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BETWEEN THE HYDROLOGICAL AND HYDROSOCIAL CYCLE: THE HISTORY OF CITIES

Some of the first and still some of the most famous descriptions of Urbanisation underline the role of water: Herodotus' fifth-century BC descriptions of cities located on the banks of the long-gone branches of the Nile in the Egyptian delta retain an importance the author could never have envisaged: his notes of these cities long since drowned by history and changing relations in water-society relations have become invaluable sources for archaeologists and for climate scientists who are trying to reconstruct the development of the Mediterranean coastline.¹

Somewhat later, but still 2,000 years ago, the Greek geographer Pausanias travelled throughout the Mediterranean region, and after visiting the urban centres of his day, wrote that no city could claim to be a real city without a fountain in its midst. Cities in this relatively dry part of Europe, where months could pass without a drop of rain falling, 'revolted' against their geographical situation by installing fountains. The fountain was the ultimate symbol of urban life; it marked the distinction between city and countryside and was a powerful, symbolic expression of the triumph of culture over nature. It was also a very visible sign of what has proved to be a structural and enduring aspect of the city as a social phenomenon: this type of social organisation requires quite complex control over water in one way or another.

This chapter will argue for the relevance of bringing water-urban systems into the centre of urban studies based on two basic premises.

First, all urban dwellers – from the few people who settled at a spring in the desert and built a wall in Jericho almost 10,000 years ago, to the Incas living in the royal city of Machu Picchu on its mountaintop in the Andes, with water carried by long aqueducts built along the mountainsides, to stock-traders living in apartments in a skyscraper in Manhattan – share the absolute need for *one* controllable resource: H₂O. The theoretical and

empirical importance of the fact that all urban dwellers – rich and poor, white and black, Hindus and Muslims, Christians and atheists – need the same amount of water can hardly be overestimated. And, moreover, as long as people live in cities, water has to be socially provided, by canals, pipes, rainwater, aquifers, rivers or desalination plants. Its control, distribution and disposal have to be technically organised and socially managed. Water is the only absolutely essential and universal urban resource that can be controlled, and all urban settlements have therefore always struggled to do this, and in this effort, urban spaces have developed and changed and cities' power relations been cemented and dissolved.²

Secondly, it is just as crucial to draw the analytical and theoretical consequences of another physical and social fact: the hydraulic system that envelops the city varies from place to place and from time to time. Spatial differences in precipitation and evaporation patterns and in urban water landscapes fundamentally define the character of cities as well as the sense of place. While all cities need to solve the water issue, they have to do so in different ways, since the urban dwellers' interactions with, and their patterns of activity in relation to, their water will reflect the local water cycles' particular characteristics and the past interactions of water and city.

All cities have been and are locked into this continuous web of relationships with water's simultaneous universalism and particularism. The history and current development of cities is therefore written in water and in the most varied ways and manners. In spite of this, mainstream urban studies have persistently tended to neglect the water issue and the interactions between urban development and water and how these in fundamental ways have impacted on the whole process of urbanisation.

THE 'DRY' TRADITION OF URBAN STUDIES

Charles Darwin wrote that science must be criticism before it can be anything else. In line with this attitude this chapter will first discuss the dominant tradition within urban studies, a tradition that has been reductionistic, in the sense that it has mostly been concerned with certain social variables and it has tended to become deterministic when natural variables were included.³ During the decades after the 1960s, when urban studies were established globally as a research field, it by and large completely neglected the importance of the confluences between the planet's water and cities and how these interactions had fundamentally impacted on urban life. It is here thought crucial to shortly discuss this research profile, in order to make it easier to open the door to less reductionist research strategies that can broaden our understanding of urban development.

It is generally acknowledged that early urban studies in the first decades of the twentieth century were concerned with 'site and location' issues and with nature's physical characteristics as a determining factor in the location and development of settlements. At the time, a number of descriptive studies of city and town establishments were published, emphasising the roles of topography, water, climate and other physical factors. The aim of much of this research was to demonstrate that the character of towns could be derived from their physical locations. However, this research tradition was later discarded not only because of its determinism, but on the broader grounds that it was concerned with the 'causal effect of physical geography' (Carter 1981: 3). Mainstream urban studies have since argued that it was the replacement of this type of causal description concerned with urban-nature relations with interpretation of the social that laid the foundations for modern urban studies. The 'site-situation' approach was criticised for being theoretically wrong, but importantly for later research practices, it was also regarded as historically outdated due to the development of the city itself. Nature had been overcome as a relevant factor in modern, large-scale, urban development, and to focus on it was therefore both theoretically and empirically anachronistic.⁴ This fascination for the social aspect was rational, as cities expanded in all sorts of directions and transformed themselves into complex societies of their own.

Concern with physical factors was thus seen as both historically outdated and theoretically immature. 'Mature perspectives' were not interested in nature or in physical factors, and mature research should only deal with how social facts constrained social action or, as it has been formulated, with 'the way in which urban patterns and processes are the outcome of the combination of human choice and wider social processes which place constraints upon this human action' (Hall 1998: 20–1). Urban choice and constraint were seen as being entirely within the social world, unfettered or at least not significantly influenced by non-social factors as nature or waterscapes. In the post-1950 period, the clearly dominant subject matter of urban geography has been defined as the set of topics that can be explained in terms of social variables, and social variables alone. Within this theoretical perspective and conceptualisation of the research field, water systems, being physical phenomena of relevance to urban development, were simply of no interest. Also when water clearly functioned as a social variable, in fountains, in coffee shops, in urban drainage and in sewage systems, it was still categorised as nature, and was on this ground outside the empirical universe of the urban scholar.

In the first decades after 1950, urban studies in general were influenced by positivism and the aim was to detect universal social laws and fundamental regularities and to build models.⁵ Proponents of what was regarded as a scientific method in human geography, for example,

argued that 'geography has to be conceived of as the science concerned with the formulation of laws governing the spatial distribution of certain features on the surface of the earth' (Schaefer 1953: 227). These 'certain features' were all social features, and Schaefer and his colleagues criticised urban geographical enquiry up to that point for being analytically naïve and insufficiently interested in social theory. This criticism was of course to the point, but this nomothetic-oriented tradition, only concerned with the social and social variables, could on the other hand not take the extremely varying roles of the nature of water in city development aboard empirically, because to do so would erode its model-building ambitions.

Two theoretical schools that were uninterested in the role of nature (and water) came to dominate the field in this effort to establish a positivist science, seeking to construct theories of spatial laws on the basis of statistical analysis and the construction of predictive spatial models. The 'ecological approach' was based on the assumption that human behaviour was determined by what were described as 'ecological principles'. This term was chosen in order to emphasise the idea that urban developments should be analysed as analogical with the biological world, because the same behavioural rules that governed the biological world determined predictive patterns of urbanisation. The social world was seen as a mirror of the biological world, but the impact and role of nature or of water was of no interest for the study of urban development.⁶ The 'urban ecology' literature was solely concerned with the social and with understanding the relationships among various competing social groups living in similar or separate areas, using physical ecology concepts.

The 'neo-classical' school was based on the assumption that human beings were motivated primarily by rational aims, and that their patterns of actions were therefore predictable. Actors were consequently locked into an eternal effort to minimise costs and maximise benefits. In line with this view, urban developments were studied as a function of this rationality, and nature or physical elements in nature were logically 'excluded' and of no interest to the analytical set-up.

A salient and shared aspect of both the 'ecological approach' and the 'neo-classical' style was that they were uninterested in water-urban systems and relations. They were solely concerned with the social and with social variables defined in sociological terms. This indifference to the water issue in general extended therefore to water also when it was part of the social sphere. Urban studies, whether we are talking about sociology, geography or history, did not at the time describe or analyse water in urban space as part of the social world – be it as an object of worship, as a mediator of social power or as an area of technological discipline and development – or how changing notions of water reflected

social and economic interests and affected urban health and urban health management, and the architecture and political economy of the city. The new sociologically oriented urban geography vitalised its identity in opposition to what was regarded as the deterministic and outdated 'site and situation' formula, and water, therefore, and everything related to it, was regarded as external to society or as part of the physical environment and therefore outside the range of interest of urban studies.⁷

In the mid-1960s, the 'new urban history' emerged within the discipline of history, being characterised by quantification and model-building aspirations. It gave rise to an influential tradition of urban studies that was primarily interested in the history of urban stratification, spatial patterns (defined sociologically and not by nature, waterscapes or waterzones, etc.) and social mobility. At the same time, what has generally been called the New Left arose as a new political force influencing academia, and encouraging politically and ideologically inspired research on history – from 'the bottom up'. It opened up a very broad topic related to all sorts of social questions. By the end of the 1960s, there was a great deal of interest in urban history, but in line with the political trends it was mainly concerned with what was termed the 'urban crisis' and social relations. The research tradition developed in the wake of the counterculture spreading in most of the Western world and was also inspired by the African-American civil rights movement in US cities in the 1960s and was therefore uninterested in the physical context. Nature or waterscapes were at the time seen as basically non-political issues, and therefore of no relevance to explaining the urban crisis, or even as a hindrance to explaining the things that mattered.

The increasing influence of structuralism led to more studies of cities as structures. The aim became to discover, beneath local differences in surface phenomena, constant laws of an abstract urban culture. This led naturally to a sharper focus on social categories such as class, elites, class struggle, and so on. The various forms of structuralism, whether structural-symbolism which, in its extreme variant, argued that the rules of how the human mind works determine the basic rules and characteristics of urban reality, or structural-historical materialism with its concepts of social formation and modes of production, meant that the role of nature or water in urban development was, if possible, even further relegated to the background. The structures that concerned structuralists were emergent systems of social rules, roles and relationships into which people are born, and which were collectively reproduced and occasionally transformed by human agents, and definitely forms of water-structuration (see below).

As this kind of structuralism went out of fashion, urban studies became more concerned with other issues that could be explained by

social variables. The focus now was more on the symbolic and cultural meanings of cities, within the geographical tradition described as a new 'cultural geography' or human geography. The main aim was described as 'unmasking the meaning of cities, landscapes or buildings' (Hall 1998: 28). The city ought to be deconstructed, or 'unpacked' as a text. This opened up a whole new and promising avenue of research. But the studies that were published show that only very few aimed to unpack the 'meaning' of urban water landscapes, or of 'water buildings', such as fountains, reservoirs, river improvement schemes, riverside developments, and so on. Moreover, since one of the most crucial urban infrastructures – the water supply and sewage system – is a truly hidden and literally invisible structure in a strict material sense (because most of it is underground or hidden in walls and in floors), this aspect of the interaction of city and water has naturally been difficult to unpack as text.

The growing influence of post-modernism and radical constructionism in the 1980s and 1990s directed attention further from the impact of nature on social development in general and also on urban development, since they argued that everything originates in the social world, and nature plays a role only to the extent that humans constitute it through their accounts, suspending all forces that are not social or man-made. The influence of nature on urban development was therefore conspicuous by its absence.

When environmental history emerged as a field in the 1980s, one might have expected that this would stimulate more focus on the history of the water-urban nexus, but that did not happen, not the least due to the way water was conceived. The most influential of these new environmental historians, Donald Worster, defined the subject in his lead article from 1990: 'Transformations of the Earth: towards an agroecological perspective in history' (Worster 1990). Environmental history should, according to Worster, be the study of 'the role and place of nature in human life', but the studies of urban environments were explicitly defined as being outside the sphere of interest. The reason was that environmental historians should not study the 'built environment' because this was seen as 'wholly expressive of culture' (Worster 1988: 292–3) and therefore having no significant connection to nature or the workings of nature. Cities were thus defined and reduced to what was seen as 'built environment',⁸ that is, as being only a product of social variables, and therefore outwith the interest of environmental historians.

The notion that the 'built environment' is 'wholly expressive of culture' can, however, not be sustained, as shown in the examples of New Orleans and Katarina, Berlin and the Spree, London and the Thames and Beijing and the South-to-North Water Transfer project. The conventional

idea that the city and town represent the artificial and built environment that humans make for themselves is a constitutive aspect of urbanisation itself; indeed, to be 'modern' is to live in an urban, built environment. This understanding overlooks the particularities of water, because the built environment one finds in cities is not only a cultural product or a human-made invention. The character of the 'built water environment' will always also reflect the character of the local hydrological cycle or of the physical waterscape, whether the city's water environment is an aquifer, a neighbouring lake or the sea (desalination), or whether the water source is fed by rain, glaciers or is renewable. A nature-centric approach that dismisses the built landscape because it is seen as solely a cultural product, will not acknowledge how nature or waterscapes impact on the built environment. It will not be able analytically to integrate how differences between the built water environment or the water supply systems and sewage systems of New York and Los Angeles, London and Beijing are affected also by different natures or waterscapes. The different control and distribution systems of water that these cities have do reflect different cultures, but they are also the outcome of a complex history of adaptations to different natural waterscapes, efforts at human control and past management ideas of water. The widespread similarities between urban water control systems in many cities all over the world are on the other hand not only the result of similar ideas about water management, but also a reflection of universal characteristics of water as a physical resource.

The three-layered water-system approach provides a way out of this self-imposed cage. It makes it possible to analyse how the urban built water environment is not only a reflection of culture, but also of nature, and both aspects can be integrated in studies of urban development. It can provide a methodology for studying how non-cultural and non-social facts affect how water has been controlled and distributed horizontally, influencing the technology that can be chosen, the material that must be used or can be used, and the size of the water distribution system and how it is operated.⁹ The approach can, moreover, link the urban to the non-urban, since urban landscapes impact the hydrosocial cycle far beyond the boundaries of the urban centres, and might indirectly impact on nature or waterscapes in non-urban landscapes far away.

In 2008, the influential *Dictionary of Human Geography* (Johnston et al. 2008) concluded that modern urban geography should deal with all aspects of urban development but one, its physical context, including the local hydrological cycle and waterscape, and hence it had no ideas about how cities impacted on the hydrosocial cycle. The *Dictionary* defines urban geography in such a way that the physical and watery aspect of city development is left outside the scope of interest (Johnston 1980; Carter

1995; Hall 1998),¹⁰ and cities and urbanisms are regarded and studied within a purely 'social world', and seen simply as a response to global and economic trends. In the book *A Theory of Urbanity* (Zijderveld 2009) there is not a word about water, although the author is concerned with the particular culture of cities. The book does not have one single paragraph about the role of rivers, riverbanks, bridges over rivers, mills, cleaning habits, bathing traditions or the role of fountains in urban cultural and artistic history. Textbooks on urban geography share the same approach: the physical context of urban development might be briefly mentioned as a constant and thus 'silent' background factor, but it is basically irrelevant in analysing city developments and the water/urban nexus is of marginal interest since the explicit focus has been on social variables (Hall and Barrett 2012; Knox and Pinch 2009; Knox and McCarthy 2012; Gottdiener and Budd 2005; Pacione 2009; Hartshorn 1980; Kaplan, Wheeler and Holloway 2008).

To summarise: there can be no doubt that the dominant tradition in urban studies has paid scant attention to the universal and structural importance of water in urbanisation processes. Peter Hall, in his acclaimed *Cities in Civilization* (1998), does discuss the role of water in the development of Rome and London, but its index includes no general entries on sewage, water supply systems, rivers, canals or aqueducts. In the same author's book on the future of cities (Hall 2002), the water issue is of marginal interest. A summary of the content of all the volumes of the journal *Urban Studies* between 2006 and 2012 shows that out of 14,363 pages only 86 were devoted to the water issue. These pages were not concerned with the physical or man-made environment as it impacts and is impacted by city development, or with its role in shaping patterns of social activities, power or control. The few articles that dealt with water treated it as a case in studies of political-economic issues, mainly and not surprisingly the water-pricing issue. A total of four articles dealt with such issues. None of them analysed interactions between water systems and cities, and how these impacted on the social and economic life of their inhabitants. The book with the all-inclusive title of *Understanding the City* (Eade and Mele 2002) does not pay the water issue any attention whatsoever. A sociology textbook in an influential series on sociology, *The World of Cities* (Orum and Xiangming Chen 2003: xi), deals only with social aspects of urbanisation, although it claims to be broad and comprehensive in its outlook. The book promises to 'take a journey across time and space, over the urban landscape and to be historical and comparative in perspective'. However, it contains no discussion on the relationship between cities and water whatsoever, nor a single reference to water, rivers, sewage or waterways and canals. Theoretical books on urban politics are either concerned with the urban-water issue and how

it shapes both power relations in cities and makes footprints in the waterscape (e.g., Parker 2003; Davies and Imbroscio 2009). The point of departure of this chapter is that modern urban studies have persistently neglected the links between city development and natural and social water systems. The new cultural geography and the textual turn in social sciences, concerned with unmasking the meaning of cities, landscapes or buildings, unpacking it as a text, have generally not been interested in unpacking the meaning of urban-water landscapes. Precisely because water supply and sewage systems are often invisible in a strict material sense, this aspect of the interaction of city and water has naturally been difficult to unpack as a text.

The 1990s saw a rapid growth of urban history in Europe.¹¹ The European Association of Urban Historians established the *Historical Urban Series* in the 1990s. The series was dominated by a focus on the modern era and a concern with ‘urban management’ or ‘urban governance’ (Doyle 2009: 499). None of the more than 35 volumes in the series deals with water and urban history. However, a growing number of books do describe water-urban relationships,¹² and in most popular stories about famous cities the river on which they are located often plays a major role. Many monographs on the history of individual cities deal with the water issue. *Cities and the Making of Europe, 1750–1914*, for example, discusses to some extent the importance both of water supply and sewage and of health issues related to water.¹³ But the more overarching questions of how the interconnections between nature and city have influenced the urbanisation process itself as well as the accompanying transformation of the natural landscape, etc. have seldom been raised in a systematic, integrated manner. Although quite a few good narratives of cities and water systems have been published (see, for example, Kelman 2003; Melosi 2008; Bakker 2010; Rinne 2011), we still lack comprehensive, comparative studies that integrate the physical attributes and evolution of cities, and how their history is also reflected in how water has flowed through urban space.

WATER AND URBAN STUDIES – A CONCEPTUAL FRAMEWORK

In spite of the traditions described above, there is a growing understanding of the fact that water-urban interactions are both fundamental and numerous, and that they impact urban economic structures as well as cultural ideas and urban power relationships. But how to analyse these interactions and the water-urban nexuses that are becoming increasingly complex? The research design must be capable of making sense of similarities and differences in urban-water variability contexts, and it

must simultaneously be able to integrate water both as a distributor of contamination and as the most efficient urban solvent, as a force of urban destruction and as a source of urban beauty and art, and as a foe and an ally in the fight against urban disease and the complexity of the urban stream syndrome.

One aim must be to be able to narrate the relationships of cities with water coherently, capturing the durability of both their permanence and change. To be able to recognise analytically this wide range of phenomena requires some unifying but also open and non-reductionist frameworks, within which the various elements and their interconnections can be studied. The recognition of the universalism of the particularity of water-urban relationships – cities and water reservoirs, cities and pipe-systems, cities and sewage systems, cities and drinking water, cities and cleaning, cities and health – also requires an analytical framework that makes non-reductionist and comparative, but rigorous, research possible.

The water-system approach suggests a research strategy that addresses the complexity of interconnectedness in ways that can be handled empirically and conceptionally. The approach enables analyses that can cater for the fact that water is very dynamic and increasingly multifunctional and historically contingent in both nature and society. It can also account for changes in nature or in the physical waterscape and, especially, for how humans have changed nature and especially the waterscape through history and hence continuously created new possibilities for city development. By employing an analytical framework that covers these different aspects of the urban-water nexus, both nature determinism and social reductionism can be overcome.

The approach suggested here is very different from that suggested by some researchers of urban development who have recently focused on the importance of water but within a mixture of post-modern and early Marxian perspectives. In general, water in these studies is conceived of primarily as a social fact and variable, described as 'streams of power', as a mirror of social development and therefore defined as a hybrid socio-natural phenomenon (Swyngedouw 1999: 445). By underlining that water is 'socio-nature', interesting aspects of power related to water are brought into focus, but the way it is conceived of and emphasised implies that the importance of the earth's water system or the character and limitations and possibilities of urban physical waterscape are of diminished relevance. The local character of the city's physical waterscapes or the confluences between the local hydrological and hydrosocial cycles are of limited or no interest, since it is this distinction between nature and the social itself that the post-modern approach seeks to overcome.¹⁴ The focus of *Water and Society* is that in order to achieve a broad and more complete understanding of the city (including the power

struggle over water and how water flows reflects power relations) and its development, it is crucial to describe and understand the enveloping hydrological context as well as the urban hydrosocial cycle and their interconnections. The narrower 'socio-natural' approach cannot explain important variations in hydraulic design, or, for example, London's position as a trading centre on the Thames for hundreds of years before the coming of the steam engine, as a result of the way the river runs in the English landscape. Similarly, the history of Alexandria, founded by Alexander the Great in 324 BC on the very edge of the Nile Delta, cannot be grasped unless the hydraulic design of the past is incorporated into the analysis; that is, how the city could grow because of the way it managed to link two natural water systems, the river and the sea, to the economy at the time. Moreover, the future of both London and Alexandria – as of a host of other cities around the world – is closely linked to potential changes in the physical water system. Authorities fear that if nothing is done, Alexandria will be gradually engulfed by the sea, and that London's future depends on a strengthened Thames Barrier. Similarly, the history of Jericho or Xian or Babylon, or the power struggle behind how New York became the leading city in the USA in competition with Boston, or the particular challenges of modern cities in addressing changing physical waterscapes in the future, cannot be grasped by limiting the perspective to water as 'socio-nature'. One of the important aspects of the history of urbanisation should rather be seen as organising a rearrangement between the importance of the hydrological and hydrosocial cycle in particular urban spaces.

The first layer in this analytical framework for urban studies is concerned with how cities have been and are impacted by the particular, though changing water-urban nexus within which they developed. To study this layer requires knowledge and reconstruction of precipitation and evaporation patterns, river discharges and velocity measurements, aquifers and their behavioural characteristics, that is, knowledge and information about the natural waterscape or hydraulic system that has relevance in the area where the city that is selected for study is located. This layer should be seen as an exogenous, enduring and universal physical factor, but at the same time always having particular characteristics and always being in a state of flux.

The framework makes it clear that there is no direct causal relationship between the physical character of the water system and the location and development of cities, but nor can the importance of the waterscape be reduced to establishing a range of different possibilities. A focus on the physical water system and its importance for city development does not suggest, however, a one-to-one relationship between a certain waterscape and city development, at the same time as all examples of such clear-cut

causal connections and correlations should not be rejected out of hand as determinism. The approach should, for example, look for structures, connections and processes between different types of water sources – such as spring water, glacial water, rain-fed water, desalinated water, pumped groundwater – and water control systems, power mechanisms and city development. The approach might also focus on issues like different forms of transport systems that are required to bring water to the city and take sewage away from the city, and how differing water-society systems structure and impact on the opportunities for urban-water control systems and urbanisation processes in general.

Jericho is a case in point. As early as between 8500 and 7500 BC, it was defended by a stone wall. By the beginning of the third millennium BC, Jericho had become a flourishing city, because it was located around what was later called the 'Ain es-Sultan'. This spring, which in the Bible is known as the Prophet Elisha's spring, provided 4,000–5,000 litres of fresh water a minute without the need for human intervention, and the water was easily distributed by gravity and canals. From the earliest times of settlement until the Ottoman period, this spring was the focus of urban development and decided the location of the city and its main economic activities. The name of the spring indicates clearly that water control was bound up with power relations in the city. Nobody has yet (2014) analysed the whole history of Jericho from a water-system perspective and how it affected the city's relations with the peoples of the surrounding desert, the city's economic activities and social structures and power; no one has as yet followed the flow of water through the city and to the fields for centuries as a method of reconstructing the development of urban power relations.

The highlands of Ethiopia offer an example of yet another locational relationship between city and water. Here rainfall is usually heavy but highly erratic and very seasonal. The location of the country's capital was decided by the presence of a source of water, but not as a dire necessity. Addis Ababa has the healing aspects of bathing as its point of origin. The Queen of Ethiopia, Taytu Betul (1851–1918), had spent much time at thermal springs and requested her husband Menelik I to build a house by a particular spring in the highlands, and the king complied. Soon it developed into a royal settlement, to which Taytu Betul gave the name Addis Ababa, meaning 'New Flower'. The king himself, aware of the curative waters and troubled by rheumatism, established a royal enclosure, a palace and an audience hall at the spring, paving the way for further city expansion. One can still see their remains today on a hilltop not far from the city centre. The location has had far-reaching implications both for the capital's economic role in the country, the building up of its sewage system, and the challenges facing its water system.

Athens undermines the simple, deterministic notion that water's impact on city location has a predictable pattern. Classical Athens was not located where it was because of abundance of water, but rather because of scarcity. According to mythology, there was a competition between Athena and Poseidon regarding who could give the best gift to the city; Athena possessing wisdom and knowledge of arts and crafts, and Poseidon, as the god of water, offering the Athenians a well at the Acropolis. Tradition says that the Athenians voted for wisdom instead of an abundance of water (Koutsoyiannis and Patrikiou 2015), with implications for the city's development up to today but in ways not yet researched. The scarcity of water has obviously impacted the city's economic activities and also the water infrastructure itself, demanding, for example, the utilisation of remote water resources through the construction of the Ilii Aqueduct in 1958 and the Mornos Aqueduct in 1980–1 (Nalbantis et al. 1992: 57–8).

It is also necessary to employ an analytical framework that can incorporate the fact that the physical character of water systems enveloping urban centres is constantly changing, often dramatically. Changes in water systems, due to variations in rainfall, droughts and floods, river velocity and sediment load, etc., impact on urban location and development in many ways. Indian urban history is a case in point. Its history during the millennia cannot be understood without factoring in the relationship between changing water systems and urban development. India is a continent of sluggish, meandering and silt-laden rivers which have given birth to a phenomenon aptly called the 'forgotten cities'. The great rivers of the Indian plain have meandered away, again and again, from cities on their banks (see Chapter 2). When the rivers left the cities, the cities were also left by history. Lacking waterways, they found themselves without the transport routes that had determined the location of the cities in the first place, and they also often lost their significance as ritual centres, due to the importance of holy rivers in Hinduism. The permanence and shifts in this relationship are main reasons for why this physical aspect of the water system cannot be relegated to the background or left in an introductory chapter. A salient aspect of the water-system approach is that it highlights the notion that this structural relationship is neither a one-to-one relationship, nor is it uni-directional, because it is often altered by humans and by nature itself.

The second layer of the water system in relation to urban studies is quite straightforward: one of the features of urban development is that people are stuck with the location of their cities, but that they have gradually become liberated from this locational power of water – by improvements in water-moving technology and in the organisational capacity to control and harness water. All cities change and must change, be retrofitted and re-purposed in relation to their water resources. The enveloping water

systems have therefore always been transformed by urban governance and citizenry, and in modern times by the architect and the designer and most importantly by the hydraulic engineer and water manager. It is therefore necessary to employ an analytical approach that captures both how the physical and natural aspects of the local waterscape are underpinning a certain city's location in the first place and produce and reproduce certain possibilities and limitations of city development, and how this water is 'appropriated' and controlled for different demands and reasons at different junctures of its development. The need for water, either for transport, as power generator, as cooler or cleaner, for drinking and production, will always be there in one form or another, at the same time as this need will always change over time, not only due to increases in urban population, but also because changing economic and social activities will put greater stress on the water resources. The waste output of even small cities has also often proven to overtax the absorptive capacity of local aquatic systems. Human modifications are therefore a must for a number of social, economic, cultural and political reasons and all cities in the world have, to different extents and in different ways, modified their natural water.¹⁵ Since the enveloping waterscape of a city is most often part of a wider watershed, a fruitful urban history must also factor in other actors' efforts at using and controlling the waters. The human modifications will therefore also in themselves have varying engineering and hydrological scales and social and political histories. Most cities today are surrounded by an engineered waterscape and a waterscape that is still mirroring, though to different degrees, the character of how the hydrological cycle manifests itself locally in the landscape. This is one reason why the crude dichotomy between nature and culture is not helpful in understanding urban processes, and why there is a need for concepts that on the one hand acknowledge nature's impact but at the same time overcome this way of conceptualising the nature/society divide.

Three examples can illustrate the point: at the time of Nebuchadnezzar II (604–562 BC), Babylon, lying beside the Euphrates on the Mesopotamian flood plain in today's Iraq, was the leading metropolis in the world, measuring about 4.5 square kilometres. Canals from the river had already been built for extensive irrigation, and some of the most impressive were built within the city itself. By the end of Nebuchadnezzar's reign, the eastern parts of the city were also protected by walls which enclosed an area of about 9 square kilometres. Babylon could not have developed where it did had not the Euphrates crossed the flood plain, but human modifications of the water landscape were also needed to develop and sustain it. Mohenjo-Daro in present-day Pakistan was established close to the River Indus but used artificial wells and developed sophisticated systems for supply and sewage. It was one of the major cities of the

Indus civilisation and one of the largest cities in the world in the third millennium BC. In the city, there were possibly more than 700 wells and perhaps as many as 2,000. Each of these had an average catchment radius of only 17 metres, making their density unparalleled in the history of water supply. The most spectacular and well-known water structure in Mohenjo-Daro is the 'Great Bath', a tank measuring 12 by 7 metres, and 2.4 metres deep. However, the use and ritual function of this bath have been more difficult to establish. Another noteworthy development in the city was that it seemed that almost every household had a separate 'bathroom'. But the most intriguing aspect of the city was the system for sewage removal. The physical foundation for this water system was the fact that the water table on the Indus Plain was very close to the surface, so accessing the waters to construct this water system was relatively easy. Modern Rotterdam is a city where water is virtually everywhere, and forms its soul, its identity and its economy. The fight against too much water made this city possible, as the latter part of the name indicates. Rotterdam is a polder city (enclosed by dikes), created by man in a successful struggle to control the water. Rising sea levels and changes in river discharges have forced the city to employ various policies in the course of its history, and the city's development has been totally dependent on the success of the water engineers and will be so in the decades and centuries ahead.

These few examples indicate just how crucial water is for urban history and development and how fruitful it is to reconstruct and analyse the interconnections between these two layers of water systems. The second layer captures everything that humans have done to bring natural water to the city – in all sorts of sectors and for all sorts of purposes. It enables us to describe and understand the water system as an integral part of any city's planning environment. It underlines the fact that this urban-water system, at any point in time the product of cumulative interactions between human purpose and natural waterscapes, both impacts on limits and patterns of action and reflects the economy and technological level of cities. One of the most interconnecting structures in cities is the bonds between people and sectors that these interactions with water produce. An approach that integrates the physical character of water and the structure of the man-made water infrastructure, and the interaction between the hydrological and hydrosocial cycle, enables analyses of linkages that create social cohesion and social hierarchies in particular ways. Analyses that are able to integrate the two layers and the two cycles will encourage investigations of a city's entire 'water machine' as a force and a reflection of urban development. Since the suggested approach includes both the natural and the modified water landscape, analyses can escape being either nature-centric or anthropocentric and this crude analytical dichotomy can be evaded.

The concept of water-urban systems or water-society systems objects to research traditions that perceive urban places and nature as geographical opposites – where cities are regarded as manufactured social creations and nature seen as being irrelevant or non-existent or of limited importance. It distances itself from conceiving nature as something opposed diametrically to the urban. Conventionally the former connotes all that is artificial and socio-technically constructed, and the latter is seen as conjuring up a vision of primal wilderness untouched by human agency. The urban world is in this view defined in terms of what the natural is not. But such a strict opposition is far too simplistic and has long-ranging analytical implications because it is blind to the unique characteristics of water, which undermines such conceived oppositions.

This dichotomic perspective is unfruitful because water is the same both in nature and in the city; water is the same chemical and physical substance when it runs through the most distant forests as when it runs in the tap or in the toilet, and after it evaporates it returns, re-emerging as ‘pure, untouched water’. Water’s centrality in urban life combined with its unusual capabilities erodes subsequently conventional theories about cities, understood as sites for the conversion of nature by human activity. The water in urban spaces is both natural and socialised at the same time, it is tamed and redirected and in this sense changed but it is still basically water as found in nature. Water in the cities is likewise both a fundamental material structure forming urban processes and a cultural product of the same urban processes, making it clear that definitions of materiality must not be reduced to brute matter or to a static thing since water is always in flux and part of a dynamic social process. The reason why this conceptional dichotomy is rejected here is, as should be clear from what is said above, diametrically the opposite of why social theorists like Latour and Beck object to distinctions between the natural and the social. They claim that nature should be reduced to a social construct, while the water-system approach which is concerned with the interactions and confluences between the hydrological and hydrosocial cycles, maintains that it is crucial for our understanding of urban processes that nature should not simply be reduced to a social construct. The water-system approach objects to the current conventional argument that pure nature does not exist any more. Since water in the hydrological cycle is reborn as pure nature continuously after being socialised, and large parts of the planet’s water bodies are not affected by the hydrosocial cycle at all, one cannot suggest that water has become social. The approach suggested in this book also distances itself from the viewpoint that the distinction between the natural and the social should be rejected because it is often difficult to delimit the imaginative and material boundaries between what is understood as natural and what

is understood as urban. The water-urban system approach argues rather that it should be maintained but reconsidered in order to cater for the fact that water itself objects to the distinction in a very particular way since it is the same or has the same characteristics and capabilities in urban centres as in the wildest nature.

The third layer of what is here in general called the water-system approach captures the 'cultural' dimension of urban water. By integrating this dimension in the analytical framework it will make it possible to analyse the linkages between cities' specific physical waterscapes and how it will always be filtered through varying cultural lenses, the modified and controlled water resources that exist at a certain time, which will always reflect actors' ideas of water and how it can be used in the past, and those conceptions and managerial plans regarding water and city development that are developed to handle the urban-water nexus, some of which will be implemented while others will lose out. This analytical layer recognises and encourages analyses of how water both in nature and in society, and as a natural resource and as a social good, will always be culturally constructed and filtered, differently by different actors, and from time to time and from place to place. A comprehensive history of the ideas of water has not yet been written.¹⁶ A comprehensive study of urban ideas about water would have thrown new light on city development.

It is necessary to focus on ideas about water in relation to a broad range of issues: as a means of exerting urban social and cultural power, as an object of management practices, as a religious and cultural symbol or object, as an image of the natural in the urban world made up of concrete, as a place of worship or of social gathering, and as a signifier of social and cultural distinctions. By being linked directly to the two other analytical layers it will highlight the importance and permanence of notions and practices about urban water management. By studying these ideas and their development, based on the premise of the increasing multifunctionality of water, it becomes possible to capture how these ideas have changed radically over the years, how they differ from urban centre to urban centre, and how different social groups in the same cities often have very different ideas about water and water control.

Ideas about water will obviously differ in Cologne and Manchester – two of the cities with the most rainy days in Europe – from those in Wadi Halfa in Northern Sudan, where years might pass without a raindrop and where the Nile brings all the water the people have under a permanently blue sky. These 'cultural' differences in the ideas of water reflect different notions of space and place, but cannot be reduced to a social construct only, since they are underpinned by differences in waterscapes and water-society relations. Ideas about management of water will also be very different in Mexico City, where around 20 million people must be

provided with water, much of which is lifted more than 1,000 metres, utilising seven reservoirs, a 127-kilometre-long aqueduct with 21 kilometres of tunnels, 7.5 kilometres of open canal and a water treatment plant, from those in Beijing, which gets much of its water from a canal 1,800 kilometres long bringing the life elixir from the Yangtze River in the south, or Bergen in Norway, where there is an annual rainfall of more than 2,000 millimetres. The role and character of these types of ideas are a neglected field of study, since such research has to combine non-social and social variables and how they interconnect over time and according to space and place.

An analytical approach that firmly integrates research on ideas of water and their relevance to urban processes will also be able to throw new light on urban power struggles, since unfolding economic processes involving particular forms of water valuation and commodification and differences in how water is understood are behind one of the most conflicting issues in the contemporary urban world: should water be seen as a normal market commodity, as a common good, or as a human right? Even in the most modern cities ancient myths and religious ideas about water can be found closely interlinked with modern-day nostrums about water as a natural element and in relation to its many functions for the biosphere and for humans in particular. This battle between different ideas about water will impact on urban development in the future, since it will influence whether water can be priced and thus the provision of urban water infrastructure.

This layer focusing on ideas of water highlights the different ways in which water is socially constructed and will integrate into the analysis of how water has been conceived differently in cities over time and in different cities at the same time, showing both the endurance and the instability of meaning and the coherence and fragmentation of habits of thoughts when it comes to water and water control. Linking the ideas of water to the two other layers of the water system allows this production of cultural metaphors to be analysed in both a material and a social context.

One contemporary example that can illustrate the importance of ideas of water and how they change and frameworks for urban developments is the growing emphasis many urban dwellers put on the importance of free-running water. In certain urban places, free-running rivers have acquired precious cultural and spiritual value. Daylighting rivers, that is, uncovering buried rivers that used to be channelled directly into culverts and underground sewer systems, has become a political movement, and will impact on future urbanisation processes. Such ideas have far-reaching consequences for urban development since their managerial implications will have an immediate impact on the basic urban infrastructure and also on social relations.

Ideas about water in cities have influenced social and economic life in the past, and still do in the present-day world. Water acts as a symbol of man's power over nature in the form of fountains (the fountain in the desert city of Phoenix where water flies many metres into the sky is an interesting case), water as a means of urban purity and health (all the baths and fountains of Rome), and water as a central expression of urban power and distinctions (the Pope's fountain on Piazza Navona, Rome). How the water runs through a city at any point in time can therefore also be treated as a mirror of urban development in general.

The concept 'open, complex and multifunctional water-systems' treats water and the city as being intertwined, bringing into focus how cities use and control their particular water at every level of urban activity, and in turn affects water in a myriad of ways as it runs through the cities. It underlines and gives a framework for analysing how the flow of natural and social water through urban space is a permanent trait of any city's development at any point in history and all over the world. From the intimacy of the modern bathroom to the buried space of the sewer or the underground aqueduct, from the thrill of the drops in a fountain to the tamed but powerful water behind dams and reservoirs, water has provided a link between the concrete and worldly experience of space and both the material and immaterial dynamics of urbanisation. Physical waterscapes and modified waterscapes also reflect and exhibit a diversity of responses to urbanisation. More or less identical urbanisation processes may have very different impacts on the enveloping waterscape also because these same waterscapes differ in their abilities to satisfy urban development. The concept encourages research that can describe and analyse how the same water plays multiple roles in the lives of cities: it has caused disease, squalor and human misery, and provided the means to battle these same urban problems.

The water-system approach can capture how human-modified water systems in their turn change the physical water system in an everlasting process of mutual interaction. It takes as a starting point the fact that no urban water landscape is either completely natural or completely controlled or socialised, because urban development presupposes on the one hand modification of the natural waterscape, but is on the other hand not able to destroy water as nature although the actual water source may be depleted or polluted. Efforts to control water and the built water environment it creates must be analysed not only as a reflection of 'culture', but also as being impacted by the physical character of the waterscape. The actual flow of water in cities must therefore be analysed as being located within both a particular physical context and a particular set of traditions related to water, which in its turn is located of course within broader political relations and social rhythms.

This chapter has suggested an approach to urban studies and the history of cities that is multidimensional and that integrates nature–society relations. The original aspect of this approach is that it enables analyses of the physical, social and cultural aspects of the water-urban nexus and their inter-relationships. The approach is also useful because on the one hand it emphasises that the empirical links between a city and its water system are always particular, while on the other hand the three layers of the water system are universally applicable as an analytical framework because all cities connect to these layers of the water system, but importantly and that is why it becomes so fascinating, in very different ways, in order to become a city. There is an urgent need to broaden and open up urban studies, making them less reductionist by developing analytical approaches that both theoretically and methodologically integrate physical and social factors of relevance to city development. This will be crucial to obtaining a fuller understanding of how cities have developed through history, but due to the extremely rapid and global urbanisation process and the growing uncertainty about the water of the future it is also an issue of great current political and economic urgency.