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MORPHOLOGICAL APPROACH FOR THE TYPOLOGICAL CLASSIFICATION OF WATERFRONT REVITALIZATION

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Abstract: Researchers from multiple disciplines have proposed classification systems for waterfront transformations: generational (according to the date of their construction) and functional (based on the function assigned to the land post-harbor use). However, an analysis based on the spatial features of the former port areas and their meaning for the waterfront transformation has been missing. This contribution is an attempt to fill this gap by proposing a classification based on morphological approach. It uses selected case studies based on cluster sampling method, following a fractal reading approach of the waterfronts, to capture a representative sample and to generalize the study following a deductive logic. Using satellite images and maps, this article first identifies the areas where the waterfront was revitalized and then it analyzes the type and function of these spaces according to the classical classifications existing in the literature on the subject. A morphological approach used as methodology framework was based on the analysis of satellite images and the cartography of the waterfront areas with simplification algorithm on ArcGIS. The resulting morphological classification of waterfront transformations reveals the relationship between the built form of the former port areas, classified here as convex, concave, or linear spaces, and the kind of revitalization type respectively classified as ribbon-shaped, convergence, or dilatation. The conclusions about the relationships between the built form available for waterfront transformations and the most appropriate type of revitalization can provide concrete indications for a sustainable future transformation of port cities, especially cities whose reconversion is lagging behind.

Keywords: port-cities; waterfront classification; morphological approach

1. Introduction

Space is not merely a backdrop for human activity, but it is its integral part. There will always be a relationship of dependence and influence between its form and its function since its form is intrinsically linked to the things it helps people do. Space, directly and indirectly, influences urban development's morphological, functional, or semantic elements. The shoreline between water and land and the development of port cities as crucial nodes in the transshipment of goods are a perfect example of this interplay between nature, spatial development, human life, and activities. The morphological analysis approach can add a valuable quantifiable component to understanding urban processes over time (Aouissi et al., 2021). It can provide insight into ongoing challenges, for example, to better understand a port and city's changing relationships and development dynamics over time (Ozgece & Edgu, 2013).

Shipping, and especially the growth of ships, has been a big part of how ports and port cities have changed through history (Tourret, 2013). In the past, ports and the cities around them were tied together because workers had to live near the port (Hein, 2016). With industrialization, this integration decreased and the port and city started to separate. Containerization in the 1960s brought an end to inner-city harbors, and consequently, city governments and developers around the world transformed the old ports into urban areas (Hoyle, 2000). The revitalization of the former port area of Baltimore in the United States of America, based on the 1967 master plan "The Inner Harbor Project I Urban Renewal Plan" emerged as a pioneer (Del Rio, 2018).

The transformation of former port areas into urban areas spread rapidly to other American cities, such as San Francisco, Boston, New York, and Toronto (Chaline & Rodrigues Malta, 1994). Cities around the globe adopted the examples of American port reconversions as a model of waterfront development for the post-industrial port city (Hayuth, 1988). The "Baltimore syndrome" (Huang et al., 2007, p. 1508) continues to spread through port cities on the five continents, as titled in Bren and Rigby's (1996) classic work on waterfront redevelopment—"Worldwide urban success story". The local press has praised these revitalizations many times, praising the water for its beauty as a setting or background for both locals and visitors. This includes the wide views it offers, the promenades along its edges, and the way to get to new buildings across it. They talk about how public spaces are made and what happens there. Also, they discuss about rare events and uses of the water, like heritage ships, ferry landings, pleasure cruising, cruise ship events, harbor birthdays, and other celebrations that take place on the water. They celebrate the history of the site by preserving historic buildings (Hein, 2016).

Many former seaports have transformed their inner-city waterfronts; the literature on these changes primarily focuses on particular cities; the papers of Bone et al. (1997), Brown (2009), Dovey (2005), Hein and Hillmann (2016) are only a few among a great number of sources. A few remarks that discuss the socio-economic problems related to the urban regeneration of a waterfront area and the effects of that effort on the city as a whole counterbalance the joyous nature of much of this material. As a result, Baltimore has become a global role model for waterfront regeneration. Researchers have also taken into account its impact (or lack thereof) on the city as a whole. Similar joyful and critical writing has been done about London's Docklands regeneration (Brownill, 1993, 1994; Schubert, 1993, 2002). Scholars occasionally question socio-economic changes that go beyond physical ones, such as the importance of social justice or the commercialization of historical artifacts. This usually occurs in response to waterfront redevelopment for exhibitions or mega-events, such as those in Seville in 1992, Barcelona in 1992 and 2004, Genova in 1992 and 2004, Lisbon in 1998, Hamburg in 2013–2015, and even in bids to host such events, like the Olympics in Hamburg.

Due to the scale and importance of waterfront revitalization project on the urban and architectural levels, these projects have given rise to a great deal of research on the subject (Wren, 1983). They were interested in how port functions changed and how old port areas were abandoned and then redeveloped after they were no longer needed. Several studies have sought to classify the types of waterfront redevelopment with different taxonomies. These include chronological logic, identifying first, second, and third generations (Hoyle et al., 1988; Huang et al., 2007); or functional classifications: use of the sites for housing, leisure, commerce, tourism, or office spaces. Yet, others have classified these in terms of the way they are planned, liberal, or reasoned (Breen & Rigby, 1996; Chaline & Rodrigues Malta, 1994; Rodrigues-Malta, 2004; Vallega, 2001). However, other authors have proposed classifications that are more indicative than exhaustive. David Gordon's (1997) work can be cited as an example based on the dominant theme of the waterfront and its classification approach for port-city reconversion: development for tertiary purposes (businesses, banks, and insurance), popular leisure activities (leisure, sports, and maritime), residential (luxury housing), ecological public space (parks, waterfront promenade, aquariums, and ecological and marine parks), culture (theatres and historic buildings), shopping centers, conference halls, and business districts.

All of these methods are useful classification attempts in finding answers to specific questions. They provide information about planning history, land use, and planning types, but none of them connect the spatial form of the pre-conversion harbor to the urban form of the redevelopment. The purpose of this study is to show the relationship between waterfront urban morphology and the typology of redevelopment employed by port reconversion projects in terms of function and vocation. The spatiality of the waterfront transformation is the subject of this article. Its contribution includes not only a posteriori seeking a new classification criterion, but also enabling foresight what would be the most appropriate layout according to the morphology of the port area. The classifications proposed in this piece can help with the selection of functions and vocations for new retrofit projects.

2. Methods

The morphological approach is a method for comprehending the relationship between a container (urban shape, space) and its contents (activities, social facts), or between space and the activity that it contains (Hillier & Hanson, 1998). The remnants of a former port are the product of natural formation and human intervention in the shipping industry. Waterfront reconversions are an interesting case study for morphological analysis because the same spatial form is given a new function as a result of the reconversion project, raising the question of whether some spatial forms are better suited for specific functional or vocational planning interventions than others. Furthermore, using the morphological approach as a methodology can assist in providing an analytical basis for design.

2.1. Selection of case studies and their standardization: cluster sampling and fractal analysis

To generalize the research, a cluster sample of port cities is chosen using a deductive method. The cities were chosen using the cluster sampling method based on both the period when the port was redeveloped and its primary functions. This technique is built on two existing key approaches to waterfront classification. Using these clustering rules, we selected a sample of eleven cities that have all been thoroughly researched. In the results section, each case study is described by its port reconversion generation and functional categorization according to the secondary literature on the subject. The fractal dimension of each fabric has been studied to ensure the disparity of the samples in terms of urban composition and the representativeness of the sample according to the clustering method, as it is considered an indicator of the morphological identity of the urban fabrics (Frankhauser, 2002). The fractal dimension (D) of each tissue of the waterfronts studied by the box-counting method was calculated using the Fractalys software created by the Théma laboratory. This research enables us to comprehend the differences and similarities between fabrics in terms of homogeneity, hierarchy, intricacy, compactness, centricity, and roughness (Badariotti, 2005; Batty & Longley 1994; Frankhauser, 1994, 1997, 1998, 2002, 2003, 2005). Figure 1 depicts how the case studies chosen cover all generations and exhibit various morphological characteristics. The result of measuring D crossed with the conversion date for each case study, emphasizes the sample's diversity and representativeness in terms of the morphological configuration of the cases examined.

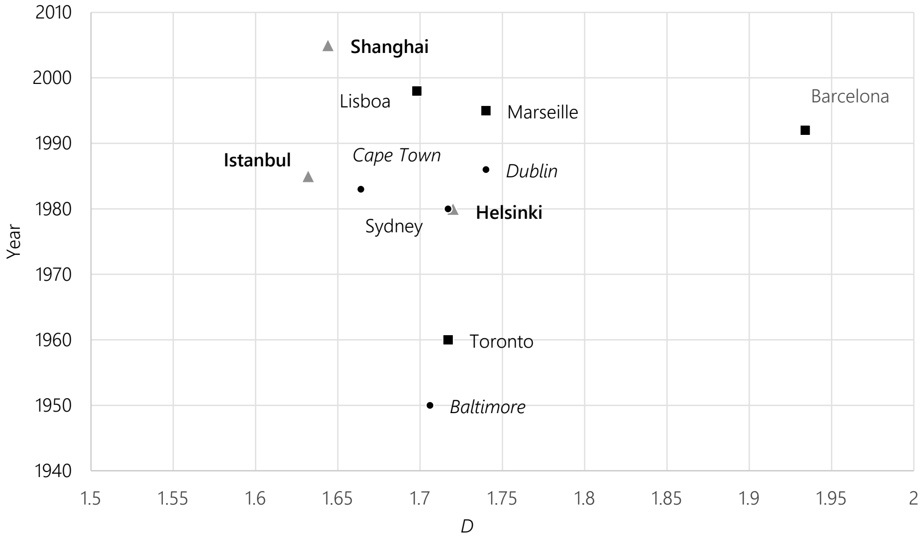

Figure 1. Presentation of the sampling studied according to the years of reconversion and according to D of each waterfront urban fabric.

Note. ▲ for waterfront in convex configuration; ● for water front in concave configuration; ■ for waterfront in linear configuration. Bold text denotes reconversions with a main vocation of development dedicated to public spaces. Italics text denotes reconversions with a main vocation of development dedicated to the creation of new centralities. Normal text denotes reconversions with a main vocation of development dedicated to ensuring urban continuity with the existing.

2.2. Morphological analysis: spatial categories by geometric simplification

The selected case studies have been submitted for empirical reading and categorization. Using ArcGIS, simplified maps of the shoreline are created using a simplification algorithm. These maps were then treated to extract their basic geometrical shapes.

To describe the spatial configuration, we processed the maps obtained by the ArcGIS software to simplify the shape of the selected entities (Douglas & Peucker, 1973). By defining a degree of simplification that depends on the maximum allowed offset, the software limits the distance that can separate the output geometry from the input geometry. For entities composed of linear segments, the output vertices are a subset of the vertices of the original entities. The method begins by joining a line's endpoints to a trend line. Each vertex's distance from the trend line is calculated perpendicularly. Vertices that are within the tolerance, but closer to the line, are removed. The line is then split into two trend lines by the vertex that is farthest away from the trend line. Once all vertices fall inside the tolerance range, the remaining vertices are measured against these lines, and the process is repeated. The software limits the distance that can separate the output geometry from the input geometry. For entities consisting of linear segments, the output vertices are a subset of the vertices of the original entities. This simplification of the coast's shape, as described, makes it possible to judge the geometrical configuration of the reconverted waterfronts. According to the simplified geometry, we identify three spatial sea-land configurations: concave, convex, and linear as shown in Figure 2.

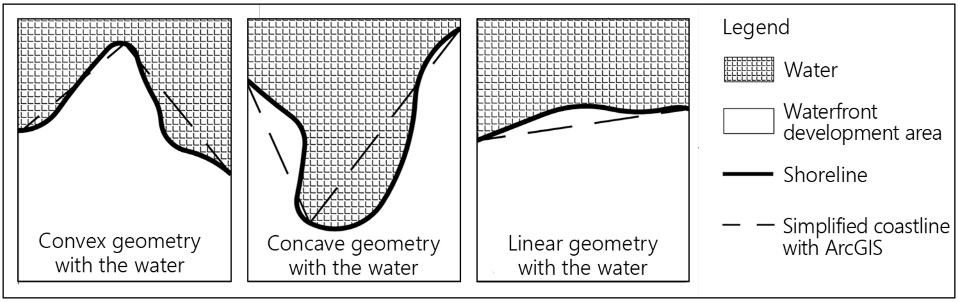

Figure 2. The three possible geometric configurations for the shoreline of waterfronts.

3. Results

The methodology described above is applied to the eleven selected waterfront transformations. Each case study is described using a morphological approach. Using mapping to determine the delineation of the waterfront reconversion area on the satellite image, a second simplified map of the shoreline (using an algorithm applied to ArcGIS) shows the geometry of the waterfront based on critical points to identify a reference shape. Each case describes the type of development adapted by the redevelopment regarding the different literature concerning the port reconversion operations presented. For the morphological reading, the area around the development is thought of as a polygon. In math, a polygon is convex if all of its interior angles are less than 180°. A so-called concave polygon must contain at least one interior angle greater than 180°. A so-called linear shape cannot form a surface, therefore it cannot be considered a polygon. For this purpose, it is imperative to retrace and regularize the geometry of the waterfronts studied to determine the form typology, i.e., concave, convex, or linear with water.

3.1. Case of Shanghai

Huangpu River revitalization was unleashed in 2005 and achieved in 2010. The redevelopment was carried out within the framework of the 2010 international exhibition. The object is to recycle the old quays on the banks of the Huangpu River, and the vocation of public spaces takes precedence along the river with the development of green spaces (Marton & Wu, 2006). Simplified coastline forms a convex shape between the developed part and the river (Figure 3A).

3.2. Case of Istanbul

After industries and the port were moved, the city of Istanbul decided to redevelop the waterfront. In 1980, a major operation was done in the Halic sector to turn the old port and industrial sites into a promenade and a green corridor, mostly for tourism and landscaping (Butuner, 2006). The convex aspect is apparent in the major part of urban design (Figure 3B).

3.3. Case of Helsinki

In 1984, a project to improve the waterfront began. Housing projects that help the environment are given priority, so green spaces and public places to relax have been set up along the waterfront (Breen & Rigby, 1996). The simplified shoreline shows two intersecting lines that form a convex silhouette with water (Figure 3C)

Figure 3. Study cases with waterfront in convex configuration with water: Shanghai (A), Istanbul (B), and Helsinki (C).

3.4. Case of Baltimore

The first case, the transformation of the Inner Harbor in 1967, is thought to have started the movement for waterfront revitalization (Wren, 1983). When port activities were moved to Locust Point, Fells Point, and Canton sites upstream toward the ocean in suburban areas with deep water, the city was able to get back 40 ha of land. This area, which is in the middle of the city, was changed into the World Trade Center, a housing complex, a museum, the McCormick head office, Harbor Place, a convention center for hotels, and high-tech installations (Del Rio, 2018). Simplified coastline shape (Figure 4A) brings out a concave shape with internal angles exceeding 180°.

3.5. Case of Dublin

Since 1986, Dublin's revitalization has been focused on the Dockland. New facilities, especially for the tertiary sector, have been built to improve the city's image and help market the old parts of the city to make sure it stays competitive and appealing in its metropolitan area (Wonneberger, 2010). After simplifying the shape, the docks form a concave entity with water (Figure 4B).

Figure 4. Study cases with waterfront in concave configuration with water: Baltimore (A), Dublin (B), Cape Town (C), and Sydney (D).

3.6. Case of Cape Town

The case of Cape Town illustrates the spread of the phenomenon of waterfront revitalization since 1980 in Africa. The Victoria and Alfred Waterfronts are characterized by their juxtaposed position between the urban core and the water area. The port reconversion is realized by the creation of a new center focused on shopping, leisure, and entertainment as tourist attractions (Association Internationale Villes et Ports, 2015). Generalization of coastline map with simplified coastline shape shows a concave form with the water clearly visible (Figure 4C).

3.7. Case of Sydney

In the 1980s, the Darling Harbor waterfront revitalization project took full advantage of Australia's modern image, especially through the iconic Sydney Opera House project, which it was a part of. The goal was to improve tourism infrastructure by implementing an urban renewal policy and building a new shopping and entertainment center (Breen & Rigby, 1996). The "toothed" shape with the waterfront gives a concave configuration to the layout with water (Figure 4D).

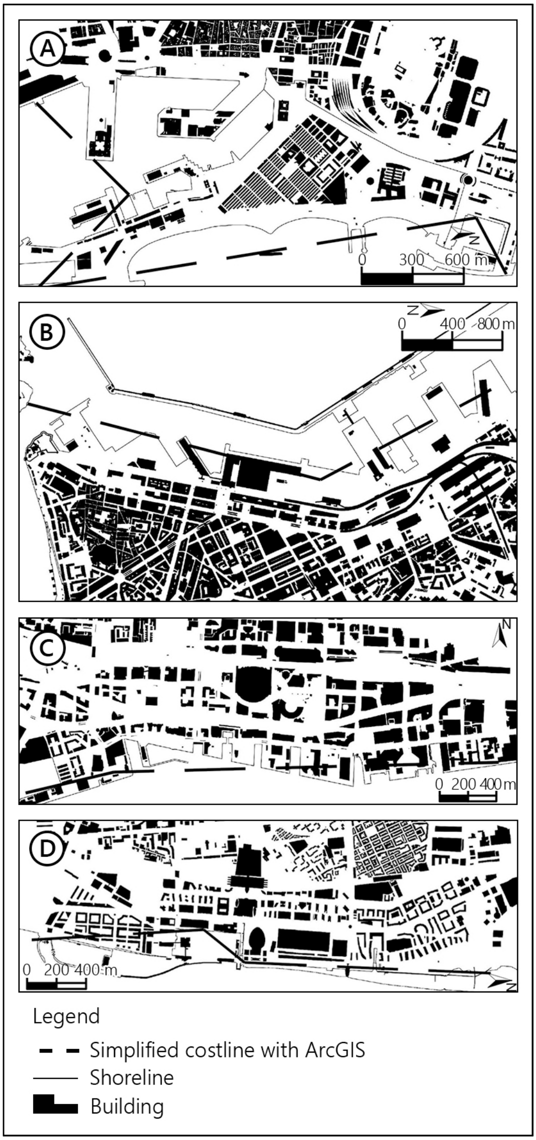

Figure 5. Study cases with waterfront in linear configuration with water: Barcelona (A), Marseille (B), Toronto (C), and Lisbon (D).

3.8. Case of Barcelona

The hosting of the Olympic Games in 1992 mainly drove the reconversion of Port Vell from 1988 to 1992 in Barcelona. The 1992 Olympic Games served as the starting point for the port reconversion. This was not limited to the creation of infrastructure for the event but also served to reconnect the port and the city (Rodrigues-Malta, 2004). Simplification shows two parallel linear forms in its two-level morphology, but the linear form is clearly distinguished (Figure 5A).

3.9. Case of Marseille

Engaged since 1995, the EuroMed 1 and 2 projects have been parts of a major urban renewal project on the European Mediterranean, to make Marseilles an attractive and competitive city on a supra-regional Mediterranean scale. The municipality has built major facilities and projects of international scopes, such as the CMA CGM Tower (Rodrigues-Malta, 2004). Linear development is dominant (Figure 5B).

3.10. Case of Toronto

In the early 1960s, and as a pilot project in Canada, the rehabilitation of the old quays was carried out for the benefit of the redevelopment of the city. Between the skyscrapers on "district drive" and the big infrastructure on the waterfront, there are four different types of cities, which are shown by four different types of development. The "central waterfront" and the second part with less imposing gauges, where the waterfront ensures continuity through the installation of housing in particular (Breen & Rigby, 1996). The linear configuration of the waterfront is easily distinguished in the case of Toronto (Figure 5C).

3.11. Case of Lisbon

Like its neighbor in Iberia, Lisbon was able to host the 1998 Universal Exhibition thanks to a port redevelopment project. The Parc des Nations project is made up of different interventions that show how the interior fabrics on the quays are getting bigger. Different urban typologies are adapted to what is already there (Aouissi, 2016). Linear aspect is clearly distinguished (Figure 5D).

4. Discussion

Aside from the three geometrical configurations of the waterfronts, which are based on the urban form and the spatial organization and occupation of the urban fabric, there are three types of development of the former port sites:

- The first type shows a convergence, which is a grouping of buildings in the old port area around a central space that is linked to the existing fabric as a whole in a radio-centric way;
- The second one looks like a ribbon and the buildings on the edge that are in contact with the water shrink overall. In place of buildings, the new development includes public space;
- The last group shows that development is slowing down, that buildings are spreading toward the water along the port-city interface center, and that a new fabric is being made that is connected to the old one in a way that looks like it has always been there. A longitudinal and syntactic cross-sectional reading of case studies shows three types of functionality and figure out what they mean.

4.1. Waterfront in concave morphology, convergence development

Four of the case study port cities have a concave shape. These cities are Baltimore, Sydney, Cape Town, and Dublin. Since the city is on a river or canal, the urban area has grown upstream, away from the main body of water. At the same time, the modern port has grown and moved downstream, closer to the open sea, so that larger quays and deeper water can be built to allow for a larger draught.

The fact that the old port is close to the city center has made it easier for a type of redevelopment called a "model of convergence" to happen. In this way, the newly available land is close together and can be used to create a single district. This new area is right next to the historical center and gives this center a chance to grow. In all of these cases, a new district has been planned with a purpose that seeks to bring new urban functions. The objective has been to revitalize the city center by ensuring territorial expansion. The plans for waterfront transformation in all of these locations used the former port lands for an expansion of the urban center. The example of Baltimore with the Inner Harbor built at the end of the 1960s, which became a tourist district with a set of leisure facilities, stands exemplary for this concept of convergence.

4.2. Waterfront in convex morphology, ribbon configuration

The waterfronts of Istanbul, Shanghai, and Helsinki have developed in a convex shape. The city has urbanized at the same pace as the port, a parameter imposed by the shape of the natural site. Due to their particular outward-looking shape, the reconfigured ports cannot become a new focal point. Instead, the planners in these cities have adopted a characteristic ribbon configuration. This model allows for a multitude of built-in and functional links.

Once the port activity has been relocated, the port reconversion is taken on by segments. The revitalized waterfront space forms a peripheral belt that runs along the city. These segments are homogenous and complementary to the adjacent urban fabric as a porous interface between the city and the waterfront. The main goal for this type of reconversion is to articulate the urban with the water. These port conversions are characterized by a linear consumption of space; the developments are horizontal so as not to form a screen for the city. The example of Istanbul, with the development of the waterfront as a green strip, exemplifies this classification. This model is also more common in the case of port reconversion and the development of riverbanks and riverside areas.

4.3. Waterfront in linear morphology, development in dilatation configuration

The shoreline of the natural site has a linear shape. The growth of the port goes along with the growth of the city, which usually grows parallel to the sea, and the linear shape gives the port conversion projects in these cities a unique look. When the waterfront is set up in a straight line, like it is in Marseille, Barcelona, Lisbon, or Toronto, the city grows. This linear layout becomes a tool for expanding the different parts of the city around the port. Each urban fabric retains its original urban characteristics, which are preserved, and the gaps are filled by the new development on the port side reconquered by the urban. This type of redevelopment is called dilation because only the architectural aspect becomes characteristic of the redeveloped part of the port and thus becomes the main element that makes up the maritime showcase of the city.

The case of Marseilles is a good example. The port reconversion has been spread over several Concerted Development Zones, and each reconverted part of the old port is characterized by a specific and separate development. The whole is heterogeneous and unified only through its shared location at the seafront. Lisbon similarly pursued such dilatation and redevelopment on the occasion of the 1998 Universal Exhibition. The central part of the port on the main axis of the city, known as Santa Maria dos Olivais, was redeveloped to receive the event with large buildings and halls for the exhibition, a large Vasco da Gama shopping center, as well as a group of towers for the tertiary sector; the northern part of Moscavid and the southern part of Cabo Ruivo was redeveloped essentially for housing. This type of waterfront in a linear configuration very often combines with the concave or convex models mentioned above to give a composite model, whose port reconversion inherits the properties of both configurations.

4.4. The composite model

In cities with a lot of port activity, the port's influence has spread out over a large area. The cases of Rotterdam and London perfectly illustrate this configuration. As a result, port reconversion operations have been carried out in different sequences and according to different situations. In the case of London (Figure 6), for example, the situation of the first reconversion, which dates from the 1980s (Andrew, 1998), in a concave morphology, led to the creation of a new emerging centrality through the creation of a business district in Canary Wharf. To the east of this site, and as part of the realization of projects for the London 2012 Olympic Games, the convex morphology of the site has led to ribbon development through the creation of green spaces, waterfront promenades, and bathing beaches.

The composite model often exists in (formerly) large ports and illustrates the combination of different waterfront morphologies and, thus, the adoption of different types of port reconversions depending on the waterfront configuration. In general, cities whose ports have evolved through several extensions progressively show various reconversion operations. Those port reconversion projects are progressively articulated on the waterfront according to the different morphologies, and following the evolutionary cycle of port extension toward the outside, the abandonment of the old sites and their reconversions go at the same rhythm, as illustrated by James Bird's (1963) “Anyport Model”.

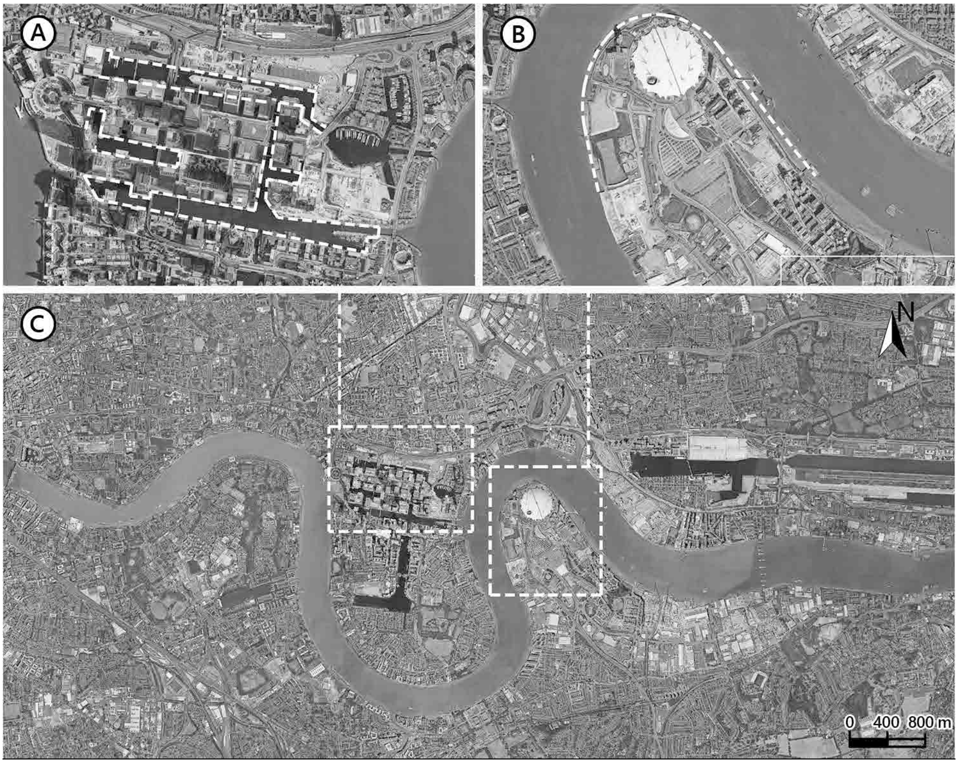

Figure 6. Docklands redevelopment achievements in London.

Note. Panel A: Satellite image of the Canary Wharf, commercial buildings built in the 1980s (Location: 51°30'18.61"N, 0° 1'24.62"W). Panel B: Satellite image of the Millennium Dome, which was built for the Olympic Games in 2012 (Location: 51°30'11.07"N, 0° 0'11.46"E). Two distinct morphologies, concave for the Canary Wharf converted into a business district according to a convergence model, and convex for the Millennium Dome bordered by a green ribbon that forms a promenade. Panel C: Satellite image with different situations of London waterfront’s. Satellite images (Imagery date: May 5, 2022) are generated using Version 7.3.4.8248 of Google Earth (2022). Copyright 2022 by Google LLC.

5. Conclusion

This morphological classification of the waterfronts enables the study of the relationship between the shape of the waterfront (convex, concave, or linear) and the type of revitalization it leads to (ribbon, convergence, or dilation). The natural environment and the engineering of the port that extends into the water are what defines the port and the city. The waterfront's morphology defines the sort of port conversion. Nevertheless, composite situations cannot be ruled out. The case of London bears witness to multiple situations with distinct configurations, but the latter configuration is supported by the sequential nature. The morphological analysis of the waterfront not only enables classification, but also provides indications of future port reconversions and the opportunity to define a coherent redevelopment proposal according to the three models given. A ribbon model may be selected if the waterfront has a convex morphological configuration; a convergence model may be selected if the waterfront has a concave morphological configuration; and a dilatation of the existing urban fabrics on the quays may be selected if the waterfront has a concave morphological configuration.

This classification method based on morphologies can be utilized to better comprehend, adapt, and direct future port reconversion operations. According to Eisenberg (2005), there are numerous factors why the waterfronts of many cities are reviving. Nonetheless, if a city, such as Hamburg, has preserved portions of its history as a well-integrated port city, this will aid any future development of its waterfronts. Understanding the role of the coastline and harbor shape in future development and utilizing this approach in future planning is particularly important for cities with historic port areas that require revitalization, such as Algiers, Tripoli, Split, Tunis, and Rijeka, where changes are imminent and planned interventions can have a significant impact on the success of waterfront redevelopment. The morphology approach is a valuable instrument for urban planning and ensuring a project's compatibility with its environs. This is because the relationship between the container and its content reveals the connection between the site and the urban form.

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