Coastal town planning in the context of rising sea level

Jiaxi Chen

School of Architecture Planning and Landscape, Newcastle University, Newcastle, United Kingdom.

Abstract. With the development of natural science, more and more attention has been paid to the relationship between man and nature, and various natural crises have begun to be valued. Global warming and sea level rise are beginning to be recognized by the public. Hard or soft measure has been tried around the world to prevent marine disasters and build ecological coasts and cities. The site selected for the project is Fish Quay in the North Shield, which is a town that is typically vulnerable to marine erosion due to its proximity to the estuary and low-lying topography. The universality of the area's qualities and the richness of the region's history make it a very well-suited testing ground for measures to deal with sea level rise. This paper takes this as an example to formulate effective and feasible survival strategies for coastal cities.

Keywords: sea level rise, coastal city construction.

1. Introduction

With the development of technology and civilisation, human has gradually become the most influential organism known on earth. But along with this development comes the destruction of nature and the warnings (natural disasters) that the planet gives us. Within the ecosystems, different organisms play different roles, but in general most develop and reproduce by consuming or devouring 'nutrients' and releasing 'wastes', which in turn often become 'nutrients' for other organisms. The released material often becomes 'nutrients' for other organisms. (Note that nutrients and wastes are relatively abstract concepts; for example, industrial equipment uses oil as a 'nutrient' and carbon dioxide as a 'waste') This cycle of nutrients and wastes gradually stabilized over the last 10 million years of biosphere development, until the dawn of the industrial age. As industrial technology advanced, human demand for natural energy increased dramatically, and with it the release of large amounts of 'waste'. [1] This change affected the previously relatively stable cycle of natural supply and demand, leading to various existential crises, global warming, and rising sea levels being among them.

On September 25, 2019, the Intergovernmental Panel on Climate Change (IPCC) issued the Special Report on the Oceans and Cryosphere in a Changing Climate (SROCC), which pointed out that in the context of global warming, sea level rise is still accelerating. If no effective countermeasures are taken, the lowest level of sea level rise by 2100 will be about 0.43 meters, and the highest level will reach 0.84 meters [2]. The Met Office assessed climate and weather events for 2021 and found that sea levels around the UK had risen by around 16.5cm since 1900, with sea levels growing at a rate of 3mm-5.2mm per year and were accelerating. With temperatures rising by just 1.5℃ by 2100, average sea levels will rise by 1.7 feet (0.52 meters). If the UN 2C target is exceeded by 2100, sea levels will rise by 0.86 m or 1.8 m in a worst-case scenario. [3] It can be seen that sea level rise has threatened the survival and construction of coastal cities. Sea level rise can cause large areas of land to be inundated. At the same time, such disasters will lead to a corresponding increase in various characteristic tide levels and an expansion of the salinity, thus affecting domestic water, agricultural water, and industrial production in coastal cities. The expansion of salinity will also lead to changes in the pH of farmland, thus affecting agricultural development. Moreover, sea level rise will also cause a lot of economic losses. A study published by the National Oceanographic Research Centre (NOC) in the UK warns that sea level rise will cost the world economy £10 trillion (about $14 trillion) per year by 2100 [4]. It can be seen that with the rise of sea level, the design and planning of coastal cities need to consider the impact of rising sea level.

2. Measures to deal with rising sea levels

There are various attempts around the world to address the challenges posed by sea level rise, mainly in terms of land area loss and loss of above-ground facilities. In traditional coastal protection facilities, "hard measure" or "gray infrastructure" is widely used. Hard protection mainly refers to strengthening coastal resilience through various measures (such as the construction of seawalls, seawalls,

breakwaters, etc.) [5]. 70% to 80% of Singapore's coast is composed of sea walls and breakwaters, and only a small part of it retains some natural coasts [6]. As shown in Figure 1, the Marina Barrage can protect freshwater reserves, discharge flood, and prevent waterlogging, and serve as a recreational space for citizens to enjoy boating, kite-flying, and partying (Fig.1). However, the construction of seawalls and other measures are costly and harmful to the original ecological environment. Therefore, soft protection measures emerge as the times require. "Soft protection" refers to more environmentally friendly measures focusing on ecological restoration and beach conservation [7]. For example, some coasts in New South Wales, Australia, adopt a combination of sand dunes and vegetation to form a natural coastal protective barrier. The sand dunes and vegetation systems also provide foraging sites and habitats for animals and protect biodiversity. There are two types of ecological coasts. One is to use the salt marsh wetlands, mangroves, seagrass beds, coral reefs, and other coastal ecosystems to eliminate waves and promote siltation, forming a natural barrier protection measure. It is based on the natural protection of coastal ecosystems. The other is ecological coastal protection combining natural and artificial facilities, such as the use of natural stones, shellfish, plants, etc. to build artificial reefs, and artificial sand filling for beach protection, and combining seawall protection with ecological landscape to build artificial ecological coasts [8]. The coastal construction measures of ecological concept need to take different measures in combination with factors such as coastal zone type, disaster risk characteristics, local hydrodynamic environment, and social and economic development level. Taking Fish Quay in the North Shield as an example, this paper designs a strategy for cities to cope with sea level rise that is time-flexible and capable of protecting and even expanding urban areas. The design addresses the issue of land loss and waste of space due to sea level rise. Moreover, this paper uses Google Academic to extensively collect the literature and cases of coastal urban design, takes a map as the medium carries out corresponding spatial analysis, investigates Fish Quay in the North Shield on the spot, and puts forward the planning scheme and strategy of coastal towns.

Fig1. Marina Barrage

3. Coastal town design with Fish Quay in the North Shield as an example

3.1 Introduction of Fish Quay in the North Shield

The chosen location is Fish Quay, located in North Shields, Newcastle, North East England（Fig.2）. Fish Quay was once the economic focal point of the whole of North Shields, which means that it has a good location and potential for development. The site has a large coastal area and the overall topography is gently sloping from high inland to low on the coast. Fish Quay as a whole is situated in a sunken site with low ground and a number of steep and complex terrains surrounding it, making the area very vulnerable to sea level rise（Fig.3）. Because of its low-lying terrain, the site is vulnerable to flooding, more and more land is being swallowed up by the sea, both as a result of tidal action carrying away sediment and also as a result of rising sea level. In addition, the site has relatively convenient transportation conditions. The site is well connected with two Metro's (North Shields station and Tynemouth station) and is also close to the main city road. The site has a good foundation for industrial and commercial development, and idle land（Fig. 4）. The universality of the area's qualities and the richness of the region's history make it a very well-suited testing ground for measures against sea level rise. The project is designed to address flood control and idle land issues and provide a more suitable coastal living environment.

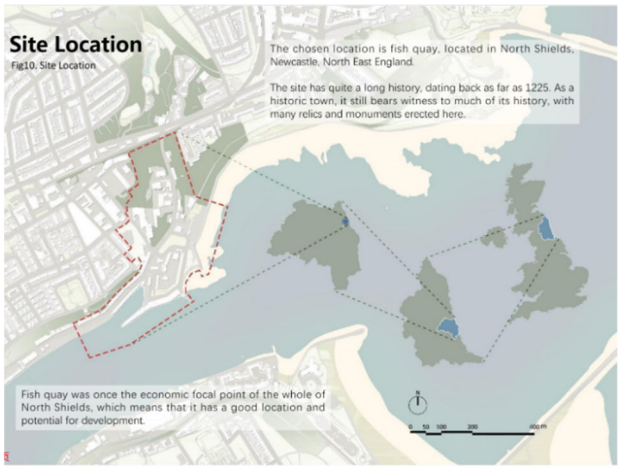

Fig.2 Site Location

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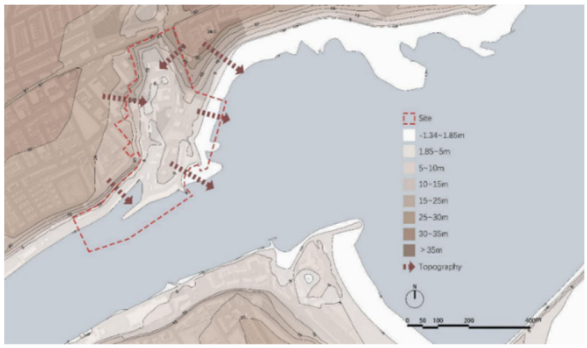

Fig.3 Topography Study

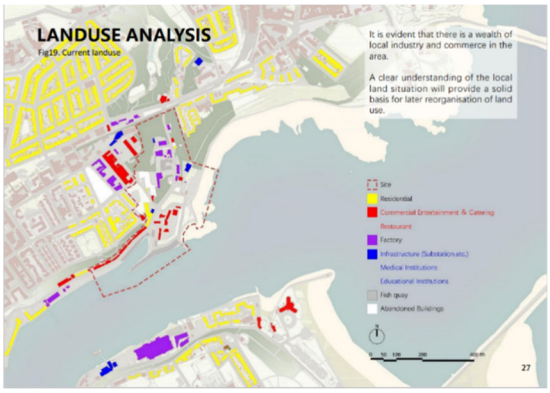

Fig.4Current land use

3.2 Fish Quay in the North Shield design

3.2.1 Flood control planning

The development of flood control measures is obviously a more favorable choice for urban construction and development in this region. Having essentially established a strategy to develop in the direction of the waterfront, it is important to start with the details. Considering the extent of water level rise over the next 30 years, we need to choose long-term strategies and short-term measures for cities with large areas affected by seawater. The process of sea level rise will not happen overnight, and the corresponding responses need to be gradual. Otherwise, if sea levels do not rise as expected, large-scale projects in the short term may not only challenge government decisions but also require a lot of manpower in the short term. Not all cities can afford the physical and financial investment.

In terms of short-term strategies, specific coastal adaptation strategies need to be developed. This can be done in a combination of ways, combining green solutions with grey solutions, or even 'inland storage'. For example, by keeping a small inland sea at a low altitude, cities can always have 'coastal' spaces and increase the richness of the urban natural environment. At the same time, it incorporates green solutions to ensure the quality of inland water bodies. Finally, it incorporates a grey solution that integrates the external coastal dam structure to ensure that fresh water is always available to the inland water bodies. In this way, it also creates hydroelectric facilities to provide energy for the city through the difference in water level between the inland and outland waters.

In terms of a long-term strategy, the first step is to restructure the urban function of the coastal sites. After basic promotion and site selection, try to ensure that there is enough space for rigid flood protection facilities. Secondly, to carry out the design of the urban functions of the flood protection facilities and to add new built-in activities to this single-function civil structure so that the coastal area does not lose its human value. Finally, the construction of flood protection facilities is planned in stages and the extent of sea level rise is regularly reviewed to ensure that the facilities themselves do not consume too many unnecessary resources. In conclusion, long-term measures are a dynamic, evolving guide for planning and action.

3.2.2 Build mangrove wetland park

The green area is a Mangrove wetland park, which is not too deep as it is inundated by seawater, and it is considered to be combined with nature to create a water park with natural coastal features. Mangroves can prevent wind and waves, protect beaches and berms, purify sea water, and form a natural protection barrier for coastal ecosystems. The problem of shoreline erosion can also be solved with oysters, which can reduce the degree of eutrophication of the sea and purify the sea. Oyster reefs can form "underwater great walls" that guard coastal zones. People can collect oyster shells, put them in large bags, and place oyster seedlings inside before throwing them into the sea. The netted oyster shells act as a "reef" against the impact of seawater on the coastline, and those oyster seedlings grow up and live on these "reefs". When extreme weather such as hurricanes and typhoons strike, the oyster reef becomes a barrier that can effectively mitigate the impact of waves on the coastal zone and resist coastal flooding disasters caused by typhoons. Oyster reefs can also provide habitats for a wide variety of organisms, not only enhancing biodiversity but also increasing fisheries resources. The wetland park, built with mangroves and oysters, has a natural beauty. Mangroves or oyster reefs can be designed as natural waterways or mazes, people can walk through the mangroves on the water by renting small canoes, experiencing the beauty of nature, and understanding the concept of living with the sea (Fig.5).

Fig.5 planning activities“upon the water”

3.2.3 Underwater Adventure Park

The blue area is the Underwater Adventure Park, for which the concept of activities is that people can explore preserved historical sites underwater with the help of diving equipment. In detail, ar codes or hidden props could be set up by staff near different buildings or monuments underwater, after which visitors with waterproof ar-scanning equipment or other "treasure hunting tools" would collect historical clues underwater. This would not only generate economic revenue for the area but also serve as a cultural export. (Fig.6)

Fig.6 Planning activities"below the water"

4. Summarize

Global sea level is rising continually due to global warming, melting of polar glaciers and thermal expansion of upper seawater. Sea level rise is a slow-changing disaster, which has a severe impact on the survival and development of coastal cities. This paper expounds the current situation and harm of sea level rise, and studies the construction measures of coastal towns under the soft protection strategy by taking Fish Quay in the North Shield as an example: 1. Establish long-term and short-term development plans for this area. 2. According to inference of sea level rise, add measures to prevent flood disasters and ensure stability and development in the area. 3. The construction of mangrove wetlands and underwater parks can not only build a natural protection barrier to protect the coast, but also expand people's activity space, improve the utilization rate of marine space, and realize the harmonious coexistence of nature, ocean, and human beings.

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