The Importance of Climate Change for Settlement Formation and Bioclimatic Design

Monika Šmiralová[1*)], Jarmila Husenicová[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; jarmila.husenicova@stuba.sk

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Abstract

Green-blue infrastructure, innovative technical solutions in terms of infrastructure construction, as well as policy interventions significantly influence economic, social and environmental factors within urban areas. Efficient management and reduction of CO^2 emissions are essential for and maintain the quality of life in cities with growing populations. This paper examines how natural conditions and climate change have influenced the development of settlements and what significant adaptation measures have been applied in cities during historical development in terms of the sustainability of settlements. The article also focuses on the importance of implementing adaptation strategies into urban planning to mitigate the impacts of climate change today. In particular, attention is paid to bioclimatic design and its benefits within certified eco-neighbourhoods in an environmental, social and economic context. The article does not aim to exhaust the vast subject matter. On the contrary, through an analysis of history and examples from the present, it is to point out the possibilities for further professional reflection on the subject.

Keywords: *climate change, settlement formation, bioclimatic design, urban planning, water management, eco-districts, resilience, sustainable development*

1. Introduction

Climate has played a fundamental role throughout history, has influenced and shaped the destiny of many civilisations. Long-term climatic changes, weather fluctuations and extreme events have influenced the functioning of societies, their overall prosperity and political decisions. Demographic developments and the migration of people have also been linked to climate. Natural disasters such as prolonged droughts, floods or volcanic eruptions could have a devastating effect on entire populations, while favourable conditions contributed to their flourishing.

Since the beginning of human civilisation, people have been aware that their survival depended on their ability to adapt to climatic conditions. They built irrigation systems, dams and canals to ensure stable food production. Droughts or, conversely, heavy rainfall crippled agricultural production, were behind famines and the spread of pests in ancient and modern history alike. Climate fluctuations have also had a significant impact on the spread of various pathogens. They have contributed, for example, to the spread of plague epidemics, cholera or the dreaded Spanish flu pandemic. However, despite its profound influence, climate has never acted as a single factor in the evolution of mankind [1].

In this article, we look at the impact climate change has had on history, what strategies societies have adopted to cope with climate variability, and what lessons we can learn from the past to address today's climate challenges.

2. The impact of landscape and natural environment on society

Climate and environment shape individual societies. Good climatic conditions and fertile soils allow strong civilisations to grow up (already within the Neolithic period important agricultural cultures began to take shape). There was a population boom, the development of agriculture, crafts and trade, and the development of infrastructure. Conversely, dry or cold climates tend to push populations to migrate, move around, giving rise to communities of pastoralists and predators [1].

In Greece, for example, a temperate climate prevailed and the cultivation of various crops such as vines, olives and flax flourished. The Greeks saw climate as one of the main elements in the formation of society. According to Herodotus, a suitable climate, without significant extremes, conditioned and facilitated the emergence of a developed society based on peasantry, freedom and reciprocity [1]. It also developed a culture of shared decision-making, freedom of expression, competitiveness, but also individual responsibility towards the community. These values strengthened an agriculturally based community that might otherwise have been more vulnerable to climate change.

3. Vulnerability

Extreme climatic events such as droughts, floods, freezes or eruptions can threaten the functioning of society, its security and its ability to meet the basic needs of the population. This makes society vulnerable. Where these phenomena affect areas within high population concentrations, vulnerability is further increased. Infrastructure can be helpful in remediating critical situations, to provide rapid assistance, or, conversely, it can contribute to undesirable effects such as the spread of pathogens over large distances across continents, etc. A crisis needs to be responded to in a short space of time. Companies are at risk even if they do not have the technological, human or administrative capacity to react quickly to an adverse situation. Crises can polarise societies, lead to political destabilisation, escalate social tensions and cause unrest.

To illustrate the causes and consequences, we will give two examples from history:

The Byzantine Empire in Justinian's time consisted of a vast and by then very dense network of cities connected by land routes and sea routes. Goods and people moved constantly in this ancient globalised world, and diseases spread with them. As many experts point out, the network of cities, the granary ships, formed the empire's own ecosystem, serving as an "invitation" to a species of animal, the common rat. These rodents literally infested the entire East Roman Byzantine world. Weather fluctuations in the form of intense rainfall affected the behaviour of the rodents, which were a natural reservoir of Yersinia pestis bacteria. The rodents proliferated due to the luxuriant vegetation from the incessant rainfall and probably entered the Byzantine Empire via trade routes across the Indian Ocean. The dense network of trade contacts and the relatively large population concentrations in the cities were more than ideal for the spread of the plague bacterium. The plague then periodically attacked Europe at certain intervals. It also appeared in the 14th century as the so-called second global plague pandemic, the so-called Black Death [1].

The consequences of catastrophic events with a global impact can also be observed in modern history. For example, in 1815 a volcano erupted on the East Asian island of Sumbawa in East Java. This phenomenon became one of the most significant climatic anomalies in Europe and North America in modern history.

The eruption of the volcano caused the temperature to drop. Abnormally low average temperatures in western and central Europe were accompanied by heavy rains and hail during the important growing months, destroying crops. This resulted in food shortages and rising prices, and increased travel and logistics costs. Food was also scarce in Ireland, where the poor in the early 19th century subsisted almost exclusively on potatoes. According to contemporary accounts, food was so scarce that people ate nettles and other weeds to stave off hunger. At least 65,000 people died. Continuous rains in early spring caused widespread flooding. Agricultural yields in many areas fell to less than a quarter of normal levels, while grain prices jumped to two to three times normal values. The year 1917 is known in Switzerland as the year of the beggars. Most of these were women and children. People moved to the cities in search of a better life. The triple combination of crop failure, famine and migration resulted in a worldwide cholera pandemic that claimed hundreds of thousands of victims. The uncontrolled mass movement of people over large areas in poor sanitary conditions became a breeding ground for the spread of epidemics. Diseases spread rapidly in establishments where soup and other food was distributed to the poor and where crowds gathered. Malnutrition weakened people's resilience. The cost of living has climbed beyond the means of most workers and thousands have become dependent on state or private charity. Riots began to grow; tensions were also fuelled by rapid industrialisation and an emerging class consciousness. The crisis triggered mass emigration in Europe. Between 1815 and 1819, tens of thousands of English, Irish, Germans, and French emigrated to the United States. The weakness of the states and their administrative apparatuses became apparent, and they struggled to transport food and humanitarian aid to the affected parts of their administered territories. The transport infrastructure was not sufficiently developed at that time, and was largely limited by geographical constraints and the agrarian conditions in the affected countries. Dusty roads were primitive, railways were not sufficiently built, waterways were few and rivers were difficult to navigate, condemning people in the more remote regions to starvation [1].

4. Resilience

Man has always tried to use the natural elements to his advantage, to adapt to nature or to conquer it. The concept of resilience refers to the ability to withstand, prevent and adapt to various challenges, such as demographic changes, economic crises, climate change or technological advances.

Historical efforts to achieve such resilience to adverse environments have manifested themselves to varying degrees and in different forms, depending on the geographical conditions and technological capabilities of a given civilisation. Already in antiquity, droughts and high temperatures led to the invention of sophisticated irrigation systems that ensured stable food production. In ancient Egypt, for example, the relief of the land and the Nile River made agriculture predictable thanks to regular flooding several times a year. Reservoirs and canals were built to help regulate the inflow of water, retain water in times of high rainfall and irrigate fields in times lack of rainfall.

The following example from history is related to active participation of citizens in decision-making. Greek Democracy, which was first applied in ancient Greece, was instrumental in building a prosperous society. The Athenians rose to the position of a trading and maritime power, despite the not always favourable climatic conditions and the semi-arid landscape. In the 5th century BC. Athens also blossomed as a scientific and cultural centre for the entire Mediterranean.

The Greeks realised that their country was mountainous and arid, many regions survived without sufficient rainfall, the country lacked large rivers or fertile soil, but their settlements nevertheless survived, and some ancient cities, such as Athens, grew immensely wealthy by the end. The Athenians attributed their prosperity to knowledge, shared decisions and the courage to pursue a common vision. To rise economically, socially, and culturally, Athens and other Greek communities were forced to find new resources, to trade, to create. They stopped adapting to the conditions of their semi-arid country, they found their own ways of life. All Athenian citizens, i.e. men (women had no civil rights), had the right to make decisions in the Diet, to participate as judges in the courts of justice, and to express their opinion in public assemblies [1]. Pericles, as the chief representative of the democratic system in Greece, declared that the Athenians maintained their freedom, not only personally but also as a community, and did not provoke disturbances. They obey the law, they obey officials, they do not neglect their leisure, they take part in physical education and sport common games and celebrations. They cultivate beauty, education, but also human body and combativeness. The Athenians devote themselves to private and public affairs, and their polity expects everyone, regardless of his craft, to engage in politics as well. Historians of the time expressed the belief that it was because of the democratic set-up that Athens rose above other settlements [6]. Along with Greek culture, legislation evolved. The Greeks learned to accept only pre-discussed and agreed-upon decrees. As a result, a special environment developed in the towns, in which arguments and oratory played a far greater role than in the surrounding civilizations. Natural resources, such as silver, were available to the entire society and were used to build up public interests. Investments were made in construction, shipping and the promotion of trade. [1]

The search for measures to ensure prosperity in the face of climate change can be found, for example, in the reign of Charlemagne. In the Middle Ages, Europe experienced several phases of cooling, which led to a reduction in agricultural productivity. The climate in Carolingian empire was more of a hindrance than a help. It is all the more remarkable that the empire developed successfully over several decades and made significant political, social and cultural advances [1] .

Under the influence of unfavourable conditions, not only climatic but also political, the trade and cities of the Frankish Empire began to decline, the circulation of coins stagnated and the economy reverted to autarctic forms (barter trade). As a result, the financial state of the state was still unsatisfactory [5].

Person who wanted to live to old age in the Carolingian period had to experience at least three famines on average during his lifetime. Nevertheless, the Carolingian Age is presented as a period of relative economic prosperity, expansion of human activities and settlements, and, according to some historians, significant demographic growth in the European population. However, given the famines, it is not generally assumed that there was a substantial increase in population in Western Europe during this period [1].

To restore trade relations, Charlemagne undertook to build a water trade route from the Rhine to the Danube (793) [5]. Although the construction of this artificial canal was interrupted at the end of the 8th century due to unfavourable conditions, it was eventually completed and successfully put into operation. Over the next 1000 years it became an unsurpassed engineering project ensuring the economy and prosperity of entire regions. This measure had its benefits, of course, but the more significant benefits of this venture are only now being seen in the light of the completion of the downstream modern infrastructure.

5. Present time

Despite many sceptical voices, climate change is becoming our everyday reality. In fact, we can watch live the impact it is having on our lives and how it is changing history. Not for the first time, but clearly unprecedented [1].Cities are trying to respond to climate change in different ways.

In the Industrial Revolution, man himself has contributed to global environmental degradation, unlike in the distant past. Urbanization, mining and manufacturing as early as the 19th century caused air, water and soil pollution, leading to widespread environmental problems. Within historical mining areas there are destroyed or disrupted the natural water cycles. The territories suffer from a lack of drinking water, Drinking water is supplied for a long distances (in Slovakia, the country of authors, for instance Košice – dam Starina over 100 km, Banská Štiavnica- River Hron valley groups water supply etc.) from drinking water dams or wells from the other water basin regions. Cities began to face an enormous population explosion. Epidemics such as cholera spread in cramped, unsanitary spaces. Communities had to start responding to the emerging problems by building housing and infrastructure, establishing buffer zones, segregating functions- zoning, imposing stricter standards for sun insolation and ventilation, etc., but that is another topic. Today, we face many challenges to ensure better and more resilient cities. Modern cities need to be designed in such a way that they can maintain their functionality and quality of life even in the face of sudden shocks and long-term stressors. As part of a holistic approach, i.e. ensuring environmental, social and economic resilience, spatial and infrastructural resilience, the aspect of digital and technological resilience also comes into play. Environmental resilience includes in particular the reduction of greenhouse gas emissions, the introduction of green and blue infrastructure (unique natural biocenoses for inst. in Slovakia, the country of authors Devínska Kobyla, forest biocentres and biocorridors, hills and mountain ridges vegetation, riparian vegetation of watercourses, tree lines stands, alleys, wetlands and peat-bogs, lakes, ponds, dams and gravel pits) to protect biodiversity and nature protection to reduce the impacts of climate change (e.g. rain gardens, parks, green roofs), sustainable water and energy management, preparedness for extreme weather events (floods, heat waves). Social resilience includes in particular the promotion of inclusive communities and social cohesion, access to housing, public services and health care, early warning systems and support for vulnerable groups. Economic resilience includes a diversified and flexible local economy, support for innovation, small and medium-sized businesses, an adaptable labour market, and the readiness of residents for the labour market. Spatial and infrastructural resilience can include a robust transportation network with diverse mobility alternatives, intermodal public transportation options. The regeneration of brownfield sites and their use for new development is also an important factor. Furthermore, the introduction of decentralised infrastructure systems of renewable energy sources for the production of electricity from solar radiation or wind can be mentioned. Digital and technological resilience includes smart city management systems, cybersecurity, protection of critical data, and innovations in urban planning supported by data and artificial intelligence. Modern planning should emphasise an integrated approach to resilience, combining natural, technical, economic and social dimensions. The goal is to create an adaptive and dynamic urban environment that can learn from and grow from crises [7].

The European Union is focusing on a comprehensive approach to climate resilience that includes legislation, policy initiatives, research and financial instruments. The aim is to create sustainable and resilient cities and regions, to mitigate the impacts of climate change and to strengthen the resilience of its Member States to its impacts. Examples include.

5.1 European Green Deal

Presented in December 2019, this strategy aims to transform the EU into a climate-neutral continent by 2050. It includes measures to reduce emissions, promote a sustainable economy and protect biodiversity [8].

5.2 European Climate Act

Adopted in 2021, this law sets a legally binding target to achieve climate neutrality by 2050 and an interim target to reduce greenhouse gas emissions by 55% by 2030 compared to 1990 levels [9].

5.3 EU Climate Change Adaptation Strategy

In 2021, the European Commission adopted a new strategy that sets the direction for preparing for the inevitable impacts of climate change. The aim is to increase the EU's resilience and preparedness for climate impacts by improving knowledge, strengthening planning and accelerating adaptation action [10].

5.4 Emissions Trading Scheme (ETS)

The EU has introduced the first major carbon market where companies have to buy permits to emit CO_2. The scheme covers around 40% of all EU greenhouse gas emissions and incentivises businesses to reduce emissions [11].

5.5 National adaptation strategies

EU Member States have developed their own adaptation strategies to climate change [12].

5.6 Financial instruments and investments

The EU is mobilising finance to support the green transformation through various programmes such as the Recovery and Resilience Facility, which finances projects aimed at increasing resilience to climate change. For example, the Recovery Plan [13]

5.7 Green Neighbourhoods

A number of countries around the world are focusing on building eco-neighbourhoods, which are designed to minimize negative environmental impacts and promote sustainable lifestyles. In this way, different countries are investing in sustainable development, creating eco-neighbourhoods and providing a better quality of life for their residents [7].

6. Examples of ecological neighbourhoods of today

6.1 Port Marianne in Montpellier

As an example we present the Port Marianne district in Montpellier in the south of France (famous scientific centre of Botany since first half of 20 century). East of Montpellier, the Port Marianne eco-district was created to address several challenges such as climate action, flood risk and responding to the high population growth in the city [2]. In 2015, the neighbourhood was given the ÉcoQuartier designation according to requirements such as environmental sustainability, thermal performance, quality of life, nature, biodiversity and mobility [3].

The neighbourhood has a total area of 400 hectares and 50,000 inhabitants. The river Lez, which flows through the area, plays a key role in the urban plan, which seeks to integrate natural elements and urban planning.

The territory is divided into socially and functionally diverse sections with a distinctive atmosphere for each of them. Within these, different teams of designers, architects and urban planners have divided their fields of activity. The architectural identity of the different parts will contribute to strengthening the awareness of the inhabitants and as a good example. In the common concept, unifying regulations were defined, such as: the repeating "box" effect, roofing forms, greening of the block cores, lighting and urban furniture, uniform architectural details, etc. [2].

The neighborhood opens onto a central public park. It is a mixed ecological district with the ability to combine the city, nature and water, quality of life and to exploit the potential of the proximity to the centre [3]. Emphasis was placed on social diversity through the following distribution: 24% social housing, 23% affordable housing and 53% free housing [2]. In Montpellier, sun and high temperatures are part of everyday life. The architects took into account the existing microclimatic conditions and positioned the buildings to make the most of the coolness of the surrounding river. The positioning of the buildings consideres the path of the sun: none of the 1200 apartments are oriented east-west, all are more or less north-south to avoid direct sunlight. Most of the blocks are pass-through to allow for good ventilation, diversity of experience and connectivity of the environment [4].

The park is the focal point of the district, located in direct relation to the river. There is a lot of green space and sports areas. The focal point of the park is a water retention pond [3]. In the park, priority was given to planting Mediterranean vegetation species that consume little water. The hydraulic function of the park secures the surrounding area from the risk of flooding.

Fig. 1. Photo of Port Marianne 1

Fig. 2. Photo of Port Marianne 2

7. Conclusion

Green-blue infrastructure and innovative adaptation strategies are an integral part of modern urban planning. History shows that climatic conditions have fundamentally shaped the development of settlements, with societies constantly looking for ways to cope with extreme weather events. Ancient Mesopotamia, examples from ancient Egypt, Greece and the Byzantine Empire show that adaptation to natural conditions was key to the long-term sustainability of cities.

The human capacity to respond flexibly to climatic shocks, to anticipate and implement measures in case of future crises, emerges as a key factor of resilience [1].

The current challenges of climate change require a comprehensive approach- a combination of technical solutions, policy strategies and active public participation. Bioclimatic design, efficient water management and the integration of green elements of blue and green infrastructure (biocentres, biocorridors and interactive ecosystems) within urban planning are key tools to mitigate its impacts of climate change.

The prosperity of strong empires cannot always be directly attributed to favourable climatic conditions, as is sometimes wrongly simplified. Already in ancient historical times, there has been an outline of a policy of resilience in different cultures and states [1].

Historical experience shows that the resilience of cities is not only related to technical innovation, but also lies in effective governance, social cohesion, understanding and respecting its own environment and the ability to adapt to changing conditions. Past and present examples can serve as inspiration and stimulus for professional sustainability discussions in the future of sustainable urban planning.

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