

MAJOR RIVER FLOOD EVENTS IN THE ANTHROPOCENE: TRANSFORMATIONS OF THE CULTURAL LANDSCAPE OF OCNA MUREȘ

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ABSTRACT. – **Major River Flood Events in the Anthropocene: Transformations of the Cultural Landscape of Ocna Mureș.** Over time, the town of Ocna Mureș has frequently been affected by floods due to its geographical location in the immediate vicinity of the Mureș River. Some of these events were of such magnitude that they caused irreversible changes to both the landscape and local human activities. The inherent resilience demonstrated highlights how the profound disruptions these hydrological events caused to human communities and ecosystem functioning necessitated specific human interventions that have shaped the current local cultural landscape within the Anthropocene. Consequently, the present and future management of this cultural landscape entails two seemingly contradictory actions: the rigorous conservation of viable elements and the simultaneous integration of new elements suited to ensuring the system's evolutionary adaptation in the context of regional trends. Furthermore, the coherent evolution of this complex structure can only be achieved through policies aligned with broad agreements on sustainable development in the Anthropocene, as the cultural landscape itself constitutes a resource that must be preserved and passed on to future generations.

Keywords: *Ocna Mureș, floods, cultural landscape, Anthropocene.*

1. INTRODUCTION

The debate concerning the proposal of the concept of the Anthropocene, a “term proposed by climatologists Paul Crutzen and Eugene Stoermer” (D. Bălțeanu, Mihaela Șerban, 2005, p. 32), remains a controversial one, as no

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clear consensus has yet been reached. Some researchers postulate that the Anthropocene emerged “from the moment humans began to influence the Earth” (e.g. Barnosky and Hadly, 2014; Barnosky et al., 2014), while others argue that “this epoch is limited to only a few decades, beginning when data from global Earth observation stations allowed the planet to be analysed as a whole, in terms of a theoretical systems approach” (Hamilton, 2016a, 2016b) (both citations in H. Hermann, 2017, p. 11).

Consequently, the Anthropocene is interpreted either as a phase included within the Holocene – defined as the geological epoch in which humans have lived and developed over the last 11,000 years, according to scientists (Ileana-Cristina Vasiliță-Crăciun, 2023, p. 19) – or as a distinct geological era that succeeds it and is characterised by predominant human influence.

In this respect, proposals have been made for the beginning of the Age of Humans to coincide with the *Neolithic Revolution*, followed by the period of the *Great Geographical Discoveries*, accelerated by the *Industrial Revolution* around the year 1800, and culminating in the recent period known as the *Great Acceleration*, noticeable from the mid-20th century. This phase is characterised by the continuous growth of the global population, industrialisation, and an unprecedented consumption of minerals and energy.

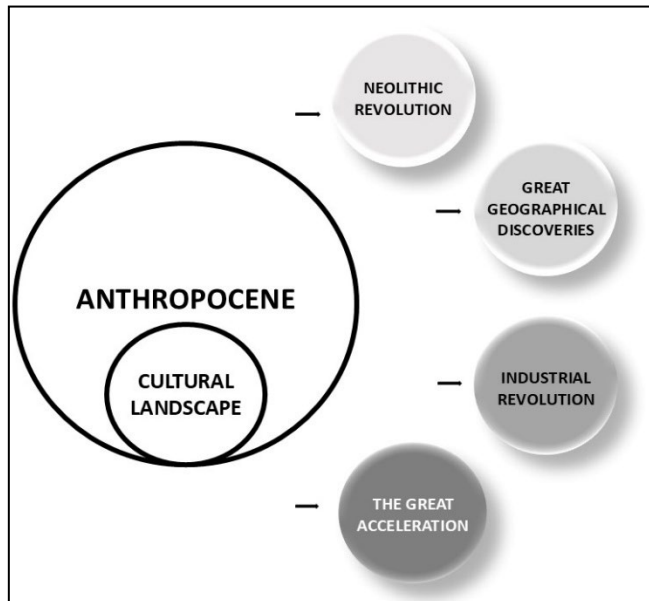


Fig. 1. Significant stages of the Anthropocene. *Source: the authors*

The century in which we live, a period in history that marks the peak of human technological development, has therefore brought about numerous human interventions in the environment, progressively transforming the cultural landscape. The latter increasingly reflects the dynamics of human actions. According to C. O. Sauer (1969, p. 343), it is “fashioned from a natural landscape by a cultural group. Culture is the agent, the natural area is the medium, and the cultural landscape is the result. Under the influence of a given culture, which itself changes over time, the landscape develops, passing through phases and probably eventually reaching the end of its developmental cycle. With the introduction of a different culture, a rejuvenation of the cultural landscape takes place, or a new landscape is superimposed upon the remnants of an older one. The natural landscape is, of course, of fundamental importance, as it provides the materials from which the cultural landscape is formed. The shaping force, however, lies in culture itself...”.

Thus, “through the process of culturalisation, humans remove increasingly vast areas of the planet from the domain of natural evolutionary laws, integrating them into an evolutionary system conditioned by the specificity of human intervention. When the optimal functional state of this system is exceeded through abusive intervention, environmental imbalances and dysfunctions are amplified, as evidenced by pollution in major metropolitan areas, increasing urban pressure on the environment, and, ultimately, disturbances observed at the level of the planetary macrosystem through phenomena generated by global climate change” (P. Cocean, Nicoleta David, 2013, p. 175).

We are therefore witnessing a clear intensification of the effects of the events mentioned above. Among the most devastating for human societies are hydrological events, namely river floods. These represent “a complex process, generated by both genetic factors and influencing factors. Genetic factors are mainly represented by climatic conditions that trigger flooding (liquid and/or solid precipitation), as well as the failure of anthropogenic and natural dams. Influencing factors may be natural (geological, morphological and morphometric characteristics, pedological features, and morphometric attributes of the drainage basin) or anthropogenic (deforestation, inadequate management of hydraulic engineering works, irrational land use, etc.)” (Mariana Soare, 2015, p. 85).

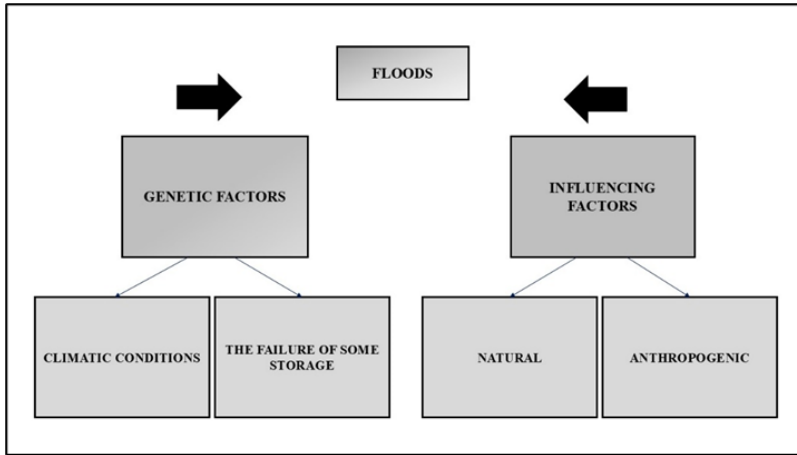


Fig. 2. Floods - Generating Factors. *Source: the authors*

The general evolution of meteorological conditions on Earth in recent decades has been marked by the frequent occurrence of extreme situations that have generated major flood events. Triggered primarily by torrential precipitation, these events may lead to river waters overflowing their channels or to the inundation of low-lying areas through massive surface runoff from slopes. The result consists of extensive areas temporarily covered by water. The recession of floodwaters varies, depending primarily on the volume of water, landform configuration, and the presence of effective anthropogenic drainage systems for the evacuation of accumulated water.

Consequently, “in the present Anthropocene, marked by numerous human-induced changes, nothing is in balance, as this epoch is still far too young and transformations are still unfolding” (M. Leismann, 2024, pp. 3, 4).

A relevant example of such extreme phenomena, namely river flooding in the Anthropocene, is provided by the town of Ocna Mureș, which has been affected by these events on multiple occasions.

2. THE TOWN OF OCNA MUREȘ: LOCATION AND PHYSICAL-GEOGRAPHICAL CHARACTERISTICS

From an administrative perspective, the town of Ocna Mureș belongs to Alba County. It is located “at the contact zone between the Mureș Floodplain and the Târnave Hills, extending across the floodplain and the lower river terraces” (Gh. Vlăsceanu, I. Ianoș, 1998, p. 386).

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The relief is characterised by low altitudes, “approximately 250 m in the Mureș floodplain and around 300 m towards the southeast, where it is dominated by Uioara Hill (444 m). To the south lies Dealul Viilor Hill (437 m)” (Gh. Vlăsceanu, I. Ianoș, 1998, p. 386). North of the Mureș river course, Dealul Cetății Hill and the hills of the Unirea II area define the local morphological framework and the axis of connectivity towards Turda and Cluj-Napoca.

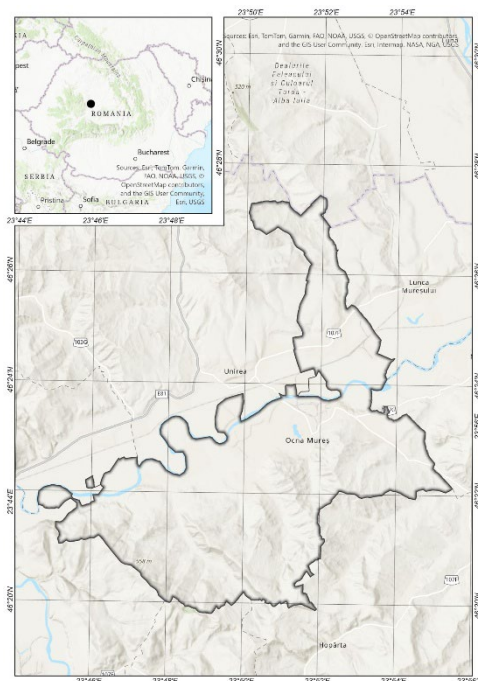


Fig. 3. Location of Ocna Mureș. *Source: the authors*

The settlement occupies the first and second terraces of the Mureș River, being developed primarily in the vicinity of the salt outcrop located south of the river course (C. Mureșan, 2019, p. 9).

The geographical position of the studied area, particularly its latitudinal setting, induces a temperate continental transitional climate and the predominance of westerly winds, “which transport moist air masses, and southerly and south-easterly winds that bring warm, tropical air masses” (N. Dobra, 1996, p. 8). In early spring, the frequent occurrence of warm foehn winds descending from the mountain ridges towards the Alba Iulia–Turda corridor causes rapid snowmelt and, in some cases, the onset of flooding.

The thermal regime is characterised by large thermal amplitudes typical of a temperate continental transitional climate. Seasonal thermal variations range between approximately 10.0–10.5°C to 11°C in spring, around 20°C in summer, 8–10°C in autumn, and 1–2°C in winter. The multiannual mean temperature aligns with the general average values recorded across Romanian territory, at approximately 10°C.

“Overall, however, both summers and winters tend to be milder, while the two transitional seasons, spring and autumn, are relatively moderate” (N. Pintea, 2017, pp. 14, 15), as a result of oceanic influences affecting the central and western regions of Romania.

With regard to precipitation, “both liquid and solid forms exert a direct influence on the triggering of flash floods. Liquid precipitation generates an immediate response, especially in smaller drainage basins. Solid precipitation represents a decisive factor in the formation of flash floods during winter periods when positive temperatures are recorded across the region, leading to snowmelt. Fluctuations in annual precipitation amounts within the upper Mureș River basin are expressed through positive and negative deviations from the multiannual mean” (Nicoleta Daniela Goron, M. Cigher, R. Negru, 2012, p. 193).

The hydrographic network of the area is dominated by the Mureș River, one of the most complex hydrographic arteries in Romania.

Analysis of the Mureș River drainage basin map highlights a more pronounced dissipation of flood waves and, implicitly, a reduction in their energy, influencing both sediment transport capacity and associated erosional processes within this area.

In its longitudinal profile, the Mureș River exhibits pronounced meandering, a consequence of its low gradient. At the confluence of the Mureș with the Arieș River, the altitude is approximately 270 m. As a result, the floodplain is frequently subject to inundation, leading to the formation of permanently or periodically waterlogged areas over relatively extensive surfaces. These areas are used primarily as pastures and hayfields. At the margin of the floodplain, secondary valleys have built alluvial fans (debris cones), which have conditioned the existence of better-drained land with potable water resources, favourable both for agricultural use and for the establishment of settlements. Along the Mureș River, as in the case of other valleys of comparable size, zones of hydrographic convergence have developed (Gr. P. Pop, 2001, p. 80).

According to G. Pandi and Cs. Horváth (2012, p. 51), “at Ocna Mureș the riverbed is relatively stable. Fluctuations commonly range between 15 and 25 cm. In 1998, an unexplained incision of 40 cm was recorded due to anthropogenic interference”.

Within the urban perimeter, the discharge of the Mureş River is supplemented by small secondary valleys, such as "Banța Valley, which passes through Ocna Mureş; Ciunga Valley, which crosses Uioara de Jos; Pusta Băgăului Valley, with a length of 13 km and a drainage basin of 72 km², passing through Micoșlaca and Cisteiu de Mureş; as well as Părăului Valley and Popii Valley, left-bank tributaries of the Mureş. On the right bank, Grind Valley and Feldioara Valley pass through Războieni Cetate. The discharge of these valleys is influenced by annual precipitation levels and generally plays a minor hydrological role" (Al. Vigh, Series 2011–2013, p. 19).

From a pedological perspective, "soils in the lowland areas towards the Mureş consist of sand and gravel, while on the hills they are composed of clay-loam soils developed on a marl substrate" (N. Pinteă, 2017, p. 39). It can be observed that in certain low-lying floodplain sectors, alluvial soils are temporarily submerged, whereas higher terrace surfaces are locally affected by landslides facilitated by steep slopes, the presence of clay, and the alternation of dry and wet periods. At the same time, the subsurface of the area contains substantial salt reserves, which have been continuously exploited by the human community from the moment of their discovery to the present day.

Vegetation and fauna are characteristic of hilly and floodplain environments and are closely correlated with the general climate as well as with local climatic particularities. They have also been adjusted over time by human intervention. Landscape diversity is primarily provided by the presence of shrub species such as blackthorn (*Prunus spinosa*), hawthorn (*Crataegus monogyna*), dog rose (*Rosa canina*), hazel (*Corylus avellana*), and elder (*Sambucus*) and characteristic deciduous trees, notably oak (*Quercus robur*) and walnut (*Juglans regia*); at higher altitudes, these occur in mixture with conifers, specifically Scots pine (*Pinus sylvestris*), the latter being a recent plantation.

Thus, the favourable natural setting, together with the presence of salt resources, stimulated the human settlement of this territory and its gradual transformation over time, with the local cultural landscape continuously accumulating new and characteristic anthropogenic elements.

2.1. Flood history

Efforts aimed at the spatial planning and organisation of the study area, Ocna Mureş, require the assessment of existing and potential vulnerabilities. "Their identification represents an indispensable condition for the formulation and promotion of sustainable development solutions whose effectiveness is not compromised by unforeseen events or by the cumulative effects of processes undergoing slow evolutionary gestation, apparently harmless at present but with major destructive potential in the future" (P. Cocean, 2002, p. 151).

In the present case, flooding is primarily determined by precipitation and snowmelt, occurring against the background of thermal oscillations, particularly during winter and spring.

From the perspective of monthly analysis, considering a 25-year period across eight hydrological stations, April emerges as the month in which floods occur most frequently in this area (Nicoleta Daniela Goron, M. Cigher, R. Negru, 2012, p. 200).

Over the past century, “the most significant floods occurred in August 1851, April 1857, June 1864, May 1877, December 1889, March–April 1895, July 1913, March 1922, July 1933, and November 1941. The floods mentioned above, with the exception of those in 1877, 1899, and 1941, were caused by the fact that the Arieș River experienced a longer-than-usual flood period, allowing the floodwaters of the Mureș to combine with those of the Arieș, thereby raising water levels and increasing the energy of the combined flood wave” (N. Pintea, 2017, p. 20).

Among the hydrological events distinguished by particularly severe consequences for the local cultural landscape, those of 1913 and 1970 are especially notable. Thus, local history highlights the overflowing of the Mureș River and the flooding of the salt mines, culminating in the collapse of their ceilings and the formation of distinctive lakes that can be seen today.



Fig. 4. Ocna Mureș Salt Lake. *Source: the authors*

3. RIVER FLOODS AND SPECIFIC HUMAN INTERVENTIONS – TRANSFORMATIONS OF THE CULTURAL LANDSCAPE

Cultural landscapes “are illustrative of the evolution of society and human settlement over time, under the influence of physical constraints and/or opportunities presented by their natural environment and by successive social, economic, and cultural forces, both external and internal” (current definition of cultural landscape adopted by the World Heritage Committee; P. J. Fowler, 2003, p. 28).

Accordingly, “where humans, as individual or institutional actors, come into contact with landscapes, an inevitable reconfiguration occurs. This reconfiguration translates either into their adaptive evolution (the cultural landscape) or into the acceptance of inevitability, that is, involution, at least for a certain period” (I. Dincă, 2005, pp. 93–94).

Challenges related to the development of human settlements, changes in land use through the considerable expansion of cultivated areas, and the intensification of extreme natural phenomena present both difficult situations and opportunities for local development. In this context, “researchers have highlighted that climate change, characterised by extreme meteorological events such as droughts, flash floods, and variations in moisture concentrations, can damage cultural landscapes. These impacts may lead to the deterioration or destruction of cultural heritage sites through erosion, flooding, and increased vulnerability to natural hazards, thereby disrupting the delicate balance between human activities and the environment” (Hollesen, 2022; Krupocin and Krupocin, 2020; Sesana et al., 2021; UNESCO, 2003, cited in M. Moussavi, A. Lak, 2024, p. 1).

Flood events inherently generate repercussions with economic, social, and environmental implications, depending on their magnitude. Consequently, such events produce profound disruptions in the lives of human communities and in the functioning of ecosystems, necessitating complex and long-term interventions aimed at reconstruction, environmental restoration, and the re-establishment of pre-event equilibrium. The tangible material and functional consequences of flooding are reflected in damage to and degradation of settlements, industrial and agricultural assets, and transport infrastructure.



Fig. 5. Levee protecting the salt mines from flooding (prior to 1918)

(Source: Author unknown. Retrieved from

<https://dinocnamures.wordpress.com/2011/01/26/salina/>)

Therefore, ensuring safety in the face of flood risk relies on a set of integrated measures, including the design and implementation of hydraulic engineering structures capable of limiting the effects of flooding. This also involves the development of effective monitoring and forecasting mechanisms for extreme events, as well as the formulation of intervention and prevention plans activated prior to their occurrence. An essential component of this process is the anticipatory analysis of potential consequences for the territory and exposed communities.

Consequently, in order to protect the local cultural landscape from flooding, embankment works were undertaken, and a new river channel was created along a specific section. "Thus, the course of the Mureș River was diverted and moved approximately 500 m away from the mine" (N. Pinteș, 2017, p. 18), in the mid-nineteenth century.

Subsequently, in mid-July 1913, following heavy precipitation, a section of the previously constructed protective levee failed under the pressure of excess water. This failure allowed the Mureș River to overflow and partially reoccupy its former course, affecting various land-use categories, including agricultural areas, residential zones, and mining sites. In this instance, the negative impact was particularly pronounced within the mining perimeter, generating considerable material losses through the flooding of existing salt mines. As a result, extraction activities were suspended for an extended period until the underground water was evacuated.



Fig. 6. Collapsed mine during the floods (photograph from 1914)
(Source: Photo by Chólnoky Jenő. Retrieved from
<https://dinocnamures.wordpress.com/2011/01/26/salina/>)

In order to defend against repeated flood events, specific engineering works were undertaken, primarily consisting of the extension of the existing protective levee along the left bank of the Mureș River.

At the same time, the necessity was established for “the construction of a deep drain, 14 m in depth and 1,045 m in length, excavated in waste material, around the salt massif on the side facing the Mureș River. This drain encircled the northern, north-western, and eastern margins of the massif. The design error of the drainage system lay in the failure to extend the drain towards the southern margin of the salt massif. Consequently, while infiltrating waters from the Mureș were intercepted by the deep drain, the southern sector of the massif remained undrained, and groundwater originating from the Banța Valley and the slopes of Banța Hill affected the southern part of the mine and subsequently the Ștefania mine” (I. Vescan, 2010, p. 105). This process gradually intensified, progressively degrading the mining area through the collapse of mine roofs.

In order to prevent the further expansion of these phenomena, in 1952 a decision was taken to fill all craters formed by the collapse of the roofs of the old mines (Roman, Iosif, Francisc, Ferdinand, Regina Maria, and Principele Nicolae) with brine. Despite sustained efforts to block freshwater infiltration, the mines were flooded again in 1978. As a result, massive salt extraction was discontinued, and solution mining was expanded. Solution mining, carried out through dissolution using boreholes, generated numerous problems, including uncontrolled collapses, true disasters in geomorphological and mining terms (I. Chintăuan, Ioana-Cristina Chintăuan Marquier, 2022, p. 40).

Salt exploitation carried out through open mine shafts, used for a certain period and subsequently abandoned due to freshwater ingress and the uncontrolled dissolution of underground voids, contributed directly to ground instability. According to the authors cited above (p. 35), the stages of evolution of the mine galleries used for salt extraction at Ocna Mureș can be traced (see Table 1).

As a result of successive overflow events of the Mureș River, in conjunction with significant groundwater infiltration from areas adjacent to the mines, several lakes were formed. Their surface areas continue to change through the progressive dissolution of salt and the collapse of their margins, giving rise to a large anthropo-saline lacustrine complex, which is currently visible within the cultural landscape.

Thus, “the constant change to which every landscape is subjected may occur very slowly, but it may also pass through catastrophic, revolutionary phases. Humans have often attempted to intervene in this process and reshape flood-prone areas for their own benefit. On numerous occasions, upon the completion of such works, it has been announced with pride and confidence that favourable conditions for the future have been secured” (E. Gerber, 1967, p. 1).

Table 1. Key milestones in the evolution of the main salt mines and the formation of the salt lakes in Ocna Mureș

Iosif Mine	Francisc Mine	Ferdinand Mine	Carolina Mine
- it opened in 1792; - it collapsed in 1934, leading to the formation of <i>Lake Iosif</i>.	- it opened in 1791; - it closed in 1934. After its collapse, <i>Lake Francisc</i> was formed.	- it opened in 1813; - following its collapse, <i>Lake Ferdinand</i> was formed, with a depth of 12 m.	- it opened in 1821.
Rudolf Mine	Ștefania Mine	Principele Nicolae Mine	Regele Mihai Mine
- mine opened in 1863 (or 1880), the mine was in operation until 1928	- It was opened in 1872 and was later named Queen Maria Mine (Mina Regina Maria). The mine operated until 1946. - Its collapse led to the formation of Lake 23 August, with a depth of 10 m.	- Opened in 1918. After 1944, it was renamed 6 March Mine (Mina 6 Martie). It operated until 1954, when flooding occurred at the -100 m level, originating from the Iosif Mine, which had already been flooded and collapsed. - Its collapse resulted in the formation of Lake 6 Martie.	- It was opened in 1932 and flooded in 1978; following its collapse, Lake 1 Mai was formed, with a depth of 2 m.

Source: I. Chintăuan, Ioana-Cristina Chintăuan Marquier, 2022, p. 35

The specific resilience of human communities in adapting to diverse environmental conditions is also reflected in this case through the conversion of salt extraction techniques in response to new constraints and through the development of tourism based on existing resources.

A relevant example is provided by the shift in the exploitation technique of local salt reserves through borehole-based solution mining, as well as by the valorisation of the saline baths at Ocna Mureș. These facilities were established due to the availability of highly concentrated sodium chloride mineral waters derived from salt resources, constituting in themselves clear evidence of social resilience in response to major environmental disturbances.

4. CONCLUSIONS

“Landscape protection encompasses actions aimed at conserving and maintaining the significant or characteristic features of a landscape, justified by its heritage value derived from its natural configuration and/or human intervention” (Cerasella Crăciun, 2015, p. 44). Its long-term management requires the preservation of viable elements and the harmonious integration of new elements necessary for the coherent evolution of this complex structure, in accordance with broader agreements concerning sustainable development in the Anthropocene.

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