the Pod Complex on Lake Ontario, Canada, Lake Michigan in Chicago.

c. Seas

A Sea is defined as “The whole body of the salt water which covers a large part of the globe.” (www.websters-online-dictionary.org 2011). As Verne (2010) stated:

> *The sea is everything. It covers seven-tenths of the terrestrial globe. Its breath is pure and life-giving. It is an immense desert place where man is never lonely, for he senses the weaving of creation on every hand. It is the physical embodiment of a supernatural existence... For the sea is itself nothing but love and emotion. It is the living infinite, as one of your poets has said. Nature manifests herself in it, with her three kingdoms: mineral, vegetable, and animal. The ocean is the vast reservoir of Nature.*

Oceans and seas are the beginning and the end of water circulation and also form boundaries between water and land. Their vast expanse can be attributed to precipitation, rivers and other sources. Oceans and seas are large surfaces where significant amounts of evaporation occurs, but this eventually comes back to earth in the form of precipitation and gets recycled back into the water ways. As it is known, life started in oceans according to the evolutionary theory; cool waters of oceans gave life to many living organisms for thousands of years. From the onset of the first settlements to today, all civilizations have given great importance to seas and have benefited from maritime transportation, which is a vital feature of coastlines. Different settlement arrangements were seen in coastline cities throughout history according to different functions like industrial, residential and commercial buildings. Except on river courses, international trade was provided by means of sea transportation routes connecting continents. Therefore, intercontinental trade was developed with the foundation of coastline civilizations.

Coastline civilizations developed by means of trade routes therefore many civilizations were founded throughout history. For example, Cretans, Achaeans (Mycenaeans), Phoenicians, etc. city states like Venice and Genoese in the Renaissance Period of Italy and Britain in the 19th century were the biggest and the most important coastline civilizations (Hattapoğlu 2004).

Development in connection to the sea first started in seaports, which later became essential to the Industrial Revolution. Afterwards, due to the abandonment of industrial areas in cities these coastal areas started to be used for other purposes. For example: Tokyo and Osaka seaports, Boston Seaport, etc (Additional information can be found in chapter 3 and 4).

There are also examples of under-sea structures that were built for touristic or scientific purposes in the past, for example The Red Sea Star Underwater Restaurant by Ayala Serfaty. Several studies have been conducted on projects such as underwater hotels, cities, museums in many parts of the world. One of the most famous architects is the French Architect Jacques Rougerie who has done major research on water structures in all kinds of scales and functions and designed many water-based projects like underwater habitats, vessels, sea centers and museums.

To sum up, water is an indispensable source of life for all living organisms and it is an undeniable fact that human beings have to be in a direct relationship with water, a natural and environmental component, and essential component in their lives. Also discussed were the different kinds of water bodies -according to its relation to land- that host the settlements on or around it and therefore the typology of the city depends on the relationship to water and the land upon which a project is sited.

2.3 GLOBAL WARMING AND WATER

Beginning with mass industrialization and deforestation, the environment was heavily impacted. These practices created pollution which affected atmospheric concentrations of water vapor, carbon dioxide, methane, and nitrous oxide and greenhouse gases increased and caused changes that can be directly linked to global warming and rising water levels on earth. As Peter F. Smith (2005) stated:

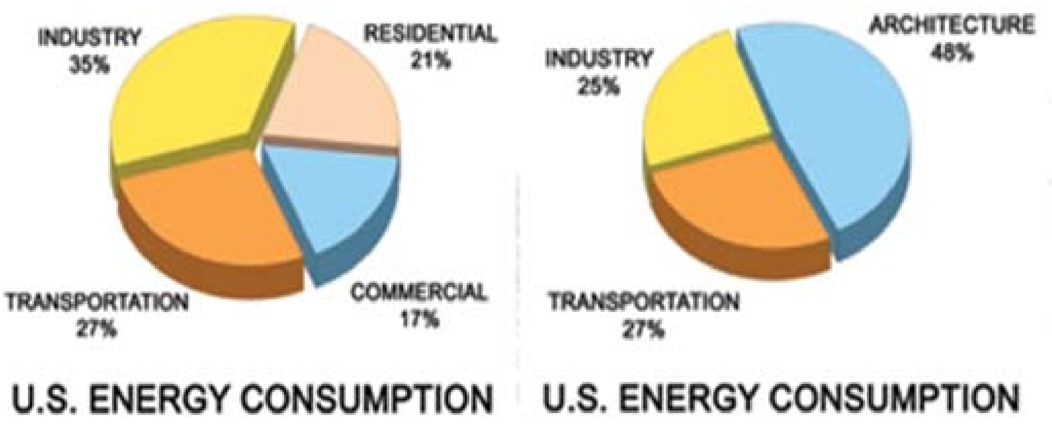
> *There is widespread agreement among climate scientists worldwide that the present clear evidence of climate change is 90 percent certain to be due to human activity mainly through the burning fossil based energy. This should be good enough to persuade us that human action can ultimately put a brake on the progress of global warming and its climate consequences.*

Also data from a February 2007, IPCC study reported that humans are causing climate change due to in great part to the chemicals used in manufacturing and other human processes. One significant influential factor is that through humans daily lifestyle practices excessive amount of carbon dioxide is being poured into the atmosphere much faster than plants and oceans can carry out natural processes which dissolve it. So it is designers place to consider their designs as being conscious of its surroundings and to place great importance on nature and the way they use its resources to create the built environment. While doing this, designers can also consider rising water levels and increasing population and design their projects in relation with water physically.

a. Global Warming Facts

It is stated that the major contributors to factors that cause global warming are; industry 35 percent, residential 21 percent, commercial 17 percent, and transportation 27 percent, and in combining the residential, commercial and also part of the industry, 48 percent of the greenhouse gases are being produced by buildings (Mazria 2003). As Mazria (2003) stated, 'We need to turn down the global thermostat' but it's locked. Who holds the key? It's the architects.'

Figure 2.3: Energy consumption in U.S.



Source: Mazria 2003

Many experts believe that humans are the major reason for the greenhouse effect which is called 'anthropogenic'. These greenhouse gases are basically the result of burning fossil fuels and the amount of gases that are being produced have reached the highest levels in time. It is known that climate change has been a natural issue for hundreds of millions of years, but in recent history it has been caused mostly by humans.

IPCC reported that, the horrible consequences of burning fossil fuels, by humans has caused recent histories climate change leading to a steady pace in which the world gets warmer. Earth has warmed at an extraordinary rate over the last hundred years and mostly over the last two decades. Since 1992, each year has been one of the 20 warmest years on record. Exactly how much warmer the atmosphere gets will depend on how quickly and effectively people can substantially reduce the activities that are causing rising temperatures (Scotese 2003).

With studies being done on global warming comprehending the facts started to help the environment and control the horrible consequences. In these studies alternatives to fossil fuels have been shown such as using solar, geothermal, wind and biomass energies instead of natural gas and fossil fuels. So as architects/designers our designs should be considering these alternative energy sources of operating mechanical and electrical systems of the buildings also the passive systems like passive ventilation should be used to reduce the impact on the environment and helping reduce factors associated to the design profession that go with global warming.

b. Glaciers Melting

Earth is often referred to as 'the blue planet'; the oceans have a significant role in protecting the world from climate change as well as other essential process, which have been increasingly disrupted by global warming. Global warming and greenhouse gases have caused changes to the oceans including ocean acidification, increased melting rates of glaciers, and rising water levels due to additional water in liquid form being generated by melting glaciers.

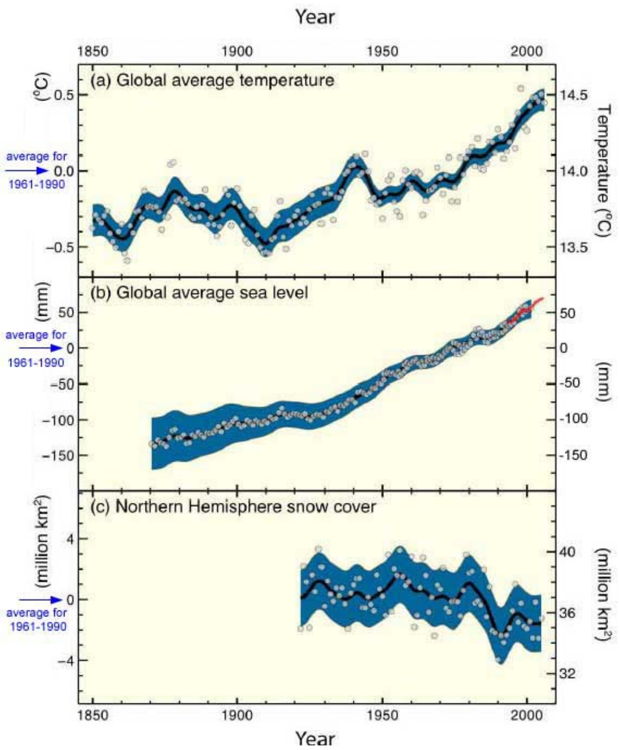
According to the Arctic Climate Impact Assessment Report (2005), climate change in the Polar region is expected to be some of the largest and most rapid, and will cause major physical, ecological, sociological, and economic impacts, especially in the Arctic, Antarctic Peninsula, and Southern Ocean (ACIA 2005).

The shrinkage of Arctic ice will not affect sea levels, because the Arctic ice cap is a sheet of ice 'floating' in water, much like ice cubes in a glass of water. If the ice cubes melt, they do not increase the level of water in the glass. In contrast, Greenland and Antarctica consist of large masses of ice resting on top of solid land, and melting of these ice sheets will raise sea levels (www.neaq.org 2011).

c. Rising Water Levels

"Even with a small sea level rise, we're going to destroy whole nations and their cultures that have existed for thousands of years", as stated by Overpeck (2004).

Figure 2.4: Rising water levels



Source: IPCC Report 2007

As a consequence of the change of climate, water levels started rising ay unexpected rates. Also, with the continually growing human population, some experts believe that people will need to start building mostly on water and create a ‘water world’ since there will be no suitable land to build on. As a result of this, new water cities will arise with housing, schools, hospitals, skyscrapers, cafes and bars.

If greenhouse gas concentrations stabilize, sea levels will continue to rise for centuries as the deep ocean slowly absorbs heat from surface waters and continues to expand. Many scientists think that sea levels will rise by at least three feet by the year 2100. However, even a rise in sea level of just a foot or two could have significant negative consequences for islands in the Caribbean and the Pacific, Netherlands and for low-lying coastal areas along North Carolina, and South Florida (IPPC 2007).

In 1995, 2.2 billion people lived within 100 km of a coastline, a figure which equals nearly 40 percent of the world’s population. Many of these people will be directly affected by increasingly severe and frequent storms and floods caused by rising sea levels. The issue, of course, of how much a low-lying shoreline retreats with increased in sea levels is. “A complex one and depends very much on the behavior of incoming currents, wave patterns, the structure, materials and form of the shoreline, and wave heights in that area and the care with which the coastline is managed.” (Roaf 2005)

Because sea levels are rising rapidly, land reclamation will need to occur more frequently and more intensely than ever before. To clarify, land reclamation can refer to either of two distinct practices: one involves creating new land from the sea or riverbeds, and the other refers to restoring an area to a more natural state. In either case, land is generally created for one of three functions: habitation, agriculture, or beach restoration (Pasternack 2009).

d. Hot Spots around the World

As a result of rising water levels, many coastal cities will be flooded. Low-lying coastal areas in Florida and Louisiana could be flooded by the sea. A 1.5 feet (50 centimeter) rise in sea level could cause the coastline to move 150 feet (45 meters) inland, resulting in substantial economic, social, and environmental impact in low-lying areas It is known that Greenland's ice sheet has enough water to raise the worldwide sea level by about 7 meters (IPCC 2007).

In addition, it is known that the most terrifying effects can be seen in the Arctic; Alaska, western Canada, and eastern Russia. With its glaciers melting rapidly the 'arctic region' may have its first completely ice-free summer by 2040 or even earlier. As a result of this, sea levels may rise around 18-59 cm by the end of the 21st century which will cause disasters like floods, large-scale food and water shortages. With only a rise of 10cm it may risk the islands on South (www.globalwarmingart.com 2011).

i. US Coastline & Architecture 2030

Beginning with just a one meter rise of the sea level, our nation would be physically under siege, with calamitous and destabilizing consequences. The U.S. is a coastal nation with over 12,000 miles of coastline. With 53 percent of all Americans living in and around coastal cities and towns, it is important to understand the impact of climate-induced sea level rise on our nation. Previous studies have focused on a six-meter rise. The following study takes a more conservative approach, beginning with a sea level rise of just one meter' (www.architecture2030.org 2010).

Figure 2.5: Rising water levels in U.S.

Source: www.architecture2030.org

1. Hollywood, Florida - 1-meter sea level rise
2. San Francisco Airport - 1.25-meter sea level rise
3. Boston, Massachusetts - 3-meter sea level rise

As we can see from the above images which are part of a study, US coastal lines are in danger because of rising water levels that are related to the effects of global warming (www.architecture2030.org 2010).

ii. Netherlands

Most of the research presented above pertained to the issue of water levels rising. Yet another example of a region that provides clear evidence of this problem is the Netherlands. The Netherlands is a geographically low-lying country, with about 25 percent of its area and 21 percent of its population located below sea level, with 50 percent of its land lying less than one meter above sea level. Significant land area has been gained through land reclamation and preserved through an elaborate system of polders and dikes. Much of the Netherlands is formed by the channel of three important European rivers and most of the country is very flat. The Netherlands proves to be a good source of information that is associated with the planning and consideration of the water levels rising. They have found several solutions to address this issue that could serve as the foundation to design principles for future developments. If in the Netherlands water levels were to rise 1 meter, half of the country would be flooded.

iii. Turkey

The effects of climate change can be seen throughout the world. Turkey is going to suffer some consequences as well. Istanbul Technical University claims that in terms of climate change, the future of Turkey is not so bright. The average heat is going to rise about 6 degree Celsius (www.kuresel-isinma.org 2010). In the last century, sea levels rose around 10-20 cm and by the end of the 21st century it will rise 40-60 cm more.

Figure 2.6: Rising water levels in Turkey

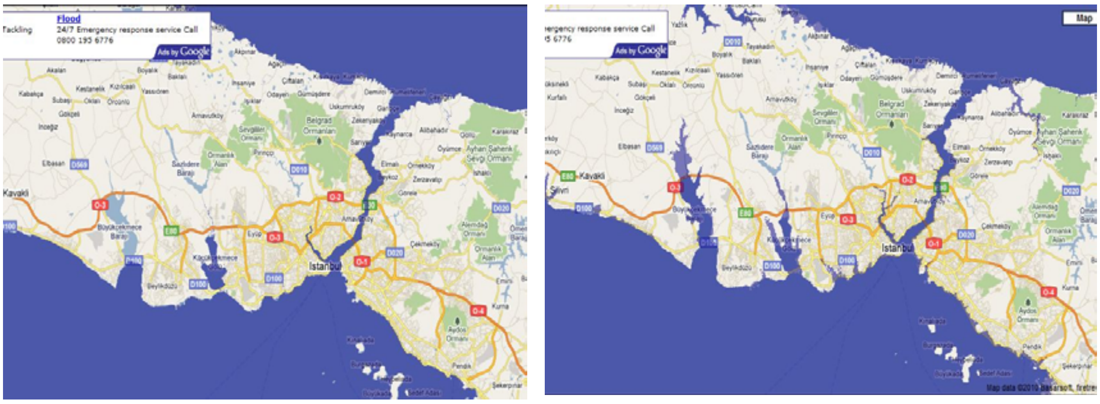
Source: Tabak 2006

As shown by the maps, some of the coastal areas in Turkey are in danger. And north-western part of the city Izmir, will go under water.

Figure 2.7: Rising water levels in Izmir

Source: www.flood.firetree.net

Figure 2.8: Rising water levels in Istanbul



Source: www.flood.firetree.net

In Istanbul: Golden Horn, Buyukcekmece and Kucukcekmece will be in danger when the water levels rise about 7 meters (flood.firetree.net 2010).

To sum up the facts of rising water levels are real, and the whole world will face the catastrophic results if designers, who can play a significant role in lessening the impacts don’t act, and take the precautions to design a more conscious built environment that includes less harming design solutions. Consequently the process of global warming and rising water levels and many more environmental issues can be handled by designing more efficiently.

3. HISTORICAL APPROACHES OF WATER-BASED ARCHITECTURE

In this section, the influence of water upon the designs of cities will be studied as well as the changing views towards water over time will be presented by examining how important water was for the biggest civilizations beginning with the first settlements founded on water. The changes in views towards water will be organized and presented based on assumed break points in certain periods throughout time.

When the importance of water is evaluated it's not only in terms of the sustainability of life, but also in terms of life styles and civilization levels of settlements changing and developing throughout history. It is seen that the relationship between many important and developed civilizations with water was an important effect in this development and that many of these trade centers contributing to these civilizations were on or near water sources. Water, with its cleansing feature, is a strong point in many belief systems determining society's life styles. For example: performing ablution in Islam, baptism in Christianity, the River Ganges being considered sacred by Indians. These factors like beliefs, trade, and defense have helped civilizations develop and expand throughout history. Therefore, the starting point of the first settlements and the archaic civilizations were generally near rivers or deltas.

The Tigris, Euphrates, and Nile are among a few rivers that have earned legendary status, not simply for their size, but also they link present time with the ancient cities and cultures that originated on their banks. Moore (1994) stated that:

> *There arose some of the earliest known civilizations, where writing, agriculture, and government first appeared. Ur, Nippur, Babylon, Uruk, and Sumer germinated in the flat plain –'the fertile crescent'- between two rivers. Mesopotamian hands filled the 'cradle' with mountainous ziggurats and hanging gardens (kept green by irrigation channels extending from the Twin Rivers), the first recorded wells and canals, and the ill-fated tower of Babel. Everything relied on the nutritive flow of water. The fact that ziggurats in Mesopotamian cities were built multilayered resembles the unique engineering resolutions of Egyptians from the floods of Nile.*

The Nile and its water permeate everything Egyptian, from the creation of myths of men and women springing from the tears of ‘Ra’ –the god of the sun-, to colossal temples with column forests capped with bundled river reeds, to hieroglyphic river symbols carved in pyramid tombs guiding travelers to the afterlife. Like a giant water ribbon, the Nile enabled the connection between all Egyptian cities, pyramids, villages, temples, and towns into one entity, creating a close knit network of an advanced civilization.

The Roman architect Marcus Vitrivious Pollio also wrote about the importance of water for Egyptians whose lives depended on the yearly flooding of the Nile valley. Ad Vitruvius stated:

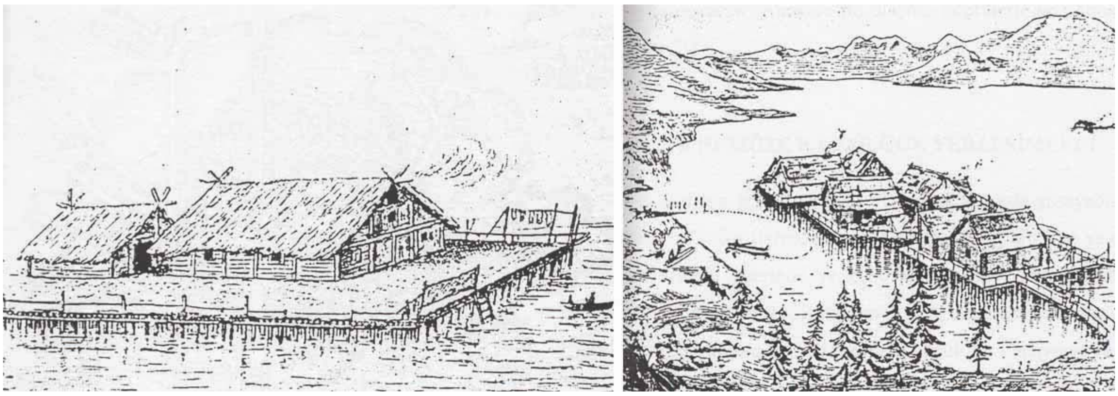
> *Hence also those who fill priesthoods of the Egyptian tradition show that all things arise from the principle of water. Therefore, after carrying water in a vessel to the precincts and temple with pure reverence, they fall upon the ground, raise their hands to heaven and return thanks to the divine goodwill for its invention.*

Also Moore (1994) stated that: “Every year, the overflowing river replenished the top soil in thin strips along each bank (beyond its reach was the sandy void of lifeless Saharan dunes), which changed the layout of the land and erased property lines and borders, limiting the civilization’s eastward or westward expansion.”

When we look at settlement history, we can see that human beings met their sheltering needs in some way beginning from the Paleolithic Age. This need led to cohabitation in time (in the middle of the Stone Age) and therefore humans formed villages. Some of these historical villages were built on water, called ‘palafit villages’.

The first findings with regards to palafits were that they were often built on lake shores, and sometimes along sea shores as well, among the most prominent examples was one found deep down in Lake Zurich, Switzerland. Apart from the examples for palafit villages in early ages, there were other recent settlements in Europe that chose to settle by the water bodies which were enclosed with hills in order to be protected from winds and floods. Piles with different lengths and diameters were driven into the ground depending on the properties and depth of the soil. The piles had to be supported with stones in hard soil as it was difficult to drive and stabilize the piles. Precautions were taken against strong currents and waves by reinforcing the piles with logs and filling the spaces between piles with clay or mud to provide large flat surfaces. Furthermore, the dimensions of the houses were designed according to the sizes of the logs that were attached to the spaces between the piles. The rectangular walls of the houses were formed by covering the small tree branches with clay. The roofs were covered up with hay and tree branches (Tyler 1921).

Figure 3.1: Palafit Villages



Source: Hattapoğlu 2004

3.1 WATER IN ANCIENT AGE SETTLEMENTS

In Ancient Ages, the formation of the settlements and the further development of large important settlements evolved around the rivers like the Nile, the Tigris and the Euphrates. Egypt, Mesopotamia and the Archaic Greek civilizations can be given as examples. As water settlements developed and improved, the attractiveness of living in these cities, which had a direct relation with water increased and therefore the need for additional safety came about to be able to protect the city from possible attacks. Consequently, defense strategies were taken into consideration. So, while on one hand the presence of water symbolizes an outward openness of the city, in contrast water also can be a restrictive element to a city due to fortifications built along the coastlines as a means of protection against any possible attacks and rising water levels.

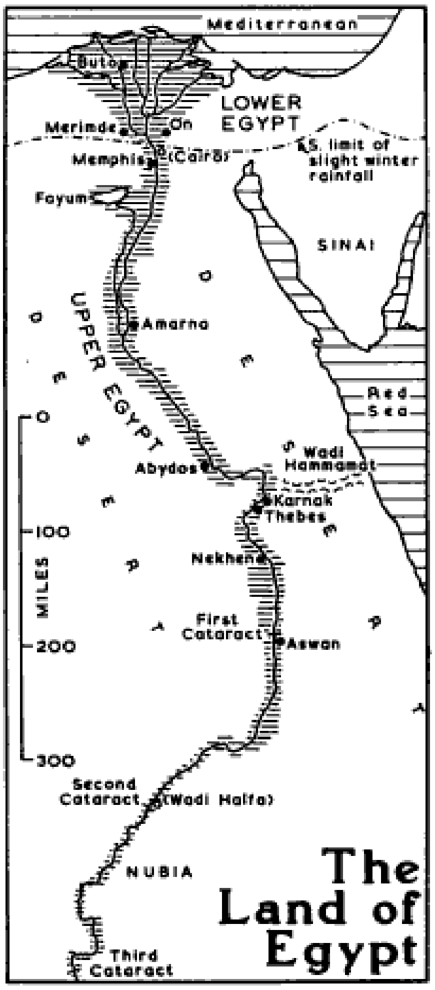
a. Egypt

Egypt is a highly important example of a water-based settlement, which preferred settling along a river as known as Nile River. The Nile is regarded as a life source for Egyptians, which has been influential in the development of a society of water. It is stated in some resources that Egyptians developed the first grid plan, which is highly regarded as a vital city planning philosophy in Greek and Roman civilizations after thousands of years and which represents innovation and equality in terms of settlement typology.

The increase in population required agricultural lands and consequently the settlements near the Nile developed rapidly. However, while choosing these areas considering the destructive effects of water, areas with high altitudes were preferred in order to be protected from the annual floods. For this reason, the houses, depending on their location, were hidden behind mounds in the form of natural or artificial soil barriers, and also on the hills, which formed naturally along the rivers. Consequentially these mounds were formed due to the accumulation of ruins from previous settlements and upon these new settlements were built up vertically (Hattapoğlu 2004).

Ancient historian Herodotus, who is known as 'father of history', stated in one of his itineraries that: "During the floods from the Nile, the cities become the only visible things on water, just like the islands in the Aegean Sea. Then, Egypt as a whole becomes a sea and only the cities are left on the surface." (Huot, Thalmann & Dominique 2000).

Figure 3.2: Ancient Egypt Map



Source: Sellman 1960

b. Mesopotamia

Through all the historical resources and archeological excavations, it has been concluded that Mesopotamia was the center of the Eastern civilizations like Egypt, Assyria and Babel. This area, which led to the birth of many important settlement centers, is a narrow and long area between the Tigris and the Euphrates and it is also known as ‘El Cezire’ (between rivers) by The Arabs.

One of the most important religious and cultural settlements of Mesopotamia was Niniv, which is also called as Nippur. This area had the first city planning design 3500 years ago. This became understood due to the archeological excavations carried out that also found components related to infrastructure and other services which were made available like a sewer system (Hattapoğlu 2004).

Oppenheim, Adolf Leo, in his work 'Mesopotamia, Portrait of a Dead Civilization' (published in 1964, Chicago,) drew the sketch of a typical Sumerian city and divided the towns into three. The first of these was the 'city' itself, in other words, the part surrounded by walls to protect their sanctuaries, the palace and the citizens. The second part was the 'banlieue' or outer city; some kind of suburb including houses, gardens and barns. The third part was 'the coastal town' or the part divided for trade activities, the place where foreigners stayed. According to Oppenheim, the fact that the Sumerian city was divided into three reflected the fact that there was a clear border between the main city and the other places (Huot, Thalmann & Dominique 2000).

Sumerians: As one of the most important ancient settlements the 'Sumerians' were also settled in this area. Moreover the earliest example for raft structures is the floating Sumerian civilization, found in Mesopotamia which was built on the Euphrates and Tigris Rivers entirely from reeds about 5,000 years ago. Therefore the settlement had the chance to camouflage itself and by building it on water it had the chance to protect itself from floods and possible attacks.

Figure 3.3: Babylonian clay tablet

Source: www.cartographic-images.net

Later, a Babylonian clay tablet (above), dating from the Persian period early 5th century B.C., shows the round world with Babylonia in the center. Its identity as a map attempting to depict the entire world is substantiated by the adjacent text, which mentions 'seven outer regions beyond the encircling ocean'. The tablet was made at a time when the Babylonian and Assyrian empires had reached their maximum extent and the map highlights the relationship of the most distant regions of the earth to the Babylonian heartland. Its features are clearly delineated and most are labeled. North is located at the top of the map. The earth is shown as a flat disk surrounded by, or floating on, an ocean, beyond which the outer regions are indicated by triangles, originally probably eight in number, on which the distance between each is indicated. A circle defines the Babylonian world. Parallel lines stand for the unnamed Euphrates River, which flows into a swamp before arriving at the sea in two outflows, each also labeled. A canal or waterway can be observed as well. The ancient author concluded by commenting that his sketch showed, as we would put it today, 'the four corners of the world' (www.cartographic-images.net 2011).

c. Ancient Greek, Rome

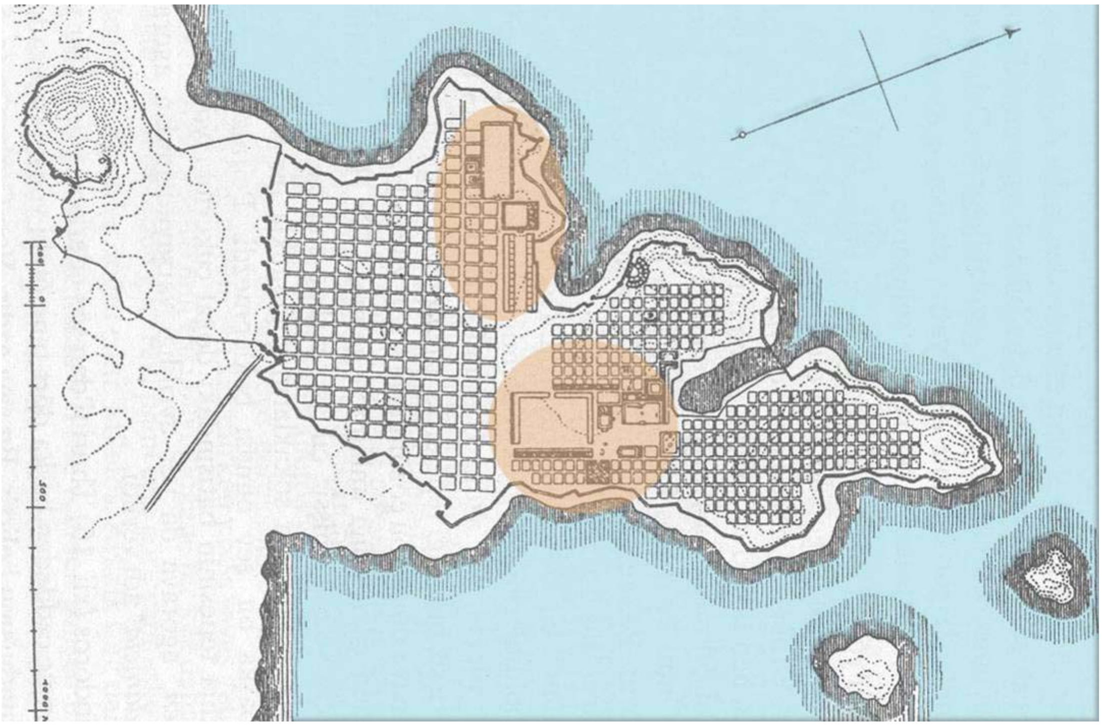
Another ancient settlement that had chosen to settle by water is Ancient Greece and Rome. In Greek settlements, although land selection was made based on security reasons primarily, other factors like economic and aesthetics also gained importance. The decision of selecting the land was also made according to the political objectives of the settlement.

In ‘On Airs, Waters and Places’, by Hippocrates, which is about city health problems, the rules to be applied in the foundation and placement of cities was explained. The content of this book were applied in Bergama and the information about the impacts of climate on human health was found to be successful. Strictly speaking, having a suitable settlement so that the effects of sunlight and air current are taken advantage of, having no swamps or sewage near settlements and most importantly settlements being near to abundant and clean water sources became a necessity together with urbanism. The theories by Hippocrates were used on new sites in Greece and later in Roman colonies. The Roman urbanism theorist, Vitruve, stated that most of these principles were also valid in the first century (Hattapoğlu 2004).

Strategic, economic and natural considerations played key roles in land selection of cities in Ancient Greece and Rome. The Greeks became the central civilization of the world by spreading their colonies to Asia, Europe and Africa. The city of Miletus was the most striking example of colony cities designed back in that era and became one of the biggest trade centers during its time.

These colonies, which spread along the coastlines of three continents, were planned as an integrated geometrical design that required many public and commercial areas that could be seen from the orthogonal grid planning in the City of Miletus. This intelligent design began to spread to the inner areas from the coastal cities in the Roman Empire, therefore agricultural parcels, roads, bridges, borders, canals and seaports were rearranged in rural areas (Hattapoğlu 2004).

Figure 3.4: Miletus city plan

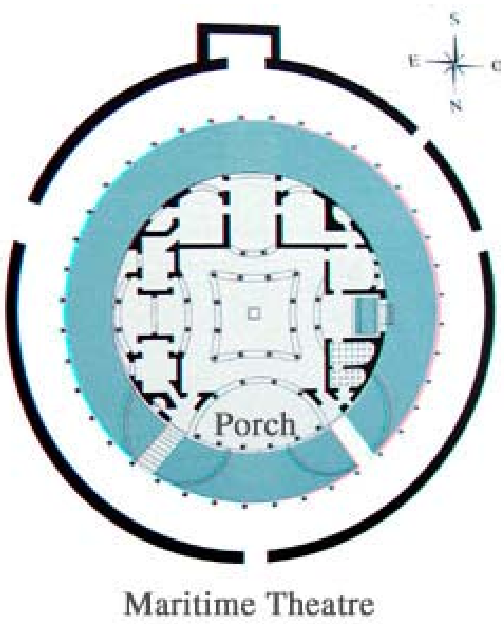


Source: Hattapoğlu 2004

Constantinople – known today as Istanbul – became the capital city in 326 AD due to the wonderful defense opportunities it provided with its relation with water. Water was brought inland with underground aqueducts, so that the enemy couldn't tamper with the water. The water flowing through these aqueducts was also stored in large reservoirs. Istanbul served as a model to other coastal cities as it had a seaport (Golden Horn) that could be closed with a chain and this assisted as a method of defense in case of any attacks.

Hadrian's Villa, Maritime Theater: Hadrian's Villa is one of the earliest examples of water-based architecture which had been built for the Roman Emperor in the 2^{nd} century AD in Tivoli. This unique building consists of a circular plan, and a surrounding canal with wooden ramps which could be removed; thus the island retreat appeared inaccessible. This was a sort of villa within the villa and provided a retreat from daily life. Several researchers have also suggested that this unique structure had cosmological significance with the central island representing earth, surrounded by water (Sullivan 2005).

Figure 3.5: Plan of Hadrian's Villa



Source: www.bluffton.edu

Figure 3.6: Hadrian's Villa

Source: www.texnai.co.jp

d. Lake Constance in Germany

As stated previously, the history of water-based settlements goes back to pre-historic times. These early settlements had basically three different construction types: pile dwellings, rafts or ships. One example was located on Lake Constance in Germany, and as excavations have shown the water settlement was built on stilts on Lake Constance about 7,000 years ago in the Neolithic Period. These water-based settlements are called 'palafit villages' and the reason why these were being built on water with stilts is to be able to protect themselves from predatory animals and their enemies. Also water was always considered as a healthy habitat to live on compare to marshlands. With the findings from archeological excavations, the whole village settlement was able to get reconstructed the way it was around 4000 BC (Flesche 2005).

Figure 3.7: Palafits on Lake Constance

Source: Hattapoğlu 2004

The first findings with regards to palafits was that they were often built on lake shores, and sometimes along sea shores as well, among the most prominent examples was one found on Lake Geneva, in Neuchatel, in Bienne and in Morges Switzerland. Also during the Bronze Age there were more examples spread around Europe specifically in Austria, France and on Lake Chalain and Bourget. The palafit on Lake Bienne is connected to land with 300 meters long and 5 meters wide bridge, which totals an area of 1.5 hectare (Hattapoğlu 2004).

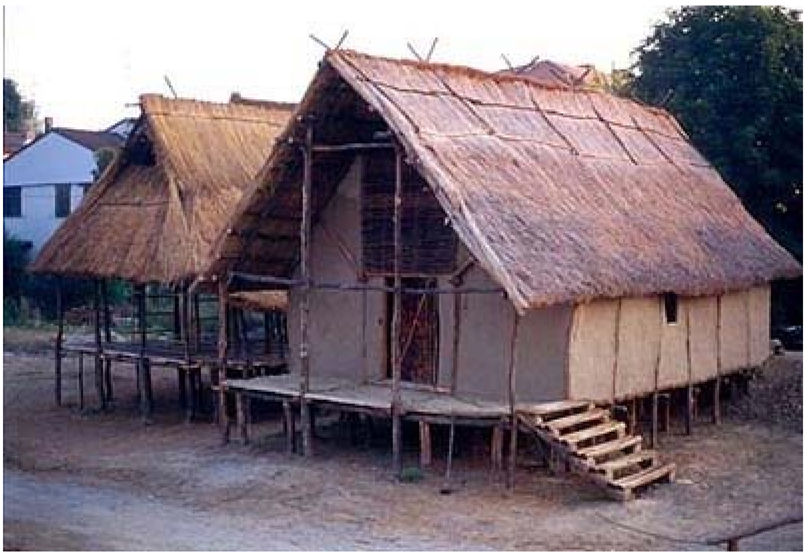
e. Terramare

Similar examples of water-based settlements can be seen in Italy, which are known as 'terramare'.Mauro Cremaschi & Chiara Pizzi (2011) stated that,

> *The term terramare is used in reference to a banked and moated village of the Middle and Late Bronze Ages (1600–1150 BC), located in the alluvial plain of the Po River in Italy. Since the early stages of research that had been carried out on terramare in the nineteenth century, it has been concluded that the moat surrounding these sites was connected to adjoining rivers from which water was obtained by canals.*

The most recent research and excavations at Terramare Santa Rosa, near Poviglio, has confirmed the consistency of this model. It has also demonstrated that these sites may have acted as key locations in a hydrological network. The moats, aside from defensive purposes, were mostly intended to collect channel water and redistribute it for agricultural purposes and ultimately serving to irrigate the surrounding fields.

Figure 3.8: Terramare, Po River, Italy

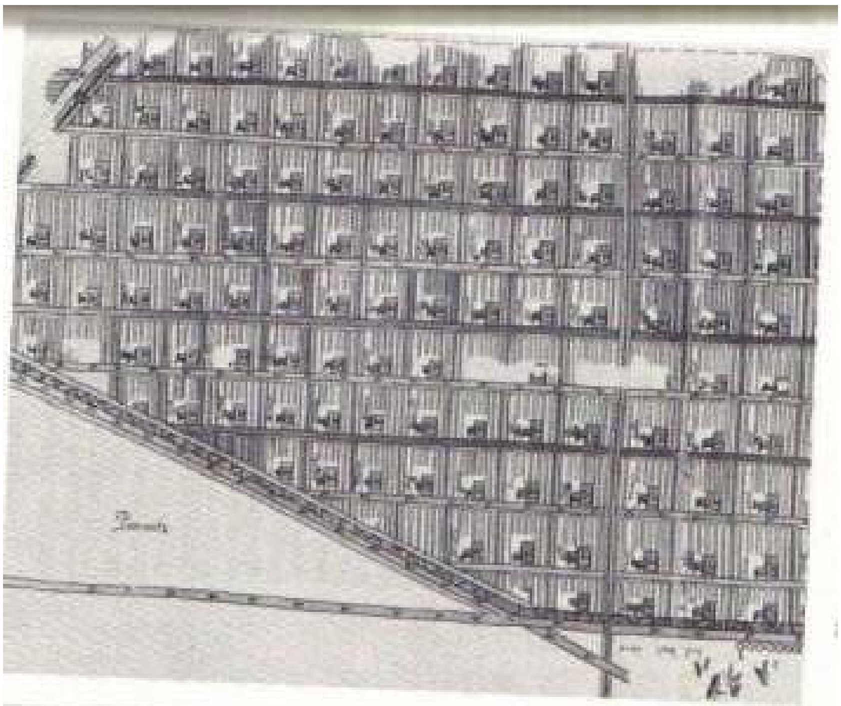


Source: www.archeobologna.beniculturali.it

f. Chinampa, Tenochtitlan Mexico

As one of the earliest examples of water-based settlements called 'Chinampas', were the villages which were built on Lake Texcoco (Xochimilco), Mexico. Chinampas was also known as Floating Gardens of Mexico, which were built by Aztecs in the Middle Postclassic period, 1150 – 1350 CE. The word 'chinampa' comes from the Nauhatle words *chinamitl* (reed basket) and pan (upon), a good description of their building methods. This settlement was built on Lake Texcoco and it was in Tenochtitlan and it use to accommodate about 200,000 people on it. This village was made of small, stationary artificial a number of narrow islands in size of 6 to 10 meters wide and 100 to 200 meters long. It was made by building wattle-fenced rectangles that were filled with mud and sediment. Each of the rectangles was supported by willow trees at the corners and was connected to the lake shore with wooden bridges.

Figure 3.9: Chinampa on Lake Texcoco, Mexico



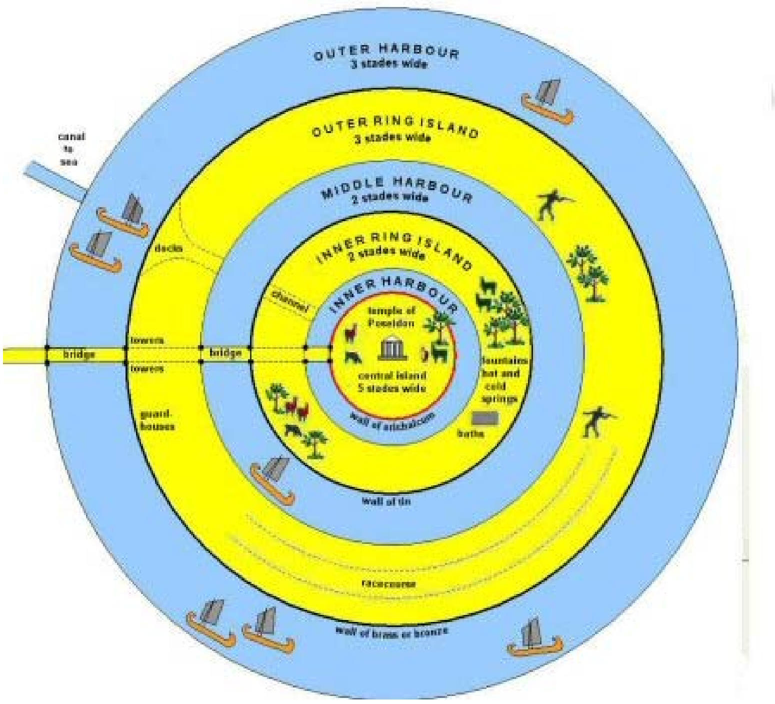
Source: Diaz del Castillo 1974

The reason why Aztecs built this settlement on water is both to extend their land, so that they could improve their economy as well as being built on water for defensive purposes (Pacific Lutheran University Chinampa Report 2011).

g. Atlantis

As mentioned above the idea of living on water dates back and it also finds a place in religion and mythology. In the Ancient Greek epic 'The Odyssey' it can be seen that water can be both creator and destroyer of life. However, in Plato's 'Timeaeus', he mentions the island Atlantis, which once existed but then disappeared in time and it is known as one the earliest water settlements (Allen 1998).

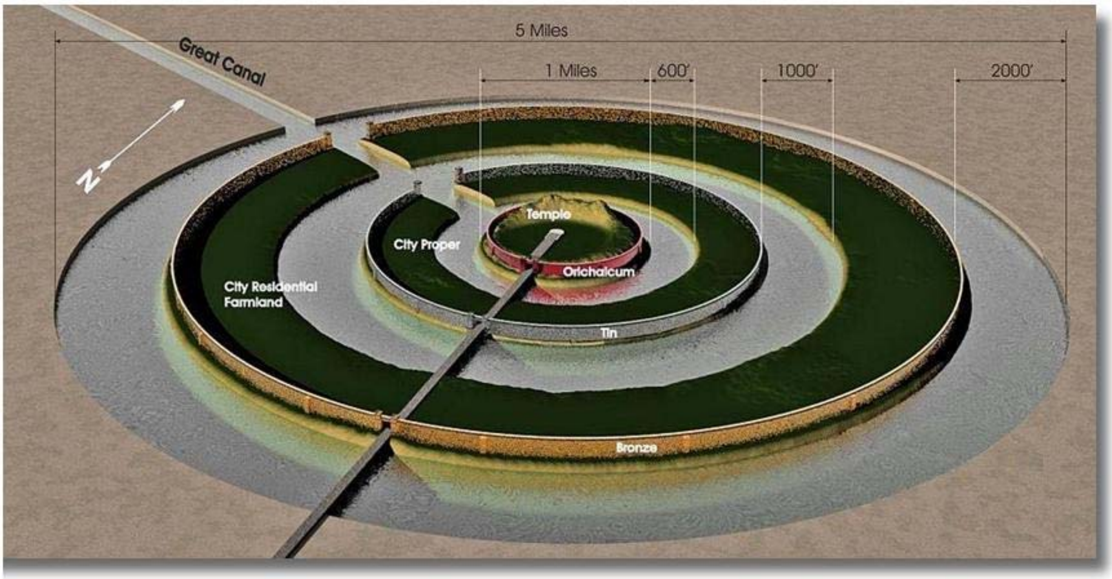
Figure 3.10: Plan of the Atlantis City



Source: Allen 1998

Flesche (2005) stated that: The circular capital on the island was divided into districts by concentric rings of water. A canal connected these rings with the sea so that ships could pass from the open water directly to the glittering gold and silver royal fortress in the center.

Figure 3.11: Dimensions of the Atlantis City



Source: www.eliteword.com

Atlantis is thought to be one of the most advanced societies of the ancient world. The city of Atlantis is seen by many as the mother of several important settlements near it, like Egypt, Mesopotamia, Israel and Europe and many others. Plato's descriptions of Atlantis are incredibly intricate. His writing provides any Atlantis seeker a detailed road map.

Figure 3.12: An illustration of Atlantis City

Source: National Geographic 2011

According to Plato Atlantis was an island kingdom with land and circular harbors, situated just beyond the Pillars of Hercules. Many scientists believe that Atlantis was in Southern Spain. According to the documentary by National Geographic it was in a delta called *Doñana* National Park. In his writings Plato describes the city as it has an area that looks like a port leading into a large circle where the concentric circles would have been a series of circular harbors with a central canal connecting them to the ocean. Also there were two temples in the center island of Atlantis, one dedicated to the God Poseidon. According to Plato's final chapter, the great city of Atlantis faced a cataclysmic disaster; violent earthquakes followed by great floods as a result of tsunamis and the city vanished overnight (Finding Atlantis 2011).

h. India

Another early example of water-based architecture can be seen in India by the Ganges River which is about 2,700 meters long and it attempts to fulfill the needs of 240 million people who live in cities settled along the Ganges. The city of Varanasi, situated in the western part of the river, had been the religious center of Aryans 2000 BC and was one of India's' sacred cities. Everyday almost 60,000 people visit this city to be pilgrims. Almost every day, people climb down the stairs (gat) and wash themselves. Another common custom is to wash their clothes in the river and lay them on the stairs near the river (Hattapoğlu 2004).

Streets in Varanasi are designed in such a way that all of them end and meet with the Ganges. All the sanctuaries and religious buildings were built along the river and their stairs were designed to reach down into the river. The buildings are elevated from the river's water level as a means to protect against floods during monsoon rains.

Figure 3.13: Relationship of water and the city of Varanasi

Source: Suarez 2008

So, as it can be seen water-based architecture is an old concept which provides several advantages to daily life. Even though the reasons why people preferred living on water-based settlements back in ancient times are slightly different then todays, it still proves that water is a favored living space with several advantages.

3.2 WATER IN MEDIEVAL AGE SETTLEMENT

The Archaic Age characterizes Greek and Roman civilizations that were influenced by eastern civilizations. It can be clearly seen that the Middle Age cities in Europe were affected by the Archaic Age cities considering the similar characteristics of their city planning. The Archaic Age led to the developmental birth of this region and helped European cities become a dominant territorial force in the whole world.

In ancient settlements, the primary structures determining the city’s image were removed in the Middle Age, leading to compact settlements that were comprised of different structures according to the need of medieval ages like religious buildings. The important settlements around the religious structures became trade centers in time and began to turn into cities with suitable conditions. Coastal cities in the Middle Age developed trade and provided new cultural improvements, which led to new urban settlements along the sea.

The most common city type in the Middle Age, in Europe, was the 'bridge city'. The main settlements in these cities were built by the rivers edges. There were one or more bridges on the river and also the city was surrounded with walls. In addition in certain cases further defense precautions were taken. An example of this is the towers that were built alongside the bridges to protect the settlements and their connection with one another. There were houses, stores and main streets that were built along the bridge as well. The river had great importance for the city; it was the main method of transportation and the source of drinking water. However, water was not seen as an aesthetic element and wasn't used in that manner during this period of time (Kostof 1992).

In European Cities which have experienced the Middle Ages, Renaissance and the Industrial Revolution, water had unquestionable impact and vital contribution in different fields like military, politics, economy and strategic decisions and urban planning on European Cities.

a. Paris

Paris is one the cities that has great importance due to its close relation with water. Paris was founded as a reinforced town on a small island on the Seine River, and expanded around the village called Cite in the 9th century. At this point the city was supported with walls on both sides of the river, because both sides of the Seine River were used and the coasts needed protection. The left side of the river – the southern part of the city – was the center for churches and schools while the other part was the center for trade (Hattapoğlu 2004).

The application of axial development in the planning of Paris impacted the future of the city. The Seine River, which established the axial framework of the city's design, also provided the basis for a series of axial developments that stretched from the river in a perpendicular direction and played an important part in the city's identity. This innovation that brings public places together in the organic texture of the Middle Age and that integrates the city with the river made it possible for water to enter the urban landscaping elements in the Middle Age and become an element in the life of the citizens.

Figure 3.14: Paris city plan during medieval ages

Source: www. historic-cities.huji.ac.il

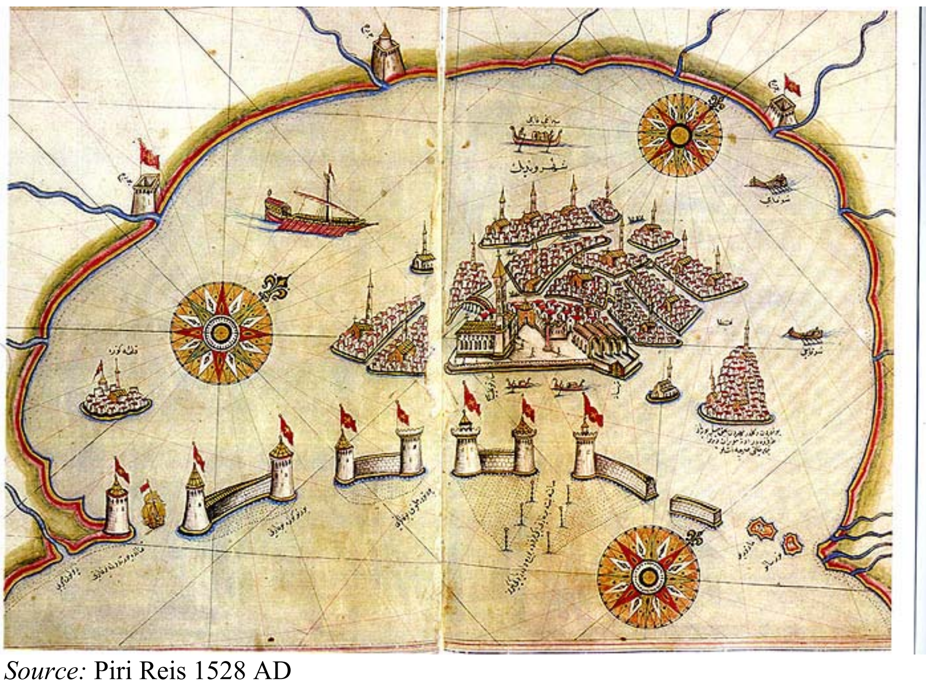
Paris is a river city that connects its streets back to its water source by using the axial layout and its geographical location as mentioned above. The axis introducing the city to the water in the organic city texture also encompasses palaces and other important structures along it. Even though Paris is not settled physically on water, it has always been a water city, through its urban plan relating to water and influencing the how the built environment was designed to embrace the city's design intent.

b. Venice

There is no another place where canals and the city itself are integrated so incredibly like in the magnificent and mysterious city of Venice. Venice is extraordinary with the connections of water arteries spread like a web throughout the city instead of having streets. Venice was built on almost 118 islands connecting each of them with the web-like planned canals. The Venice lagoon is a 50 km bay, which is connected to the sea by its three ports. These 3 ports did not only serve as connection points, but they also functioned as exit points that created openings through which the tides could come in and assist in cleaning the lagoon (Hattapoğlu 2004).

The lagoon is protected with barrier sea walls built in the middle of the 18th century, which were intended to defend from sea attacks. The center of Venice has been divided into two by the Grand Canal. The canals determined the city's macro-form and shaped the structure of the islands and transportation axis. Bridges, which are amongst the fundamental elements of water cities, contributed a lot to the unique city of Venice.

Figure 3.15: Venice city plan during medieval ages



Source: Piri Reis 1528 AD

The winding and narrow streets of the city evokes the feeling of 'being lost', but landmarks such as squares, churches and bridges along the canals gives certain clues about ones location and figuring out directions. There are few straight streets in Venice because of the way the canals and buildings were planned. This is why although the distances are not that long; the city promotes pedestrian travel as a means of exploring the city. The canals also had a great influence on the design of buildings like the palace and government departments and also the Venetian Gothic buildings representing the architectural identity of the city have stood in Venice's Grand Canal since the 12th century.

It can be seen that in the texture of Venice, the way the squares come together with churches and other buildings is determinant by the most dominant element of the city, which are the canals. As canals are the main determinant of the structure islands and transportation system, they play an important role in the formation of squares also.

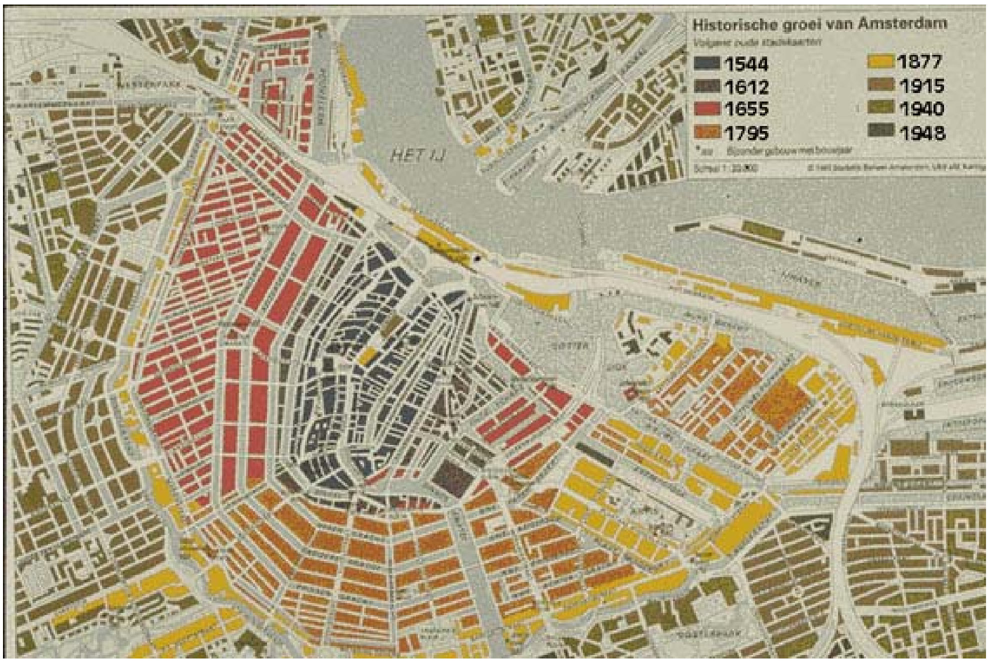
Once the center of international sea trade, later the center of art and humanism after the Renaissance it then became the center of tourism and culture of Europe as it's known today. Venice has been able to protect its original texture, architectural and cultural heritage so far although there have been some changes in the city's identity in time.

c. Amsterdam

Amsterdam was founded as a fishing village in the 13^{th} century in the area where the Amstel River flowed into IJ River water and has sustained its development on both sides of the river. Firstly, the city was protected against the overflow of the Amstel River by digging ditches upon which the first settlements were established. Later, two moats were dug for defensive purposes and filled with the water of the Amstel River. In the middle of the 16^{th} century, the old moat was converted into a canal and it was surrounded by towers to defend it. As the needs increased in the city, more ditches and canals started to be designed. At the end of the 16^{th} century, the plans of 3 canals which would expand the city almost three fold were put up for discussion. This project would become approved and was completed in the middle of the 17th century and when completed included 3 canals, street nets and other canals connecting the trio.

With the conversion of marshlands into canals and construction sites, Amsterdam began to carry out its new city plan. In this new plan, buildings would be built closer to the canals by building barriers to protect the buildings against the threat of flood. Along with the new canals and the barriers built buildings were allowed to establish a closer relationship with the water as in Istanbul and Venice.

Figure 3.16: Amsterdam city plan



Source: Hattapoğlu 2004

Moore (1994) stated that:

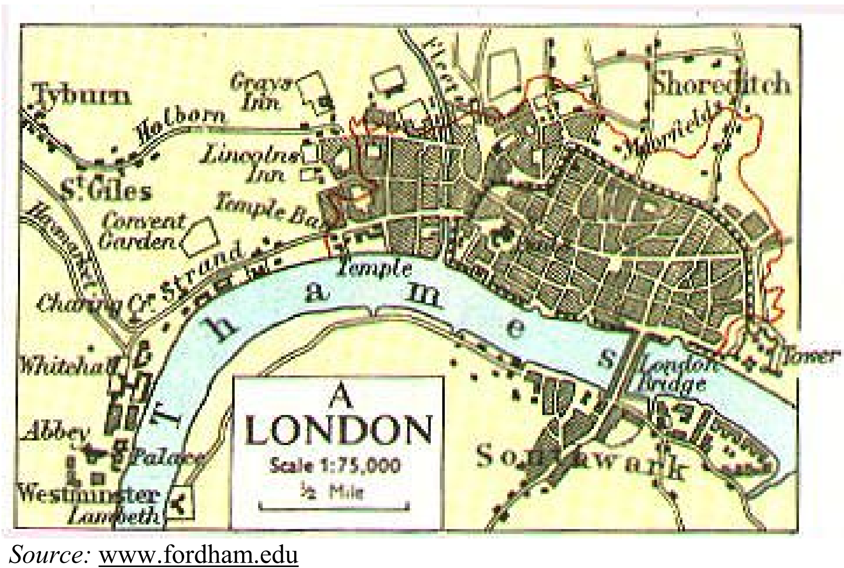
> *In contrast to the subtle organic pattern that prescribes the canal layouts in Venice, Bruges, or Suzhou, Amsterdam preferred a more regularized pattern, often described as a rigid semicircular spider's web of canals, dams and locks. Amsterdam began as a simple town around the river in a series of concentric arcs where each canal was longer than the last, and some had streets on each side and sites of warehouses, factories, and houses along the edges. Built on the resources of a bustling manufacture and trade, the canals allowed raw materials and goods to be moved quickly and cheaply around the city and out to ports for international trade. The beneficiaries of the thriving economy built skinny Dutch houses - all lined with whitewashed window frames and mullions and frosted with eccentric attics and dormers elbowing for attention and space – these were built along the canals.*

In many cases, water becomes so integrated with buildings that its existence shapes all characteristics of the environment as it does in Venice. Holland's struggle to change a feebly stable marshland, which is growing thin while it goes from the river to the sea into an arable, cultivated land and its continuous war against the sea and also its struggle to draw-up an irrigation project has succeeded. This economic logic has proved itself in the grids of the irrigation canals and in the labyrint look of the concentric canals.

d. London

London, one of the most important metropolises in the world, has a power and prominence, which has increased through history with the Thames River. The history of the city goes back to nearly 2,000 years ago and it's known that the first settlement was established during the Roman Empire.

Figure 3.17: London city plan



Source: www.fordham.edu

People noticed the strategic significance of the Thames River. First, they set up an encampment on the north edge of the river and then realized that the Thames River was an ideal place to develop and build a port as well as a sanctuary. The surging trade of the city through the years made London more special and the city that was designed according to the grid plan established by the Romans had been the center of commerce for many years. The Thames River had become the backbone of commerce. However, the rivers tide has been a threat which makes the city face a perpetual flood hazard and it's also known that this situation has caused a number of disasters and deaths already.

The commercial development of the city had resulted from the port facilities prospering along the east part of the city. The rest of the city has extended westwards, lineally, around the big curve of the river .The river's controlling and commercial power, has tied two sides known as Westminster and City. This linear development is also seen in the texture of the city where many streets run parallel to the river. In all the buildings the front door faces the main street and the door which opens to the water faces the Thames River, which was a prominent design decision that determined the river look of London (Hattapoğlu 2004).

London has always prospered thanks to its geography and especially because it has a significant water way. This flourish has been backed up with a new port system as well as shipyards. With this new infrastructure, the appearance of the Thames has been altered as well as making the city prosperous, again. However, because of the change in transportation techniques in the 20th century, the city has lost the use of its port.

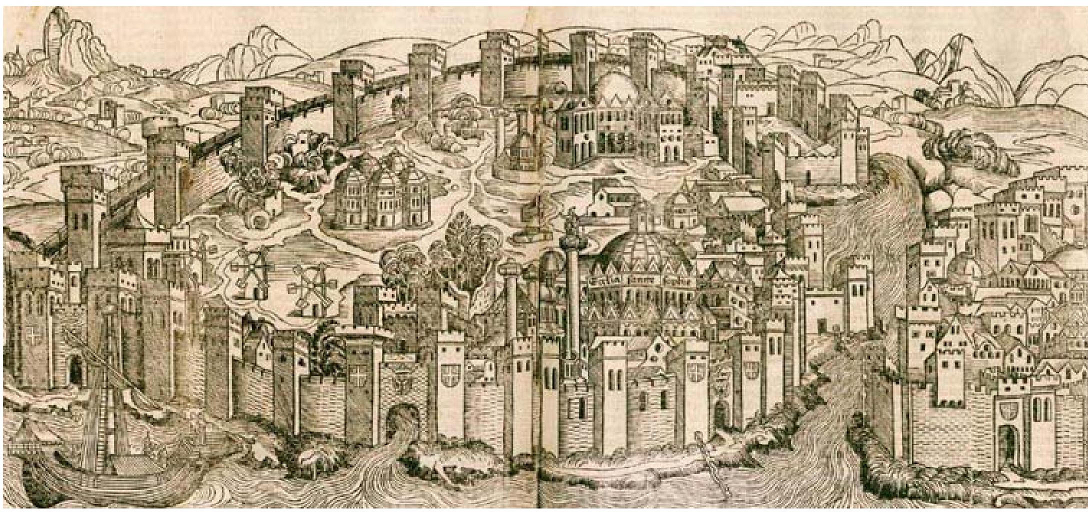
e. Istanbul

The relationship between Istanbul and water is unique; it's unlike any example in Europe or even in the world. Istanbul is a city whose relationship with the Bosporus is not the same since its formation as is the case in London and many European cities. The relationship of water and Istanbul changed over time because Istanbul's prominent cultural and trade centers shifted as the city expanded. However, Istanbul has always endured its natural boundaries in contrast to a number of European cities where new canals open through the passing of time.

In medieval Europe, many settlements were shaped in relation with the natural sources and the topography on which they were located. However, the disparity between Istanbul and these cities is that it stretches on an area a few fold wider than all of them. This situation results from the variety, inability to identify, and the character of the waters surrounding Istanbul. The Bosporus is extraordinarily narrow and too deep to be a bay and too short to be a river. As for the Bosporus strait, it is too short and wide to be a river and, as well as being too narrow to be a sea. Even Marmara, known as the biggest inland sea, which is too big to be a lake and too small to be a normal sea is like a big strait, which is not linear and just exists to merge The Aegean and the Black Sea (Hattapoğlu 2004).

The existence of Istanbul on both sides of the Bosporus stretches to prehistory. (2000 B.C.) It wasn't until the 15th century that Istanbul was a walled city like the other medieval cities of Europe. Byzantine, the historic walled peninsula surrounded with water had a very convenient location in terms of security and wealth. Since it completely blocks the mouth of the Black Sea no one could enter the sea or exit without the permission of Byzantine. Therefore, the city thanks to this political and economic structure was dominant at this location of the sea during that period of time and even into the next centuries (Kuban 1994).

Figure 3.18: A Gravure of Istanbul in medieval ages



Source: www. historic-cities.huji.ac.il

From the beginning of the 16th century, the city began to extend over to the Golden Horn and Bosporus shore. At the end of the 18th and at the beginning of the 19th century, The Golden Horn, the Bosporus and the shores of Marmara were included in the cities borders. While the shores of Marmara and Bosporus were mainly used for transportation and as holiday resorts, the Golden Horn served mostly for integrated functions. Such functions included the following: domestic trade (Eminönü), foreign trade (Galata), shipyards (Kasımpaşa), settlements (Fener, Eyüp), inland transportation, recreation and summer housing (Kağıthane). Therefore, the Golden Horn was seen as the center of the city as it hosted human activities in a densely populated area representative of the cities texture, which contributed to the magnificent silhouette of the city (Bilgin, 2003).

The growing city has become a trade center and thus the city center moved to Galata where foreign trade takes place. The settlements of the Bosporus, with palaces and mansions which were constructed along both sides of this magnificent water way have become a culture-water way. With the city's natural hilly topography, the relationship between water and city can be easily established. Therefore, mosques and squares were erected on the hills in order to create a visual connection to the flowing waters of the Bosporus.

3.3 WATER IN THE 19TH AND 20TH CENTURY SETTLEMENTS

3.3.1 Fishing Villages

Even though there have been several settlements built in relation with water, there were also some that have been built on water with different systems just like fishing villages that can be seen all around the world, but mostly in Asia. The main reason to live and build on water was to protect the settlements from floods and also for defense purposes, but later it turned into a need because of several reasons; sustainable life, economic problems, land use, commercial purposes, rising tides.

a. Derince Fishing Village, Izmit / Turkey

This village was built on water for obligatory reasons. The inhabitants made a living by fishing, so they had to be close to water to be able to hunt, and they also had to be close to land to sell their fish. The village is set on a marshland and the houses are sitting on wooden stilts (Tabak 2006).

These stilts were tied to each other, and create a base for the wood floors. The walls, roof and the rest are built depending on the material the village has like the metal panels which are used for this example.

Figure 3.19: Derince fishing village

Source: Tabak 2006

b. Damnoen Saduak, Bangkok, Thailand

Damnoen Saduak is another water-based settlement in Bangkok, Thailand. The reason why this village was set on water is because land is too valuable and expensive, and its soil is of perfect quality for agricultural use. This is why people preferred leaving their land and living on water, and selling their products at the floating market. This water-based settlement is about 100 years old and is mostly made of wood and is connected to each other with bridges.

Figure 3.20: Floating Market, Damnoen Saduak

Source: www.mkphang.com

Figure 3.21: A floating house above water

Source: Soykut 2006

The structure that can be seen above is a floating salon for special occasions being used by the king. It is different than the rest of the village because it was built on steel pontoons, moored by chains and poles, and connected to land by a simple footbridge. Also it is covered with ornamentations like a temple and has a great view.

c. Ganvie, Benin - The Venice of Africa

Ganvie is a lake village in Benin, on the Lake Nokoué, Africa and it accommodates roughly 30,000 people, it's comprised of nearly 3,000 stilted buildings and is probably the largest lake village in Africa. Ganvie means: 'the collectivity of those who found peace at last'. The village dates back to between the 16th and 17th century and was built to save people from slavery, so they were built several kilometers from the nearest coast. Moving around the village is only possible by boats carved from tree trunks called 'pirogues'.

The houses of Ganvie were usually built on four bamboo stilts and roofs made up of different sizes of bamboo. They were also elevated from the water level by 1.70 meters, and the bedrooms were elevated about 2.20 meters to be used as a refuge (Tabak 2006). There is a very limited dry land at the village which is being used as a village school and a part of it as a cemetery.

Figure 3.22: Aerial city photo

Source: www.paxgaea.com

Figure 3.23: A traditional house in Ganvie

Source: whc.unesco.org

d. The Floating Villages of Chong Khneas, Cambodia

The floating villages of Chong Khneas were built on Lake Tonle Sap, and it accommodates around 5,000 residents, in over 1,300 houseboats. The village services are no different than the ones on land, because it has schools, houses, markets, religious buildings, cemeteries etc. The buildings are made of wood and bamboo. For the walls and roof, dried tree branches and leaves are also commonly used. The reason why this village was built on water is the same as with the village Damnoen Saduak, people have been living in these primitive houses and earning their lives by both fishing and agriculture (Soykut 2006).

Figure 3.24: An image from Chong Khneas

Source: Soykut 2006

e. Kukup Fishing Village, Johor, Malaysia

Kukup is a small roughly 200 year old fishing village that is located about 40 km southwest of Johor Bahru, in Malaysia which was built on stilts over the water. Like many other water-based settlements, wooden stilts were used to elevate and carry the buildings loads. This village is a touristic area, which is popular for its seafood restaurants and also its unique houses.

Figure 3.25: A genereal view from Kukup Fishing Village

Source: Chua, 2010

Later in Europe cities like Amsterdam, Venice and Bruges were also built on piles driven into the sea bed. Presently architects are still using this type of construction system, but with different materials like aluminium or concrete. An example is the project called Aluminium Forest designed in Netherlands in the last decade. Also a similar type of construction is being used commonly for piers all around United States coastlines.

Figure 3.26: Pismo Beach pier, California

Source: Chua, 2010

3.3.2 Boathouses

Starting with the Sumerians floating structures as discussed in the previous parts of this study, boathouses or houseboats have been commonly used all around the world. The reason to live on water differs from person to person and region to region, but it is usually to protect people from rising tides, defense, ecological reasons and for some people the reason is comfort.

a. London, Thames River

A prime example for boathouses is those which are lined up along the Thames River in London. These houses were built for after the industrial revolution and today approximately 16,500 people live on these boathouses. Boathouse residents chose to live here because the expenses are lower and these houses offer a modest lifestyle with roughly a 30 square meter total living space (Tabak 2006).

Figure 3.27: Boathouses along the Thames River

Source: Tabak 2006

b. San Sausalito, San Francisco, California

San Sausalito is another boathouse community which was established in the beginning of 18th century. This community sited on the northern part of San Francisco, California accommodates around 400 floating houses. The residents of these boathouses preferred to live here for comfort and because of their proximity to water. In addition, each of the boathouses was made in a different understanding of design, and material.

Most of the houses have the ability to change its location by floating, and can attach to the circulation decks with hold-down wraps. The most important advantage of these houses is their ability to move vertically with the rising tides, without any flood threat.

Figure 3.28: San Sausalito boathouse community

Source: Mosey 2009

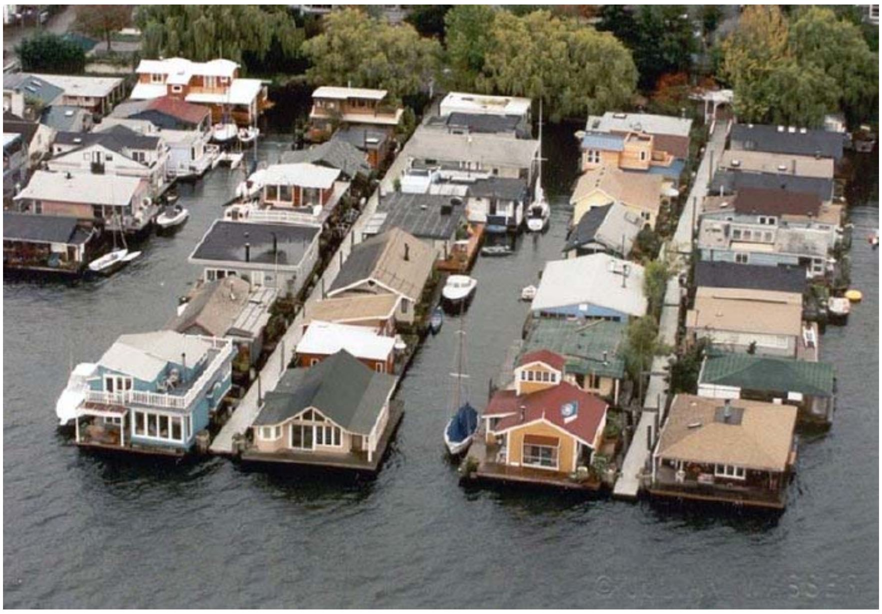
Figure 3.29: San Sausalito's different boathouse designs

Source: Mosey 2009

c. Seattle, Lake Union

This houseboat community is located on Lake Union, Seattle, Washington and it is approximately 100 years old. The first residents of this community were the sailors, people with low incomes, and then the community started to get bigger because of land shortage and the economic crisis which started by 1930s. Today, these boathouses have cable, telephone, gas, and sewer systems (Tabak 2006).

Figure 3.30: Boathouses on Lake Union



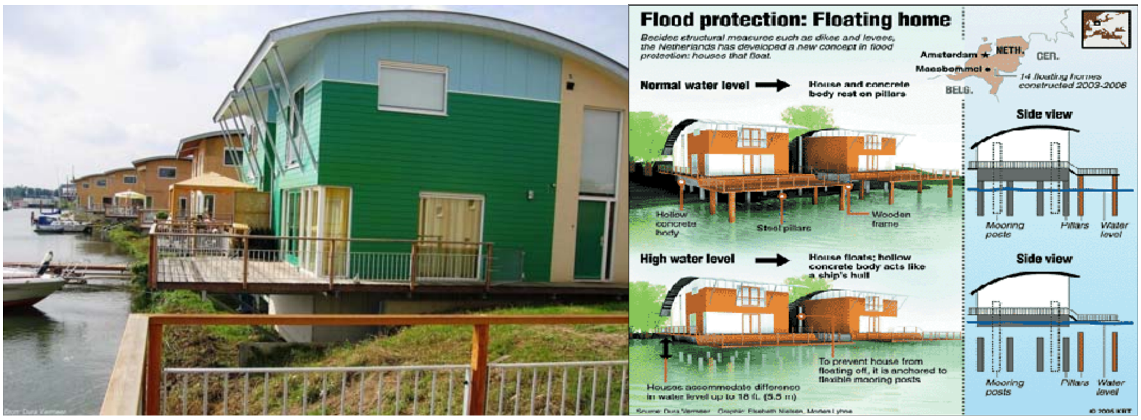
Source: www.inspirationgreen.com

d. Housing Project for Netherlands (Amphibian Homes)

This project was designed to be sited half on water and half on earth. The reason behind this was in case there was a flood the home would float off its foundation and adapt vertically to the change in water level, but still remain attached to keep it in place. This is an example of a 'floating' project. It was designed by architect Ger Kengen, and constructed by the firm Dura Vermeer in Gelderland (Pasternack 2009).

Amphibious homes are characterized as sitting on concrete piers which have been installed at the bottom of the sea and that permit the house to move vertically when the water level change on the river. The construction of this project started in 2004 and ended in 2005, and they have been built all along the Maas River.

Figure 3.31: Amphibian Homes on Maas River



Source: Pasternack 2009

3.3.3 Waterfronts After Industrial Revolution

After the Industrial Revolution waterfronts from cities all around the world changed gradually. The Industrial Revolution started to affect the entire world with the new techniques of production and rapidly growing industrialization. The new system changed whole city planning and offered new transportation systems with the invention of steam boats. Along with industrialization more employees were needed to work, that is why the migration to cities increased, which caused an unplanned growth in cities. With the invention of steam-powered boats, products began to be transported mainly by these new boats since they were cheaper, faster and could hold big quantities. Thus, waterfronts started to be used as ports, pier, docks etc. However the heavy industrialization caused an extensive pollution and destroyed the waterfront. By the second half of the 20th century the shipping industry had moved to outside of the metropolises as well as all the port and port related buildings. By the end of the century cities started to re-discover waterfronts and planned new residential, social & cultural areas that offered citizens the opportunity to live in the heart of the city, but have the comfort of living in a rural neighbourhood (Ryan 2010).

Along with the industrialization of cities came improvements that included social, cultural and economical. City's though were surrounded with fortifications to be able to maintain the city protect from attacks. This solution may have helped the city to maintain themselves but the fortifications that have been built along the waterfronts blocked the connection of water and the city and only provided the connection at the harbors. Industrial revolution has changed cities and life styles rapidly and completely, and turned the city into a creation of mass production, which has no characteristics or relation with the history of the city.

There have been several instances where throughout history waterfronts have been underutilized, which have led to a disconnection between them and proximate neighborhoods. There have also been instances in which wetland habitats have been harmed by the encroachment of developments. However, over time humans have been lead to taking advantage of these substantial areas and where there are no rules and regulations, designers and businessmen have taken advantage of the situation and have designed buildings/habitats without thinking about the consequences of their actions and ignoring the known methods for the establishment of proper relationship between nature and the built environment. This subject will be discussed more in depth in chapter 4.

a. Metabolist Movement

The Metabolist Movement occurred at the end of 20th century by taking all the historical water-based architectural examples into consideration. Hence it was a revolutionary movement for architecture and the studies that have been done on this movement are extremely important and have influenced today's designs and floating city approaches.

Who are the Metabolists? According to the book "Beyond Metabolism" written by Michael Franklin Ross in 1978, the family tree of Metabolists consists of the five young designers during 1960, which combined their diverse, futurists urban context. The individual involved were: Kisho Kurokawa, Fumihiko Maki, Masato Otaka, Kiyonori Kikutake, and Noboru Kawazoe.

What is Metabolism? Changeability and flexibility were the key elements that the Metabolist group seized upon and explored. Metabolism is the biological process by which life is maintained through the continuous cycle of producing and destroying protoplasm. To the Japanese architects who adopted the name, it meant creating a dynamic environment that could live and grow by discarding its outdated parts and regenerating newer, more viable elements. Kawazoe (1972) stated: "To develop a building system that could cope with the problems of our rapidly changing society, and at the same time maintain stabilized human lives."

This new approach for Modern Urbanism was founded by young architects in beginning of the second half of 20th century. This approach was an avant-garde, futuristic way of designing and experimenting architectural practices and it was known as 'Metabolists'. Metabolism was originated in Tokyo, in 1960. One of the members of the group Arata Isozaki called Metabolism as a 'pure form of technological utopia'.

At one of the meetings of these architects agreed on using a biological term as both the key concept of design and the name of the group, so Kawazoe suggested the term 'Metabolism'. Kawazoe recalled that he chose this name because metabolism, as the organic function of material and energy exchange between living organisms and the exterior world, is the essential process of life. In addition to its biological meaning, the literal translation of metabolism in Japanese, shinchin taisha, also embodies the idiomatic meaning of 'out with the old, in with the new.' It thus came in line with the architects' notion that the city should be capable of continuous growth and renewal-a process' they believed, as important as an organism's natural metabolism. Kawazoe argued that shinchin taisha-interpreted either technically or colloquially-would change how people viewed the city. Instead of Japanese phrase, however, the architects decided to use the English translation to emphasize the concept's universality (Lin 2010).

Lin (2010) stated that:

> *After the economic growth in 1950s the population in Japan began to concentrate in big cities and kept growing. However all the metropolitan cities were at the point of reaching their boundaries? At this point the plan to extend urban areas over Tokyo*

Bay emerged. And as an experienced architect from the project in Boston Bay, USA; he presented the model 'Plan for Tokyo' at 1960s Tokyo World Design Conference.

To accommodate a city's growth and regeneration, Metabolists advanced transformable technologies based on prefabricated components and the replacement of obsolete parts according to verifying life cycles. Lin (2010) argues that the Metabolists' fantastic urban ideas, which often envisioned and the sea and the sky as human habitats of the future, were in fact the architects' response to the particular urban and cultural crises confronting postwar Japanese society. This idea was about designing artificial lands, marina civilization, metabolic cycle, megastructure and group forms to fit into the social change which was happening in Japan.

For metabolists, new buildings and new cities would be like organisms, through making full and expressive use of new structural and communications technology and modern materials. Buildings would be open-ended, would be able to grow, and would be asymmetrical, because symmetry implies completion; they would also be receptive to change and not permanent.

So Metabolist Urban Utopias are understood as 'city as process'. According to metabolists the city was meant to be a living organism. This living organism would able to change, evolve and represent the metamorphosis of a living creature, the city.

Metabolists' urban visions followed a longstanding tradition of urban planning, in which speculations of future environment were combined with ideals of social progress. Since ancient times, conceptions of the good life or a perfect commonwealth have been firmly anchored to the form of the city. It was in this sense that Lewis Mumford claimed that 'the first utopia was the city itself' (Mumford 1973).

Metabolism is a legitimate mega-structural movement and the word 'mega-structure' was found by a Metabolist-Fumiho Maki. According to Maki's definition in the 1964, 'mega-structure' refers to a strategy in urban design that tends to house the programs of a whole city or part of a city in a single structure. Although he traced its origin to ancient Italian hill-towns; Maki insisted that 'mega-structure' was made possible by present technology. This was reflected in the manifesto of the group, Metabolism: The Proposals for New Urbanism, published at the World Design Conference. The manifesto opened with the following statement (Lin 2010, pg.24):

> *'Metabolism' is the name if the group, in which each member proposes future designs of our coming world through his concrete designs and illustrations. We regard human society as a vital process a continuous development from atom to nebula. The reason why we use such a biological word, metabolism, is that we believe design and technology should be a denotation of human society. We are not going to accept metabolism as a natural historical process, but try to encourage active metabolic development of our society through our proposals.*

Perhaps the most innovative architecture in the world today is being done in Japan by the new wave of young architects who have followed the so-called "Metabolist" movement that was inspired by the internationally- renowned architect, Kenzo Tange, the names of these post-Metabolist architects are by and large still unknown in the west, but their daring, even revolutionary approaches toward building in a densely-populated, highly industrialized society, have captured the attention and the imagination of architects and those interested in architecture around the world.

Tange's Plan for Tokyo proposed an alternative to the uncontrolled expanding metropolis. It called for an 'information and communication' network capable of growth and change through the extension of parallel loops forming an extended spine that stretched from The Imperial Palace, in central Tokyo, across Tokyo Bay, to the suburbs of Chiba Prefecture.

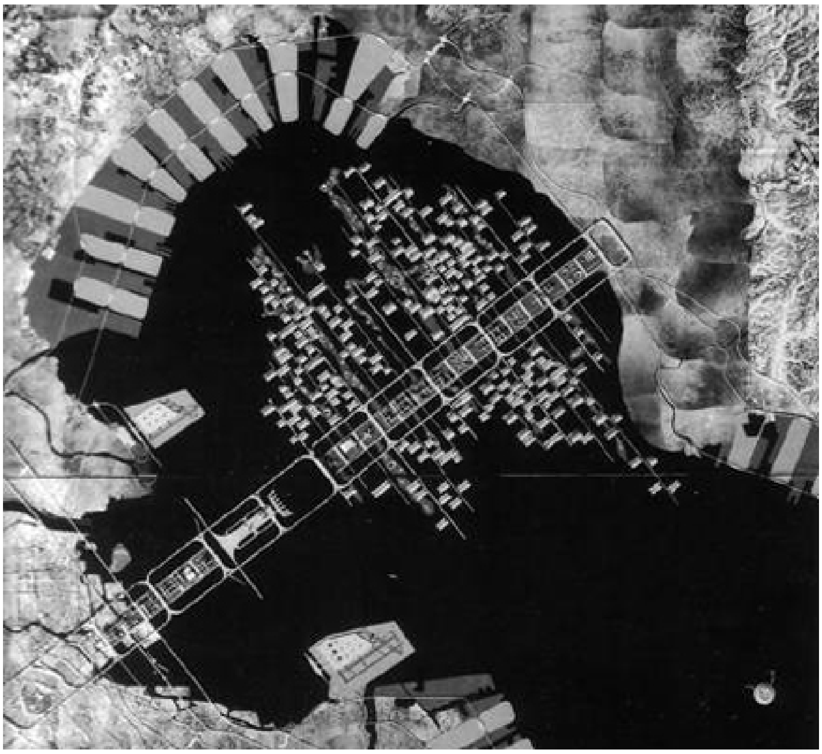
So the publication of Metabolism 1960 was an exploration into variations and alternative solutions to the megastructure principle set forth in Tange's Plan for Tokyo. Tange's design developed from the belief that certain elements of the urban environment change or require replacement at a much higher frequency than other elements. He explained that (Lin 2010):

> *Short-lived items are becoming more and more short-lived, and cycle is shrinking at a corresponding rate. On the other hand, accumulation of capital has made it possible to build in large scale operations. Reformations of natural topography:*

dams, harbors, and highways are of a size and scope that involve long cycles of time, and these are man-made works that tend to divide the overall systems of age. The two tendencies-toward shorter cycles and toward longer cycles- are both necessary to modern life and to humanity itself.

Tange proceeded to develop his mega structuring principles. The Plan for Tokyo was designed around the idea that transportation technology would change at a far slower rate than residential building technology. The infrastructure or skeleton is made up of highways, bridges and communication channels as well as the physical structural frame, which can accept a variety of interchangeable plug-in residential and office units.

Figure 3.31: Tokyo Bay Plan by Kenzo Tange

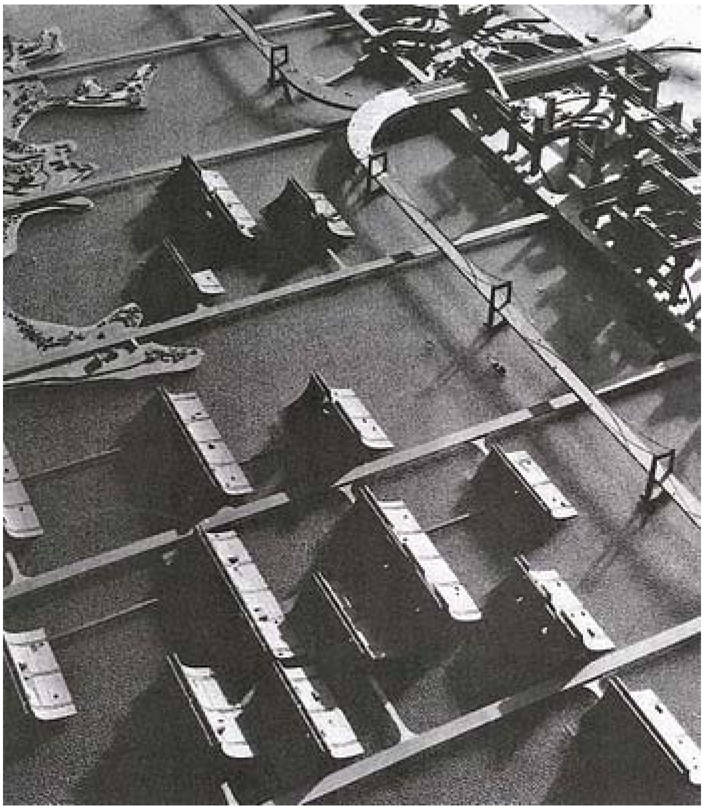


Source: www.archiveofaffinities.tumblr.com

Tange reiterated that: "By interoperating elements of space, speed and drastic change in the physical environment, we created a method of structuring having elasticity and changeability." (www.archiveofaffinities.tumblr.com 2011).

Adaptability to change was the basic ingredient common to all Metabolist projects. Different members of the group developed the idea in different ways. Eventually the term Metabolism was developed into the concept of Metamorphosis, which dealt with changes in the physical form and structure of cities that in turn could respond to the needs of a dynamic society.

Figure 3.32: An aerial view of Tokyo Bay Plan



Source: www.archiveofaffinities.tumblr.com

The dream of building a megastructural system of interlocking shafts, bridges and communication spaces, which had been promulgated by Tange and his disciples.

4. CONTEMPORARY APPROACHES OF WATER-BASED ARCHITECTURE

It can be understood that from the archaic times and up until to today's modern cities, humans have commonly used water as a key element of the city. This is evident through the use of water for different purposes like transportation, and defense. There were many cities which used water to their advantage and that over the years turned into today's modern metropolises.

During different eras water was used in various ways; at the beginning of the Renaissance period water was not only seen by the shores, but also it was an important element for squares, courtyards and all other open public spaces. Later with the industrial revolution, water lost its value and the connection between the city and water was gone.

In this part of the study contemporary approaches of water-based architecture and the impacts of industrialization on waterfronts will be briefly discussed. Then 8 projects from different parts of the world and with different programs will be examined within their ID cards, these 8 projects will be divided into two groups: built and un-built projects.

a. Revitalizing the Waterfront

Waterfronts have been one of the key elements in the establishment of civilizations. They have also contributed to the design and redevelopment of cities seeking a more harmonious relationship between water and land in the effort to develop those cities. Throughout history civilized cities were the ones that were built near or in close relation with canals, rivers, seas and oceans. It is evident that water played a critical role in the development of cities like New York, Lisbon and Chicago. With water based development came industrialization and pollution in these cities, but recently with the

design of recreational areas and by decreasing the impact of industrialization, waterfronts have become more livable places gaining importance for environmental and community purposes. Presently waterfronts are not the best choice for the establishment of industrial complexes; in fact waterfronts are more commonly being planned with social and cultural considerations. This is why coastlines in disrepair have the potential of becoming premium sites for cultural, recreational and mixed-use developments.
As Ann Breen and Dick Rigby, co-founders of the Waterfront Center in Washington, DC, assert, "Urban waterfront planning and development became a 'civic interest that is persuasive and powerful'." Large-scale renewal projects were initially designed around the 1960's when this was a hot topic in the industry (Breen and Rigby, 1996).

Beginning in the 1960's U.S. cities made a significant push to make renewing their waterfronts a priority; some examples include Inner Harbor of Baltimore, downtown Boston, San Francisco and the metamorphosis of other cities are still continuing all around the world including Barcelona, Amsterdam, Shanghai and London. Osaka is another city that pursued waterfront renewal and followed two different design approaches. One of the design approaches taken was through the adaptive re-use of existing industrial buildings. The other approach was through the design of new modern buildings that would become a focal point of the area and would help in the efforts of revitalizing the water's edge by achieving interaction between the city and the waterfront much like the Guggenheim Museum does in Bilbao.

Figure 4.1: Guggenheim Museum, Bilbao

Source: www.guggenheim-bilbao.es

Although the nature of a waterfront provides a unique realm for development entailing social, recreational and environmental benefits as well as serving political and economic interests, the potential for synergy between the built environment and water is not something achieved through a simplistic approach. This synergy can be achieved through a complex and integrated process that requires mindful strategies, a substantial investment of time, money and above all research and design development. Once determined, however, it also calls for continuous reassessments (Ryan 2010).

Comparatively, some cities are taking more 'uncongenial' approaches to the revitalization and establishment of their waterfronts. One of these approaches includes the construction of artificial islands that are being built on landfills made up of sand. Projects like these are taking place in United Arab Emirates and Dubai. These projects are revolutionary in nature and seek to bring a whole new perspective to architecture by embracing water as a new project site. These projects are true feats of design as these artificial islands can be as big as 100 kilometer square.

Landscape architect Adrian Geuze stated that: "Something new is that sand is being sprouted in pancake layers to form land on an extensive scale. "

Figure 4.2: The Palm Project, Dubai

Source: www.palmjumeirah.ae

Each of these islands, like The Palm Jumeirah, and The Palm Jebel Ali, accommodate 2,500 properties that are built considering the increasing population, economy and the tourism of the country. Although these projects seem to help to develop the cities waterfronts, the idea of placing sand that displaces water may not be the best solution looking at it from a sustainability standpoint. These projects are being built to form artificial islands that are made of sand. By filling up the sea and damaging the underwater habitat is not an efficient solution. In addition to that, research on these projects shows that these manmade islands are sinking into the sea by millimeters per day and this is being attributed to the weight of the project and the unstable properties of the sand that was placed. Therefore this type of constriction technique is not an efficient way to build if we also consider the rising water levels.

An architectural urban design office Urbanlab in Chicago, pointed out the decrease in potable water sources and increasing water needs. So what they have proposed is a

Figure 4.3: Eco-Boulevards by Urbanlab

Source: Ryan 2010

revolutionary system, that would allow the city to re-use water, as well as the water coming from Michigan Lake, by creating new boulevards called "Eco-Boulevards", there function would be to clean and filter the used water while carrying it back to its source. The new boulevards would act like veins of the city, and by creating large open green areas, prairies, walk/bike trails, gardens and even farms these components would turn the city into a greener and more environment-friendly habitat (Ryan 2010).

One of the present plans for New York/New Jersey Upper Bay area has been generated by Guy Nordenson and his team (Nordenson is a structural engineering and architecture professor at Princeton University). Nordenson's team includes the local New York architectural office of Catherine Seavitt Studio, who has been involved in creating resilient coastlines with archipelagos of islands and reefs, tidal marshes and parks.

Figure 4.4: An aerial view of the plan proposed by Nordenson

Source: Ryan 2010

Ryan (2010) stated that: "The plan was to create an environment which could evolve and change over time according to needs, by addressing ecological, technical and economic issues."

The aim of the project is to convert underutilized industrial zones into recreational areas by cultivate social and cultural environment by taking the facts of global warming into consideration. Their strategy is to extend the relation between development of the city and the water to cure the results of rising sea levels on coastal communities, ecosystems and local infrastructures by 2050 (Ryan 2010).They proposed more flexible solutions, rather than placing seawalls and bulkheads. Their proposal was adjustable, so that it could be used in the future even though environmental, social and cultural demands will change. The aim of the proposed design was to accentuate the overall quality of life of the city by creating islands made from landfills with the sand that would be excavated from the bottom of the bay. Adam Yarinsky (2009) stated that: "The concept combines nature, commerce, culture and recreation into a kind of Central Park of the 21st century."

Therefore, architects and designers should consider reducing the negative effects on the environment, by designing more environmentally-friendly buildings to help decrease greenhouse gases that are being produced by the needs of the built-environment. As Ryan stated, "Water neutrality, or being able to live within the natural water budget, has become an imperative for projects on waterfront settings." (Ryan 2010).

b. Rediscovery of the Waterfront

Throughout history human civilizations have initially appeared within close proximity to rivers, lakes and canals. In Mesopotamia for example ancient civilizations thrived between the life-giving rivers the Tigris and Euphrates, also in Egypt by the Nile River and in Mexico by Lake Xochimilco. As Ryan (2010) stated, "Throughout the world, cultural history has always been associated with hydrology." Like all other organisms, humans are dependent on water for survival and have been using water for agriculture, tourism, art, transportation, defense, as well as commercial activities which were established by the onset of maritime technology. However, lately humans have become more dependent on water, by developing technology, changing environmental balances; there may be more need for water in daily life. As Ryan (2010) discusses in her book 'Building with Water': "Today, water is not only essential for life, it is imperative to mimic its natural systems to reintegrate waterfront improvements into the surrounding urban fabric as socially and ecologically responsible developments."

Transformations of waterfront's functional and spatial conditions were first caused by de-industrialization of ports with changes brought upon by transportation means and trade routes. Cities were left with degraded sites often triggering programs of urban renewal which looked to reintegrate the waterfront into the cities context.

Living, working and playing by the waterfronts become increasingly favored over time, and large investments have been made to redevelop some of the biggest cities waterfronts around the world. For example, Rome's waterfront on the Tiber River has accomplished this with the new Maxxi National Modern Art Museum, which was designed by Zaha Hadid and finished in 2010. Like Rome, other world renowned cities have taken upon them to provide the cities constituents with the redesign of their waterfront regions and have in the process rediscovered an apparently lost practice that allows the opportunity to design iconic architectural works at these locations.

Nevertheless, sometimes architects and designers neglect to take into account existing habitats as well as cultural and historical heritage and lose the long-term impact that comes along with designing community renewal projects. Ryan (2010) stated that:

> *Unfortunately, some fast growing cities around the world, like Ahmedabad, Manila and Panama City are quickly ceding their prime waterfront space to excessive privatization and missing an opportunity of a lifetime to protect public access to land along the urban waterfront.*

In order to successfully design sustainable waterfronts the following factors must be considered: natural, social, economical, historical, cultural and political. Designers must consider not only the above factors but must also incorporate design elements that will provide links between the downtown areas of the city and the waterfront, supply freshwater and improve the waste water system, and also offer a diverse building typology that promotes cultural, commercial, recreational, residential and entertainment activities throughout different times of the year.

Therefore, designing sculptures as buildings and creating cities out of ornamentations wouldn't support the idea of habitual success and livability of our environment, so designers should focus on sustainable waterfront planning for more manageable, fresh and clean neighborhoods by the edge of the water.

Ryan (2010) explained that:

> *Ultimately, waterfront planning begs an age-old question, namely why is living at the water's edge so appealing to the human race and why is building on water so attractive world-wide? Each waterfront locale creates a distinct environment conveying a set of unique values and inspirations to every individual. Without the water, neither iconic architecture, nor incredible art, nor cutting edge design can achieve such a lively and constantly changing world, increasing the stimulation of our senses and elevating our experience to live in harmony with the natural environment*

4.1 BUILT

In this part of the study, 4 different projects will be discussed which are all designed and built following contemporary design approaches. All the projects are different from each other according to their programs, functions and sizes. There are examples from Japan, Canada, Netherlands and Austria, so it can be seen that water-based architecture is a building type which can be seen all around the world.

Table 4.1: ID card for Kansai International Airport Terminal

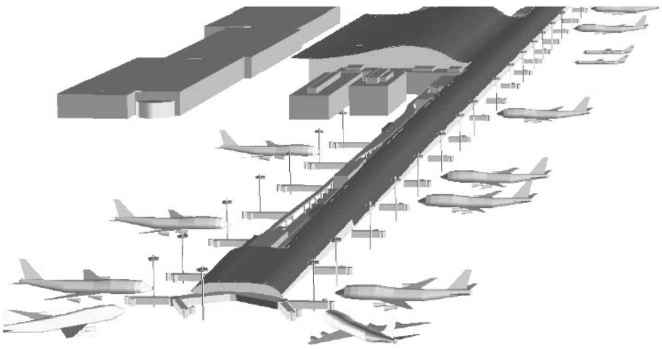
Kansai International Airport Terminal
Osaka / Japan

Renzo Piano
1994
www.rpbw.com

The Kansai Airport, located on an artificial island in the Bay of Osaka, was built in 3 years by 6,000 workers. It is 1.7km long and can holds about 100,000 passengers every day. The roof consists of a series of arches whose form and size are determined by research into the dynamic lines of air flow circulating the building. The general structure follows the movement of a wave. The shape of Kansai fits in perfectly with the surrounding environment.

The airport sits on an artificial which was built between the years 1987 to 1991 and turned out to be the largest man-made island in the world with 22.000.000 square meters. Then as a result of the design competition which was done for the airport project, the project by Renzo Piano decided to be built.

Final cost of constructing both island and passenger terminal was $14 billion US dollars. However the island is sinking to the sea, though time but since 2002 the rate of submergence has decreased and even by the hit of the Kobe Earthquake of 1995 the terminal sustained no damage.



Source: www.rpbw.com

Table 4.2: ID card for Floating House

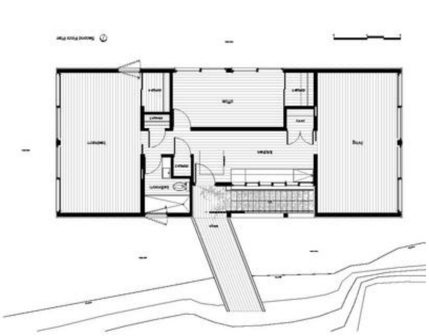
Floating House
Ontario / Canada

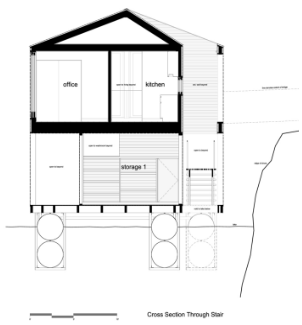
MOS Architects
2007
www.mos-office.net

This house is designed to float on a pontoon based on water. Thus this allows it to rise and fall with tidal changes. Pontoons are the foundation for the steel & wood structure above and they are 2.4 meters long and 1 meter wide, and they all are filled with air.

The house has slatted structural frames that allow air flow through the building not only to provide natural ventilation but also to keep the weight balanced on top of the pontoons. The mechanical equipment of the building like plumbing and electricity is being supplied by flexible hoses to allow building to float on water more comfortably.

Thus Floating House which was designed by MOS architects is environmentally friendly, functional, and aesthetically pleasing in terms of the form and the materials that have been used to give it its character.





Source: www.mos-office.net

Table 4.3: ID card for Silodam

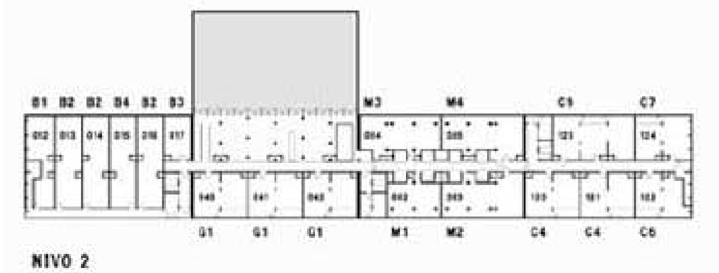
Silodam
Amsterdam / Netherlands

MVRDV
2002
www.mvrdv.nl

The Stacked box – like design of the project expresses different functions with the different use of materials on the façade which creates little neighborhoods with their own distinct identity. This container looking units are representative of the previous use of the water front which was an industrial wasteland, thus this project helps revitalize the new urban waterfront settings. The project accommodates 17,000 modular residential units with 15 different apartment types and is sited along the IJ River in Amsterdam.

The project also has 600 square meters of commercial space. Most of the commercial spaces are placed at ground level. The residents of Silodam have the opportunity to enjoy the IJ River from a big terrace and use the mooring area below the building to park their boats.

The building was built on a 300m long pier with concrete pillars occupying a 2,600 square meters site area with the total building area of 26,000 square meters.



Source: www.mvrdv.nl

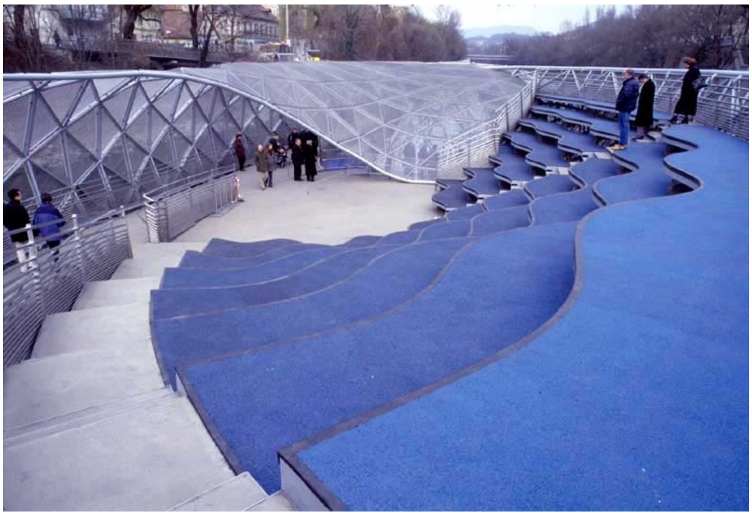
Table 4.4: ID card for Mur Island

Mur Island
Graz / Austria

Studio Acconci
www.acconci.com

The initial concept used in designing this building was to connect two sides of the river and create a focal point. The designers of the island were inspired from a 'bowl', which would house the theater in it, however after some revisions during the design process by twisting and turning it upside down, the bowl turned into this bulbous form, which resembles a seashell.

As the designer Hearing Vitto Acconci explains his design, "One space twists and turns and wraps to become the other." So the building has a fluid design, where spaces run from one to another like water. The island accommodates an outdoor amphitheater, café and has 2 bridges that connect the island to land. The project can also move up and down to adapt to the tidal changes even though just its steel framework weighs 320 tons.



Source: www.acconci.com

4.2 UN-BUILT

In this part of the study, four un-built projects will be briefly discussed within their ID cards. Additional examples of water-based architecture are listed in Table 4.5.

Table 4.5: Project index according to their relations to site

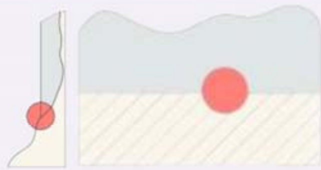
LAND	LAND + WATER	WATER
		
Floating Mega Arcology for Boston's Harbor, *Kevin Schopfer, Boston / USA, 2010*	***The Ark***, *Disaster Proof Hotel, Remistudio, 2011*	***Noah's Tower, Kenneth Cheung Shiu Lun, Hong Kong***
POSTECH Marine Sciences Campus, SmithGroup, Uljin / South Korea, 2010	***Miyi Tower and Master plan***, *Studio SHIFT & SWA Group, estimated time 2013*	***Coral Reef***, *Matrix and Plug-In For 1000 Passive Houses, Port-au-Prince / Haiti, 2011*
Aquatic Center, *Studio Shift, Sichuan Province / China, 2013*	***NOAH*** *- Heavenly Abode, E. Kevin Schopfer, New Orleans / USA, 2011*	***World's First Solar-Powered Floating Island,*** *Seou*
	W Hotel Dubai, *Jean Nouvel, Dubai / United Arab Emirates, 2005*	***Low Carbon Future City, SBA Design,*** *Yinggehai / China, 2011*
	Freshwater Factory Skyscraper, *DCA (Design Crew For Architecture)****,*** *Almeria / Spain****, 2010***	***Waterdwellings IJburg, Hybrids,*** *Marlies Rohmer, Amsterdam / Netherlands, 2010*
	The Floating Islands, *Vincent Callebaut, Hammerfest Norway, 2004*	***Gadeokdo Zero Carbon Island,*** *EFFEKT, South Korea*
	Sahat El Shohada, The Underwater Venice Of Beirut, Vincent Callebaut, Beirut / Lebanon, 2004	***Ocean Imagination***, *Unsangdong Architects, Yeosu Expo/ Korea, 2012*
	Performing Arts Centre, *ZAHA HADID, Abu Dhabi*	***Transforming Abandoned Oil Rigs into Habitable Structures, Ku Yee Kee, Hor Sue-Wern,*** *Malaysia, 2011*
	Oslo Opera House, Oslo, Norway	***Futuristic Oceanic Pavilion,*** *Emergent Architecture and Kokkugia, Yeosu Expo / Korea, 2012*
	Zero-Energy Housing Wedge in Denmark Covered in Solar Panels, *C.F.Møller, Aalborg, Denmark*	***The Iceberg,*** *CEBRA OG JDS Architects & Louis Paillard, The Aarhus Docklands / Denmark, 2010*
		Middelburg Bridge House, *Architecten van Mourik, Middelburg / Netherlands, 2004*
		Underwater Skyscraper , *Higinio Llames, Ifigeneia Arvaniti, Spain, Annual Skyscraper Competition*
		Wavescape Pavilion, *AQSO Arquitectos + Ydesign , Yeosu Expo / Korea, 2012*
earth building water		***Amphibius 1000,*** *Giancarlo Zema Design Group, Qater / Saudi Arabia, 2008*
		Wetropolis, *S+PBA, Bangkok / Thailand, 2011*

Table 4.6: ID card for Marine Research Center

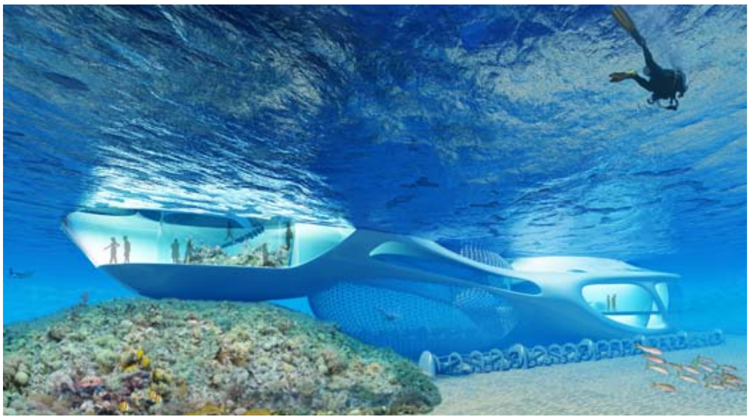
Marine Research Center
Bali / Indonesia

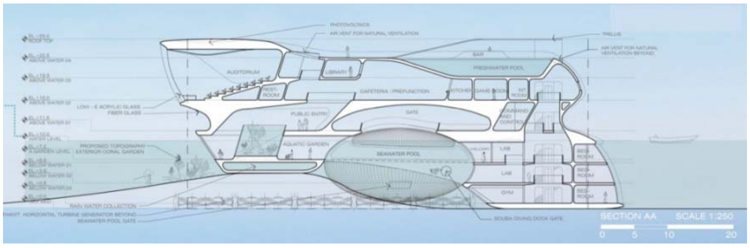
Solus 4
2010
www.solus4.com

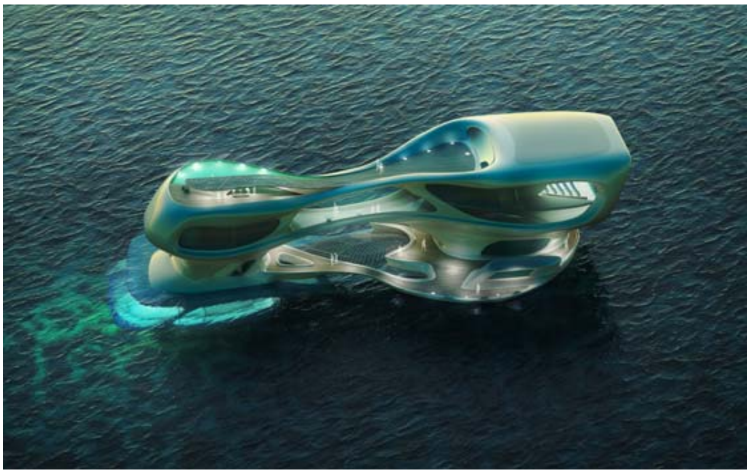
The Marine Research Center is planned to be located 100 meters away and parallel to the shore of Kuta Beach, Bali, Indonesia. The projects total area is 2,500 square meters and the program is composed of three main components: public, semipublic and private which includes a variety of spaces: underwater labs, scientist bedrooms and an aquatic garden to sea water pool, swimming pool terrace, bar and an auditorium. The spaces are located both above and under water and allow the visitors and scientist to take full advantage of the landscape of Bali and the underwater habitat. This project represents a new typology for stationary in-water based projects that can be reached by means of a boat.

The design is both aesthetically imposing and seamlessly integrated into its aquatic natural environment. The result is a very fluid structure born of the sea and its immediate and direct visual connection to the exterior.

The center will serve not only as an architectural icon for Bali, but also as an international model for modern sustainable design with its use of on-site renewable energy resources. The project is intended to be completely energy efficient through its integration of such technologies as tidal wave energy generation, natural ventilation, rain water collection, passive solar energy, low E glass, and high reflectance fiber glass materials. (Solus 4)







Source: www.solus4.com

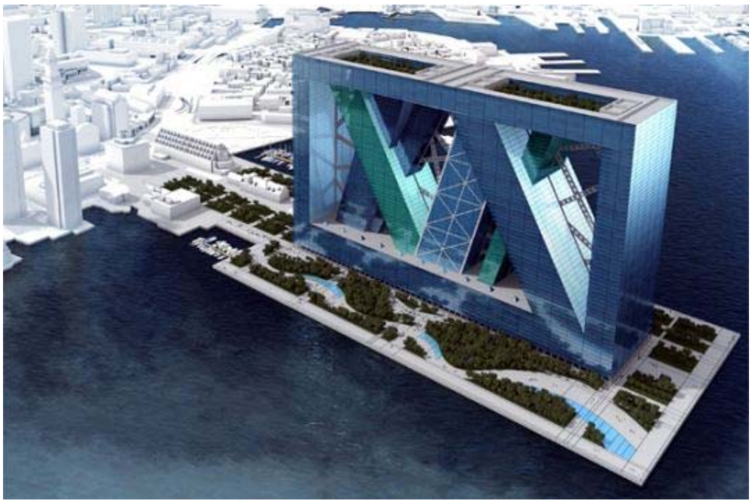
Table 4.7: ID card for BOA

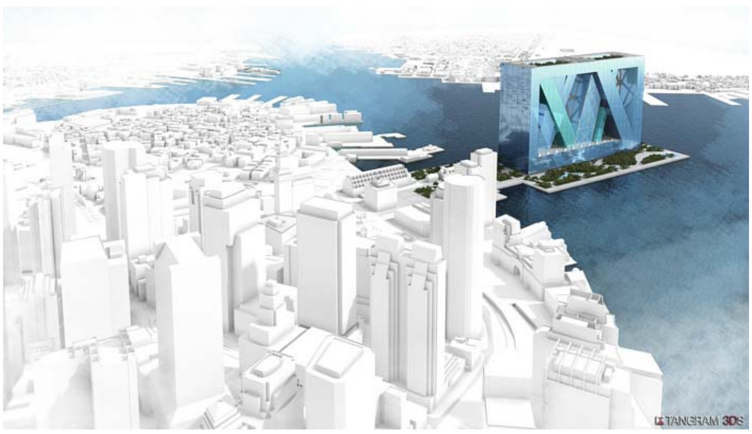
BOA
Boston / USA

Kevin Schopfer, AIA, RIBA
2010
www.schopferassociates.com

The BoA, short for Boston Arcology, is a sustainable mega structure designed by Kevin Schopfer. The BoA will accommodate 15,000 people in hotels, offices, retail spaces, museums, condominiums, and will also house a new city hall. Built to LEED standards with golden proportions, this amazing building would serve as an expansion of the city without any impact to the existing city itself. The Mega city will be placed on a buoyant platform of concrete cells and will be located in the Boston Harbor next to downtown. Also, The BoA will sit perpendicular to the waterfront; therefore it will minimize the view sheds of existing buildings onshore in Boston. The massing of the structure was designed using the principles of the golden rectangles. Angles and towers criss-cross inside of a fixed perimeter structure, giving support to the projections contained within. Elevators and moving walkways aid the circulation of residents, employees and visitors in order to create an all pedestrian environment. The BOA will have sky gardens which will be located every 30 floors and act as public squares for gathering spaces.

The city will be generating its energy via wind turbines, solar panels and harbor based water turbines. Natural daylight will flood the building with the help of a passive glazing system. The BoA will also include a grey water recycling system, sky garden heating and cooling vents.

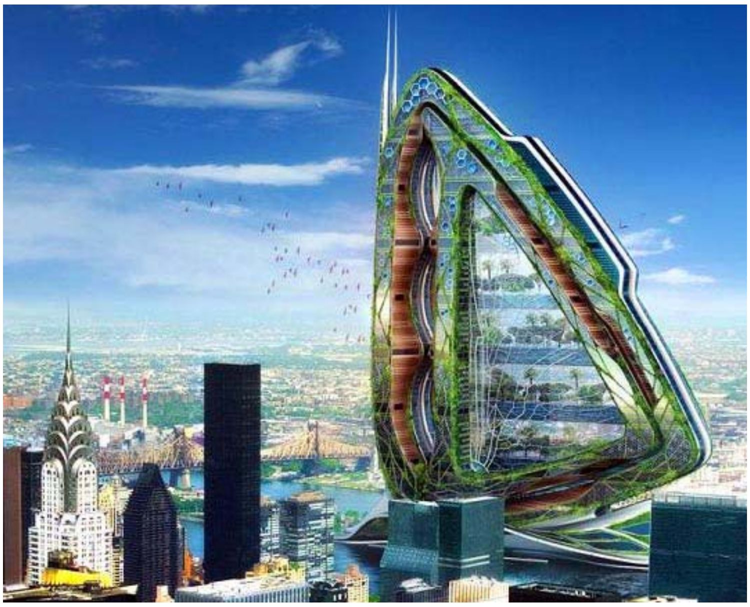
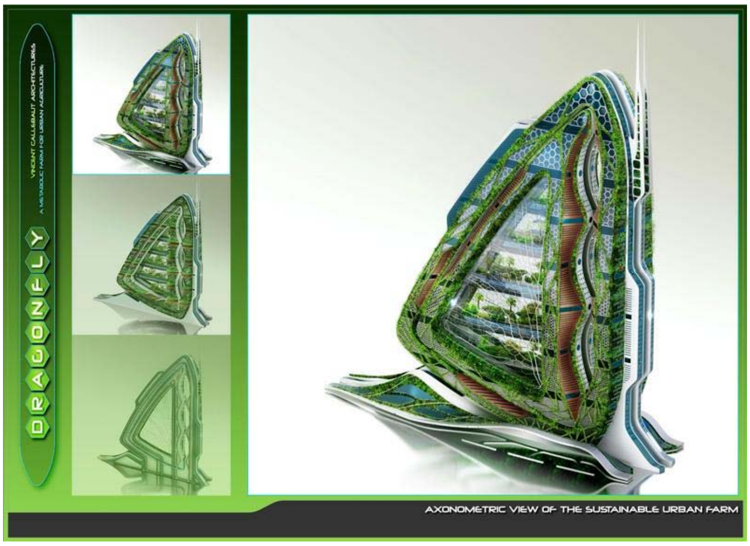




Source: www. schopferassociates.com

Table 4.8: ID card for Dragonfly

<table>
<tr>
<td>Dragonfly, a Metabolic Farm for Responsible Eco-Cities
NYC, Roosevelt Island / USA

Vincent Callebaut
2009
www.vincent.callebaut.org</td>
<td rowspan="2">



</td>
</tr>
<tr>
<td>This new eco-city of New York City was modeled after the wings of a dragonfly, and it aims to ease the problems of food mileage and shortage, and seeks to reconnect consumers with producers. Dragonfly is a 132 floor building with 600m height that accommodate 28 different agricultural fields for the production of fruit, vegetables, grains, as well as meat and dairy. A combination of solar and wind power make Belgian architect Vincent Callebaut's Dragonfly concept 100 percent self-sufficient.

This utopian superstructure includes offices, research labs, housing, and communal areas that are interspersed between orchards, farms, and production rooms. Plant and animal farming is arranged throughout the Dragonfly’s steel and glass set of wings so as to maintain proper soil nutrient levels and facilitate the reuse of bio waste. The spaces between the wings are designed to take advantage of solar energy by accumulating warm air in the structure during winter. Cooling in the summer will be provided through natural ventilation and evapo-perspiration from the plants. Exterior vertical gardens filter rain water, which is then mixed with domestic liquid waste. Together they are treated organically before being recirculated for farm use, preserving and distributing nitrogen, phosphorus and potassium.</td>
</tr>
</table>

Source: www.vincent.callebaut.org

Table 4.9: ID card for High tide Street

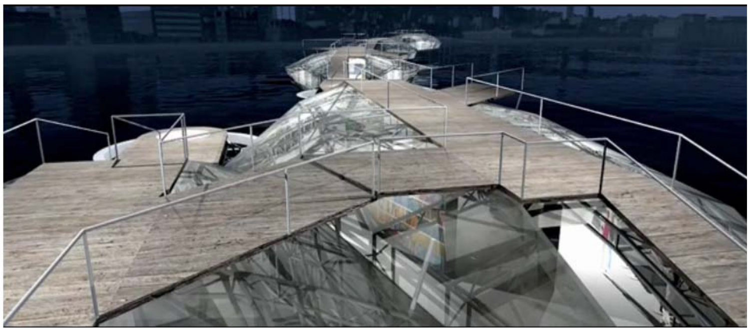
High Tide Street
Thames River, London / UK

James Gardener
2010
www.jamesgardener.com

Gardener stated (2010), “Floating delicately between the physical and cultural boundaries of Silvertown and Woolwich, a new inhabitable bridge generates ephemeral connections and its constantly shifting configurations are governed by the rhythmic ebb and flow of the Thames. Londoners can begin to re-territorialize the once vibrant artery of the city in this vacillating new cultural hub for London.”

James Gardener is an architecture student at University of Westminster who has designed this conceptual bridge for the River Thames, London. This bridge is made from a series of floating elements that would be linked together and free to move with the tide. Each of the floating pieces is able to move and they will be connected by the use of flexible hinges that could be reconfigured.

The program proposes for a new cultural ‘high street’ for Silvertown/ Woolwich/ London, including a Thames Oyster bar, a floating library, a concert hall and fish market, all continuously shifting with the tide. (www.dezeen.com)



Source: www. jamesgardener.com

5. COMPERATIVE ANALYSIS OF OFF-SHORE ARCHITECTURE

In this part of the study, only six projects will be discussed. All the selected projects are off-shore floating city proposals; none of them have been built and none of them have a connection with land. First, all six projects will be presented briefly within their ID cards, then these off-shore architecture examples will be analyzed considering six design principles, and for each of the principles two of the six selected projects will be compared from a self-sustainability standpoint as well as seeking to exemplify the importance of each project in minimizing its impact and contribution to environmental issues previously discussed in this study.

The six design criteria are:

i. Mobility
ii. Form
iii. Structure
iv. Spatial Organization
v. Function
vi. Self-sustainability

Table 5.1: ID card for Lilypad

Lilypad
Prototype

Vincent Callebaut
2008
www. vincent.callebaut.org

Relation to the site: Prototype designed on water for any of the overcrowding cities and also the ones that will be affected by the rise of water levels. Components are both above & underwater.

Mobility: Each Lilypad is mobile and can travel all around the world.

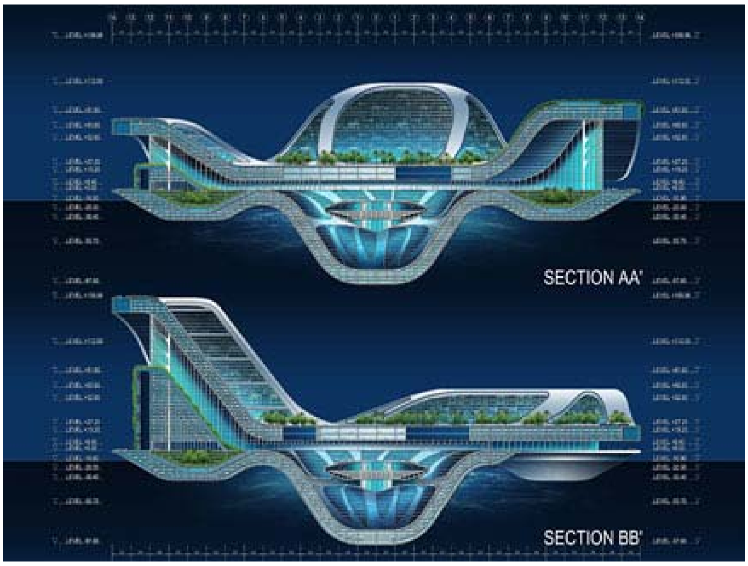
Form: The floating structure is and analogical design, which was directly inspired from the aquatic plant with highly ribbed leaves, an exceptional plasticity and an organic form.

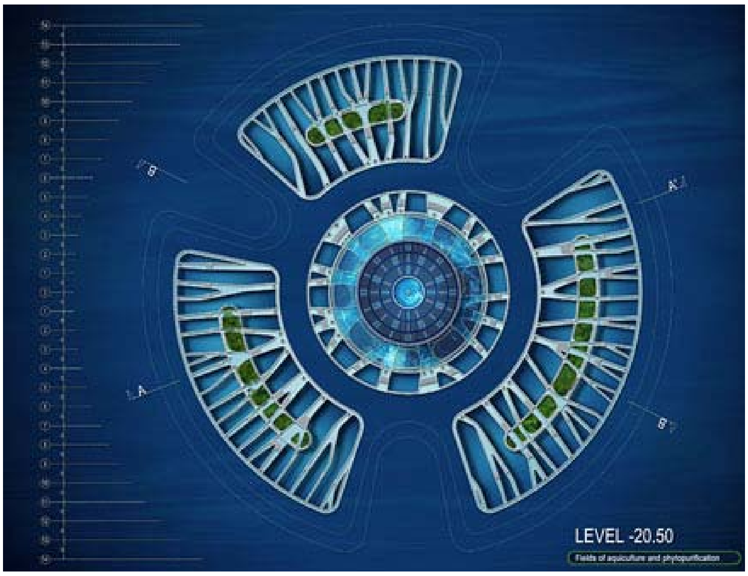
Structure: 500,000 m² surface area

Spatial organization: Amphibian facility, accommodating 50,000 inhabitants, has three marinas and three mountains dedicated respectively to work, shops and entertainment. The whole site is covered by a stratum of planted housing in suspended gardens and crossed by a network of streets and alleyways with organic outline.

Function: Mix use facility / City: Residential, marinas, offices, commercial and entertainment areas as well as suspended gardens.

Self-sustainability: The project has zero carbon emission due to the integration of all the renewable energy systems (solar, thermal and photovoltaic energies, wind energy, hydraulic, tidal power station, osmotic energies, phytopurification, biomass) producing thus more energy than it consumes.





Source: www.vincent.callebaut.org

Table 5.2: ID card for Harvest City

Harvest City
Haiti

E. Kevin Schopfer, AIA, RIBA
2010
www.schopferassociates.com

Relation to the site: Harvest City is planned as a two mile diameter off-shore complex.

Mobility: The city consists of tethered floating modules. The entire complex will float and be cable secured to the sea bed.

Form: The form of the Harvest city is planned geometrically making it very practical for the spatial organization of the city. The circular form of the crop growth parts were chosen to deflect waves and for its use of rotating irrigation systems.

Structure: Designers think that through the low profile of the perimeters, hurricanes and typhoon will have little effect on this community. Also a breakwater, which will be formed by the concrete rubble debris from the earthquake of Haiti, will be constructed to add to the city's stability. The system of floating platforms allows for a master plan to grow and link to other future `cities within the harbor.

Spatial organization: The overall design is divided into four zones, which are interconnected by a linear canal system. The four major canals will feed the neighborhoods that are designed as four story housing complexes. The outer perimeter of the design is predominately 'one acre' crop circles with secondary feeder canals. The inner 'harbor' will house the city center with schools, administrative, community activities and general marketplace.

Function: It is a floating agricultural / light industrial city offered as a solution to Haiti's dwelling problems. It includes residential units, processing warehouses, crop circles, schools, administrative units, community activities and general marketplace.

Self-sustainability: It is planned to use the electrical power produced by a combination of solar collection roof panels and wind turbine arrangement. The floating aquifers have been proposed as water tanks that would be secured to concrete hulls with gravity fed piping to specific neighborhoods. These facilities will use covered tops to collect water and protect it.

Source: www.schopferassociates.com

Table 5.3: ID card for Green Float

Green Float
Equatorial Ocean

Shimizu Corporation
2010
www.shimz.co.jp

Relation to the site: The Green Float City is designed for the equatorial region where sunlight is plentiful and the impact of typhoons is minimal. It is off-shore and measuring one kilometer high and wide.

Mobility: Green Float isn't fixed in place; instead, it floats slowly along with the ocean current.

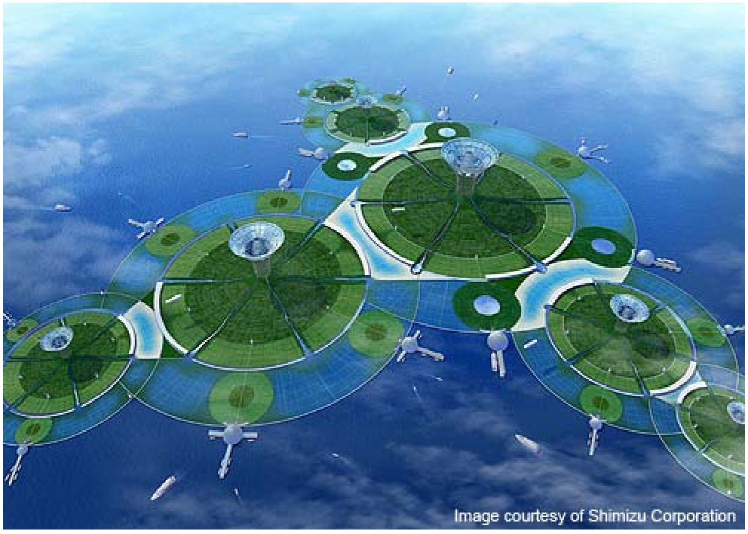
Form: As the population increases this self-sustaining city has the opportunity to grow just like a lily floating on water.

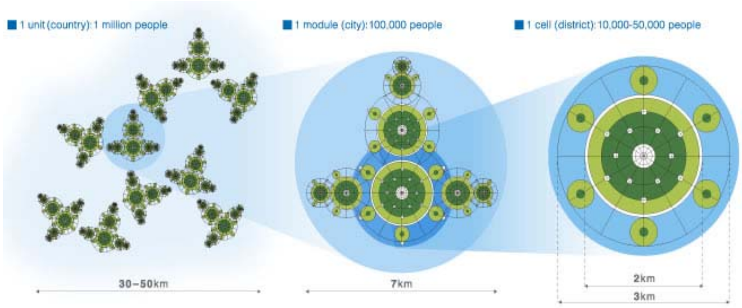
Structure: Green Float will be built by "marine smart engineering," utilizing the buoyancy force of seawater. This will enable it to be built safely and efficiently.

Spatial organization: The tower is about 1000m and the part between 700 and 1,000 m high is the urban area where the actual city is placed due to the climatic reasons. On the periphery of the floating city, there are residences and hospitals, and in the center, there are offices and commercial uses. The tower is designed to be used as a plant factory that grows vegetables. The agricultural areas are placed at the lower part and here is where cereals are grown. Also the marine cultivation is taking place at this lower area. The plant factory where the CO2, wastewater, and garbage from the urban area become nutrients is below all the other parts of the city.

Function: It is designed to be a city complex, and with a group of these cities it may even create a new country. It consists of urban areas, residences, hospitals, offices, commercial, plant factory, vegetable and cereal fields, plant factory, and in the shallows, fish and seaweed are cultivated (marine cultivation)

Self-sustainability: The Floating city is designed to fully employ a range of natural energy sources including space solar power satellites, ocean thermal energy conversion, waves, wind and solar power. Its botanical gardens absorb CO2. There are also arterial cycling, waste product cycling, sea water purification, as well as assisting in purifying the great pacific garbage patch to produce energy.





Source: www.shimz.co.jp

Table 5.4: ID card for HO2 Scraper

HO2 Scraper
Malaysia

Sarly Adre Bin Sarkum
2010
www.evolo.com

Relation to the site: HO2 scraper is an off-shore self-sustaining city.

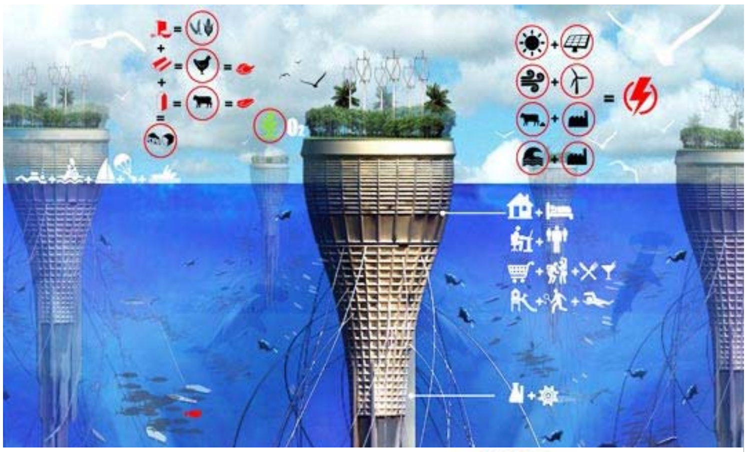
Mobility: The Water Scraper has the ability to move with the tides by keeping its balance with its tentacles.

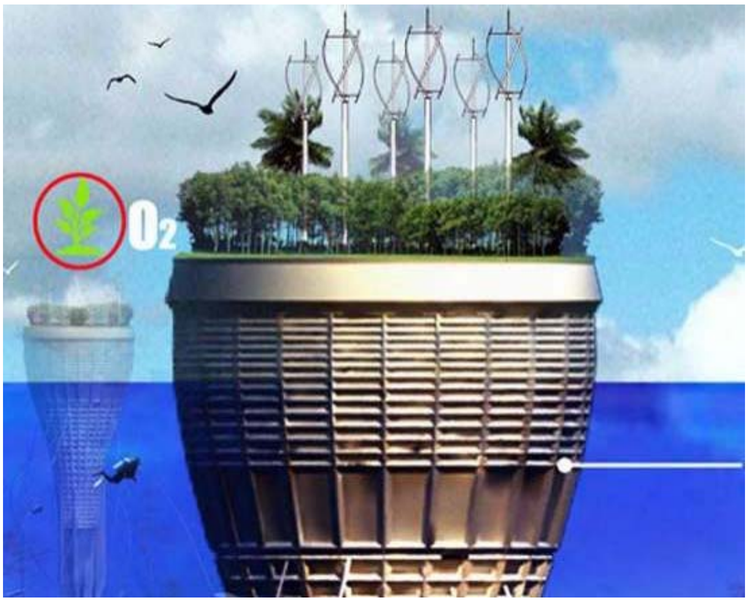
Form: HO2 scraper is a jelly-fish like building with its tentacles, it is about 100m high and most of it is underwater.

Structure: The building is placed directly in balance through a system using a tank to provide equilibrium. The tentacles are used as a means to balance the structure and to generate power through the continuous wave movement as the complex moves along. Buoyancy and ballast controls are placed at the bottom to keep the building upright using a system of ballasts aided by a set of squid-like tentacles.

Spatial organization: The HO2 scraper basic program components are areas to live, work, sports, treatment and maintenance. The living, shopping, office, restaurant spaces are located underwater, but close to the water's surface to be able to get enough daylight. The mechanical and technical spaces are located below the sea level and are kept in the deeper parts of the floating scraper. The program requires no special external resources so the wind generators are placed at the roof garden. There is also animal farming component is placed there, so that they can get the natural light and the air best.
Function: It is designed to be a floating city, which consists of the functions as follows: residential, work, sports, treatment, animal farming, and a small forest.

Self-sustainability: The HO2 Scraper generates its own electricity using wave, wind, and solar power and it produces its own food through farming, aquaculture, and hydroponic techniques. The surface of the submerged skyscraper sustains a small forest. The floating city has a set of squid-like tentacles that generate kinetic energy.





Source: www.evolo.com

Table 5.5: ID card for The Floating States of Maldives

The Floating States of Maldives
Maldives

FLaT
2010
www. archdaily.com

Relation to the site: The project is designed as a floating island just like the islands of Maldives and was planned to accommodate 400,000 people in its vertical components.

Mobility: Mobile floating city.

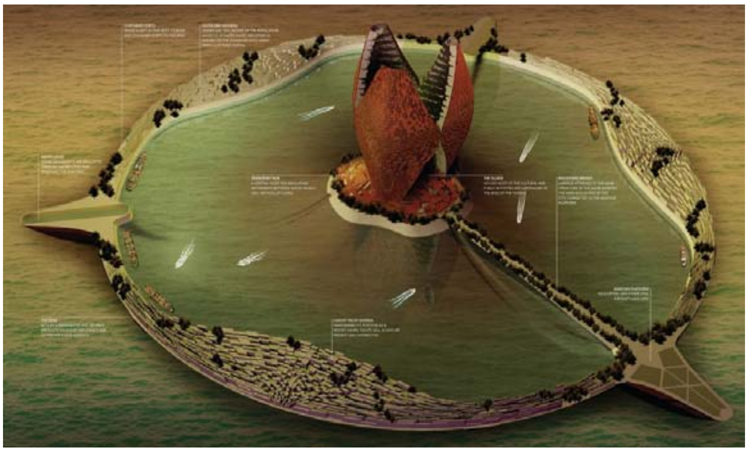
Form: The understanding of form of the floating Maldives is organic, but also considers stability with its symmetrical design.

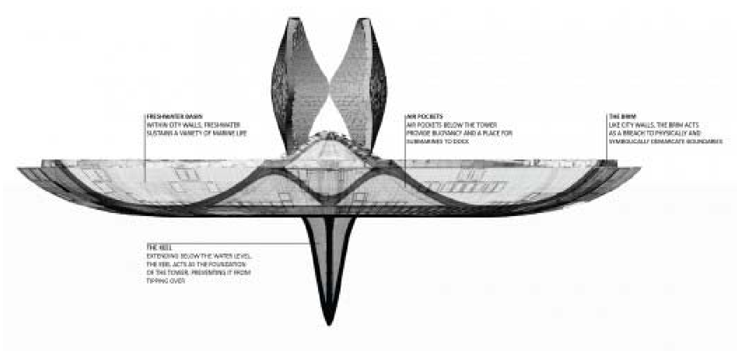
Structure: The floating structure is made of steel, with an advanced truss system, which consists of primary bracing and transport conduits and also a secondary truss structure that integrates with the main system. Also there are essentially engineering marvels of buoyancy and height. The networks of towers soar to a maximum of 1000m above sea level and the keels dive 1000m below the sea.

Spatial organization: The floating city is designed in two main parts, the tower and the platform that surrounds the entire project. The towers vertical spatial organization order is as follows: communication satellites, labs, administrative offices, luxury residential areas, hotels, central business offices, sky lobby, hotels, residential, schools, civic place, stadium, transport hub, submarine docks, water theme park, shipyard, fish farms, eco-hotels, underwater observatories, agricultural areas and the deep-sea research laboratories. According to designers the outer ring of the project is a large 'bowl' that functions both as a method of buoyancy, but also as 'city walls' of sorts, helping protect it against rough seas.

Function: Floating States of Maldives is a floating facility, as a city complex it consists of, labs, administrative offices, luxury residential areas, central business offices, sky lobby, hotels, schools, stadium, transport hub, submarine docks, underwater observatories, and agricultural areas.

Self-sustainability: The City has seafood culture farms and also fish farms.



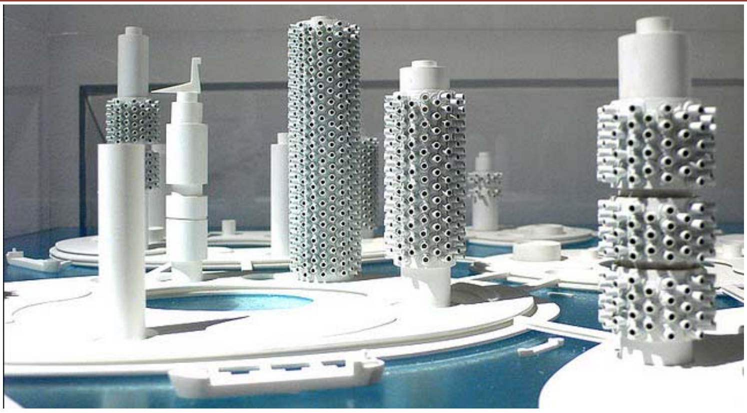


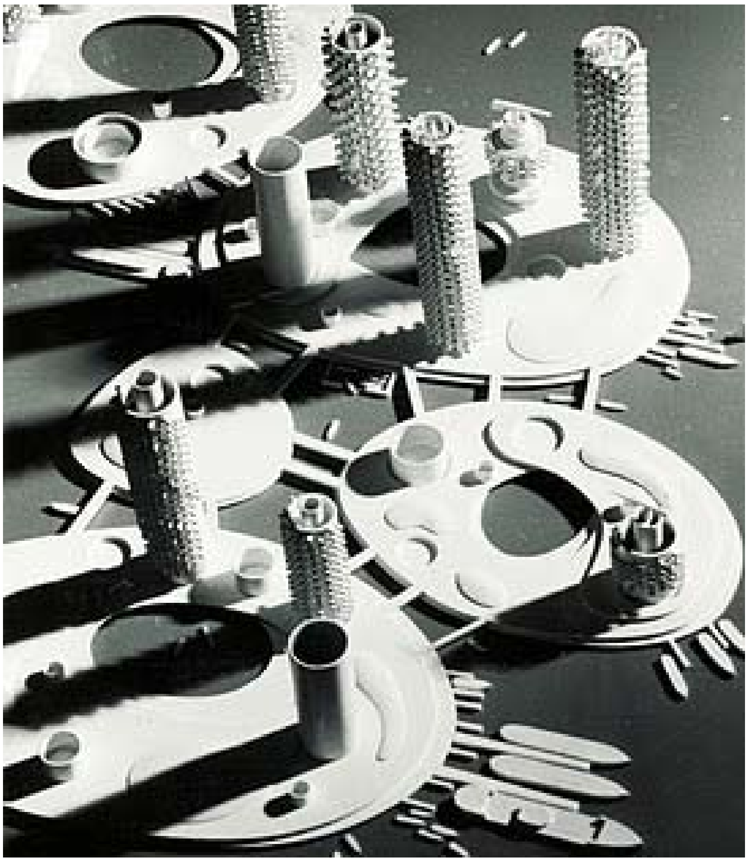
Source: www.archdaily.com

Table 5.6: ID card for Marine City

Marine City
Japan

Kiyonori Kikutake
1959
www.kikutake.co.jp





Relation to the site: The Marine City Capsules Project designed by architect Kiyonori Kikutake in 1960 -as a way of unblocking the heart of Tokyo- can now be considered a leading edge solution. Marine city was designed to be a floating city with a series of cylindrical residential towers built on several constructed islands.

Mobility: The city components weren't planned to be anchored at a fixed point, but could rather move anywhere, like an organism.

Form: In this space Kikutake elaborated a vision of nomadic, organically adaptable human habitats in previously uninhabitable territory. His vision was futuristic, technocratic, romantic, and most importantly it was modular and metabolic with its evolving cylindrical towers.

Structure: In this project pontoons carry a concrete deck like a raft. Piercing the deck and extending a hundred or more feet below the waters surface are great concrete cylinders. Kikutake also developed the idea of artificial land as a vertical wall plane rather than as horizontal ground planes. Houses would be attached to the wall, not to the ground. He proposed 300 meters high concrete cylinders accommodating 5,000 people.

Spatial organization: Marine City was developed as a way of exploring infinite expansion and multiplication. It is a complete network of living facilities, based on a modular system in which fixed structures allow building units to grow and die and grow again. The ground of the artificial island would be reserved for agriculture, industry, and entertainment, while residential towers would grow downward beneath the water's surface, reaching as deep as 200 meters.

Function: It was designed as a solution to the labyrinthine density of Japan's metropolitan areas. The city sustains agricultural, industrial, and entertainment areas, also the residential towers.

Self-sustainability: This floating city, claims self-sufficiency through energy generation attributed to a perimeter of solar collectors and by incorporating a tidal energy generating plant.

Source: www.kikutake.co.jp

Table 5.7: Comparative analysis chart

Comparative Analysis of Off-shore Architecture	Lilypad	Harvest City	Green Float	HO2 Scraper	Floating States of Maldives	Marine City
Relation to the Site	Off-shore	Off-shore	Off-shore	Off-shore	Off-shore	Off-shore
Mobility	Mobile	Non-Mobile	Mobile	Mobile	Mobile	Mobile
Form	Analogic-Organic	Geometric	Geometric	Analogic	Parametric	Geometric -Analogic
Structure	Steel	Concrete	Magnesium Alloys-Concrete	Concrete	Steel	Concrete
Spatial organization	Clustered	Centralized – Horizontal	Clustered	Vertical Planning	Centralized	Clustered Islands
Function	City	City	City	City + social activity areas	City + social activity areas	City
Self-sustainability	Self-sustainable	Self-sustainable	Self-sustainable	Self-sustainable	Partially Self-sustainable	Partially Self-sustainable

5.1 MOBILITY

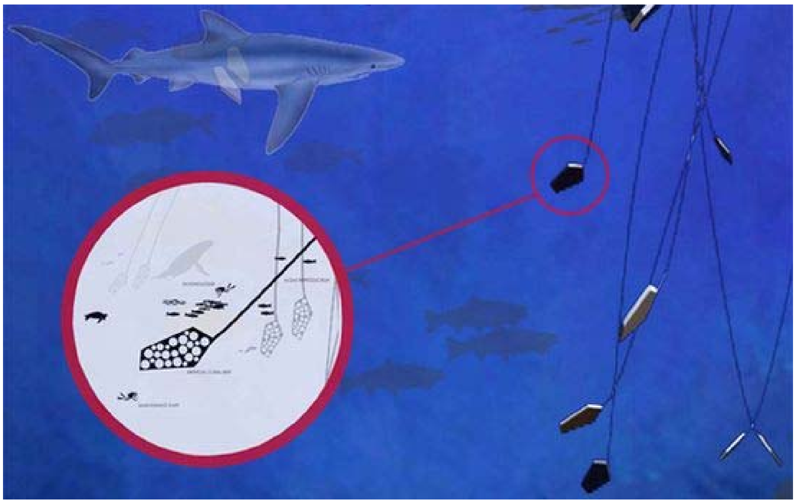
Mobile Architecture is an innovative idea which started with the fishing villages built on rafts around the world, but most prominent in Asia. Each day the idea of living in a mobile house or city has become more popular. Mobility allows humans to change location and adapt to new living environments. This would be highly beneficial in the case of natural disasters like hurricanes, earthquakes and floods, the inhabitants of these cities lose their houses and in some cases entire cities are lost. So then they either can decide to move to a whole different city/location or try to recover from the results of the disasters that they have been through. A case can therefore be made for 'mobile architecture' as one of the solutions to this problem. At this point the Harvest City, which had been designed for the inhabitants of Haiti after the devastating earthquake in 2010, can be an example for this type of architecture. The Harvest City proposes to Haiti's nature refugees a floating agricultural / light industrial city off the shores of Haiti and it is designed as a two mile diameter off-shore community. The city consists of tethered floating modules and the entire complex will float on the ocean's surface, but will be secured to the sea bed through the use of cable ties. Also since the Harvest City is planned as a horizontal complex as it expands it gets harder for it to move and travel around the world to provide a 'home' for other nature refugees. Therefore although The Harvest City is planned as a floating landmass to help people who need a new environment to live in, with its non-mobile features it also limits its usefulness.

Figure 5.1: Harvest City illustration

Source: www.schopferassociates.com

Mobile Architecture is not only a solution for disasters, but also a conscious and innovative way of planning for the future. The ability to adapt to a new environment with these mobile buildings/cities allows people to change where and how they live. In today's world cities are faced with several problems like lack of resources, climate problems and the rising rates of unemployment. All these reasons drive people to leave their current location moving in search of another city with better conditions. However, mobile cities are not dependent on these facts because they have the ability to change the conditions and adapt to a new place by moving. The HO2 Scraper is designed as a floating mobile city, which can travel all around the world. The Water Scraper has the ability to move with the tides by keeping its balance with its tentacles. The tentacles generate power and they also serve to balance the city structure. The ability to move around the world and find new living environments for a floating city would offer its inhabitants access to resources and a dependable place to spend their lives.

Figure 5.2: HO2 Scraper's tentacle detail



Source: www.evolo.com

Since about 70 percent of Earth's surface is ocean, and there is the truth of rising water levels besides many other reasons, so it is only natural development that humans will live on the sea someday. Although these floating mobile cities used to be a fantasy back in history, it is now possible with the emerging and available technological improvements. So architects have the opportunity to design and build these futuristic cities, or even countries made from several floating cities coming together. However, design rules for such cities must include ideas like consuming zero energy, using fewer resources and also seek to establish or maintain a tie to nature.

5.2 FORM

Designing a floating off-shore city is a complex process with several variables. The understanding of form for these projects relies on different factors, but most importantly the impact of form on the self-sustainability features of a floating city is unquestionably of great importance. Projects' forms drive the stability, structure, spatial organization, function and their relationship with water as well as their sustainability. In addition, the form of an off-shore city is a highly important issue because its harmony, the relation and interaction with water is different and more critical compared to a building on land. The floating eco-city Lilypad is a fine example of an amphibian city which is a half aquatic and half terrestrial city and it roughly accommodates 50,000 inhabitants.

Figure 5.3: Lilypad's understanding of form

Source: www.vincent.callebaut.org

The floating structure is an analogical design, which was directly inspired from the aquatic plant the Lilypad of Amazonia Victoria Regia that has highly ribbed leaves, an exceptional plasticity and an organic form. The architect of the project Vincent Callebaut (2008) stated that:

> *True biotope entirely recyclable, this floating Ecopolis tends thus towards the positive eco-accountancy of the building in the oceanic ecosystems by generating its own electricity, filtering the oxygen, recycling the CO2 and the waste, by purifying and softening biologically used waters and by integrating ecological niches, aquaculture fields and biotic corridors on and under its body to meet its own food needs.*

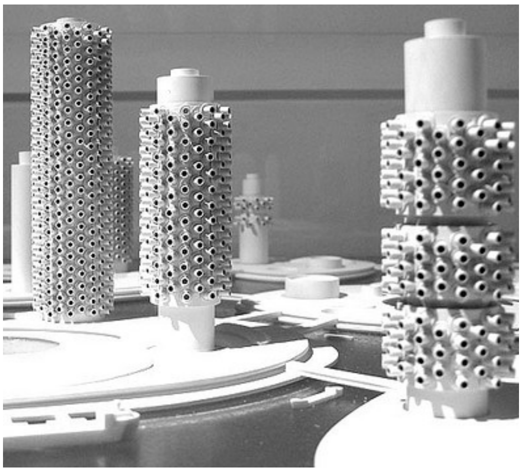
The whole city is covered by a texture which is created by planted housing in suspended gardens and intersected by a network of streets and alleyways with organic outline. That way the relation between humans and nature can be explored in this new living floating eco-city environment.

As stated above the analogic design understanding of the city helps it to live like an actual organism, like a lilypad. It is non-symmetrical and has three marinas and three mountains dedicated respectively to work areas, shops and entertainment. Each of the mountains has a different height allowing the other regions to have outside views of the city and also to help with cross ventilation. Also the location of ventilation equipment and photovoltaic panels are placed and designed according to the form of the project to allow for optimal energy gains with its analogic design. Callebaut (2008) stated that:

> *It will be one of the major challenges of the 21st Century to create an international convention inventing new special means to accommodate the environmental migrants by recognizing their rights and obligations. Political and social challenge, the urban sustainable development must more than ever enter in resonance worldly with the human sustainable development.*

However this issue dates back into the middle of 20^{th} century and back into the days when the first floating eco-cities were proposed by Kiyonori Kikutake as a solution to the labyrinthine density of Japan’s metropolitan areas. After all, the early concepts of these industrial islands developed in the design of Marine City with its 300 meter high towers. Marine city was a proposal to build up a new world for the future of human kind. Kikutake’s city for half a million inhabitants was planned as an ocean garden city around functionally zoned concentric rings. Each of the 300 meter high towers was planned to accommodate 5,000 residents that would be living in prefabricated apartment cylinders which were attached to the towers surface magnetically. The design of the towers is like a corn cob with the cylindrical pieces attached to the external surface of the core.

Figure 5.4: Marine City's concrete towers



Source: Architectural International 1959

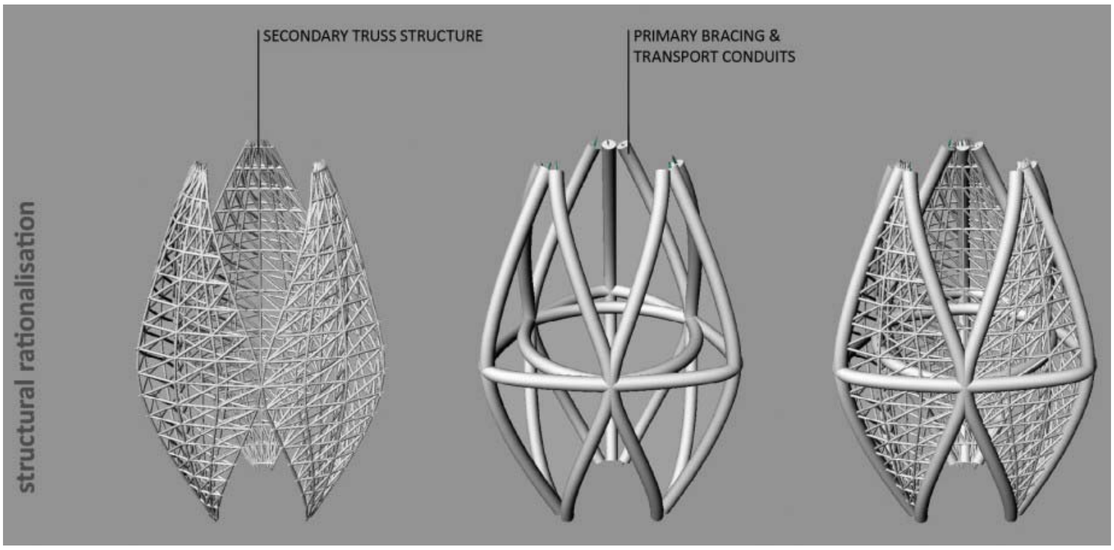
So the design of the towers can be taken as an analogical design derived from an actual corn cob. This understanding matches the Metabolist movement. Through Marine City, Kikutake elaborated a vision of nomadic, organically adaptable human habitats in previously uninhabitable territory. His vision was futuristic, technocratic, romantic, and most importantly it was modular and metabolic with its evolving cylindrical towers. The cylindrical apartment units were planned in such a way that they can be replaced with newer ones over time.

So the design and form understanding allows it to be sustainable and adapt to changing environments and evolve on its own as required. Also the corn cob-like towers will not to be anchored at any fixed point, so that the city was to be able to cruise to new places if necessary. Also Kikutake argued that at the end of its useful life, the city would sink in to ocean and used as a fish bed under the sea. It can be seen that from the mid-20th century until now architects have been designing floating cities with similar, but also with different perspectives. The floating cities designed by the Metabolists were more geometric and systematic; however todays floating cities have more organic features with self-sustainability as a significant component and concern.

5.3 STRUCTURE

Structure should not only be considered and defined by its load-bearing role, but also by its contribution to architecture and its aesthetic and functional assets. Structure may also fulfill an improvement in architectures usability and give certain characteristics making it unique. Hence structure is a fundamental architectural element that is directly integrated and involved with in the design, and it plays an important role which engages the senses, hearts and minds of building users. Moreover, structure is severely important for a floating city when considering stability, choice of material and its relation with the flora and the fauna of the sea. The Floating States of Maldives was designed by a group of designers called FLaT for the skyscraper competition that took place in 2010. This project was one of the finalists and they proposed floating cities for the country because global warming and rising water levels have shown its effects on Maldives. Thus, this design group offered new artificial floating islands additional to the many existing Maldives islands. It was planned to accommodate 400,000 people in its vertical structures and they were designed as a series of islands.

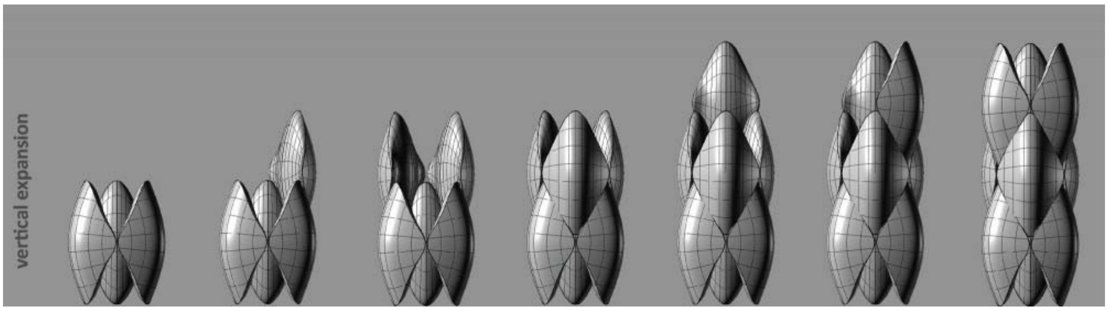
Figure 5.5: The structural framework of Floating States of Maldives' Tower



Source: www.archdaily.com

The floating structure is made of steel, with an advanced truss system that consists of primary bracing and transport conduits and also a secondary truss structure that integrates with the main system. These structures are essentially engineering marvels of buoyancy and height. The network of towers soar to a maximum height of 1,000m above sea level and their keels dive 1,000m below the water's surface. Hence the building has no connection with the sea bed, which is a positive feature because it is less intrusive to life in the ocean.

Figure 5.6: The modularity of Floating States of Maldives' Tower

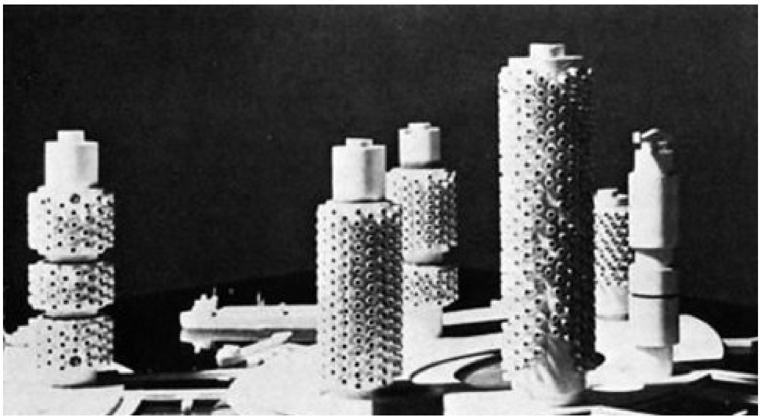


Source: www.archdaily.com

As the population increases, additional modules can be placed at the top of each tower. The tower is surrounded by a large 'bowl' that functions both as a design element for buoyancy, but that was also planned to function as 'city walls'. This bowl is like a border between the ocean and the floating city; it creates its own sea water reservoirs inside and uses this water as a means of transportation, to create marinas and to sustain the fish farms. On the other hand the Marine City (1959) by the Japanese Metabolist Kiyonori Kikutake was a floating city which consisted of decks designed like islands and they were constructed out of concrete. Another design element was the plug-in capsules, which were set into free-standing concrete service shafts of the towers.

According to Kikutake's plan the houses would be attached to the wall and not to the ground. The cylinder would be built in the following way. A factory would be established to manufacture building materials and with these materials the factory would first prepare massive foundations and would then proceed to enclose itself within the concrete cylinder. When the cylinder is completed, the factory would then convert itself to the production of pre-fabricated housing units, which would be lifted by a crane and literally plugged into the surface of the cylinder. The units themselves resemble the lens of a camera or, in the architect's analogy, 'encrustations on a shell or the leaves on a branch'. The factory would continue to study and improve the design of the individual dwelling units and would replace them as they aged (www.ecoredux.com 2011).

Figure 5.7: Marine City's concrete towers



Source: Architectural International 1959

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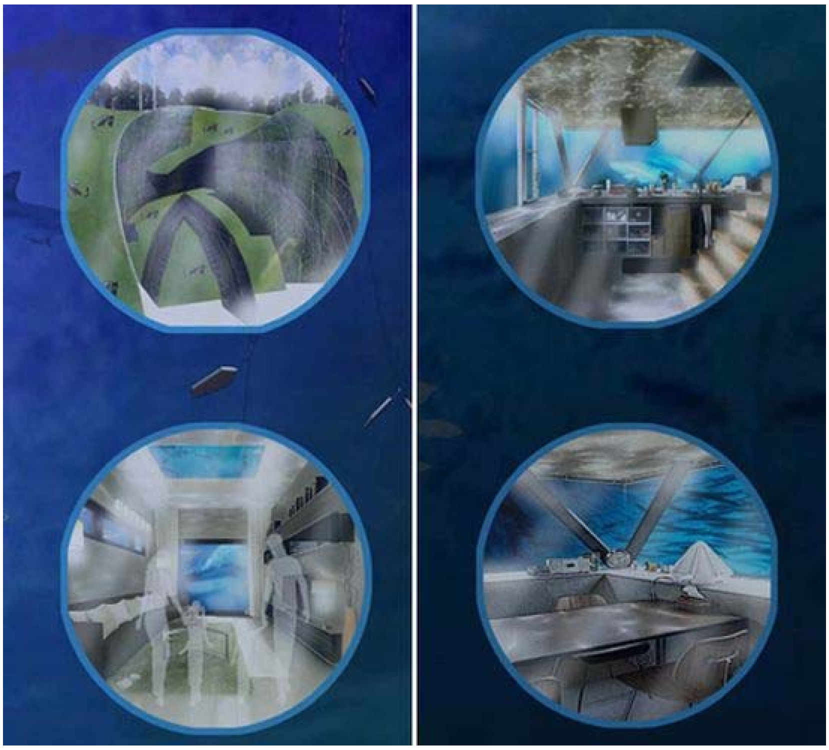
Hence even though the main structure of the towers is stable the apartment units can be renewed and replaced with new units. So the Marine City is a good example for a Metabolist project, but it is a controversial issue if it is suitable for water, or just for land. As a result architects should question themselves about how structure can assist their design to add aesthetic and functional value to their design.

5.4 SPATIAL ORGANIZATION

Spatial organization is dependent on several factors like scale, geometry, structure, form because each of the factors is connected to other factors. Designers should follow their design intents when they are organizing the spaces. The way spatial organization is done directly affects the use and the functionality of a building. For the HO2 project, which was proposed as a self-sufficient underwater architecture that employs a variety of sustainable technologies to produce renewable energy and grow its own food. It fulfills its energy requirements by harvesting wave, wind and solar power and also the 'floating city' uses modern techniques of farming, including aquaculture and hydroponic methods, to grow its own food underwater. HO2 scraper basic program components are areas to live, work, sports, treatment and maintenance. The living, shopping, office and restaurant spaces are located underwater, but are located close to the water's surface to be able to get enough daylight. The mechanical and technical spaces are located below surface and are in the deeper parts of the floating scraper since they don't need much natural light. The buildings program requires no special external resources. For energy generation it makes use of wind generators incorporated into the design. The project has a roof garden that is spread evenly placed across the island. There is also an animal farming component that is placed along portions of the roof, and other than this part the whole life is maintained under water. It can be said that the spatial organization of HO2 Scraper was done by keeping in mind the self-sustaining features and the way these affect the formation of the building.

Figure 5.8: HO2 Scraper interior illustrations



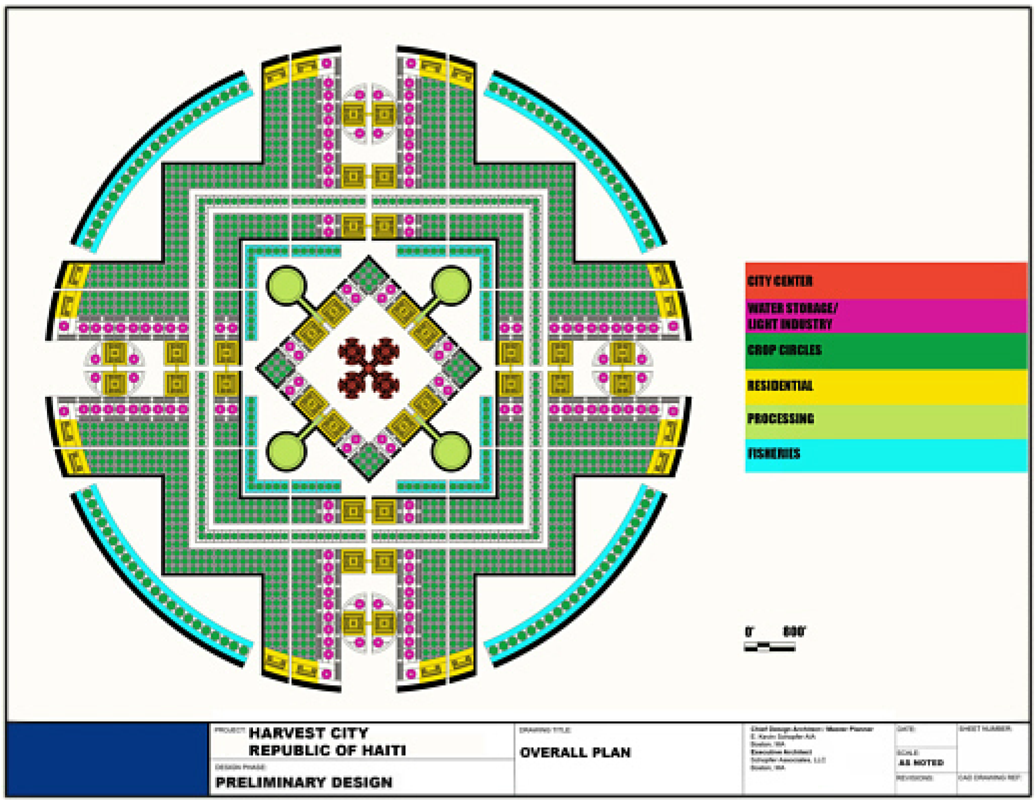
Source: www.inhabitat.com

On the other hand the Harvest city which was designed for Haiti has a different spatial organization then the HO2 Scraper. According to the designer of this city E. Kevin Schopfer, this project proposes a floating agricultural / light industrial city off the shores of Haiti which embraces four major concepts:

i. The creation of an artificial, floating, productive and livable land desperately needed for Haiti.
ii. A design which is practical and economical to build and operate in today's world.
iii. A city designed based on the principle of Arcology (Architecture and Ecology) which embodies an ecologically sustainable and practical urban platform.
iv. That Harvest City should be established as a "Charter City". Charter City is a relatively new and advanced economic model specifically developed for struggling nations (www.schopferassociates.com 2011).

In addition to accommodating city services, Harvest City was designed with an integral program of economic capabilities. This mixture is two thirds agriculture and one third light industrial. The overall design is divided into four zones, which are interconnected by a linear canal system. The four major canals will feed the neighbourhoods that are

Figure 5.9: Spatial organization of Harvest City



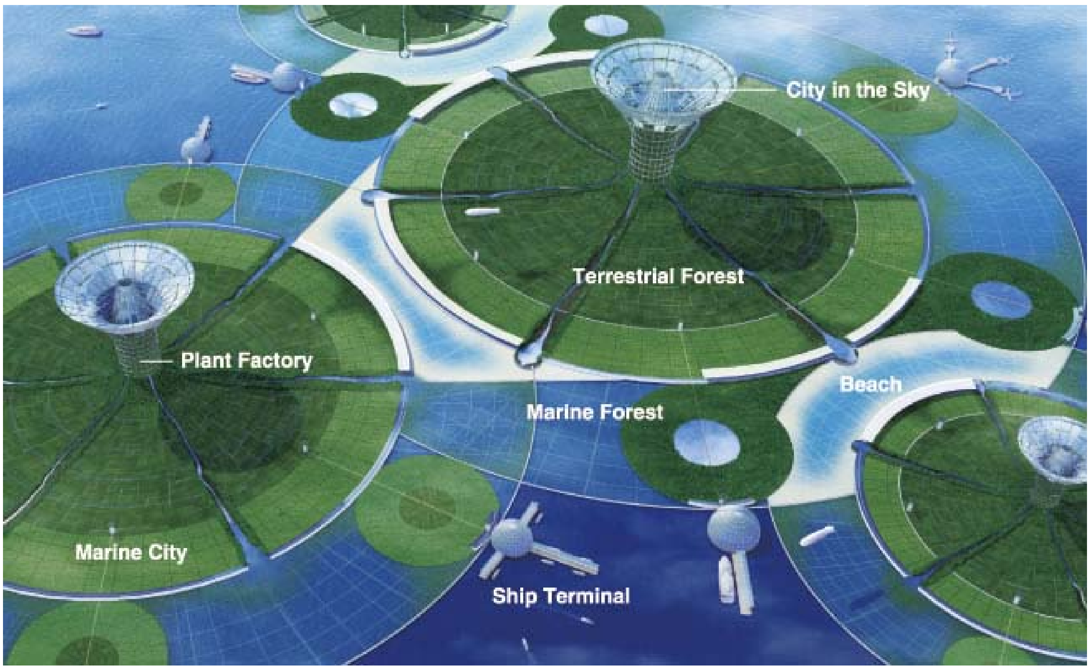
Source: www.schopferassociates.com

designed as four story housing complexes. The outer perimeter of the design is predominately 'one acre' crop circles with secondary feeder canals. The inner 'harbour' will house the city center with schools, administrative, community activities and general marketplace. The spatial organization of the city is centralized and symmetrical, which creates different layers from the outside to its center. Harvest City's spatial organization was design in horizontal relations between spaces, unlike HO2 Scraper because H2O scraper has a vertical spatial organization according to its general form.

5.5 FUNCTION

All 6 projects presented in this chapter are mix-used floating cities. However, each of the projects offers different functions for its users. For instance “Green Float” is an artificial island project in the Equatorial Ocean, with the aim of achieving self-sufficient, carbon-negative cities with zero waste and it is designed by Shimizu Corporation. In Green Float, each cell has a radius 1 km. Its planning consists of a city of cells and these cities will define the countries. The design allows a chance for the city to grow by adding new cells as the population increases. The tower of the city is about 1000m and the part between 700 and 1,000 m high is the urban area where the actual city is placed. On the periphery of the floating city, there are residences and hospitals, and in the center, there are offices and commercial facilities. The tower is designed to

Figure 5.10: Aerial illustration of Green Float

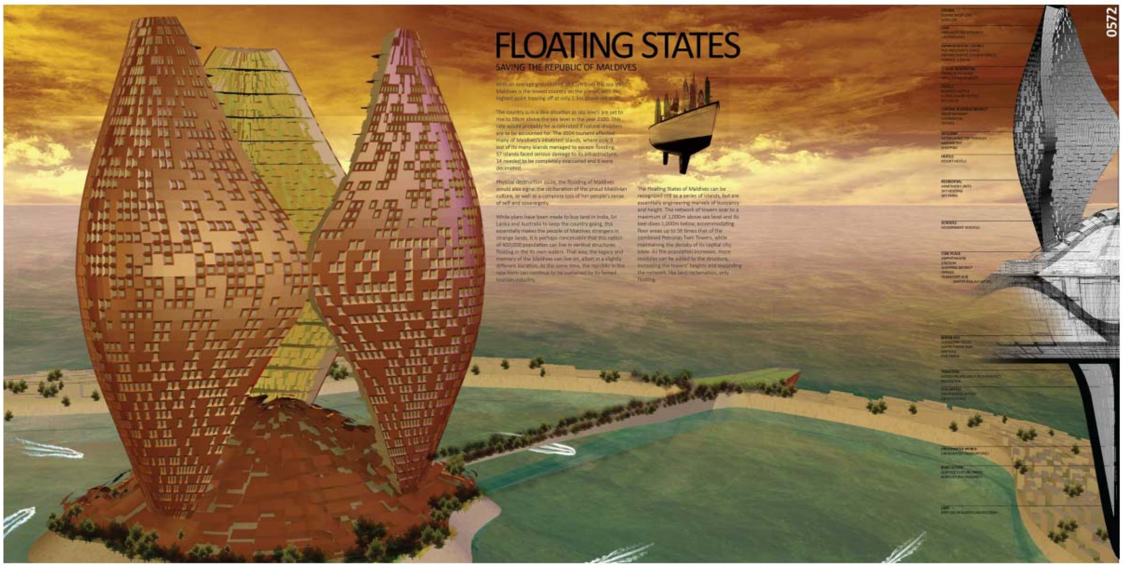


Source: www.shimz.co.jp

to be used as a plant factory, which grows vegetables. The agricultural areas are placed at the lower part which is where grains are grown. Also at this lower portion is where the marine cultivation is taking place. The plant factory is where the CO_2, wastewater, and garbage from the urban area become nutrients for other parts of the city. So, the whole city is planned to use only its natural energy sources that it produces by these gardens, plant factories, marinas etc. There are also beaches and ship terminals are been foreseen for the floating eco-city.

On the other hand the project Floating States of Maldives, which was designed by FLaT, proposes other facilities. This city is designed in two parts as the tower and the 'bowl'. The tower contains many functions like, communication satellites, labs, administrative offices, luxury residential, central business offices, sky lobby, residential, schools, civic place, stadium, transport hub, submarine docks, water theme park, shipyard, fish farms, eco-hotels, underwater observatories, and agricultural areas and the deep-sea research laboratories. According to the designers the outer ring of the project

Figure 5.11: Aerial illustration of Floating States of Maldives



Source: www.archdaily.com

is a large 'bowl 'that functions both as a method of buoyancy, and also as the 'city walls' for protection of any kind. This so called 'bowl' includes, water locks, luxury yacht marina, aviation platform, container ports and also outer rim housing which hosts a significant percentage of the population working in water-based industries. This is housed on the perimeter with green parks scattered across. In addition to the perimeter there is a boulevard bridge designed to connect the aviation and the tower island in the middle of the floating city.

Hence, it seems like Floating States of Maldives has a broad range of functional facilities when compared to the project Green Float, however this particular one is less environmentally concerned since it only has fish farms and marine cultivation in case of sustainability when the other has solar power satellites, plant factories, marine forests and terrestrial forests.

5.6 SELF-SUSTAINABILITY

With global warming becoming a talked about topic in the industry, architects started to pay more attention to environmental issues and green designs. A self-sustainable city is a system that can sustain itself without any external support and that provides its own needs like energy, food, water and that could also recycle itself with no harm to the environment. Lately, rising water levels and increasing population are the factors that are making architects consider building and living on water in a different manner than it was in history. The new floating cities are designed to be self-sustaining and can be offered as a possible solution to lessening environmental problems.

The Lilypad project, a prototype of a auto-sufficient amphibious city is designed by Vincent Callebaut and has zero carbon emissions by the integration of all the renewable energies (solar, thermal and photovoltaic energies, wind energy, hydraulic, tidal power station, osmotic energies, phyto-purification, biomass) which generate more energy than that which it consumes. According to Callebaut (2008):

> *The goal is to create a harmonious coexistence of the couple Human / Nature and to explore new modes of living the sea by building with fluidity collective spaces in proximity, overwhelming spaces of social inclusion suitable to the meeting of all the inhabitants – denizen or foreign-born, recent or old, young or aged people.*

While Netherlands and United Arabic Emirates clutter their coastal lines by spending extreme amounts of money to build their short-living polders and their protective dams for a decade, the floating city Lilypad proposes a tenable solution to the environment crises like rising water levels (www.vincent.callebaut.org 2011).

Another floating city which has been proposed after the earthquake in Haiti is Harvest City by E. Kevin Schopfer. The intent of this project is that the design components be easily constructed, practical, and a simple, refined design execution. It is designed as an off-shore self-sustaining floating city.

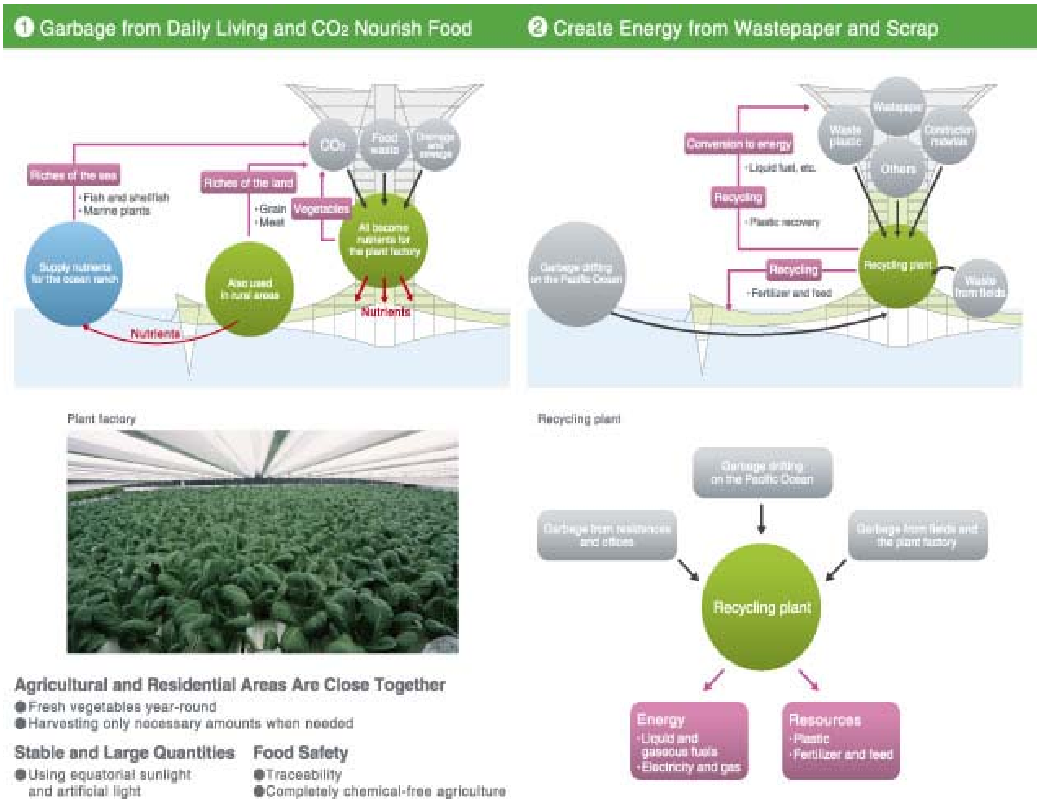
The Harvest City is planned to produce its own electrical power through a combination of solar collection roof panels and wind turbine arrangement. According to the designers, floating aquifers have been proposed as water tanks secured to concrete hulls with gravity fed piping to specific neighbourhoods. These facilities will use covered tops to collect water and protect it. This proposal recommends that some water be piped from land to these aquifers to protect the land based aquifer supply.

Additionally, the Green Float project designed by Shimizu Corporation is researching the construction of artificial islands in the equatorial ocean that would essentially be self-sufficient, carbon-negative cities with zero waste. Measuring one kilometer high and wide, the environmentally friendly cities of the future feature urban, arable, and marine zones and can scale efficiently as their populations increase. They have planned a botanical floating city that creates a space for a thriving diversity of life through a mixture of forest, fields, waterways, reservoirs and grasslands. According to the designers of the project (Shimizu 2010):

> *On the Equator, it's hot, but the temperature is stable. Also, the Equator isn't prone to typhoons, so the climate is stable from this aspect as well. The idea is to build towers like this, 1,000 m high. At that elevation, it's cooler, so we'd create "cities in the sky" with a year-round temperature of 26 degrees C.*

The Floating city is designed to fully employ a range of natural energy sources including space solar power satellites, ocean thermal energy conversion, waves, wind and solar power. Its botanical gardens absorb CO_2 and there are also arterial cycling, waste product cycling, sea water purification, purifying the great pacific garbage patch to produce energy. Shimizu aims to make Green Float a reality by the year 2025.

Figure 5.12: Green Float's Self-Sustainability charts



Source: www.shimz.co.jp

HO2 Scraper is a sea Ambassador independent urban fabric and a self-sustaining city, which can travel around the world due to the oceans tides. HO2 Scraper generates its own electricity using wave, wind, and solar power and it produces its own food through farming, aquaculture, and hydroponic techniques. The surface of the submerged skyscraper sustains a small forest. The floating city has a set of squid-like tentacles that generate kinetic energy used to power the city.

The Floating States of Maldives were designed due to the environmental problems that Maldives had been going through. The problems stem from the Maldives being the lowest country on earth with an average ground level of 1.5 m above sea level. As a result of the tsunami which took place in 2004 only 9 out of its many islands managed to escape flooding. 57 islands faced serious damage to its infrastructure, 14 needed to be completely evacuated and 6 were decimated.

So in this project which was designed by group FLaT, which offers a solution for the future Maldives. This floating city proposes seafood culture farms and also fish farms, which is an important case of self-sustainability of the project, even though it is not enough for the city to sustain itself without any outside sources.

Kisho Kurokawa was a member of the Metabolist movement in Japan, and he believed that cities could be designed according to organic paradigms. Metabolist architects planned buildings as biological processes so that it would give them efficient ways to handle the accelerating growth and technological progress of the cities all over the world. So he designed Marine City, with 300 meters high towers on water, as stated previously. This floating city is comprised of residential towers and centers of production, and produces its energy through a perimeter of solar collectors and using a plant of tidal energy, systems which assist with self-sufficiency.

In short, Ocean Cities are not a fantasy; scientifically and technologically they are a reality. As Olthuis and Keuning (2011) stated:

> *The fact that there was no momentum in the past for floating cities, does not mean that that is still true today. In many ways, the current period can no longer be compared with the situation in the 1960s and 1970s. The context in which ideas for floating cities appear has changed radically in the last 50 years.*

The point is to design a mix-used, multicultural floating eco-city which could be in direct relation and harmony with the cycles of nature. Hence the self-sustainable floating cities will be one of the biggest challenges of this era to be able to live through all the environmental crises that have been experienced around world.

6. CONCLUSION

Global warming and its impacts on water level changes are irrefutable, and the facts have been presented. As previously mentioned there's research and studies being conducted around the world which exhibit that rising water levels around the countries' coast lines could have devastating consequences. As a result of rising water levels and increasing population around the world humanity will be forced to live on water due to several reasons including natural, social and economic causes. As seen through the numerous examples of water based structures presented, architects have begun to seek to understand the implications of having to design water structures. Architects have significant influence on the built environment and therefore play a key role in designing efficient eco-friendly water-based structures to successfully settle on water and define it as a new living environment.

Building and settling on water may help land regain what it has lost over time due to human abuse. The experience humans gained from building on land can be a lesson to build on water. Also, historical examples that can be seen around the world may be able to guide designers as to how to build on water. This consequently will further globalization through which the world is becoming 'one' by interconnecting between countries and must take care by learning from the mistakes that have been made on land and design new cities by using new technologies to be able to live on water.

Scientists through their research have provided recommendations that coastal regions, authorities, and planners must begin to consider and implement the process of accepting that new designs must address the issue of rising sea levels. If designers keep delaying the process and refuse to accept the facts about global warming and rising water levels, when the time comes it may already be too late. A range of strategies are being used and proposed for building on water, ranging from designs inspired by nature to those coming from technological innovation.

i. Mobility: One of the innovative design ideas is ‘mobility’, which allows people the flexibility to change the location of their floating residence and adapt to new environments. A few of the most prominent reasons that drive people to leave their current living environments and move to another city and seek better conditions are as follows: lack of resources, lack of space, climate fluctuation as well as rising rates of unemployment. On the other hand, mobile cities are not dependent on these facts because they have the ability to change their conditions by moving around. Almost all of the futuristic water-based cities that have been discussed in chapter 5 have mobile features. This analysis shows that the ability to move around the oceans make these cities more efficient with the ability to access varying resources and also more secure and livable considering the environmental issues.

ii. Form: ‘Form’ is an important consideration of any design and for eco-cities, it’s predominantly driven by the fact that they’re designed to float on water, they have an analogical design understanding and their forms are generally inspired from sea organisms. These water structures can therefore function like a living organism and adjust and survive in a particular environment which proves that an analogical design may be a better way to approach a water-based architecture in order to create a symbiotic relationship with the particular water habitat at a specific location.

iii. Function: Even though many of the cities presented within this study were built as a floating city that included all the functional needs that a ‘city’ would need fulfilled some of the projects did not fully address and considered the social needs of a city. When planning a city the social and cultural parts of the city should not be overlooked because a city must have an identity defining it and creating a healthy environment of interaction amongst its residents to ensure its success.

iv. Spatial Organization: The spatial organization of a water-based structure is highly dependent on the function of the building. Moreover a water-based city includes several functions, and it is one of the key elements for an efficient design. As it has been discussed in chapter 5, all off-shore city examples have different spatial organization related to several factors like form, scale, geometry and structure. However, they have some similarities like the relation of their spatial organization and the use of natural light. For instance, all of the selected projects' residential units have been placed above sea level in order to take full advantage of the natural light. Also most of the mechanical and technical spaces are placed below sea level since they don't need sunlight. Therefore light has a great influence on the spatial organization of an off-shore city and that it is also important in case of sustainability. Furthermore 'form' is another criteria that derives the spatial organization. Thus a vertical off-shore city which is designed like a tower has a vertical relation between its spaces, and one which has horizontal features exhibit a horizontal relation between its spaces.

v. Structure: Furthermore, the structure of a floating city is very different from a building on land due to that particular environment. A water-based structure must not only be able to be load-bearing, aesthetical or functional. It is severely important to consider stability, choice of material and its relation with the flora and the fauna of the sea. As a result of the analysis, even though most of the futuristic cities have self-sufficient features the choice of material and construction of the structures are not primarily considered to be environmentally friendly, which doesn't coincide with the intent of building eco-cities. Architects must therefore be more considerate and insure that the products being used on the project are more sustainable.

vi. Self-Sustainability: A 'self-sustainable city' should be able to sustain itself without any external support consequently providing its own needs and also have advanced recycling systems so it would give no harm to its surroundings. The off-shore water-based city examples that have been examined through the comparative analysis of this study asserts that, most of the contemporary approaches can be considered to be environmentally friendly and self-sufficient, which proves that the reality of global warming as well as other environmental problems have a significant influence on today's designs.

Architects must embrace the opportunity that water based architecture provides. Architects and designers must understand that they can't realistically solve the issue of global warming or prevent water levels from rising, but they can strive to eliminate the negative impact of the industry of architecture on the planet through better informed design. This can be achieved by producing water based designs that include self-sustaining systems that don't rely on natural resources or produce harmful off gassing. This can be done through the use of alternative energy sources such as wind generators, solar and biomass energy that would serve to provide electricity. Also, by using day light and by designing in close connection with nature the impacts of global warming can be reduced. With the above in mind architects can design to adapt architecture to rising water levels. However, to be able to build these eco-friendly buildings and cities, architects also should consider using new materials and construction techniques, so that the whole process of designing and living in harmony with water as well as the environment as a whole can become more of a reality.

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