THE WATERWHEEL: A SOCIO-SPATIAL METHOD FOR UNDERSTANDING AND DISPLAYING HOLISTIC WATER SYSTEMS

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KEYWORDS

geo-historical spatial mapping, water systems, resilience,

ABSTRACT

Many megacities around the world are located in deltas where the possibilities of shipping and the availability of flat fertile lands have attracted large numbers of people, industries and businesses. These areas also face multiple water-based challenges: the provision of clean drinking water, the cleaning of sewage water, subsidence, delivery of water for agricultural and industrial purposes, issues of land reclamation from the sea for agriculture and construction, but also protection against rising sea levels, salination or the need to keep waterways and ports open for shipping. These water-related challenges are interconnected and require coordinated and integrated responses from all stakeholders, city and regional governments, private and public actors, port authorities, as well as NGO's and citizens. Exploring cities in urban deltas in general and port cities in particular from a long-term perspective shows that these cities have a long tradition of resilience, as diverse public and private stakeholders have developed formal and informal institutional and planning traditions that have allowed them to address and overcome diverse challenges meaningfully, forcefully and rapidly. This paper first proposes that an analysis of resilience in port cities can serve as a foundation for addressing the water-related challenges of the future. It argues that we need knowledge of the spatial and social conditions necessary for developing such systemic and evolutionary resilience. It posits that we need to combine a thorough understanding of socio-spatial patterns of water systems to provide insight into earlier moments of water transitions and into long-term implications of policies and structures and provide a foundation for future design. Taking advantage of the vast number of longitudinal datasets recently digitized or undergoing digitization, we propose to employ a methodology to pursue a multi- and trans-disciplinary analysis. We exemplify it through application of the concept to the theme of water and particularly port cities, calling it the Waterwheel for this specific application. The presentation proposes first steps towards the development of a methodology and presents selected case studies notably from Rotterdam, Hamburg and London to get a better understanding of water culture through the lens of port-city relations. In conclusion, the presentation explores how such a methodology can help explore conflict and consensus around issues of water and heritage through a new water culture that includes a new holistic water management approach in megacities to meet water challenges for livable cities.

1 INTRODUCTION

Many megacities around the world are located in deltas where the possibilities of shipping and the availability of flat fertile lands have attracted large numbers of people, industries and businesses. The opportunities that these locations offer, are balanced by multiple, often water-based challenges that are

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interconnected. Cities in urban deltas, near rivers and seas experience some challenges that are universal and others that are more particular. Their location near the sea and the presence of salty water adds an additional challenge to the provision of clean drinking water and delivery of water for agricultural and industrial purposes. Their location at or close to sea-level can challenge the drainage of sewage water. The historical existence of swamps can result in land subsidence that can damage buildings. Other specific water issues include land reclamation from the sea for agriculture and construction, but also protection against rising sea levels, defense against salination or the need to keep waterways and ports open for shipping.

These water-related challenges are interconnected and require coordinated and integrated responses from all stakeholders, city and regional governments, private and public actors, port authorities, as well as NGO's and citizens. (Port) cities in urban deltas have developed formal and informal institutional and planning traditions that have allowed them to address and overcome diverse challenges meaningfully, forcefully and rapidly. Despite the extensive list of publications on individual port and water cities, a comprehensive approach to the question of why (port) cities and cities in urban deltas are so resilient, is missing. Access to large data sets and new computing tools allows for mapping of spatial and social factors and may provide us with new ways of understanding of the spatial and social conditions of historical resilience in port cities and other cities in urban deltas. It can also serve as a "gap-finder" (Hein & van Mil, 2020) for (water-)related challenges and opportunities and a foundation for addressing the water-related challenges of the future and designing for future spatial, social and cultural resilience.

Following a brief reflection on resilience as a concept, this article proposes a research methodology aimed at gathering (historical) data, presenting and analyzing it through geo-spatial mapping, and presenting the findings to stakeholders in a cyclical way. The paper proposes to apply these general steps to theme of water and port cities, labelling it the Waterwheel for this purpose. We argue that understanding and measuring resilient patterns, and ultimately developing tools to engage stakeholders in discussions around these will help decision-makers to build on the long-term historical and heritage structures and the path dependence to (re)-design the metropolises of the past for the future.

2 RESILIENCE AS A PRODUCT OF LONG-TERM SPATIAL INVESTMENT AND INTERNATIONAL PATH DEPENDENCE

Planning for resilience is very difficult, given the high degree of incalculable dangers, or *uncertainties* as defined by the German sociologist Ulrich Beck (1992), and unclear spatial implications of disasters. The entangled challenges of water are exemplary for the complexities of creating resilience. The ecologist Crawford Stanley Holling (1973) introduced the concept of resilience, referring to the behavior of ecological systems, and confronted it with the concept of stability (a system can be highly stable, but with a low resilience). He wrote: 'Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of variables, driving variables, and parameters, and still persist. In this definition resilience is the property of the system and persistence or probability of extinction is the result.' Or, to put it differently: 'Resilience is "the capacity of a system to undergo disturbance and maintain its functions and controls" (Gunderson and Holling, 2001; quoted in Jabareen, 2013: 220). A major strategy chosen for evolution is one that allows persistence (survival) by maintaining flexibility.

The resilience framework requires a qualitative ability to develop systems that can absorb and accommodate future events in any unexpected form. If we knew exactly when, where and how crises would occur in the future, we could design our systems to withstand them (Godschalk, 2003). Resilience is an important goal because the vulnerability of technological and social systems cannot be fully predicted (Foster 1997). For a long time, the paradigm of modernist and reductionist ideas and approaches in science, technology and design has prevailed, suggesting that it is possible to know and understand the social and physical world completely and, consequently, to plan and develop the future world completely (Meyer, 2016). But the events of each year prove that disturbances can occur suddenly and unexpectedly and that the extent and magnitude of these disturbances and changes are unknown.

Resilience is also the ability to adapt to changes more generally. These are not necessarily negative (as in the case of the Iron Curtain) (Hein, Schubert, 2020), and resilience is not always positive (Vale, 2016). If a place was profoundly unequal before the disaster, any sense of resilience could mean a return to similarly unequal conditions. In this sense, a disaster can be a window on the structural inequalities of a society at the time immediately before the disaster occurred. The experience of post-disaster recovery shows both how the interests of the elite benefited disproportionately from many types of post-disaster investment and how marginalized groups tried to cope, often showing a deep-rooted resilience (micro-level resilience of urban communities), even if it was not always described as such. *Critical resilience* means assessing the impact of a disaster for example in light of diversity and inclusion.

Resilience as a concept for water, ports, and cities can't be based on a state similar to what cognitive sciences call the survival mode in human behavior, when reactions to a disaster must be urgent. Survival mode denies all other activities except survival and doesn't allow for long-term planning. In survival mode, the emphasis is on danger (unforeseen events, surprises, uncertainty) and on a fear-based mindset that refuses risks and opportunities. Such a mode happens in a war, but it can't be a constant state. To build resilience in the (port) cities of urban deltas, we need to create dynamic and complex systems in line with Folke and others (2010). Such resilience is characterized by multiple pathways of development, interacting periods of gradual and rapid change, feedback and non-linear dynamics, thresholds, tipping points and shifts between pathways, and how such dynamics interact across temporal and spatial scales (Folke et al., 2011, p. 721). This commitment and the tendency of institutions (actors with political, economic, social, cultural and/or combined power) (or technologies) to develop or follow privileged paths in certain ways because of their structural characteristics or their beliefs and values leads to *path dependency*, a key concept in explaining why institutions in political life do not change as much as one would expect.

Port cities have astonishing capacity to both persist in their function and to adapt to new challenges, often water-related ones. This capacity is a quality of resilience (Hein, Schubert, 2020). The quality of resilience of port cities is often linked to past decisions and path-dependent decisions have enabled many ports and cities to build up an *evolutionary resilience* (especially with regard to their relationship with shipping functions as part of their urban activities). The scientific debate on port cities and path dependency has so far relied heavily on institutional and governance aspects, while the role of physical space and historical investment in port and urban infrastructure, institutions and culture remains under-explored (Hein, Schubert, 2020). Urban deltas and port cities are tied to a specific type of location, to the meeting of sea and land, and represent a distinctive urban type that differs from other types of cities such as capitals, factory cities or university centres. They require financially demanding, long-term planning to erect large and specialised infrastructure that is built over the long term and for the long term, such as docks, quays, cranes and warehouses. The construction of these structures requires long-term planning and collaboration between different actors. These infrastructures, cities and the infrastructures that created them become path dependent institutions and characterized by an inability to break away from history (Martin and Sunley, 2006), potentially hindering the emergence of resilience.

The resilience of port cities includes in particular ecological, economic, institutional or social, but also technological and spatial aspects (Hein and Schubert, 2020). From an environmental perspective, ports and port cities must develop permanent and temporary solutions in order to design their urban structure and function to meet the challenges of proximity to large bodies of water (river, delta, sea, ocean), including the constant threat of water-related disasters. The port, including its infrastructure and industries, creates its own environmental impacts, i.e. water, soil, air and noise pollution; sea and land transport contribute even more. Taking economic resilience into account, port actors, often in cooperation with local and sometimes national managers, will invest in the continuation of port-related functions (such as shipping, trade, storage, production and administration) that are crucial for economic growth.

Stable relationships and close cooperation between all institutional actors and government authorities in the port, city and region can assure institutional and social resilience. Spatial resilience, partly due to the longevity of costly and expanding (port) infrastructure, can have both positive and negative connotations: It can help a port city to maintain its role as a center of shipping, maritime expertise, administration and logistics; it can also lead to the continuation of environmental, economic, social or other practices that were historically relevant and accepted as part of a paradigm, but which no longer meet evolving needs and views which can be detrimental to resilience. The complexity of the multiple port city conditions (location, technical, social, cultural) and patterns of resilience in terms of complex systems of scales, actors, governance structures, policies, temporalities, inequalities, and cultures highlight the complexity of creating resilience, of how it works, for whom and through what. Examples from the past consistently show an *unequal resilience* (Vale, 2016), so that it is of no use to speak of an entire resilient urban delta or (port) city region.

To understand how water-related changes have influenced urban deltas and port city regions over time, and what this means for resilience, we argue that a methodology that ties long-term historical analysis based on big data to the future can be helpful. A close analysis of the historic transformation of the built environment (such as land use, land ownership, infrastructures), the development of institutional structures (municipal boundaries) and the narrative that accompanies them (as embedded in maps and plans) through historical geo-spatial mapping can facilitate the identification of 'gaps,' where spatial, institutional, or cultural opportunities and challenges exist and where planning can be useful. Such an understanding, we argue, can provide novel insights into the conditions and complexity of climate change and the multiple transitions (energy, digital, technological). Advanced knowledge about the long-standing technical and social conditions in port city regions can provide a better understanding of resources and systems, advanced understanding for future design and the planning of measures to strengthen them. Such a methodology can be applied to support a new holistic approach to water management also in megacities to meet the water challenges for livable cities.

3 THE WATERWHEEL METHODOLOGY: BIG DATA OF THE PAST FOR THE DESIGN OF THE FUTURE

The proposed methodology (developed by a group working on Digital Humanities at Delft University of Technology and notably in the Chair History of Architecture and Urban Planning) aims to problematize our understanding of the past to better design the future. It focuses on gathering (historical) data, presenting and analyzing it through geo-spatial mapping, and presenting the findings to stakeholders in a cyclical way. For the purpose of this paper we apply the methodology to the field of water and port cites—and metaphorically call it the Waterwheel (Figure 1). A water wheel is a machine for converting the energy of flowing or falling water into useful forms of power, often in a watermill. The Waterwheel stands for the continuous process in geospatial mapping of collecting, preparing, analyzing, visualizing and sharing data. It also emphasizes the circular quality of the approach, which allows for the process to consistently add on new knowledge and integrate findings from one round into the next analysis. It is in line with the UNESCO Historical Urban Landscape approach (and other approaches i.e.

Hydrobiography, a term coined by Eric Luiten in 2014) using historically-grounded investigation and geo-spatial mapping as a basis for informed planning and policy-making, education, outreach and training.

We argue that such an approach can help protect and develop historic cities in urban deltas based on long-term comparative analysis. The methodology, applied here as the Waterwheel, can help to build greater awareness of how port cities developed in, on, and along the water, how the water between sea, river and land has changed over time, and how key stakeholders have dealt with water related issues and water related interventions building resilience.

The methodology consists of five steps, specifically:

1.Definitions, Collection, Assessment

2. Preparation of the collected data.

3. Analysis of the collected and organized data.

4. Data visualization.

5. Sharing, dissemination, pilot studies.

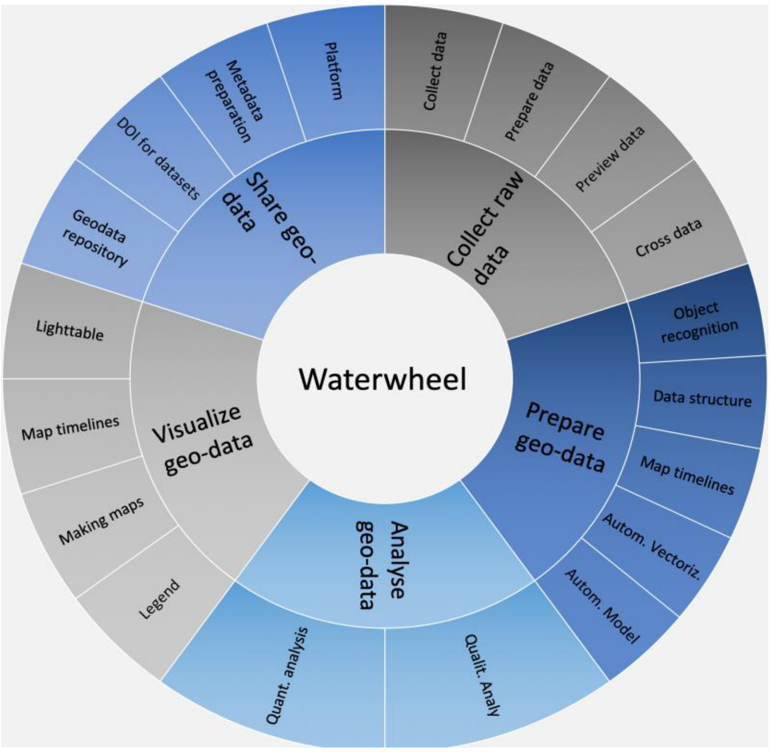


Figure 1. The Waterwheel methodology (by Carola Hein and a group working on Digital Humanities at Delft University of Technology).

4 DESCRIPTION OF THE METHODOLOGY

Step 1 – Definitions, Collection, Assessment

Finding--or building--the right reliable dataset is one of the biggest challenges in research. To establish a dataset that shows the changing relationship in delta cities of sea and land we need to evaluate historical maps and align them with each other. We also need to establish a glossary of appropriate terms and definitions for the identification of water and port related sites and intangible practices and water-related challenges and crossing this information with other visual, written or data sources. Existing datasets imply not only definitions, but also decisions; they reflect local particularities and historical choices that may already shape answers. Establishing this dataset requires the right humanities and social-science based knowledge and labour to process datasets to obtain meaningful and reliable results.

Step 2 – Preparation of the collected data.

Preparation of spatial data on water-land spaces in urban deltas is time-consuming and involves scholarly expertise. The data needs to be adjusted for inclusion in a GIS-based mapping through georectification of historic maps, geolocalisation of non-spatial information, optimization of the database and semantic enrichment of the data in diverse localities. Collaboration with computer scientists using crowdsourcing and artificial intelligence allows scholars to get a more comprehensive understanding of historic cities in light of changing water patterns and port form and function through big data.

Step 3 – Analysis of the collected and organized data.

The geospatial datasets allow for a big data analysis using a combination of qualitative and quantitative approaches to understand societal long-term effects of decisions and to connect spatial, social and cultural aspects of water and port impact on natural and built heritage. Social scientists, historians and humanities scholars can use the datasets to draw a more complete picture on short- and long-term effects of water and port developments in urban deltas and port cities and allow for an assessment of contemporary proposals in the light of long-term developments.

Step 4 – Data visualization.

Once collected, organized and analyzed, the findings need to be visualized through geo-spatial mapping and infographics to show the complex correlation between spatial structures, spatial changes through time and social phenomena. Used as a gap-finder, the visualizations can help identify sites and urban areas in light of new climate change-based challenges and in terms of existing resilience. In depth analysis can reveal long-term effects of decisions on the water system and allow divulgation of the findings to large and diverse audiences.

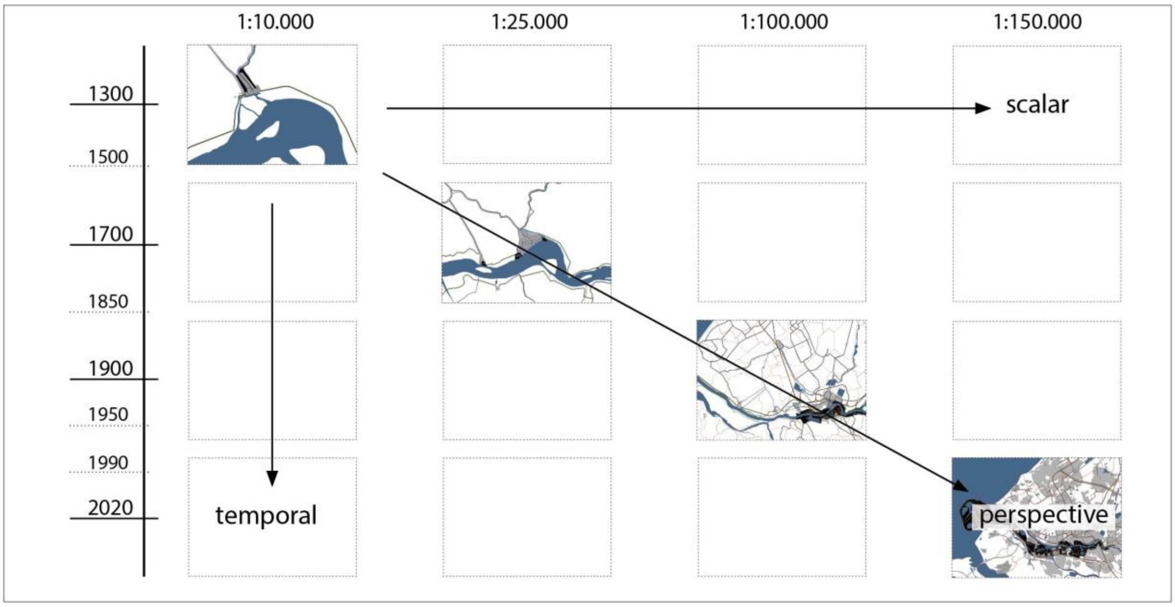
Step 5 – Sharing, dissemination, pilot studies.

The collected data, its analysis and visualization can be presented open source. The data sets and their visualization can then be used for education of academics, professionals and general citizens. An online platform allows local and global stakeholders to explore the visualizations as an inspiration to develop new spatial perspectives for living with water. Such a comprehensive investigation of urban deltas and port cities can promote the integration of longitudinal knowledge into design and become a foundation for next turns of the wheel.

5 PILOT CASE STUDIES: ROTTERDAM, HAMBURG AND LONDON

Using ongoing research into North Sea port city regions by the Chair History of Architecture and Urban Planning at Delft University of Technology, we have started to apply the methodology. We have selected three port city regions that have developed in relation to each other around the North Sea and use them as pilot studies. The choice of a shared body of water, the North Sea, as the foundation for comparative research, allows us to test the methodology for long-term analysis of water and land interaction in urban deltas and port cities. This pilot study is focused primarily on the relation between sea and land, between port and city at an urban scale. It focuses on select themes, notably water-land relations, infrastructure, land use and municipal borders. We have therefore opted to focus on the growing scale of the city over time (Figure 2).

Figure 2. Conceptualization of different approaches to historical geo-spatial mapping and their usefulness for particular disciplinary approaches or questions. Figure by Carola Hein, Yvonne van Mil,



Blanka Borbely, and Batuhan Özaltun based on Global Administrative Boundaries (2018) CORINE Land Cover (2016) and EuroGlobalMap (2017).

This pilot study in mapping shows the three cities, Rotterdam, Hamburg, and London at an increasing scale and at selected moments in time that we identified in relation to major political, technological and social changes. All three cities experienced historical shocks and often the same water-related ones. The comparative mapping method shows that the three cities responded to these changes in distinctive ways developing different patterns of resilience in regard to the relation between city and port, the focus of this research. The maps provide insight into the potential opportunities of spatial mapping and visualization as gap-finder to recognize specific water-related challenges and their impact over time, such as sea-level rise, the impact of ship size or of the maritime and port technologies on urban deltas and port cities. The maps show the importance of comparatively investigating how each city responded to these challenges in unique and local ways in order to predict the impact of these spaces and institutions on the future. This approach can be refined by data sets that include information on drinking water supply or drainage, on land reclamation, or flooding at a city-wide scale. The approach can also be refined at a smaller scale to investigate water issues at a building level.

Preparation of the collected data, analysis of the collected and organized data and data visualisation for the three pilot case studies

For the comparative study of the three port city regions we used geo-spatial mapping (GIS), overlaying different data layers, providing a similar level of abstraction, and a uniform legend. To establish the analytical geo-spatial historical maps of the three port city regions we started with contemporary GIS datasets for the year 2020. This required datasets covering several nation states with sufficient spatial resolution to analyze and compare them in a consistent and systematic way, such as global and continental GIS data sets. We used EuroGlobalMap (2017), Global Administrative Boundaries (2018) CORINE Land Cover (2016). National and regional data can be more detailed and accurate, but has its own definitions and criteria making it difficult to combine and compare. Critical interpretation of the data is necessary, as is editing the GIS data to obtain comparable and uniform maps.

To better understand the spatial development of port cities in relation to water and their connection to the hinterland, we opted to show the morphology of the water, port and city area, important infrastructures and political boundaries as a foundation to building up a comprehensive historical water-land analysis (Figure 3). From the contemporary state we had to generate data for the earlier periods, using national sources and historical maps of different scale and quality. For the year 1900, national topographic maps, such as the maps of the Ordnance Survey, allowed us to identify changes in infrastructure and the built environment. For earlier periods, historical city maps were among the few available resources.

Water and Port Histories in Rotterdam, Hamburg, and London

The continued importance of Rotterdam, Hamburg and London as port cities but with changing spatial and institutional constellations raises the question of water (or port-)related resilience and path dependencies. Public and private actors have planned and administered the relationship with water and port in different ways in these three cities. The maps in Figure 3 shows that the development paths of water, port and city spaces and the actors who shape them are not always aligned. In the case of Rotterdam, the port has been the heart of city development, growing from the historic center to the outskirts, with urban institutions trying to catch up to the expansion of the port. The case of the city-state Hamburg illustrates the development of long-term public leadership that has provided direction for the expanding port as well as for the growing city. The case of London is led by private investment, building and relocating a world-class port and administering it from the city center, while local and national institutions only intervene to balance spatial or social short-comings of the private actors. This historical analysis and visualization points to the resilience of the port function, but each of these cities address challenges differently creating specific development paths.

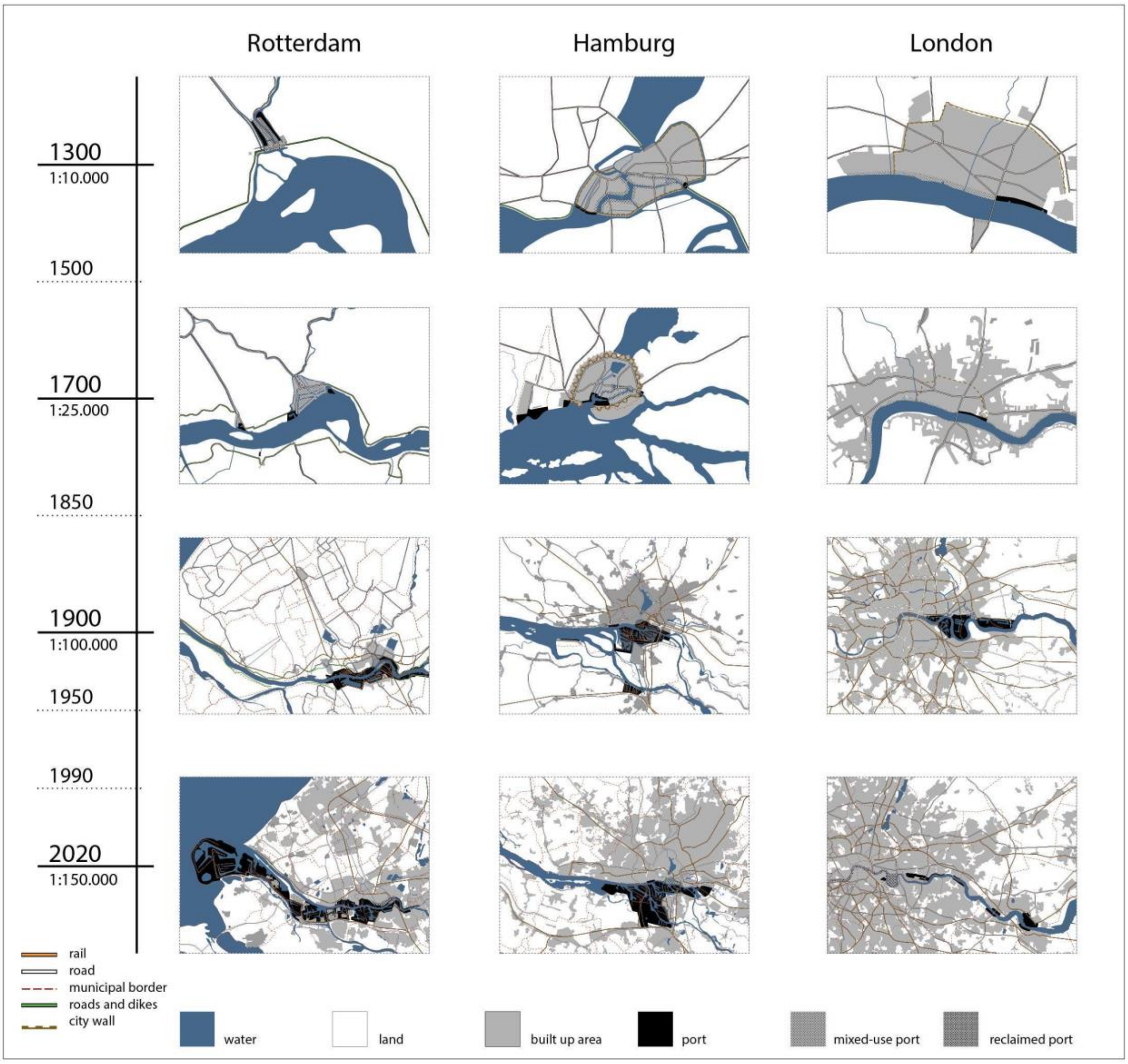


Figure 3. First draft for comparative geo-spatial mapping methodology, with case study of London, Hamburg and Rotterdam. Figure by Carola Hein, Yvonne van Mil, Blanka Borbely, and Batuhan Özaltun based on Global Administrative Boundaries (2018) CORINE Land Cover (2016) and EuroGlobalMap (2017).

Brief Analysis of Water in the Map Series

The series of maps provides some insights into questions of water-development in urban deltas. In 1300, the maps show fledgling cities controlled by dykes and dams and located near rivers for shipping, and as a place of crossing (Hein & Van Mil 2020). All three cities depended on the proximity to shippable water for trade, while dealing with challenges of flooding, and safe drinking water provision. The city of Rotterdam is then many times smaller than Hamburg and London, although the ports of the three cities are almost the same size.

In 1700, access to shippable water for traditional industries and for trade became a key element for urban development. In Rotterdam and Hamburg, the ports expanded considerably through reclamation and the formation of new port islands in the Rivers Maas and Elbe. By 1700, London was the most important port in Britain. The port's facilities could not accommodate the rapid growth of ships. The cities were economically depended on the water. Hamburg and Rotterdam protected itself from the surrounding areas, while London extended along the water and into the countryside.

With industrialization in the late 19th century and the development of new forms of transport, private actors, port companies and some city governments created dedicated port areas separate from the urban spaces in all three cities. pecific patterns varied, but in every case, port spaces expanded dramatically and started to occupy land in the estuaries or rivers. The spread of water-borne diseases, like cholera, led to the development of new infrastructures that could be shown through mapping. Rotterdam built a piped drinking water system in the 1870s, reducing the numbers of deaths from infectious diseases. In Altona, on the outskirts of Hamburg, large waterworks prevented cholera at the end of the 19th century, confining the disease to Hamburg. The Thames in London became the source of cholera, as it was used both as a source of drinking and bathing and as a sewerage system.

The maps of 2020 show a further reclamation of water for port purposes towards the sea (downstream). Through the attendance of containerization the industrial port moved away from the cities. Old ports areas were reclaimed and became part of the historical values of the city. Master plans for city and port were prepared (Maasvlakte 2 in Rotterdam, Hafencity in Hamburg, London: strategy titled Protect, Improve, Promote), as well as the new protection against water (in Rotterdam The Maeslant Barrier, in Hamburg Niederhafen Promenade, in London The Thames Barrier). The water in the estuaries or rivers is channeled and controlled for shipping purposes, chemical industries, refineries and energie storage.

Conclusions: toward an advanced research agenda?

Planning for urbanized deltas is possible, but requires a clear understanding and needs to be explored through developed methods. Understanding of long-term development is highly relevant to build resilient (port) cities and deltas. The historical perspective needs to be taken into account for future design beyond the fields of science, design and technology (Meyer, 2016). Multidisciplinarity, including spatial, social and cultural perspective is needed to offer a broad horizontal spectrum of views. Historical geo-spatial mapping allows and enables detailed investigations. This first pilot study shows that a better understanding of historical processes in port cities and urban deltas can help identify particular processes and patterns of resilience that are relevant for the planning processes of urban deltas and megacities. A holistic approach to understanding and representing water systems in space is needed to connect water for shipping, irrigation and drinking. Our presentation explored how such a methodology (one of many) can help to reveal conflicts and consensus on water and heritage issues in megacities through a longitudinal perspective in order to address the challenges of water for livable cities. Our interest is to be able to compare which water issues have shaped practices and spaces in a networked way and what long-term effects this has had and continues to have. Such a first step can lead towards an advanced research agenda in this field.

References

Beck, U. (1992). Risk Society: Toward a New Modernity. London: Sage.

Folke, C., Carpenter, S. R., Walker, B. H., Scheffer, M., Chapin, F. S., III, & Rockstro, J. (2010). “Resilience thinking: Integrating resilience, adaptability and transformability.” Ecology and Society, 15, 20.

Folke, C., Jansson, Å., Rockström, J., Olsson, P., Carpenter, S. R., Chapin, F. S., Crépin, A. S., & al. (2011). “Reconnecting to the biosphere.” AMBIO: A Journal of the Human Environment, 40(7), 719–738.

Foster, H. D. (1997). The Ozymandias principles: Thirty-one strategies for surviving change, UBC Press, Victoria, Canada.

Godschalk, D.R. (2003). “Urban Hazard Mitigation: Creating Resilient Cities.” *Natural Hazards Review* 4/3: 136-43.

Hein, C. & Y. Van Mil (2019). "Towards a Comparative Spatial Analysis for Port City Regions Based on Historical Geo-spatial Mapping." PORTUSplus 8 (Special Issue).

Hein, C. & D. Schubert (2020). "Resilience and path dependance: A Comparative Study of the Port Cities of London, Hamburg, and Philadelphia." Journal of Urban History: 1-31.

Hein, C. & P. Van de Laar (2020). The Separation of Ports from Cities: The Case of Rotterdam. European Port Cities in Transition. A. Carpenter and R. Lozano. Cham, Switzerland, Springer.

Holling, C.S. (1973). "Resilience and Stability of Ecological Systems." Annual Review of Ecology, Evolution, and Systematics, 4: 1-23.

Jabareen, Y. (2013). "Planning the resilient city: concepts and strategies for coping with climate change and environmental risk." Cities 31, 220-229.

Martin, R., & Sunley, P. (2006)."Path dependence and regional economic evolution." Journal of economic geography, *6*(4), 395-437.

Meyer, H (2016). "Making urbanizing deltas more resilient by design." In Carola Hein (ed.) *International Planning History Society Proceedings*, 17th IPHS Conference, History-Urbanism-Resilience, TU Delft 17-21 July 2016, V.03, TU Delft Open.

Schoor, A. van der, & N. Schadee (1999). Stad in aanwas: geschiedenis van Rotterdam tot 1813. Zwolle, Waanders.

Vale, L.J. (2016). "Towards critical resilience: learning from the history of post-trauma urbanism." In Carola Hein (ed.) *International Planning History Society Proceedings*, 17th IPHS Conference, History-Urbanism-Resilience, TU Delft 17-21 July 2016, V.03, TU Delft Open.