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Consequences of the River Bank Erosion in the Southern Part of the Pannonian Basin: Case Study – Serbia and the Republic of Srpska

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Abstract

Bank erosion is one of the dominant geomorphological processes in the southern part of the Pannonian Basin. The consequences of bank erosion on the territory of Serbia and the Republic of Srpska were analysed including landscape degradation (lateral migration), socio-economic (land loss, land use changes, economical losses) and geopolitical consequences. The analysis covered the Danube River and the Drina River as the international river border, the Bosna River as a boundary watercourse along the administrative border and the Kolubara River with dominantly antropogenic impacts on the rate of bank erosion . The total amount of lateral migration of the Kolubara riverbed for the period 1925-2010 is 155 m and the Bosna riverbed for the period 1958-2012 is 352.2 m. Lateral migration has caused serious problems through loss of arable land (approximately 40 ha) and land use changes in both basins, but also economic loss due to the reduction of agricultural production. For the protection of the Bosna River banks it is necessary to invest 7.91 million Euros, while in the case of the Kolubara River for their recovery 2.54 million Euros were needed. The geopolitical consequences due to the bank erosion acting and lateral migration of the river course were analysed on three paradigmatic examples: the Danube River (the border between Serbia and Croatia), Drina River (the border between Serbia and Bosnia and Herzegovina) and Bosna River (the border between the Republic of Srpska and the Federation of B&H). The results of this investigation are applicable in the field of water and soil resources management, hydro-technical works, geopolitical studies, as well as in different aspects of the environmental protection.

Keywords: *bank erosion, lateral migration, land loss, land use changes, environmental aspect, geopolitical consequences*

Rezumat. Consecințele eroziunii malurilor în sudul Bazinului Panonic. Studiu de caz – Serbia și Republica Srpska

Eroziunea malurilor este unul din procesele geomorfologice predominante în partea de sud a Bazinului Panonic. Consecințele eroziunii malurilor de pe teritoriul Serbiei și al Republicii Srpska au fost analizate din punct de vedere al degradării peisajului (migrare laterală), socio-economic (pierderi de teren, schimbări în utilizarea terenurilor, pierderi economice) și geopolitic. A fost analizat fluviul Dunărea și Drina, ca râuri ce formează granițe naturale, râul Bosna care formează iar o graniță administrativă și râul Kolubara unde predomină impactul antropic asupra eroziunii malurilor. În perioada 1925-2010, patul albiei râului Kolubara a migrat lateral cu 155 m, iar cel al râului Bosna cu 353,2 m în perioada 1958-2012. Migrarea laterală a generat probleme serioase din cauza pierderii de teren arabil (aprox. 40 ha) și a schimbărilor în utilizarea terenurilor din ambele bazine hidrografice, precum și pierderi financiare datorită reducerii producției agricole. Pentru protecția malurilor râului Bosna sunt necesare investiții de 7,91 mil. EUR, iar pentru râul Kolubara alte 2,54 milioane. Consecințele geopolitice ale eroziunii malurilor și migrării laterale a cursului râului au fost analizate prin intermediul a trei exemple paradigmatice: fluviul Dunărea (granița dintre Serbia și Croația), râul Drina (granița dintre Serbia și Bosnia și Herțegovina) și râul Bosna (granița dintre Republica Srpska și Bosnia-Herțegovina). Rezultatele acestui studiu sunt utile pentru managementul resurselor de apă și sol, lucrărilor hidro-tehnice, studiilor geopolitice, precum și pentru diverse aspecte ale protecției mediului.

Cuvinte-cheie: *eroziunea malurilor, migrare laterală, pierdere de teren, schimbări în utilizarea terenurilor, aspect de mediu, consecințe geopolitice*

Introduction

Bank erosion and river lateral migration are the most important geomorphological processes in the alluvial plain in Serbia and the Republic of Srpska. The causes of river bank degradation are various and complex and usually result from the interaction between natural processes and human activities. The map of the first trend of relative relief of Serbia has shown that almost the whole terrain in the southern Pannonian Basin has been under tectonic movement of slow subsidence (Manojlovic et al., 2004). Tectonic characteristics of this area, more precisely the Savski Fault, had influenced the orientation of the hydrological network in the southern part of the Pannonian Basin. During the Late Paleogene and the Early Neogene the Pannonian Sea and small bays had existed on the territory of Serbia and the Republic of Srpska. After regression, fluvial erosion started and formed today's hydrological network of the Danube River. With tectonic movements (subsidence) in the southern part of the Pannonian Basin, significant decrease of stream velocity happened, and caused sediment accumulation in the riverbeds, bank erosion, forming of meanders and changes in the river course. Sometimes, human activities can cause changes in river morphology and bank erosion rates that are more significant than those induced by natural events (Surian & Rinaldi, 2003; Gregory, 2006; Hooke, 2006; James & Marcus, 2006; Roksandic et al., 2011; Vandenberghe et al., 2012; Dragicevic et al., 2012a).

In the region, the consequences of changes in river course and bank erosion intensity have been well-documented in the literature (Blanka & Kiss 2011; Kiss et al., 2008; Rădoane et al., 2010; Zaharia et al., 2011; Loczy, 2011; Floriou, 2011; Dragicevic et al., 2012a). There were many changes in a fluvial landscape in the southern part of the Pannonian Basin which caused serious environmental, socio-economic and geopolitical consequences. In previous research in Serbia and the Republic of Srpska, the rate of bank erosion, land loss and land use changes caused by bank erosion, sediment accumulation and flooding were fully investigated only in the Kolubara River Basin (Dragicevic, 2002, 2007; Dragicevic et al., 2008, 2012a, 2013) and in the Serbian part of the Tisa Valley (Popov et al., 2008).

In this paper, the consequences of bank erosion on the territory of Serbia and the Republic of Srpska were analysed with regard to landscape degradation (lateral migration), socio-economic (land loss, land use changes, economical losses) and geopolitical consequences. The analyses included the Kolubara River, with dominantly antropogenic impacts on the bank erosion intensity, Drina River and Danube River as the international river border, and the Bosna River as a boundary watercourse along the administrative border (between the Republic of Srpska and the Federation of Bosnia and Herzegovina).

Beside its fundamental significance, the results of this investigation are applicable in the field of water and soil resources management, hydro-technical works, geopolitical questions, as well as in different aspects of the environmental protection. Bank erosion and the riverbed movement can become a geopolitical and security issue if along the river the border is drawn between states or other political-territorial entities. The research is a first attempt in Serbia to explain complex effects of the river course diversion, which is obviously realised without long-term planning and respect for the principles of sustainable management. The results of our study should provide information for relevant institutions responsible for planning and protection against bank erosion.

Study Area

The research covered the southern edge of the Pannonian Basin in Serbia and the Republic of Srpska, or the watercourses with the direction which is predominantly determined by the Savski Fault. All streams in the analyzed sectors have meridional direction, with the phenomenon of laretal migration and bank erosion. The analyses included the Danube River and the Drina River as the international river border, the Bosna River as a boundary watercourse along the administrative border (between the Republic of Srpska and the Federation of Bosnia and Herzegovina) and the Kolubara River with dominantly antropogenic impacts on the bank erosion intensity.

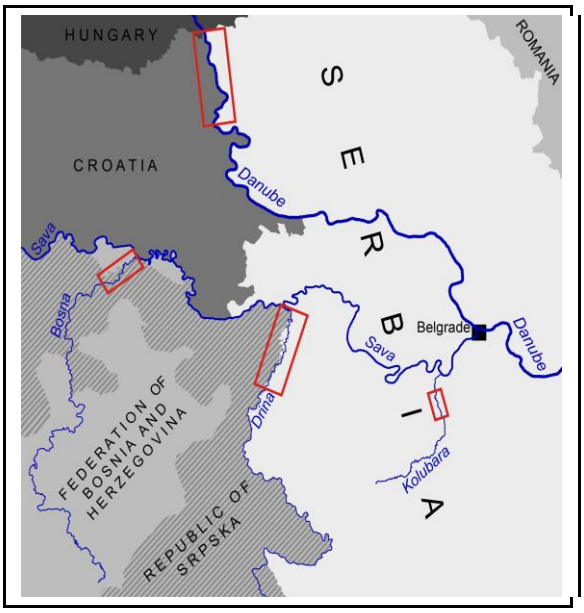

Fig. 1: The analyzed watercourse sectors in Serbia and the Republic of Srpska

The Danube is an international river that flows through 10 European countries. In Serbia, the length of its course is 588 km, of which a length of 367 km is a river border with Croatia (137.6 km) and Romania (230 km). Therefore, this study has not only national but also regional significance. The analysis included the Danube sector from its entering the territory of Serbia to the confluence of the Drava River.

The Drina River is the largest tributary of the Sava River, not only by flow length (346 km) and drainage basin area (19946 km^2), but also by discharge (Q_{av} - 395 m^3s^{-1}). Most of the border (river/lake) between Serbia and Bosnia-Herzegovina (Republic of Srpska) follows the Drina River. Compared to the total length of 382.8 km, the border drawn by the rivers and artificial lakes is 228.5 km long (59.7%). Analysis covered the lower course of the Drina River.

The Bosna River drains the central parts of the Dinaric Karst Massif and the central part of Bosnia and Herzegovina, and after the course of 70 km, by the southern border of the Pannonian Basin, empties into the Sava River. The drainage basin area is of 10662 km^2, course length of 275 km, mean annual discharge at the confluence with the Sava River is 180.5 m^3s^{-1}, specific discharge 15.6 $ls^{-1}km^{-2}$, and the average fall is 1.48 m/km. Characteristic features of the lower part of the Bosna River come to the fore on the section from the Modrica bridge to the confluence with the recipient - the Sava River, with a total length of about 25 kilometers, which is the course length in the studied sector of the Bosna River. In this section, the water is formed in its own alluvium, with frequent sharp curves and meanders, so the watercourse riverbed is unstable in time and space.

The Kolubara River Basin is situated in the western part of Serbia and covers 4.12% of Serbia. The Kolubara River is the last major tributary of the Sava River, and according to course length (86.4 km) and drainage basin area (3641 km^2), is classified as a medium-size river within the territory of Serbia (Dragicevic et al., 2012b). The study area is characterised by intense lateral dynamics of the river channels, making it vulnerable to the risks induced by fluvial dynamics because of the economic importance of the area and the significant density of the agricultural population and settlements. The analysed part of the Donjokolubarski Basin, where the land parcels were changed due to lateral erosion, is occupied by the villages of Drazevac, Konatice and Poljane. The area is mostly agricultural, and the predominant land use is arable land.

Method

Analyses of topographical maps, aerial photo and orthophoto images were used in previous research aiming at determining the lateral migration of the Danube, Drina, Bosna and Kolubara riverbeds. The methods of monitoring bank erosion, lateral migration and its consequences in the study area were divided in two groups: remote sensing (Danube and Drina River) and on-site measurements (Kolubara and Bosna River). To estimate the rates of the Kolubara's bank erosion, land loss and land use changes, several main sources of remote sensing data were used: topographical maps in the scale of 1:50000, cadastral maps in the scale of 1:2500 dating from 1967, aerial photo images from 1981 and orthophoto images from 2004 and 2010. Based on the topographical maps from 1958, 1976 in the scale of 1:50000 and orthophoto images from 2001, 2006, 2008 and 2012, we estimated the area of diminished land parcels and their land loss caused by the Bosna River bank erosion. Comparing the data from different periods, we determined the evolution of the river course over different periods. The position of the river course was marked in each data source. River bank lines were digitized, and the bank erosion extent was calculated using GeoMedia Professional 5.0. On-site measurements were conducted in the Kolubara's river banks using Trimble 5800 GPS receiver system (accuracy ± 1.5 cm).

The changes in the riverbed position evolved through the meandering process on the unstable river profiles. The determination of the rate of riverbed migration comprises the horizontal movement distance between the first and last year of the observed period. Therefore, the ratio of the old to new position was determined for each river bank on the river profiles where the changes occurred. The total amount of riverbed migration was calculated as the average deviation of the maximum distances at all of these profiles on the left and right sides of the riverbed.

The river borders are result of the predominantly applied natural-geographic demarcation principle, and from the geographical environment in which they were drawn, they belong to the type of hydrographic boundaries. There are two basic methods for determining the borders on the river courses: a) by the centerline of the river, and b) by the centerline of the waterway or mainstream line (thalweg included). The first rule is older, and today only used for smaller streams. The second rule has been in use since the early nineteenth century and is used for large, navigable rivers (Ilic & Stankovic, 2005). When actual demarcation, this is just a starting point for negotiations and intergovernmental contract between the interested parties. It is usually difficult to adhere to the above mentioned regulations literally, becauses rivers have branches and deltas, riverbeds are meandering, by erosion of one river bank, and accumulation on the other, river courses during major floods can completely change, middle of a river and

thalweg move depending on the water level even within a year (Ilic & Stepic, 1994).

Discussion

Environmental Aspects of River Bank Erosion

The environmental aspects of the riverbank movement was analysed in detail, and shown in the intensity analysis of the bank erosion, lateral migration and landscape degradation as a result of intensive bank erosion (Dragicevic et al., 2012a, 2013). In comparison with the bank intensity of the Danube River and the Drina River, where, due to the lack of the field measurement, historic-geographic and mapping sources were used, there are very detailed measurements of the riverbank movement for the Bosna River and the Kolubara River.

The amount of the horizontal shift of riverbed by the alluvial plain is a very important indicator of the process dynamics. It provides the basic argument for the adoption of measures to protect bank areas. The more so, because the area of the studied rivers meandering is populated, and, except the households, the land plots of very high quality are the most vulnerable. In determining the movement amount, the river sectors at the beginning and end of the given time period were compared. To present this work, only the average deviation value of the left and right meander peak points in relation to the initial state will be reported. This provides insight into the spatial-ecological component, important for the weak points of defence in the alluvial plain which were not threatened in the period of history. However, the situation is more complex because it involves a process within an undefended part of the alluvial plain, which is not covered by this presentation, but is also economically important and is the first targeted by erosion.

In the research sector, the Kolubara River length was 7.5 km in 1925, 8.2 km in 1967, 9.6 km in 1981, 10.06 km in 2004 and 10.14 km in 2010. The dynamics of the riverbank migration were observed by analysing the Kolubara riverbed movement during the periods of 1925-1967, 1967-1981, 1981-2004 and 2004-2010 (Roksandic, 2012).

In the lower course of the Kolubara River, comparing the 1:50000 topographic maps from 1925 and 1951, it was calculated that the Kolubara riverbed moved by 36.8 m, of which 22.3 m to the left, and 14.5 m to the right. The average annual movement in this period was 1.41 m. During the period of 1951-1967, it was calculated that the Kolubara river course migration totaled 32.8 m, of which the course moved by 11.8 m to the left, and by 21 m the right. The average annual movement in this period was 2.05 m. During the period 1967-1981, the total amount of the Kolubara River migration was 57 m, when the left bank moved by 32.5 m and the right bank by 24.5 m. In this period, the average riverbed movement was 4.1 m per year. Further comparison of aerial photo images from 1981 and orthophoto images from 2010 show that the Kolubara riverbed stabilized, because during 29 years its course moved by 28.9 m, of which 13.1 m to the left, and 15.8 m to the right. This would mean that it moved annually by 1 m, which is approximately four times less than in the previous observation period (1967-1981), when the Kolubara river course on the average shifted by 4.1 m.

The geodetic survey of the Kolubara river bank near the bridge in Drazevac, showed that its average movement due to flood wave in June 2010 was 3.06 m, and in the most endangered area 6.16 m. This resulted in the loss of the bank part in front of the bridge, which initiated the urgent bank fortification making to protect this important infrastructural object (Dragicevic et al., 2013).

Geomorphological analysis of dominant erosion processes and their intensity quantification of the Kolubara River Basin, was done in previous research (Dragicevic, 2007). The results showed that the study area was characterized by intense lateral dynamics of the river channels. The bank erosion (Roksandic et al. 2011; Dragicevic et al. 2012a), sediment yield and sediment accumulation (Dragicevic, 2002), floods and landslides (Dragicevic 2012a; 2012b), soil and water pollution are the major environmental problems in the Kolubara River Basin.

Although the alluvial rivers meandering is a natural process, it must be noted that in the case of the Kolubara River, human impact is responsible for its intensification. The area of the Lower Kolubara, where the studied sector of the river is located, mostly belongs to a lignite mining basin, whose exploitation in the thermal power plants provides half the electricity in Serbia. This major economic giant was not uncommon with the fact of relocating whole settlements to allow space for new surface excavations, and the river courses moving was already common practice. The most drastic example, one that is relevant for the current situation of the Kolubara River and its raging at the valley bottom, is shifting of the Pestan riverbed, which is the right tributary of the Kolubara River and was formerly running in parallel in a length of 20 km. In fact, nothing was done to increase the capacity of the new riverbed and adjust to a much higher discharge. The bypass was performed in 1959, and the consequences of the Kolubara River "non- fitting" in the new riverbed are visible even today.

In the studied sector (Fig. 3), the Bosna River length was 25.8 km in 1958, 24.9 km in 1976, 27.6 km in 2001, 27.1 km in 2006, 24.6 in 2008 and 23.9 km in 2012. In the Bosna River lower course, by the

analysis of the topographic bases and ortophoto images of the research area, the average shift of the Bosna riverbed in the period 1958-2012 amounted to 132.4 m. However, it is important to emphasize that the value of the maximum movement in the period 1958-2006 amounted to 1055.3 m. Apart from this period, the maximum values of the period 1958-1976, 517.8 m, 1958-2001, 934.7 m, 1958-2008, 467.0 m are also significant and, and the period from 1958 to 2012, 506.2 m. The analysis showed that the average movement in the period 1958-2012 amounted to 90 m to the left, and the maximum value of this movement in the analysed period was 330.1 m. In terms of shift to the right, it was found that its average value in the period 1958-2012 amounted to 156.1 m, and that in this period the value of the maximum movement in this direction was 506.2 m.

Almost in the entire sector, the concave curve banks are damaged, vertically notched by mainstream high waters and subject to constant erosion. It is a general phenomenon that in the bands, the concave banks are being destroyed, while the silt is deposited on the convex banks. In each occurrence of high waters, due to the high saturation of water with silt deposit, on all watercourse curves, on the concave side of the bend, there is a minor displacement on the riverbed within the inundation, while on the convex side of the bend there is a deposit of silt. The global movement of minor riverbeds, during inundation, is routed to the mainstream course formed by the floods, with a tendency to form a common corridor of low and high waters.

Socio-Economic Aspect of the Consequences of the River Bank Erosion

Because lateral erosion is more intense, the concave river banks on the side of the river often collapse, and farmers who have arable land parcels on the river bank (in the area of the three villages that the Kolubara River flows through) lose the parts of the parcels that were carried away by the river.

In the lower part of the Drina River Basin, the bank erosion caused many problems with the demarcation between two countries. In this area, the Serbian farmers who had arable land parcels on the right river banks in Serbia (100 years ago), beacause of very intensive lateral erosion, lost the parts of the parcels or whole parcels. In recent time, their land parcels have been located in the Republic of Srpska. And vice versa! Identical problems occur along the Danube border line between Serbia and Croatia. Serbian farmers who had arable land parcels on the left river banks in Serbia (50 years ago), beacause of very intensive lateral erosion lost the parts of the parcels. In recent time, their land parcels have been located in Croatia. And vice versa!

In the analysed part of the Donjokolubarski Basin, there were 247 endangered land parcels in the villages of Drazevac, Konatice and Poljane, and 136 of them contained arable land with an area of 111.6 ha in 1967 and 72 ha in 2010, meaning that in 43 years, 35.5 % (39.58 ha) of the land allocated for agricultural production was lost. The area of 21 endangered woodland parcels was 6.9 ha in 1967 and 2.8 ha in 2010, which lost 4.1 ha (59.4 %) from its initial area. There are only three endangered pastures, and their area was 1.3 ha in 1967 and 0.6 ha in 2010. The areas of 80 sandbanks were diminished from 25.3 ha to 4.4 ha. The total area of 247 endangered land parcels was 148.3 ha in 1967 and 81 ha in 2010. Therefore, due to bank erosion, over 43 years (1967-2010), 67.3 ha of land were lost in the Municipality of Obrenovac (Roksandic, 2012).

The economic effects caused by the bank erosion were analysed, both land loss and the reduction in the agricultural production. In the period 1967-2010, the average corn yield of the study area was 4.27 t/ha, and the average wheat yield was 3.27 t/ha. These yield values corresponded with the Serbian average yields. The permanent corn production that was lost up to 2010 was 3255 t and 1271 t of wheat. However, the level of production losses was steadily increasing over time. Consequently, the final effects of the potential losses are immeasurable. The total value of the permanent losses of arable land by 2010 was 80560 USD, and the total loss in agricultural production was 634240 USD.

Based on the orthophoto images from 2001, 2006, 2008 and 2012, we have estimated the area of diminished land parcels and their land loss caused by the bank erosion of the Bosna River. Compared to the base year of 2001, when the first orthophoto images distinguished several categories of land use: arable land, forests and low vegetation, meadows and pastures, populated areas (plot areas), and gravel excavations and depots, the significant losses of areas under the above categories of the land use manners were determined. In the period from 2001-2012 42.30 ha of arable land were lost, 171.9 ha of forests and low vegetation, 0.1 ha of plot areas, 31.8 ha of meadows and pastures, and 41.9 ha of sand and gravel pits and depots.

In 2001, an initiative was launched in recognition of the Bosna riverbed condition, especially concave-eroding river banks. Further analysis revealed that along the lower Bosna River the bank revetment had to be repaired at the length of 15999 m to secure the concave river banks and stabilize the primary riverbed. To protect the concave banks, a detailed cost analysis of making the bank fortifications per running meter was done and found that the bank revetments of gabions and reno mattresses represented the best solution in terms of finance, and had practical applications because they could be

carried out of local materials (sand and gravel). Therefore, the cost of securing a concave river bank running meter is 494.93 Euros, which means for the repair the above mentioned part of the Bosna riverbed, that is, to secure the concave river banks, 7.91 million Euros are needed.

Geopolitical Consequences of River Bank Erosion

The borders on the river courses, where the river bank erosion is dominant, are often the subject of international disputes and conflicts. As a rule, these problems are particularly complicated, difficult to solve, last long and often re-establish in the post-conflict areas, as every, even the smallest concession (and they are required) - is interpreted as "national treason". This is the case on the former Yugoslav territory and can be analysed on three paradigmatic examples - on the Danube River between Serbia and Croatia, on the Drina River lower course between Serbia and the Republic of Srpska (Bosnia and Herzegovina) and the Bosna River lower course between the Republic of Srpska and the Federation of Bosnia and Herzegovina.

The origin of the problem - According to the historical-genetic criteria, the borders of Serbia and other countries emerging from the former Yugoslavia can be divided into "old" (according to the former Yugoslavian neighbours) and "new" (between the former federal units / republics of the former Yugoslavia). The "old" borders are mostly unproblematic, while the "new" are questionable and subject to mutual disputes (Stankovic, 2010). The cause of this is found in the inherited administrative-political abutment of the republics, which were traced according to the ideological needs and territorial organization of the Communist Party, and were not in accordance with the strict application of any principle (first of all, the ethnic principle) (Stepic, 1994). What is more, the internal borders have never, under any legal act, been precisely established, marked and verified neither in the parliament of Yugoslavia, nor in the parliaments of the federal units/ republics. The problem was not solved by the *Arbitration Commission of the European Un*ion (the Badinter Commission) in 1991 by its general agreement that the inter-republic borders were immutable and became inter-state borders. It turned out that this was not contributed by the mitigated solution that the borders could be subject to change by agreement, that was enacted in 1992 on the London Conference on Yugoslavia (Stankovic, 1992). On the contrary, there were diametrically opposite approaches and understandings of the border line determination, especially along the river courses. Although these are the territorially minimal disputes in question, their inter-political and geopolitical conflict potential is enormous.

The problem of the border between Serbia and Croatia on the Danube River – The border between Serbia and Croatia on the Danube River is 137.6 km long, which amounts to 53.1% of the total length of the border between the two countries. On the Danube sector, the border is from 1945, when the inner borders of the Democratic Federal Republic of Yugoslavia were formed, and when Vojvodina was established as an autonomous province within the People's Republic of Serbia. It was found that its border with the People's Republic of Croatia in part "goes by the Danube River" (Article 1, Paragraph 3 of the Law on the Establishment and Organization of the Autonomous Province of Vojvodina, Official Gazette of the People's Republic of Serbia no. 28/45). If we join the decisions of the so-called Badinter Commission in 1991and the London Conference in 1992, nothing could be disputed. Also, the official government position of Serbia is that the border is along the centerline of the Danube River waterway, which is in accordance with the international standards for border waterways, the Danube Convention and the regulations of the Danube Commission.

But Croatia is of the opinion that the inter-state border is not on the Danube, but along the boundaries of the border cadastral municipalities established in the late nineteenth century, reflecting the state of a property and legal status of that time and which at the time of Austro-Hungary belonged to the administration centers on the right side of the Danube River. As a result of e lateral migration, bank erosion, regulation and movement of the Danube riverbed to the west in the past more than 100 years, those border cadastral municipalities are now mostly on the left side of the Danube River, in the regions of Backa in Serbia, and partially on the right side of the Danube River in Croatia. They are drawn along the former Danube river course, and now abandoned meanders and river branches, causing the disputable territorial "pockets". On the left side of the Danube River there are about twenty such "pockets", which are in Croatia by the cadaster, with a total area of around 9600 ha. On the right side of the Danube River, in Croatia, a few "pockets" are only located, with a much less total area of about 910 ha (Stankovic, 2005) (*Figure* 2a).

The geopolitical issue of the disputed border on the Danube River between Serbia and Croatia is aggravated because of strained relationships, and they are the result of a violent, war destruction of the former Yugoslavia. Both countries accuse each other of great aspirations and in such conditions even the slightly controversial areas are magnified into a major problem. Moreover, these "pockets" are perceived as important geostrategic "bridgeheads" of the rival on the other side of the river and its potential "springboard" for further appearance of a new, hypothetical conflict. Croatia especially insists

that the border should not be along the current course of the Danube River, because on the left side of the river is 10 times larger area that is in Croatia by the cadaster than the one on the right side and is in Serbia by the cadaster. If the state border should be established by taking into account the cadastral boundaries, and not the international legal standards and following the practice of the borders of a navigable river, the Danube waterway, an important future Trans-European diagonal of river transport and projected Corridor 7, would be cut on a relatively short sector in several places. The problem gets wider, international dimensions, after Croatia joins the EU in 2013, when it will enter future negotiations with a strong support.

The problem of the border between Serbia and Bosnia and Herzegovina (Republic of Srpska) on the Drina River – The border between Serbia and Bosnia and Herzegovina is in the whole length with one of its two political-territorial subdivisions - the Republic of Srpska. In comparison to the total length of 382.8 km, the border drawn by the rivers and artificial lakes is 228.5 km long (59.7%).

Most of the river/lake border between Serbia and Bosnia and Herzegovina (Republic of Srpska) is located on the Drina River. In the recent history, the state border here appeared after the Berlin Congress in 1878, when Serbia gained independence, and Austria-Hungary was allowed to perform the occupation of Bosnia and Herzegovina, a province that formally remained a part of Turkey. After the Austro-Hungarian annexation of Bosnia and Herzegovina in 1908, and enhanced tensions between Austria-Hungary and Serbia, caused by the so-called Annexation Crisis, the two countries soon joined the process of demarcation.

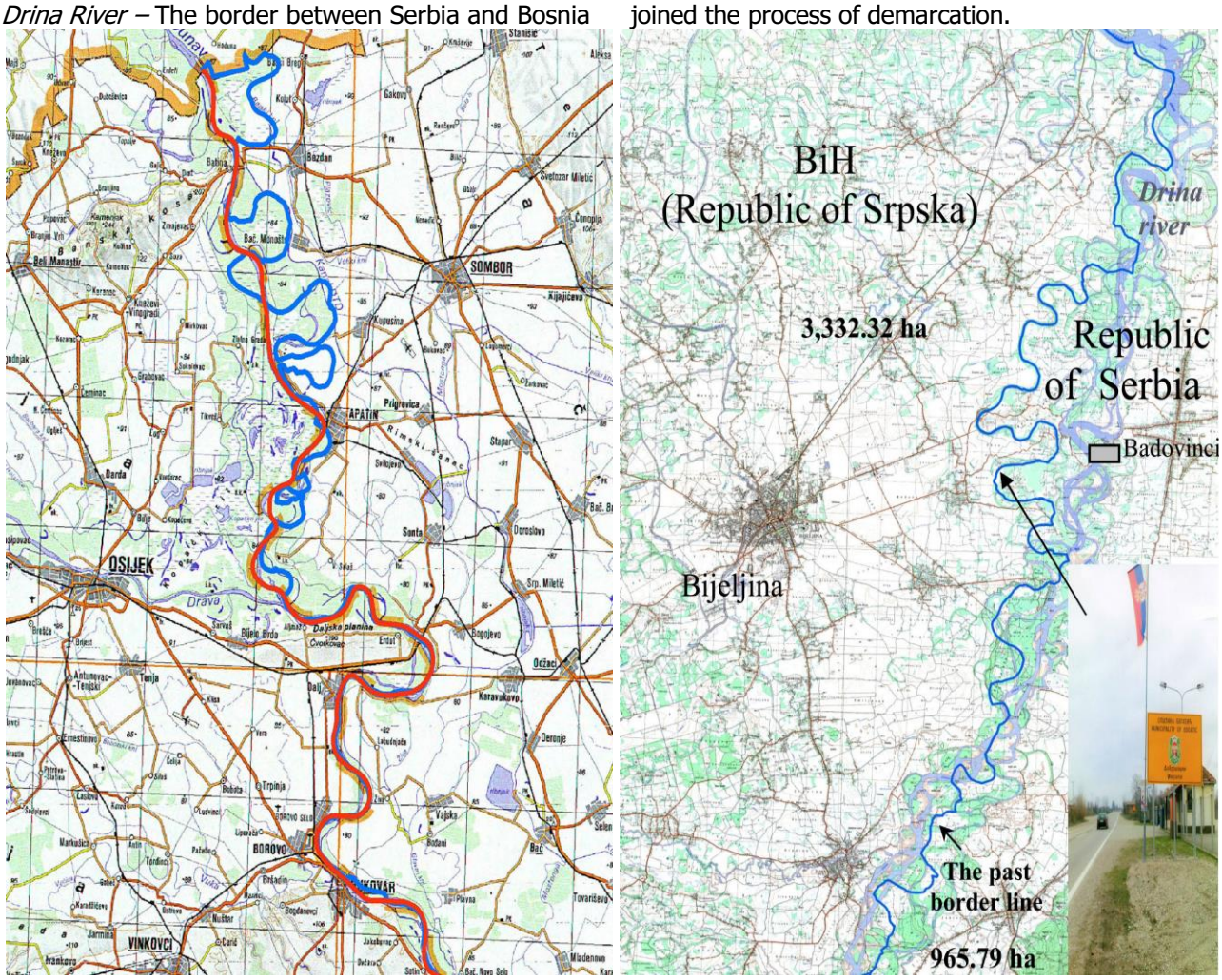

Fig. 2: The border on the Danube River between Serbia and Croatia (left) and between Serbia and Bosnia and Herzegovina (Republic of Srpska) as compared to the present-day course of the Drina River (right)

They carried out the precise geodetic land survey of the area along the river, then did the mapping display of the Drina river course, marked the disputed land and evidenced the requirements of both sides, and all printed in the *Elaborate of the land survey on the Drina River* (*Elaborat der Drina-Aufnahme*) in 1910. This was followed by the Balkan Wars and the First World War, after which in 1918, the Yugoslav state was created, and the border on the Drina River became irrelevant. Analogous to other federal units/republics, in 1945, Bosnia and Herzegovina was constituted, but, as in the case of others, its borders were not clearly defined and legally verified as well. With the disintegration of Yugoslavia in 1991/1992, i.e., with the creation of "The Dayton-Paris Bosnia and Herzegovina" in 1995, this border also was actualized as the "new" border between Serbia and Bosnia and Herzegovina.

Among other disputed issues (enclave Medjurečje as part of the Municipality of Rudo in the Republic of Srpska, and surrounded by the territory of Serbia; demarcation on the Drina River's artificial lakes and hydropower plants; part of the Belgrade-Bar railway, which passes through the Republic of Srpska in the length of 11 km), there was a problem of demarcation in the lower course of the Drina River. The river meanders through the valley and significantly alters its course each year. Variable riverbed was cut through the large alluvial fan, so on its left side, in the Republic of Srpska, the area of Semberija is located, and on the right, in Serbia, the area of Mačva. The entire lower Drina River Valley, from Zvornik to its confluence in the Sava River, there are the abandoned riverbeds in the alluvial plain that are activated during floods. Compared to the condition of 100 years ago, that is, compared with the mapping showing the active course and abandoned meanders from 1910, and set thalweg of 1883-1884, the situation has changed considerably (Map: *III Übersicht*, in: *Elaborat der Drina-Aufnahme, 1910.*). But the boundaries of the cadastral municipalities remained almost the same, and they are now (as opposed to 1910) almost off the river, but mostly on the left side of the valley. Thus, the total area in Serbia by the cadaster, located on the left side of the Drina River, is 3332.3 ha, and the total area in the Republic of Srpska, on the right side of the Drina River is 965.8 ha (*Figure 2b*).

Geopolitical issue of the unresolved border between Serbia and Bosnia and Herzegovina (Republic of Srpska) along the lower Drina River has no great conflict potential for the time being. The Drina River is not navigable (though it was so in the nineteenth century), so it would be logical for the border to be drawn along the centerline. However, the constant riverbed movement can cause problems. Also, the border line demarcated by surveying in time can run at a distance from the riverbed and cause numerous practical difficulties (in flood management, transport, land treatment ...). Identified inter-republic border (cadaster border) is mainly located several hundred meters west of the present Drina riverbed. "Pavlovića most" near Badovinci and the border crossing next to it were built entirety on the area belonging to Serbia by the cadaster, and the border is even several kilometers to the west. Everyday life, transport and people's work on both sides of the river is facilitated by a small degree of the border barriers. Pursuant to the good relations between Serbia and the Republic of Srpska, and their agreement on the so-called Special and Parallel Relations, proceeded from the Dayton-Paris Agreement in 1995, the demarcation could be resolved without major problems. However, possible complications may arise as a reflection of the strained relations within Bosnia and Herzegovina - between the Federation of Bosnia and Herzegovina and the Republic of Srpska.

The problem of the border between the Republic of Srpska and the Federation of Bosnia and Herzegovina on the Bosna River - After completion of the Civil War, based on the *General Framework Agreement for Peace in Bosnia and Herzegovina*, reached at the U.S. "Wright-Patterson Air Force Base" in Dayton, Ohio, USA, 1-21 November 1995, and definitely accepted and signed in Paris on the 14 December 1995, Bosnia and Herzegovina was created as a state of two "entities" – the Federation of Bosnia and Herzegovina and the Republic of Srpska. One of the key principles of the constitution was the division based on the ratio of 51% of the territory to the Federation of Bosnia and Herzegovina "entity", and 49% to the Republic of Srpska "entity" (at the expense of the Republic of Srpska, this principle from the very beginning was not fully respected). "Entity Border Line" was set at 1:50000 scale maps, which included possible deviation of about 50 m. Special Article was related to the sectors of the inter-entity border lines drawn by the rivers. Accordingly, it is concluded that the "line will follow natural changes" and "artificial changes in the river course will not affect the position of the border line between the entities", but leaves room for correction by the mutual agreement of the entities, particularly "in the case of sudden natural changes in the river course (land separation and cutting of the new riverbed)" (Lukic & Popovic, 1996).

The characteristic part of the inter-entity border lies between the Republic of Srpska and west (Odžak) fragment of a two-part Posavski Canton of the Federation of Bosnia and Herzegovina. In "Approximate description of the Republic of Srpska border line" is stated that from the confluence of the Bosna River into the Sava River near Šamac the "border line runs along the Bosna River to the trigonometer 93 (which is located on the right bank