Water - A Key Element for Microclimate

Monika Šmiralová[1*)], Filip Bránický[2)]

[1*)] Slovak University of Technology, Radlinského 2766/11, 810 05 Bratislava, Slovak republic; monika.smiralova@stuba.sk; 0009-0009-9829-3596

[2)] Slovak University of Technology, Radlinského 2766/11, 810 05 Bratislava, Slovak republic; filip.branicky@stuba.sk; 0009-0000-9905-6407

https://doi.org/10.29227/IM-2025-02-02-033

Submission date: *2025-04-02* | Review date: *2025-05-06*

Abstract

Water is an integral part of microclimate regulation in urbanised environments and plays a key role in mitigating the heat island effect. Water management measures have been actively applied throughout human history. Their level and effectiveness continues to evolve today under the influence of climate change. However, despite these efforts, there is still space for improvement and learning from examples of good practice. This article focuses on specific solutions in urban and bioclimatic design that use water features to optimise microclimatic conditions. Key approaches include, for example, the introduction of water features such as fountains, rain gardens and retention basins that cool and humidify the environment through evaporation. Linking vegetation with water features helps to regulate temperatures, especially in the hot summer months, and promotes the ecological balance of cities. Case study analyses show that effective stormwater management, the use of permeable surfaces and bioclimatic design can make a significant contribution to improving the thermal comfort of inhabitants. The main results highlight the importance of a holistic approach to urban planning, in which water serves as an essential element for urban adaptation to climate change.

Keywords: *water management, microclimate, urban design, bioclimatic planning, stormwater retention, thermal comfort, eco-districts, climate adaptation*

1. Introduction

Human history is closely linked to water not only in terms of survival but also in terms of shaping society and economic power. Man, for his existence, has always sought water, choosing climatically optimal areas for his settlements. For example, he avoided the wet lowlands threatened by floods.

Water represents a kind of infiltration zone that mitigates socio-cultural differences and natural factors. Throughout human history, water has enabled different communities to clash. In particular, the adaptation zones located along the courses of the main rivers, where different cultures came into contact with each other, were key. These areas represent trade routes, foundations for progress and innovation, and the exchange of skills and knowledge between cultures. Rivers in the past (before they were regulated) formed a mosaic of countless meanders (bends), arms and channels. Communities living on opposite banks could communicate without any barriers. The arms of the watercourses meandered across the landscape [1].

Extensive areas around the watercourse were covered with alluvial deposits. From this hinterland, people made fertile zones suitable for agriculture. In contrast, mountain ranges formed spatial barriers that, due to their environmental complexity (more difficult to adapt to natural conditions), slowed and stopped the penetration of cultural influences [1].

2. History

Water has been a mediator of communication and transmission of cultural influences since the earliest days of human civilization. Wherever water was present, conditions for life were more favourable. The first advanced civilizations and urban formations based on agricultural production arose near rivers [3]. Under the influence of favorable climatic and relief conditions with the presence of rivers, advanced centers and densely populated cities emerged.

In the Neolithic period, settlements were established mainly in the inundation areas (the area adjacent to a watercourse, which is usually flooded during the original period by water poured from the riverbed. They also offered the possibility of obtaining supplementary food (fish, turtles shells, snails and so on) [1]. Here the conditions were much more favourable for intensive cultivation of the soil. As a result, the settlements of the first farmers developed continuously in size and number. Technological advances, namely the artificial irrigation of fields, also helped. The climate and favourable topography allowed the emergence of advanced civilisations in Mesopotamia and Egypt, for example [2].

Abundant crops and livestock breeding were ensured by the annual flooding of rivers. The Egyptians built elaborate irrigation systems for large waterworks. With water control infrastructure, the population was protected from both floods and droughts. In some parts of our planet, we also see the construction of elaborate water management structures to retain rainwater. This system ensured the stability of water resources during a year with significant fluctuations in rainfall. For example, in the case of the Khmer empire, monsoon rains played a significant role. This civilisation, which flourished from the ninth to the fifteenth century, used a system of canals, reservoirs and dams to supply water. Angkor Vat, the centre of the Khmer empire, grew to cover an area of more than a thousand square kilometres, comparable to the size of Los Angeles today.

Where unfavourable geographical conditions (mountains, deserts, forested areas) slowed down social development and natural conditions were not good enough to create the conditions for the division of labour and the exchange of goods, small villages, sparse settlements or nomadic ways of life prevailed and the local population lived in primitive forms.

The rivers also provided strategic advantages in terms of defence. Settlements were built close to rivers or directly on their banks, as the waterways served as natural barriers against enemies or military invasions.

Rivers also played a key role in establishing trade networks. Transporting goods by river was more efficient and cheaper than by land. Trade routes along rivers became important for the exchange of goods and the development of more complex societies.

The water canal system also formed the basis of the Chinese economy. In China, the irrigation canal system has been known since the 2nd century b.c. It was built during the Qin dynasty. The Huanghe (Yellow river) and Yangtze canals were used for transporting goods, irrigation and harnessing hydropower. During the Tang dynasties (7th to 10th centuries), China grew as canals linked different regions of the country. Maintaining them, however, required high costs and labour. During floods, the canals became clogged with mud and dried up during droughts [3].

In an era of climate change that has caused less or excess rainfall and drying water sources, we are witnessing destabilization, famine, spreading epidemics and the migration of peoples in search of better conditions.

The movement of the Huns, for example, can be seen as an event conditioned by changes in their environment. In the fourth century AD, conditions of prolonged and extreme drought triggered a sequence of events, also known as the Migration of Peoples, which ended with the fall of the Roman Empire. The Huns, coming from the Asian steppes, were thus climate refugees equipped with weapons and horses. In the worsening climatic conditions, they had no choice but to make the long journey across the continent to the west [1].

It is no coincidence at all that ancient Western civilisations began to take shape around the Mediterranean Sea, and its richest and most developed provinces were located on its shores. Water was also an important strategic factor in the founding of new cities. The Phoenicians, who formed a cultural bridge between East and West, founded trading towns such as Millet, Syracuse, Massilia (Marseilles) and Carthage near or at the mouths of rivers, which provided advantageous geographical and trading positions. The geographical location, which was particularly important, made it possible to make long-distance voyages, to colonise and to establish trading ports. The commercially connected cities became centres of advanced craftsmanship and trade. Phoenician influence extended all along the southern Mediterranean coast as far as Gibraltar and also into southern Hispania, southern Italy, Cyprus and Crete. The rugged terrain and numerous rivers were a significant factor in shaping ancient Greece. The Greeks devoted themselves mainly to the cultivation of barley, vines and olives. Advanced navigation technology via rivers and the sea allowed contact between a large number of tribes, initially at a lower cultural level. Advanced centres emerged - the polis - which laid the foundations of western culture in the form of democracy. In the Hellenistic period, Rome emerges as the legitimate heir to the legacy of Greece. The Romans gave cities a power base. They were great engineers building aqueducts, roads, bridges, land reclamation, waterworks, sewers [2].

Water also played an important role in the life of the Celts. They came to Europe as a result of the progressive warming around 100 AD. The Celts tended to establish their dwellings higher up the river, moving to lower ground closer to the river in quieter periods. Settlements at higher elevations allowed them to exploit the terrain of the floodplain forests and river floodplains, which were very fertile [2]. Rivers served as natural transport routes for the Celts, facilitating trade and communication between neighbouring tribes. The Danube became their habitat in central Europe. As early as the Roman Empire, the Limes Romanus was located along it. The Danube was thus the dividing line between the advanced ancient civilisation of the Romans and the barbarian society made up mainly of Celts and Germans. In addition to providing the basic necessities for survival, the river served as an important trade artery. The Celtic oppidum, often situated on hilltops, had wider strategic significance. It controlled the adjacent territory, important river crossings. Many Celtic fortresses later became cities of the Western Roman Empire and have survived to the present day, for example Paris (Lutetia), Nyon (Novidium), Vienna (Vindobona) [2].

Water also played an important role in the establishment of free cities in the Middle Ages. The waterworks were of key importance for the economic and technical development of medieval towns, using water to power various equipment such as mill wheels, gristmills, sawmills and other machinery. These devices enabled efficient production, which was the basis for the development of industry in medieval towns. Cities in this period were characterised by their high compactness, but green spaces and water had a primarily utilitarian function.

Water also found its application in the form of the construction of a defence system in the form of a moat. For example, in the town of Nymburk in Bohemia, founded by Dutch colonists in the 14th century, who already knew the perfect water fortification technique.

During the Middle Ages, Europe's rugged environment with its many rivers and mountain ranges gave rise to an ethnic diversity and the emergence of a number of small but powerful states. Cities, if they were in an advantageous geographical and transport-strategic position, gradually became settlements of a higher type [2]. Most often, urban structures form on the remains of ancient cities, as market villages, or emerge as new formations founded by locators- the so-called locational cities. At the same time, feudal relations are strengthened with the new type of settlement.

Water entered the compositional principles of cities, i.e. as an aesthetic element, only with the advent of the Renaissance and Baroque, when the expressive range of urbanism began to enrich. This was mainly related to the consolidation of political power in the form of absolutism and the onset of the Counter-Reformation in the Baroque period. Natural elements, first gardens, then landscapes, together with the water element, began to be applied to a greater extent. Landscape greenery and gardens, together with fountains, began to form part of public spaces and contributed to changing the architectural image of cities. This was most evident in Versailles, which became a model for the European cultural world in the 17th century. There, stunning landscaped gardens and monumental water features were created that had both functional and symbolic meanings. The construction of these elaborate landscapes and water features, with their many fountains, achieved illusionistic forms, theatrical and even bizarre effects [2].

During the Industrial Revolution, industrial and later recreational development began to develop around the rivers. The centre of interest shifted to areas rich mainly in minerals such as coal, iron and other metals, which were essential for the development of industry. The concentration of population is mainly in areas of heavy industry and in areas of new technical raw materials (coal, iron). A population explosion is occurring in the cities.

Even in the Industrial Revolution, rivers made it possible to transport raw materials cheaply and efficiently. They became important transport arteries, supporting the emergence of new trade networks and contributing to the growth of cities. Coastal ports such as Liverpool, London, Rotterdam or New York became key points for international trade. But inland ports such as Paris, Manchester and Birmingham, located close to rivers, have also become important commercial centres. With the growing importance of commercial ports and river transport, canals and dams were built, which also made transport even more efficient. Rivers also provided the energy to power machinery in early industrial enterprises. Water was used to power various equipment in textile mills, paper mills and sawmills, and later to generate electricity. Steam engines, water mills and water turbines enabled mechanisation and

more efficient production, which was the basis for streamlining production processes. Rivers also provided the water needed for cooling machinery in industrial enterprises, as well as for human needs and irrigation [4].

3. Examples of Ecological Neighbourhoods of Today

Water is an important factor in the planning of ecological neighbourhoods in the current climate change.

Today, more and more cities are focusing on creating eco-neighbourhoods that integrate sustainable technologies, greenery and blue-green infrastructure elements. Water plays an important role in the context of an eco-neighbourhood - it is used as part of rainwater retention systems, for irrigation, or to create urban biodiversity. Water features, such as canals or ponds, retention basins, reduce urban overheating. Water can therefore be not only an aesthetic but also a functional element of ecological urbanism.

France is a country where the policy of building eco-neighbourhoods is strongly supported by the state. The "ÉcoQuartier" certificate, under the auspices of the Ministry for Ecological Transformation, promotes new ways of designing, building and managing the city in a sustainable way. The specificity of the ÉcoQuartier "French-style" designation consists of an assessment of 20 key sustainability indicators. Each region has its own specificities in this assessment, based on respect for local culture, history, traditions and way of life [5]. For example, the Docks de Saint-Ouen district in Paris has key objectives set on this basis: creating a new district on a metropolitan scale, creating a district with an identity based on history, mixing and diversity, combating global warming, an exemplary environment, a district designed and lived in a participatory way. Based on these objectives, precise indicators have been put in place to measure compliance with the objectives throughout the process. Key indicators include, for example: the number of m² of green space per inhabitant, the percentage of rental housing, the number of shared parking spaces, the percentage of renewable energies, etc. In the following text we give examples of three Ecological Neighbourhoods.

3.1 The Olympic Village of Saint Denis in Paris

The Saint Denis Olympic Village was built for the purpose of the 2024 Summer Olympic and Paralympic Games held in Paris. The Summer Olympic Games were thus used as a catalyst for ecological transformation. This modern neighbourhood is also considered an ÉcoQuartier.

It is built on the site of a former industrial zone, following the river Seine. The entire district covers an area of 52 hectares. It includes 2,800 new housing units for 6,000 inhabitants [6]. It is being built according to the best environmental standards in order to reduce the impact of its construction and to adapt to climatic conditions [7]. The vision of ÉcoQuartier Saint Denis is built on fundamental pillars such as sustainability (biodiversity, controlled carbon budget and quality of life), accessibility (for people with physical and sensory disabilities or cognitive impairments), social cohesion (social integration and social diversity) [5].

In the Olympic Village, the buildings are designed with bioclimatic design principles in mind, for example, the buildings are oriented perpendicular to the flow of the Seine River, which ensures air flow, wastewater and urine is recycled for further use as agricultural fertilizer. Thermal comfort inside the buildings is ensured not only by the design of the timber-framed façades, but also by solar panels located outside the façades. The buildings are heated by geothermal energy and therefore also capable of cooling. Paris is prepared for the temperature increases. In 2050 the temperature there will be the same as today in Seville.

Through photovoltaic installations, power will be provided for 700 households. Green-blue measures support local biodiversity. The vegetated roofs of the buildings are adapted for bird migration and bird nests are integrated into the façades. Among other things, the protection of the 2 800 wild animal and plant species in the city, which are essential to the city's ecosystem, has been ensured. The urban gardens have also been expanded and renovated [8].

3.2 Docks de Saint-Ouen in Paris

In 2012, the Docks de Saint-Ouen district in Paris was also awarded the ÉcoQuartier certificate, particularly in the field of innovation. From the design stage, it integrates all issues related to the environmental impact of a project.

This district is located on the edge of the historic centre of Saint-Ouen in the north-west of Paris. It is served by metro lines and the RER (Regional Railway) [5]. It is a large 100-hectare area on the banks of the Seine. It is an area of brownfields that in the past formed a network of docks. Over the last 10 years, the district has been transformed and is now fully integrated into the existing city. The new eco-district of Docks de Saint-Ouen comprises more than 5 000 apartments, including affordable housing. One of the main objectives of the project was to connect the city centre with the Seine thanks to a 12-hectare park on the banks of the river. The city reconnects with the river in all its components: ecological (green and blue infrastructure), landscape (park and promenade along the river) and economic (convenient location, attractiveness, energy savings).

The climate park located in the district is made up of valleys, ponds and large sunken areas that serve to retain rainwater. The bioclimatic park is bounded by a modern hydraulic facility, a huge reservoir with a filtration system. The retained water is used to irrigate the greenery in the park and also for climate mitigation on hot days. The park with a promenade offers various kinds of social uses and experiences [10].

The park houses diverse community activities such as: an educational greenhouse, community gardens, a kitchen, a large space for experiments and events, a large skatepark, an amphitheater, playgrounds, etc. The functional zones of the park serve multiple age groups. The zones are designed specifically for the park and make the most of the topography and context of the site. They make use of playful water features [11]. The park, planted with approximately one hundred species of local trees, shrubs and plants, will allow for the arrival of new species of fauna and flora. The selection of species is structured around 4 themes that contribute to the different atmospheres of the site: aquatic environment, shaded environment, arid environment and anthropogenic environment.

The park also includes an extensive wetland. Water is also retained on several elevated levels and purified by gravity overflow through vegetated filtering devices. The water present is mainly used to irrigate the park and the excess water is then discharged into the Seine. Part of the rainwater can be stored. Rainwater is also captured in public areas made up of paved surfaces. It is channelled towards the park and forms a supporting blue network. The construction of a hydraulic dam was also an important water management measure. This system helps to control the impact of heavy rainfall and reduce the risk of overloading the network. Small inner-city green spaces, neighbourhood parks and linear street greenery are irrigated from this water. Heat recovery from the production of steam (from the waters of the Seine) from the current Syctom waste incineration plant will also be used to heat the neighbourhood. This heating method significantly reduces the consumption of fossil fuels [5]. These buildings are designed with the application of bioclimatic design. By taking into account climatic characteristics such as sunshine as well as the physical characteristics of the site, it was possible to optimize the orientation, morphology and the actual design of the buildings and houses [9].

Fig. 1. Docks de Saint-Ouen

4. Conclusion

Throughout human history, water has shaped settlements, economies and cultures. From ancient irrigation systems to sophisticated canal networks, advanced civilizations have optimized water management. Water bodies facilitate climate regulation, trade and transport. To cope with rising temperatures and a changing climate, we need new measures to ensure their resilience. We therefore need to learn from past examples and adapt cities to new climate challenges. Elements of blue-green infrastructure integration such as rain gardens, retention basins and permeable surfaces are not new, but are becoming increasingly relevant today. Based on historical practices and modern technologies, cities can integrate blue-green infrastructure to improve cooling, biodiversity and sustainability.

Examples such as the French ÉcoQuartier-certified projects, including the Saint-Denis Olympic Village and the Docks de Saint-Ouen, are good examples to demonstrate effective water-centric planning.

The Saint-Denis Olympic Village uses sustainable strategies such as water recycling, geothermal heating and bioclimatic design. The Docks de Saint-Ouen eco-district includes green areas for stormwater management and cooling, retention ponds and wetlands. A comprehensive and progressive approach to water management is critical for resilient urban growth.

References

1. Kovár, B., Benediková, L., & Zajac, O. (Eds.). Climate in History: How Nature and Climate Change Affected People. Premedia. ISBN 978-80-8242-101-2. 2022
2. Hruška, E. Development of City Construction. Slovak Academy of Sciences Publishing. 1961
3. Drábik, J., & Kovár, B. (Eds.). The Fall of Empires. Premedia. 2024
4. OpenAI. ChatGPT (Mar 14 version) [Large language model]. Retrieved from https://chat.openai.com/chat. 2024
5. Ministères de l'Aménagement du Territoire et de la Transition Écologique. Eco-neighbourhood Approach. Retrieved from https://www.ecoquartiers.logement.gouv.fr/20-engagements/. 2025
6. Paris.fr. Major Projects That Will Transform Paris in 2024. Retrieved from https://www.paris.fr/pages/ces-grands-projets-qui-vont-changer-paris-en-2024-25988. 2023
7. Paris 2024. Building Less, Better, and Usefully. Retrieved from https://olympics.com/en/paris-2024/information/infrastructures. 2024
8. actu Seine-Saint-Denis. In Saint-Ouen, the Approaching Olympic Games Confirm an Inevitable Gentrification. Retrieved from https://actu.fr/ile-de-france/saint-ouen-sur-seine_93070/a-saint-ouen-l-approche-des-jeux-olympiques-confirme-une-inevitable-gentrification_52771244.html. 2022
9. Les Docks. A 100-Hectare Eco-Neighbourhood on the Seine Riverbank. Retrieved from http://docks-saintouen.fr/2015-2025-les-realisations/les-logements/. 2015
10. Šmiralová, M., & Husenicová, J. Impact of the 2024 Olympic Games on the Development of Paris. Urban Planning and Spatial Development, 18 pages. ISSN 1212-0855, MK ČR E 7021. 2024
11. Šmiralová, M. Eco-Innovation and Responsibility: The Paris Olympics 2024 and its Impact on City Urbanism. In EU-CONEXUS EENVIRO Research Conference – The 9th Conference of the Sustainable Solutions for Energy and Environment (EENVIRO 2024). E3S Web of Conferences, Volume 608. 2025