

RECONSTRUCTION OF THE SAVA COURSE IN THE WIDER ZAGREB AREA IN THE EIGHTEENTH AND NINETEENTH CENTURIES

REKONSTRUKCIJA TOKA RIJEKE SAVE NA ŠIREM ZAGREBAČKOM PODRUČJU U 18. I 19. STOLJEĆU

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Received/Priljeno: 12. 12. 2022.

Accepted/Prihvaćeno: 30. 12. 2022.

Original scientific paper/Izvorni znanstveni rad
UDK / UDC: 556.51(497.542-282.24Sava)

“17/18”(091)

627.15(497.542-282.24Sava)

“17/18”(091)

Summary

The paper presents, in the form of cartographic supplements, the results of geoinformational reconstruction of the Sava River course in the wider area of Zagreb during the 18th and 19th centuries based on maps of the Habsburg Monarchy. By comparing the obtained results with the present state, both natural (resulting from hydrographic and morphological actions of the river) and anthropogenic changes in the Sava River course are examined. Eight examples are highlighted that illustrate these changes – whether they are clearly visible today (such as the position of roads and settlements) or hidden, absorbed by the urban development of Zagreb to a greater or lesser extent (primarily along the right riverbank).

Keywords: the Sava River, Zagreb, GIS, river-course reconstruction, Habsburg Monarchy

Ključne riječi: rijeka Sava, Zagreb, GIS, rekonstrukcija toka, Habsburška Monarhija

1. INTRODUCTION

The true characteristics of the Sava River, which elegantly meanders between Podsused and Homeland bridges, have been largely concealed in the contemporary landscape. This body of water, once a potent entity in the plains preceding Zagreb, has been domesticated; its current state, nestled between embankments and drainage canals, significantly differs from its erstwhile wild nature that continuously, almost annually, transformed the landscape at Zagreb's foothills. This raises a compelling question: Can any remnants of this 'original' aspect of the Sava still be observed in the river's present contours? The primary objective of our study is to construct a comprehensive overview of the Sava River's course during the 18th and 19th centuries, drawing on multiple maps and systematic measurements. Subsequently, the findings will be juxtaposed against the contemporary course of the Sava River and satellite imagery of Zagreb using a Geographic Information System (GIS) to potentially detect 'footprints' of the past, that is, former river courses that still shape the city's appearance today (such as the position of streets and the so-called thickets in dried-out meanders, among others). The majority of the research will be prefaced by an in-depth discussion of the methodologies deployed, with a detailed examination of each map or plan utilized, their respective applications, and potential complications encountered. Prior to this, we deem it beneficial to succinctly illuminate the history of the Sava River itself, for which the early modern era has been selected as the starting point.

2. THE SAVA RIVER – CHARACTERISTICS AND HISTORY

As per the etymology provided by Jürgen Udolph, the term “Sava” derives from the Indo-European root **seu-* (indicating “something wet”), thus the name intrinsically denotes “that which irrigates”. The Sava River, falling within the Black Sea basin, is one of the tributaries of the Danube. The river springs from the Alps and is constituted by the confluence of two streams, namely Sava Dolinka and Sava Bohinjka. The wider Zagreb region forms part of the river’s middle course, characterized by a plethora of meanders, branches (or sometimes called distributaries), shoals, islands, etc., partially shaped by the perpetual deposition of large and fine gravel carried downstream by the river. The Sava is an exceedingly dynamic river, which is why its width and depth, as well as its course, have varied significantly in the past. This, in turn, is linked to the gravelly character of the terrain around Zagreb, which was shaped by the river’s influence. The Sava is renowned for its frequent floods, making inundation a recurring historical event in the wider Zagreb area.

East of Zagreb, in the region presently known as Slavonia, the Sava transforms into a slow lowland river, devoid of the vigor to carry away even the stumps and trees in its path. In this region, the Sava starts to meander with fewer branches, and although shifts in its course are still detectable over the investigated period, the differences are less dramatic.

Until the advent of the 20th century, Zagreb lacked adequate flood defenses, relying instead on natural topographical features – the marshlands lining the river and the hills upon which Gradec and Kaptol were elevated above the plains. The marshy character of the region surrounding the Sava, in addition to the vast number of river’s branches, played a positive defensive role – throughout the period of Ottoman threat, Zagreb was never besieged. The sole instance when it faced imminent peril (in 1469) the Sava’s flooding prevented the Ottomans from initiating an assault.

The Sava has been navigable since ancient times and, in the early modern era, has been particularly essential for the commerce of salt and grain. Given the dynamic nature of the river two things are particularly interesting to examine. First, various toponyms in the Zagreb area that are influenced by changes in the Sava’s course and, secondly, where and when crossings over the Sava are mentioned. Although some of these crossings (ferries) remained functional until the 20th century (the Trnje ferry was operational until 1981), our focus in this study lies particularly on the construction of the first bridge over the Sava in Zagreb. As the traffic from Karlovac to Zagreb expanded towards the close of the 18th century, ferries proved inadequate for the transportation of goods, prompting Emperor Joseph II to decree the construction of a bridge at Zagreb in 1783. The construction spanned over two years, ultimately resulting in the erection of a series of three bridges over three branches of the Sava River. Their precise location can be discerned on the map as the time of construction coincides with the first survey addressed in this paper. All three bridges were built utilizing *the best oak*. Throughout the 18th century, numerous attempts were made to dredge the Sava’s bed to facilitate navigation, with documented accounts of these interventions – for instance, a report from 1759 concerning works on the Sava and Kupa. In 1771, a Directorate for Navigation was established in Civil Croatia and Slavonia. The rapid escalation in the economic and commercial significance of the Sava from the 18th century must indeed be associated with the liberation of large portions of the Sava–Drava interfluvium from Ottoman rule, as ratified by the Treaty of Karlowitz (1699) and the Treaty of Passarowitz (1718). Following these wars, the entire Sava–Drava interfluvium came under Habsburg rule, sparking river’s commercial renaissance.

With the advent of the railway in Zagreb in 1862 and the expansion of suburban villages in the broader lowland region below Zagreb, both fueled by the city’s economic growth in the 19th century, the need to regulate the Sava emerged. Although some regulatory plans had existed previously, these earlier efforts did not yield results (for instance, in 1840, under the leadership of Imperial and Royal (k. und k.) chamberlain Ement von Inkey, a commission for the regulation of the Sava was assembled). In 1870, a track of the Royal Hungarian Railway was constructed. Since it was elevated on a small embankment it providing some protection to the Lower Town area from floods; however, the region south of the railway remained vulnerable and suffered two major floods in March and October of 1895. Spurred by these floods and the city’s expansion southwards, city authorities finally resolved to regulate river. The project



Figure 1. Example of the Issue of Accurate Sheet Overlapping in GIS (source: Arcanum Maps).

was initiated in 1899, but due to a series of complications and two world wars, it was only concluded in the 1950s. The most recent significant regulation of the Sava River, that is, the construction of sturdier embankments, was executed following the extensive flood of 1964, when a significant area of Zagreb around the river was inundated.

3. METHODOLOGY AND TERMINOLOGY

The primary objective of this study was to reconstruct the course of the Sava River during the 18th and 19th centuries. In order to accomplish this, our initial step involved tracing the courses of the Sava into a Geographic Information System (GIS). We opted for two distinct surveys – the Josephinian (1783 – 1784) and the Franciscan (1865 – 1869) – along with several maps, utilized for comparison with the current state. These surveys were primarily selected as they represent the first two systematic topographic assessments, and furthermore, they are readily accessible via the *Arcanum Maps* website (until recently called *Mapire*). Despite some inaccuracies within these measurements, which we will address in subsequent sections, minor modifications enabled us to reconstruct a hydrographic network of the wider Zagreb region. This synthesized network was then juxtaposed with contemporary images of Zagreb to discern where the influences of old Sava courses are visible on the city's development. Moreover, satellite images from the second half of the 20th century were occasionally incorporated as they more vividly delineate the influence of the Sava on areas currently obscured due to urban expansion. These digital orthophoto maps from 1968 are, just like the ones from 2011, available on the website of the *Physical planning information system*.

Furthermore, in the context of GIS work, various cartographic bases were employed: *HERE Maps*, *OpenStreetMaps*, *Bing*, as well as satellite imagery. All maps were incorporated into the GIS, georeferenced, and displayed in the WGS 84/Pseudo-Mercator or Web Mercator projection (EPSG:3857). For the Josephinian and Franciscan Survey maps we did not encounter significant issues, as the georeferencing was already executed by the authors who published them on *Arcanum Maps*.

However, the overlays are not completely accurate, a challenge that arose during the survey process itself. Scholars conducting analogous research for the area of the Mura River determined that the Josephinian Survey in that area deviates in accuracy between 30 and 100 meters on average, and a similar circumstance is observable in the Zagreb region.¹ The Franciscan Survey exhibits much smaller

¹ Gábor, TÓTH, Engi SZUSZSANNA, János MAJDÁN, Szabolcs Ákos FÁBIÁN, "Historijsko-morfološka rekonstrukcija inondacije rijeke Mure," *Ekonomska i ekohistorija* 9 (2013): 30.

deviations than the Josephinian. Both, however, still carry a significant disadvantage for the Geographic Information System in the sense that maps are divided into a series of sheets that occasionally do not overlap with the best accuracy, resulting in additional discrepancies. Nevertheless, despite their deviations in accuracy, these two sources were of paramount importance to our study, and when illustrating certain smaller regions we made manual calibrations to compensate as accurately as possible for errors in the mapping.

In addition to the tracing old courses and comparing them to today's maps, we can identify three additional indicators of the existence of former courses:²

- Differential vegetation in the area of the former course (generally denser vegetation and trees with towering canopies).
- The orientation of fields, meadows, and forests. On occasion, river courses can be detected in the unusual arrangement of parcel boundaries or different surfaces.
- Contemporary water bodies (creeks, channels, etc.) are generated from former river branches and oxbow lakes that remain filled with water.

3.1. Josephinian Survey

The first systematic survey of the entire territory of the Habsburg Monarchy was conducted between 1763 and 1787, earning its name from Emperor Joseph II. The genesis of this comprehensive project can be traced back to the military reform implemented by Maria Theresa in 1757. Thus, the survey was primarily executed for military purposes and all maps were held as classified military information until 1864.³ The surveys were undertaken without a projection and coordinate grid (which presents a challenge when utilizing GIS), and a total of 5400 sheets of 64 x 42 cm (24 x 16 Vienna inches), or 210 km² per sheet, were drafted.⁴ Each sheet was accompanied by a detailed topographic description of the area, intended to facilitate easier navigation for the military, with specific emphasis on known river crossings when pertaining to riverine regions.

All maps were produced at a scale of 1:28800, with the cartography based on a geodetic foundation of trigonometric points. Surveys were performed in accordance with the territorial division of the Monarchy, hence the area surrounding Zagreb was mapped between 1783 and 1784 as part of the surveys of the Civil Croatia and Slavonia. The entire territory of the Civil Croatia is encapsulated within 69 sheets, while the broader area of Zagreb is depicted within four sheets.

3.2. Franciscan Survey

The second systematic survey of the territory of the Habsburg Monarchy spanned from 1806 to 1869. This survey was initiated to rectify certain inaccuracies identified during the execution of the first measurement, thereby rendering this survey considerably more precise (which is discernible in the region of Zagreb as well). The dimensions of the sheets largely emulate those of the first survey, culminating in a total of 3,333 sheets at a scale of 1:28800. The territories of Croatia, Slavonia, and the Military Frontier underwent survey between 1865 and 1869, embodied within a total of 244 sheets, while the broader area of Zagreb is depicted within ten sheets.⁵

Although cadastral maps were not utilized in this study, it is certainly noteworthy to mention that cadastral surveying was introduced from 1817. The territories of Croatia and Slavonia were surveyed between 1847 and 1877, and it is remarkable to note that the present-day cadastre of the Republic of Croatia still relies on these surveys for approximately 70% of its area.⁶

² KULEJ, Toni, "Geomorfološke promjene korita Drave od Repaša do Ferdinandovca," (Master's Thesis, Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu, 2019), 8.

³ SLUKAN-ALTIĆ, Mirela, *Povijesna kartografija: kartografski izvori u povijesnim znanostima* (Samobor: Meridijani, 2003), 144.

⁴ IBID. 142, 178; GÁBOR, ZSUZSANNA, MAJDÁN AND FÁBIÁN 2013, 30.

⁵ SLUKAN-ALTIĆ 2003, 145 – 146.

⁶ For an overview of cadastral surveys of the Zagreb area, see: IVKOVIĆ, Mira, Marko DŽAPO, Loris REDOVNIKOVIĆ, "Katastarske izmjere grada Zagreba," *Geodetski list* 66/4 (2012): 303 – 320.

3.3 Other Used Plans and Maps

Although the majority of the reconstruction relies on the Josephinian and Franciscan Surveys, a few other plans and maps were used when comparing it to the present state. Firstly, the map of Leopold Kneidinger from 1766, at a scale of approximately 1:25000, made on paper dimensions 70.5 x 46.5 cm in ink and aquarelle-color.⁷ This drawing exclusively depicts the territory of the “Free Royal City of Zagreb,” and therefore does not include the Kaptol area, capturing the Sava River only in one of its smaller segments.

Somewhat earlier, based on measurements conducted between 1729 and 1735, the first hydrographic map of the entire course of the Sava River was created. The measurements were performed by engineers Ernest Wenzel Durchlasser, Friedrich Conrad Renner, and Abraham Kaltschmidt. This map, at a scale of 1:270000, consists of six sheets, with the sheet titled *Pars Styriae Pars Regni [C]arnioliae Croatiae* being pertinent for the area of Zagreb.⁸ Given the size of the scale, the branched nature of the Sava near Zagreb is not elaborately detailed, but the map is nevertheless a valuable source for generally tracing its course. In this regard, a map from 1735 by Fritsch András Erik – *Mappa über ein Theil des Sau Stroms in Croatien* – is somewhat better.⁹ From 1786, we have another hydrographic map (authored by Joannes Baptista Bachinij) which more comprehensively depicts the course of the Sava near Zagreb.¹⁰

Lastly, four maps from the 19th century deserve mention. The first was crafted in 1822 by Josip Seman.¹¹ The second was created in 1878 based on the first cadastral survey of Zagreb conducted between 1861 and 1862.¹² The third is from 1889 and was produced as a regulatory basis compiled by the City Construction Office.¹³ The fourth was created at the turn of the century as a draft of the regulation of the course of the Sava River in 1899/1900.¹⁴ Apart from Seman’s map, the other three only depict a smaller part of the Sava River in the immediate vicinity of the city.

The maps we have mentioned are merely some of the available ones. The potential list of maps for further research is significantly larger¹⁵, but they are mostly kept in archives and not easily accessible online, which presents a major problem in georeferencing (expensive scans would first need to be conducted). For this reason, the study has chosen to focus on those maps and drawings that are easily accessible in high resolution on the internet, leaving the possibility for additional expansion in the future.

3.4 Terminology

The following is a concise overview of the fundamental terminology concerning rivers, which is critical for the substance and comprehension of maps that will follow.

- Braided river – This term designates a river that contains multiple interwoven branches (or distributaries). The Sava River in Zagreb, historically, exemplified a braided river.
- Floodplain – This term refers to the lower portion of land adjacent to a river, directly or indirectly subject to the influence of a river, such as flooding and groundwater. In the context of Zagreb, this area is formed along the northern bank of the Sava River.¹⁶

⁷ SLUKAN-ALTIĆ 2003, 260; DOBRONIĆ, Lelja, *Stari planovi Zagreba* (Zagreb: Urbanistički zavod grada Zagreba, 1961), 8.

⁸ Available online at: <https://mapy.mzk.cz/mzk03/001/039/040/2619266947/>.

⁹ Available online at: http://mnl.gov.hu/mnl/ol/vizrajzi_es_vizszabalyozasi_terkepek.

¹⁰ *Mappa totum fluxum Savi inde ab ... ducatus Styriae et Carnioliae usque Regimen Gradiscanum per ... Comitatum Zagrabensem devurrentis exhibens ...* Available online at: <https://maps.hungaricana.hu/en/MOLTerkeptar/5043/>.

¹¹ Available online at: <https://digitalna.nsk.hr/pb/?object=info&id=17236> (scale of 1: 37100).

¹² Available online at: <https://digitalna.nsk.hr/pb/?object=info&id=10389> (scale of 1: 11520); IVKOVIĆ, DŽAPO, REDOVNIKVIĆ 2012, 304 – 305.

¹³ Available online at: <https://digitalna.nsk.hr/pb/?object=info&id=17060> (scale of 1: 11520)

¹⁴ Published in: MLINAR, Ivan, *Remetinečki gaj - Početak sustavne urbanizacije novozagrebačkog područja* (Zagreb: Centar za kulturu Novi Zagreb, Arhitektonski fakultet Sveučilišta u Zagrebu, 2014), 10; SLUKAN-ALTIĆ 2010, 206.

¹⁵ For detailed list see: SLUKAN-ALTIĆ 2003, 167 – 168, 197 – 209, 259 – 265.

¹⁶ SLUKAN-ALTIĆ 2010, 207.

- Terrace plain – This term refers to the higher portion of land adjacent to a river, which is less influenced by a river than the lower floodplain and thus is more suitable for urban development. In the context of Zagreb, this terrace plain is formed along the southern bank of the Sava River.¹⁷
- Shoal (or Sandbar) – This is a dynamic (that is, frequently and easily alterable) landform that forms through the accumulation of material in a riverbed.
- River Island – Dynamic relief forms created by the merging of several sandbars, i.e. result of accumulation of materials; or relief form that emerges due to soil erosion under the influence of the river, i.e. island formed by separation of existing soil from the riverbank.¹⁸
- Meander – A bend or “curve” in a river course. It consists of a neck, a bar, and an apex.¹⁹
- Oxbow lake – A remnant of a former meander. It can be dry or filled with water.²⁰
- Branch (or Distributary) – A narrower portion of the riverbed, connected to the main river course, through which most of the river doesn’t flow; it diverges from the main course and flows separately until rejoining the main body of the river (sometimes also called Anabranch). They often separate river islands from the riverbank. During dry periods, they may dry up.²¹
- Dead Branch – Forms when a branch of river loses its connection to the main river course. Occasionally, they may be flooded and receive water, but ultimately they dry up. In the interim, until they dry up, they are characterized by marshy terrain.²²

4. RECONSTRUCTION OF THE SAVA RIVER COURSE

The end result obtained in GIS by overlaying different courses can provide insight into the past course of the Sava River and its influence on the city. In this paper, we present a comprehensive reconstruction of the Sava River course near Zagreb and several illustrations of the river’s past trajectories contrasted with its current state. Of course, there are numerous other potential outlines. Given that presenting high-resolution maps on paper can cause issues due to compression, and therefore result in the loss of map readability, we decided to display all examples individually, utilizing as much of the page as possible in the following sections. The commentary and descriptions will be presented in footnotes to conserve space. In all the diagrams attached to this paper, a darker shade of blue symbolizes the river course in the 18th century, while a lighter shade represents the river course in the 19th century.

The attached images clearly illustrate what we have reiterated multiple times – the Sava is a river with numerous branches, and its dynamism induces consistent changes and the formation of new meanders. Over the course of roughly a hundred years (first survey 1783 – 1784, second survey 1865 – 1869), the river’s course has completely altered in certain areas. Further insights into the dynamic nature of the river are provided by satellite imagery from 1968, which uncovers numerous oxbow lakes and dead branches that do not align with any of the courses shown on this map.

It’s important to note that the presented reconstruction serves merely as an initial step towards more ambitious research endeavors. Specifically, it would be both intriguing and beneficial for historiography to delve into the socio-ecological system of the Sava River in the broader Zagreb area.²³ We owe

¹⁷ IBID.

¹⁸ KULEJ 2019, 27.

¹⁹ ŠAFAREK, Goran, “Dinamika rijeka,” *Priroda Hrvatske*; KULEJ 2019, 3.

²⁰ BOGNAR, Andrija, “Geomorfološka obilježja korita rijeke Drave i njenog poloja u širem području naselja Križnica,” *Hrvatski geografski glasnik* 70/2 (2008): 62.

²¹ ŠAFAREK, Goran, “Rukavci,” *Priroda Hrvatske*; KULEJ 2019, 26.

²² ŠAFAREK, Goran, “Mrtvi rukavci,” *Priroda Hrvatske*.

²³ A relevant reference in this regard could be the recent work of Luka Jakopčić, who approached a similar issue in the case of the Brod Posavina region (see JAKOPČIĆ, Luka, *Divljina s pečatom: socioekološki sustav brodske Posavine u 18. stoljeću*. Slavonski Brod: Hrvatski institut za povijest – Podružnica za povijest Slavonije, Srijema i Baranje, 2016). As Jakopčić states, “By introducing elements of the environment, namely the Sava River and the ecosystem it forms in this area, as active historical factors, we want to raise awareness of the fact that the Brod Posavina region [and future research on the Zagreb area, author’s note], like any other area shaped in dialogue with a prominent, or as we will say in this work, a ‘strong’ environment (sea, rivers, mountains), can be understood as a valuable historical source!” (IBID. 22).

our gratitude to a number of Zagreb historians – chiefly Ivan Krstitelj Tkalčić – for the compilation of *Povijesni spomenicu grada Zagreba* [*Historical Monuments of the City of Zagreb*], which is rich in accounts about the symbiotic relationship between the people of Zagreb and the Sava River. By creating a reconstruction of the Sava River course, we also establish a spatial-geographical determinant of this relationship – the next step is to integrate the river with historical sources to enhance our understanding of the interplay between humans and nature in the broader Zagreb area during the 18th and 19th century.²⁴

4.1. The Course of the Sava River in the 18th and 19th Centuries

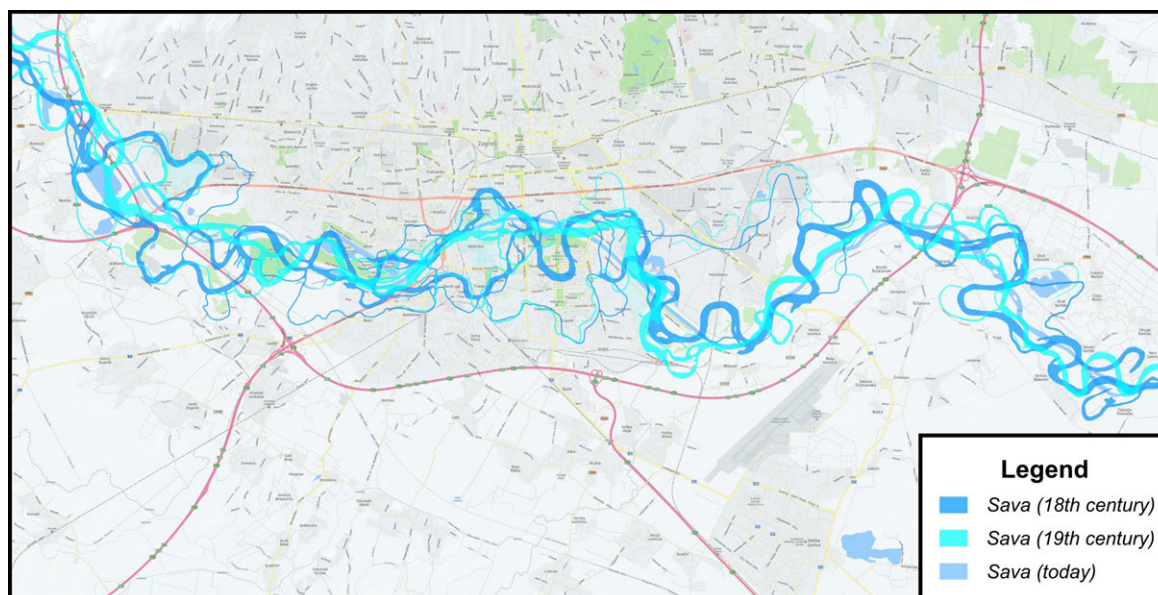


Figure 2. The Sava River in the 18th and 19th centuries (base map: Here Maps).

4.2. Karlovačka and Remetinečka Street

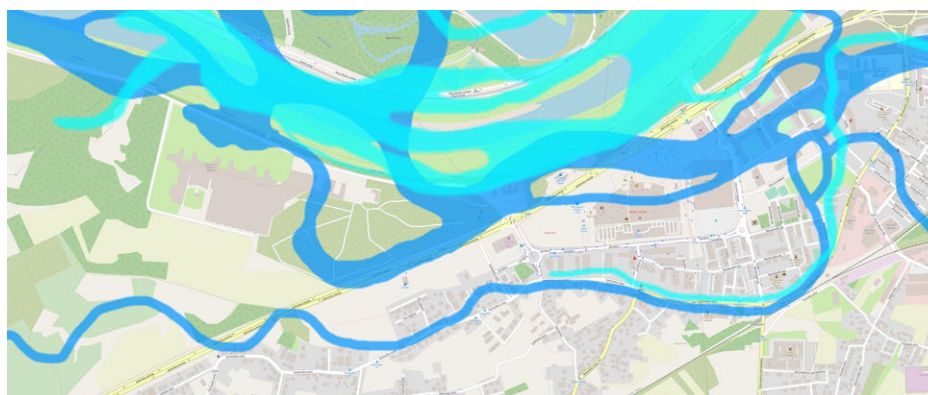


Figure 3. Karlovačka Street in relation to the course of the Sava River in the 18th and 19th centuries (base map: OpenStreetMap). It is important to note that the 18th-century depiction is not the most accurate and complete due to the limitations of the survey techniques at

that time. However, considering this, we can clearly recognize that the direction of Karlovačka Street was the same in the past and present. This alignment is influenced by the presence of a smaller branch of the river that separated from the main course approximately at the location where Jadranska Avenue and Savski Nasip intersect today. It flowed separately until rejoining the main course somewhere in the area of present-day Lanište. The direction of Remetinečka Street is also partially influenced by the course of this branch.

²⁴ This interrelationship was not exclusive to the area of Gradec and Kaptol but also extended to the surrounding villages in an equal – if not greater – proportion (see DOBRONIĆ, Lelja, *Stari "vijenac" sela oko Zagreba*. Zagreb: Muzej grada Zagreba, 2003). It is interesting to note that all the examined maps, as well as Lelja Dobronić's book, demonstrate that the area of the southern bank of the Sava River – present-day Novi Zagreb – was continuously inhabited throughout the early modern period (in fact, it formed a relatively dense network of rural settlements). See especially: DOBRONIĆ 2003, 139-145.

4.3. Podsused

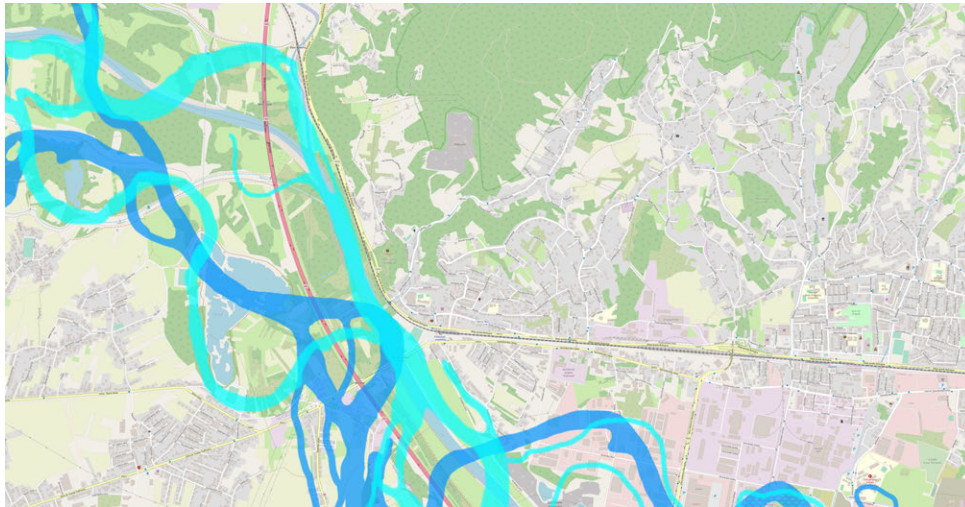


Figure 4. Podsused in relation to the course of the Sava River in the 18th and 19th centuries (base map: OpenStreetMap).



Figure 5. Podsused on maps from the 18th and 19th centuries (source: Arcanum Maps). At Podsused, upon entering the Zagreb area, the Sava River maintained its presence from the western side, as it does today, throughout the 18th and 19th centuries. However, an important distinction can be observed between these two periods. In the 18th century, the confluence of the Krapina River with the Sava occurred in close proximity to Susedgrad, while in the 19th century it shifted significantly further north. Over time, the confluence has gradually moved closer to Susedgrad again, but it remains distinctly further away compared to its 18th-century position.



Figure 6. Confluence of the Krapina River with the Sava River near Podsused on the map from 1786 (source: <https://maps.hungaricana.hu/en/MOLTerkepar/5043/>).

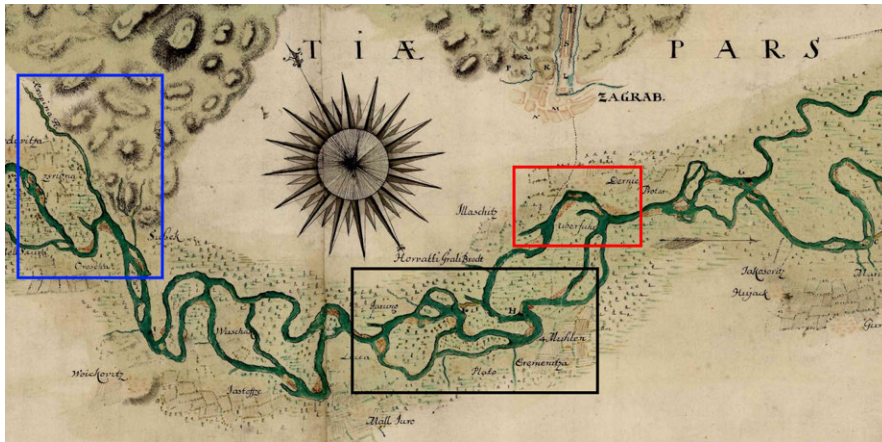


Figure 7. Confluence of the Krapina River with the Sava River near Susedgrad (left); Sava River north of the current Remetinečka and Karlovačka Streets (middle); and meander in the area of today's Lavoslav Ružička Street (right) on the map from 1735 (source: http://mnl.gov.hu/mnl/ol/vizrajzi_es_vizszabalyozasi_terkepek).

4.4. Lavoslav Ružička Street

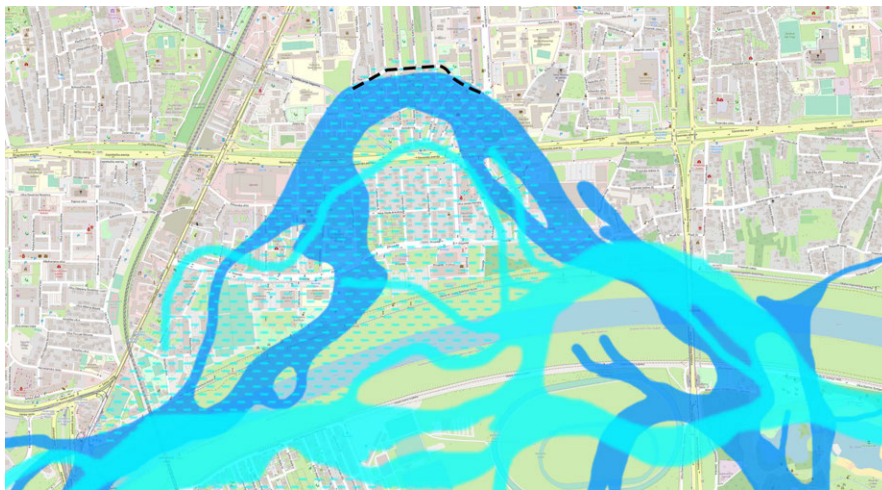


Figure 8. Lavoslav Ružička Street in relation to the course of the Sava River in the 18th and 19th centuries (base map: OpenStreetMap).

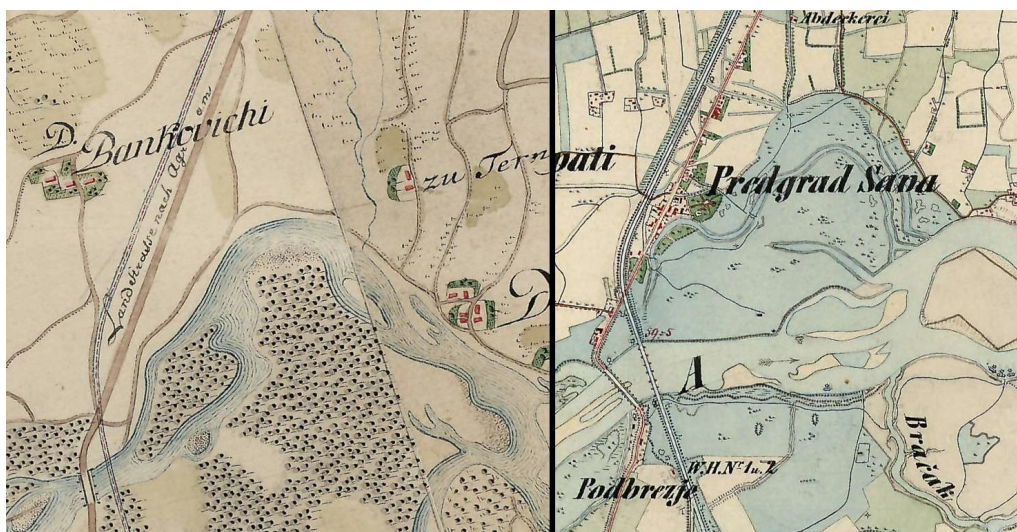


Figure 9. Lavoslav Ružička Street on maps from the 18th and 19th centuries (source: Arcanum Maps). Lavoslav Ružička Street serves as perhaps the most prominent example of the discernible impact of the Sava River on the contemporary urban layout. The historical presence of the Sava River in this particular segment of Zagreb endured until its subsequent 20th-century regulation, as clearly shown by the earlier drawings and plans dating back to 1878 and 1889. The earlier depictions, spanning from 1735, 1766, and 1786, further attest to the long existence of this meander.



Figure 10. Meander in the area of present-day Lavoslav Ružička Street on Leopold Kneidinger's map from 1766 (source: DOBRONIĆ 1961, 8).



Figure 11. Meander in the area of present-day Lavoslav Ružička Street on the regulatory basis map of Zagreb from 1889 (source: <https://digitalna.nsk.hr/pb/?object=info&id=17060>).

4.5. Oxbow lake near Bundek that was engulfed by Novi Zagreb

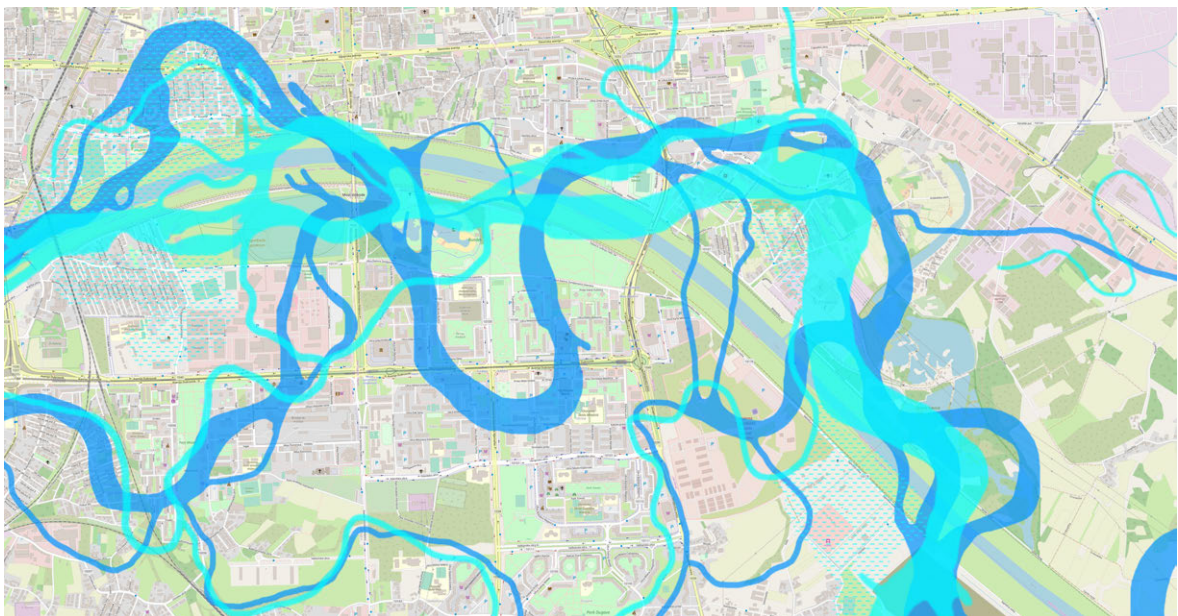


Figure 12. Meander south of present-day Bundek lake formed as a result of the river course in the 18th century (base map: OpenStreetMap).



Figure 13. Oxbow lake south of present-day Bundek on a satellite image from 1968 (source: Physical planning information system). On the satellite image from 1968, prior to the construction of Središće, Sopot, and Utrine, at least two oxbow lakes (or maybe even dead branches) can be observed. The southern one, located further away from Bundek lake, is a remnant of the river's course from the 18th century.

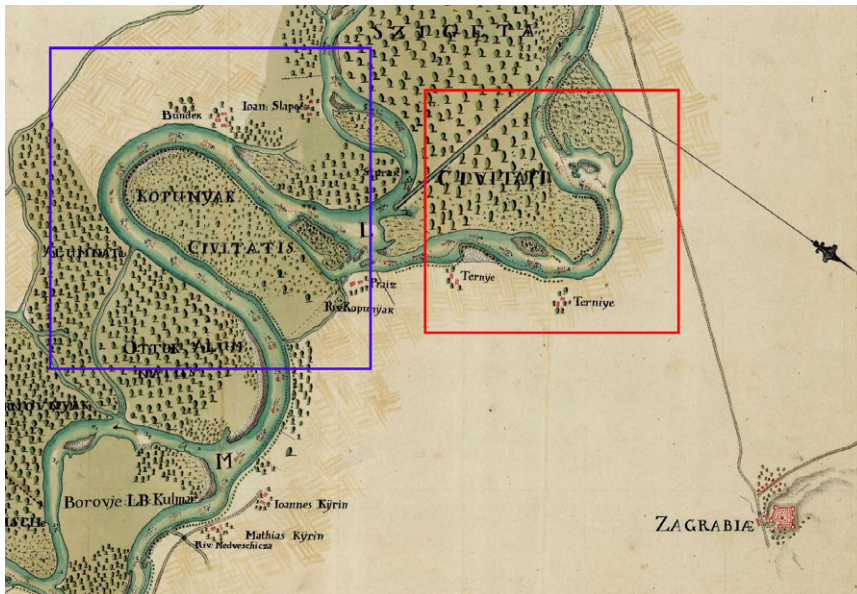


Figure 14. Oxbow lake at the location of Bundek (left) and meander at the location of Lavoslava Ružičke Street (right) on the map from 1786 (source: <https://maps.hungaricana.hu/en/MOLTerkeptar/5043/>).

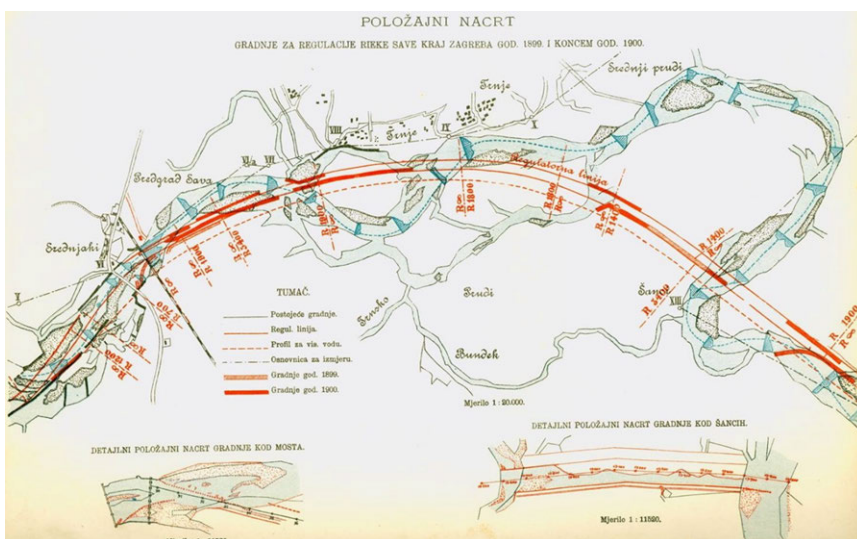


Figure 15. Several additional branches of the Sava River visible in the area of present-day Novi Zagreb on the map from 1899 (source: MLINAR 2014, 10; SLUKAN-ALTIĆ 2010, 206).

4.6. Hruščica – the impact of the Sava on the settlement

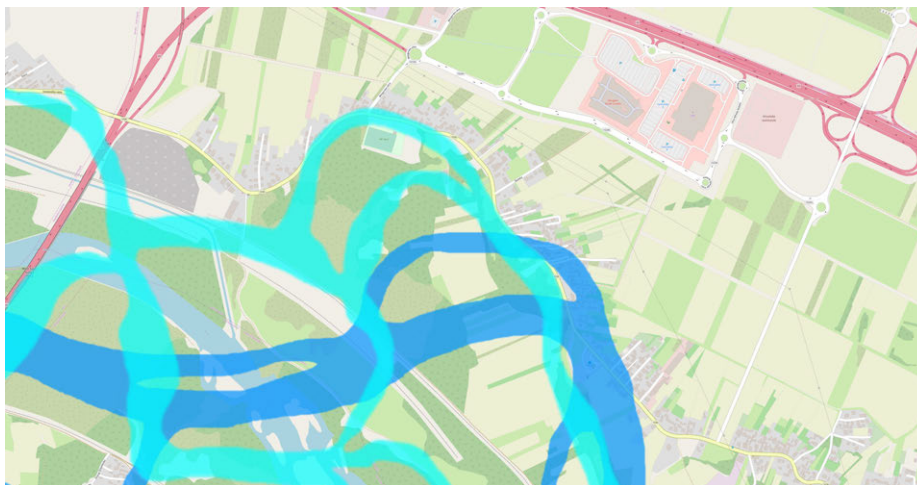


Figure 16. Hruščica in relation to the course of the Sava River in the 18th and 19th centuries (base map: OpenStreetMap).



Figure 17. Hruščica on maps from the 18th and 19th centuries (source: Arcanum Maps). Hruščica, a small settlement southeast of Ivanja Reka, serves as an excellent example of the influence of the river on the development of settlements. As evident from the

accompanying maps, the present-day Ivanja Reka Road was historically bounded by the Sava River on its southern side, which hindered the development of the settlement in that area. Consequently, the settlement developed solely along the northern side of the street, and Hruščica has maintained this shape until the present day.



Figure 18. The area of the Sava River near the settlement of Hruščica (near Ivanja Reka) on a map from 1735. Although the settlement of Hruščica was too small to be relevant for the cartographer to include, based on its proximity to Ivanja Reka and the appearance of the river course, we can infer that this represents the area of the settlement (source: http://mnl.gov.hu/mnl/ol/vizrajzi_es_vizszabalyozasi_terkepek).

4.7. Velika Kosnica – an example of a dead branch

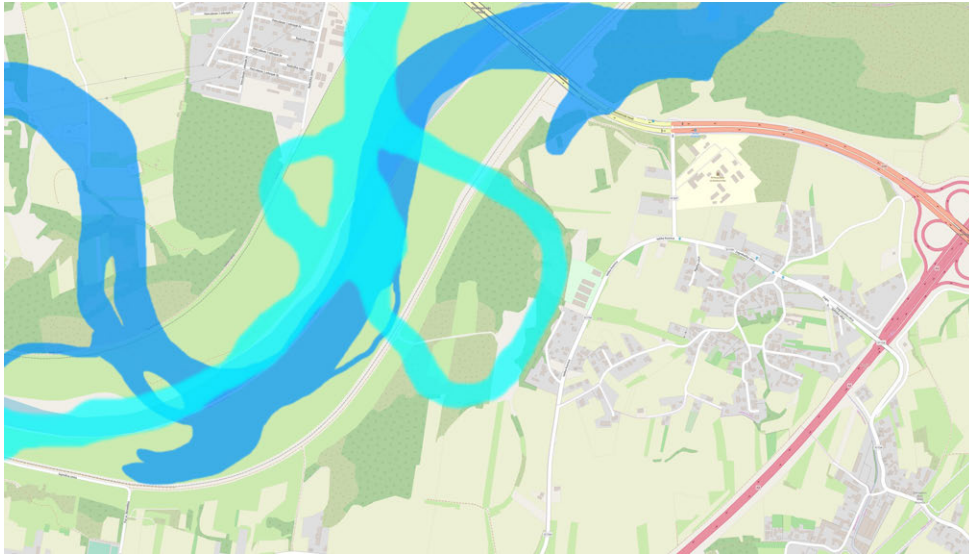


Figure 19. Dead branch near Velika Kosnica formed as a result of the 19th-century river course (base map: OpenStreetMap).



Figure 20. Satellite images of the dead river branch near Velika Kosnica in 1968 and 2011 (source: Physical planning information system). The branch near Velika Kosnica serves as a compelling example of the fate of such river formations when they become separated from the main course. In the 1968 satellite image, we observe its complete detachment from the main course due to the presence of an embankment, although it still retains some water. The 2011 image reveals that this branch has transformed into a dead river branch, devoid of significant presence of water. Moreover, it exhibits the aforementioned characteristics that enable the identification of former river courses, even without imagery, such as distinct vegetation patterns along the former course and the alignment of fields, meadows, and forests, which often reflect the historical flow. In addition, the 1968 image highlights a third element – the presence of water bodies formed from previous branches that still retain water.

4.8. Oxbow lake near Zagreb Sorting Station (Zagrebački Ranžirni Kolodvor)

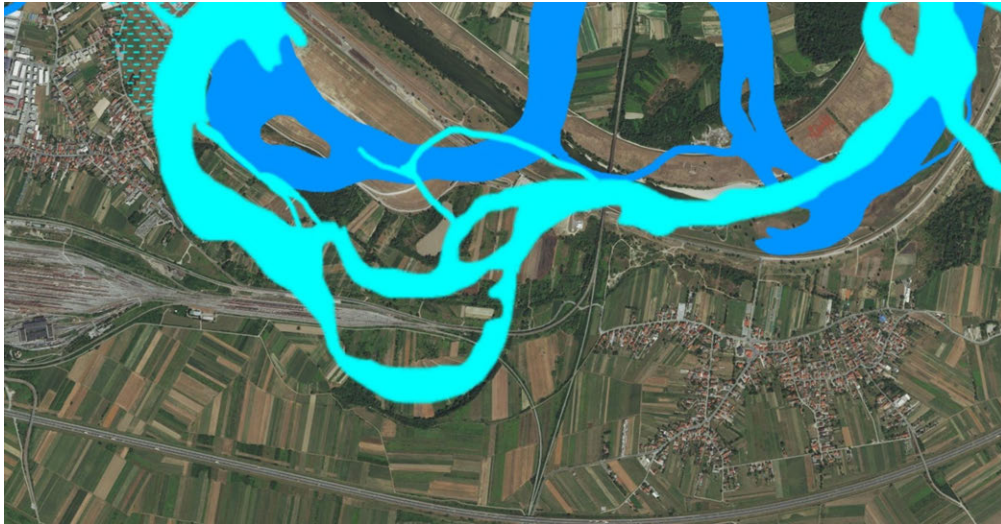


Figure 21. Oxbow lake near Zagreb Sorting Station as a result of the 19th-century river course (base map: Bing).



Figure 22. Satellite images of the oxbow lake near Zagreb Sorting Station in 2011 (source: Physical planning information system). The oxbow lake adjacent to the Zagreb Sorting Station originated as a consequence of the meandering path of the Sava River during the 19th century, and its persistent visibility in the present day can be attributed to the distinctive vegetation lining the southern periphery of its former course and the alignment of the fields along its inner bank.

4.9. Jarun - Former Riverbed, Now a Lake



Figure 23. Jarun Lake (present state, post-renovation in the 1980s) in relation to the course of the Sava River in the 18th and 19th centuries (base map: Bing).



Figure 24. Jarun Lake on a satellite image from 1968, prior to the renovation for the 1987 Summer Universiade games (source: Physical planning information system). Jarun Lake serves as an example of how a former riverbed can be assimilated into a new urban environment. The records from the 18th and 19th centuries do not exhibit a clear overlap between the riverbed and the entire length of the lake prior to its renovation. However, the satellite imagery from 1968 provides clear evidence of the former course direction (from later period, not covered by surveys analyzed in this study).

5. CONCLUSION

The Sava River in the wider Zagreb area was characterized in the past by an intricate network of meanders, branches, shoals, islands, and river islands. Remnants of its former course are still partially visible in the current landscape, and in some cases even in the direction of Zagreb's streets. We have selected eight representative examples to illustrate the diversity of impacts, but there are, of course, many more. Utilizing old maps, particularly the early systematic measurements such as the Habsburg Military Surveys, opens the door to answering numerous eco-historical questions – how the river influenced human settlements and the environment, and how humans influenced the river. River course reconstructions provide valuable insights into past times and help us better understand specific historical circumstances. For example, understanding why the Ottomans never seriously attempted to attack Zagreb becomes easier when we consider the nature of the Sava River, which essentially acted as a natural fortification for Gradec and Kaptol.

While geoinformatic approaches to the Habsburg Military Surveys have limitations, stemming from their inherent inaccuracies (especially in the First Survey), it is still possible, with some minor adjustments, to obtain a reliable depiction of the river's past course. River course reconstructions offer fascinating and novel perspectives on rivers, particularly in the vicinity of urban areas that we now perceive as “passive” and “tamed.” A single glance at the map of the Sava River in the Zagreb area during the 18th and 19th centuries reveals the true and enduring potential of this river, which, let us not forget, just six decades ago exemplified its formidable might by causing significant flooding in the adjacent urban areas, thus serving as a vivid reminder of its power.

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Rad donosi, u obliku kartografskih priloga, rezultate geoinformacijske rekonstrukcije toka rijeke Save na širem području grada Zagreba u 18. i 19. stoljeću na temelju karata Habsburške Monarhije. U komparaciji dobivenih rezultata s današnjim stanjem sagledavaju se prirodne (nastale usred hidrografskih i morfoloških djelovanja rijeke) i antropogene promjene toka rijeke Save. Izdvojeno je osam primjera koji oslikavaju te promjene – bilo da je riječ o onima danas jasno vidljivima (na primjeru položaja prometnica i naselja) bilo onima, danas skrivenima, koje je urbanistički razvoj Zagreba (prije svega prema južnoj obali rijeke) »progutao« u većoj ili manjoj mjeri.

Ekonomska i ekohistorija
Economic- and Ecohistory

Časopis za gospodarsku povijest i povijest okoliša

Journal for Economic History and Environmental History

Volumen XVIII. / Broj 18
Zagreb – Samobor 2022.
ISSN 1845-5867
UDK 33 + 9 + 504.3

Nakladnici / Publishers:

Društvo za hrvatsku ekonomsku povijest i ekohistoriju
Society for Croatian Economic History and Environmental History
Ivana Lučića 3, HR – 10000 Zagreb
sites.google.com/site/ekoekohist/

Izdavačka kuća Meridijani
p.p. 132, 10430 Samobor
tel.: 01/33-62-367, faks: 01/33-60-321
e-mail: meridijani@meridijani.com
www.meridijani.com

Sunakladnik / Co-publisher: Ekohistorijski laboratorij Centra za komparativnohistorijske i interkulturene studije Filozofskog fakulteta Sveučilišta u Zagrebu Ivana Lučića 3, 10000 Zagreb, Hrvatska www.ffzg.unizg.hr; <http://ckhis.ffzg.unizg.hr/>

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UDK oznake članaka / Article's UDC markups:

Ivica Zvonar

Prijelom / Layout:

Saša Bogadi

Za nakladnike / Journal directors:

Petra Somek, Hrvoje Petrić, Domagoj Tončinić

ISSN 1849-0190 (Online) ISSN 1845-5867 (Tisak)

Tisak / Print by:

Bogadigrafika, Koprivnica 2023.

Adresa uredništva / Mailing addresses:

Hrvoje Petrić (editor/urednik)
Odsjek za povijest, Filozofski fakultet
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Tiskano uz djelomičnu potporu Grada Koprivnice

Print partially supported by the City of Koprivnica

Na naslovnici / Cover:

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