Chapter 5
Hydromorphology of the Lower Drava

Ulrich Schwarz

Abstract Together with the Sava, the Drava is the most important tributary of the Danube flowing from west to east. In contrast to the Sava, however, the hydrological and sedimentological regime of the Drava is mainly driven by the Alps. The headwaters of the upper Drava and the most important tributary, the upper Mura, show glacial regimes and their sediment load mainly originates from the Central Alps and partly from the Southern Calcareous Alps. The Drava follows in broad valleys with braided channel pattern and narrow gorges in Austria and Slovenia before it enters the lowland. Downstream the Mura confluence, the river tends to present anabranching characteristics, but with decreasing slope turns to the meandering type. Regarding the sediment in the middle course, all kinds of gravel fractions occur whereas on the lower course sandy fractions prevail. Lateral channel shift is also typical along the lower course. The upper course and parts of the middle course in Austria, Slovenia, and Croatia are used for hydropower generation and affect the sediment balance as well as the long-term hydromorphological regime of the entire lower course. Hydromorphological inventories of the middle and lower Drava and the lower Mura since the late 1990s and hydromorphological assessments since 2005 indicate still rich riparian ecosystems under changing conditions. The need to observe and evaluate the long-term effects of hydropower dams and interrupted sediment continuum as well as the changing hydrographical conditions call for the consideration of new options for river management and river and floodplain restoration in the coming decades.

Keywords Hydromorphology of drava · River section types
Hydromorphological alterations and assessment · Loss of floodplain
Overall restoration potential

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5.1 Introduction

The Drava-Mura river system with a drainage basin of 40,150 km^2 (Fig. 5.1) and an average discharge of about 550 m^3 s^{-1} is the third largest in the Danube Basin. It is predominantly influenced by Alpine conditions in the headwaters namely by discharge and sediment budget. Huge gravel deposits dominate in the basins of Graz and Klagenfurt and again downstream the Drava breakthrough in Slovenia accumulated along the foothills expanding downstream to the Mura confluence. Here the river has a strong mountainous (Alpine) character. The relief of the Lower Drava consists mostly of lowlands with Quaternary sediments and loess-mantled terrace systems. The course partly follows geological lineaments (e.g. high banks in Hungary). Also the lower course is dominated by sands and silts and the banks have much lower cohesion than those in the neighboring lower Sava system. Therefore, the lower Drava used to be characterized by strong lateral shifting and meandering under natural conditions.

The area of the Drava confluence with the Danube, the Kopački Rit, is still the largest riparian wetland (roughly 25,000 ha area) of the entire middle Danube (i.e. from Bratislava on the Slovakian-Hungarian border to the Iron Gate/Djerdap on the Serbian-Romanian border). This triangular wetland of international importance (Ramsar site) lies in a geomorphological depression, and subsidence is compensated by accumulation of fine material over millennia. The north-to-south Hungarian Danube section ends at a resistant loess steep bank (Erdutski breg), where the river turns 90° and then again nearly 180° following the steep right bank towards Vukovar in eastern direction. The confluence situation and the strongly

Fig. 5.1 The Drava River Basin covers territories in Italy, Austria, Slovenia, Hungary and Croatia

accumulating sandy lowland Drava River, reduces the slope of the Danube channel to 0.00001. As a consequence, floods are lasting long, up to three months in the lowest-lying areas. (This is one of the reasons why the area was not drained and ameliorated.) This situation is not typical for the still alpine Danube in this section. Downstream the Tisa and Sava confluences, just within the next 100 river km, the Danube changes its entire hydromorphological regime. The Drava has been of great importance for the survival and rejuvenation of the Kopački Rit area.

Regarding the drainage network of Drava and Mura rivers, the catchment is clearly structured in the larger Alpine tributaries coming mainly from the north (the Isel, Möll, Lieser) and by the only major right-bank tributary, the Gail. From the north the only and by far largest tributary, the Mura, enters the Drava just upstream of its lower course at about rkm 235. (The contemporary length development of the river was observed for the last about 40 years and indicate discrepancies of several rkm due to shifts and cutoffs.) All typical channel pattern types, from straight over braided to meandering, are present in a broad range. Downstream the Mura confluence, the Drava is of transitional type from anabranching towards meandering.

The hydrological regime is determined by the alpine region. The highest discharge occurs between May and July. The Upper Drava has still a glacial regime (climatic change with fast melting glaciers) whilst the Mura, its most important tributary, has a nival regime (peak already in May). The higher discharge in autumn is due to the more Mediterranean precipitation pattern in the middle-southern (including parts of the Southern Alps) and lower course of the river, but is not predominant as along the Sava River, which is strongly influenced by its Balkan tributaries. The natural water level fluctuation is 5–6 m near Botovo (Croatia, downstream of the Mura confluence), the mean long-term annual average of discharge ranges between 237 $m^3 s^{-1}$ (low water; absolute minimum around 70 $m^3 s^{-1}$), 526 $m^3 s^{-1}$ (mean water) and 850 $m^3 s^{-1}$ (high water). The discharge for the 10-year flood is about 2,100 $m^3 s^{-1}$ and the 100-year flood about 3,200 $m^3 s^{-1}$.

5.2 River Section Types and Reference Conditions for the Lower Drava

River section types are meant to describe river stretches with prevailing hydromorphological conditions based on so-called *reference conditions* without human intervention and were developed for the lower Drava and Mura rivers in earlier studies (Schwarz 2007) using historical map analysis, as a basic framework for hydromorphological assessments and for restoration options (Schwarz 2013).

The Drava hosts several stretches with at least near-natural features—here illustrated by two photographs (Figs. 5.2 and 5.3).

The following presentation and hydromorphological assessment focus on the lower Drava reach from the Mura confluence (rkm 235) to the mouth into Danube. The two main river section types for lower Drava are

Fig. 5.2 Two examples for reaches serving as potential reference sites. Just 10 rkm downstream of the Mura confluence the anabranching river builds gravel bars and islands (photo by Arno Mohl)

Fig. 5.3 Two examples for reaches serving as potential reference sites. One of the most dynamic meander reaches is at about rkm 180, highlighting the driving force, the lateral shift of river channels: erosion of land on the one side, rejuvenation of habitats on the other side (photo by Darko Grlica)

- transitional anabranching from the higly dynamic partially braided Drava upstream the Mura confluence to the meandering downstream (D-II, rkm 235–185) and
- meandering large lowland river with sand bed and extensive floodplain (D-III, rkm 185) (Figs. 5.2, 5.3, and 5.4).

The morphological description of the reference conditions offers a comprehensive way to compare the current situation with the reference state of a river section and indicate changes in the fluvio-morphological processes. Assessments for the entire riverine landscape provide valuable information on the targets of long-term restoration.

The detailed description of the reference conditions of section types should comprise available data on the position in the river continuum, morphological river type, channel width, valley floor shape, slope and characteristics of the valley, channel planform and pattern, rate of lateral shift, longitudinal profile (channel slope and structure, flow characteristics and variation), river bed structure and substrate, cross section characteristics and with/depth variance, bank structure, basic flood indicators as well as properties of the riparian landscape (substrates, forms and vegetation) (Schwarz 2007) (Fig. 5.5).

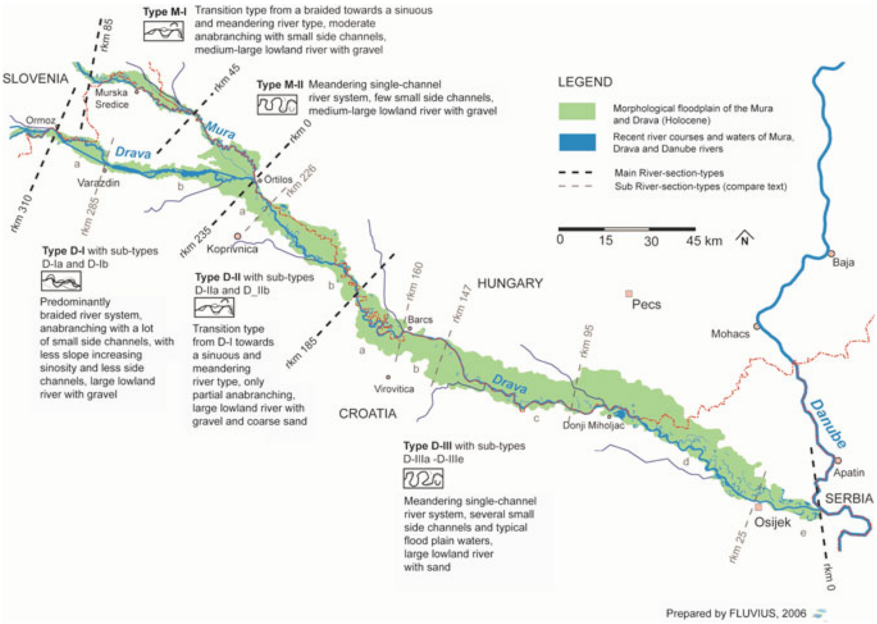

Fig. 5.4 River section types of the lower Drava and Mura system

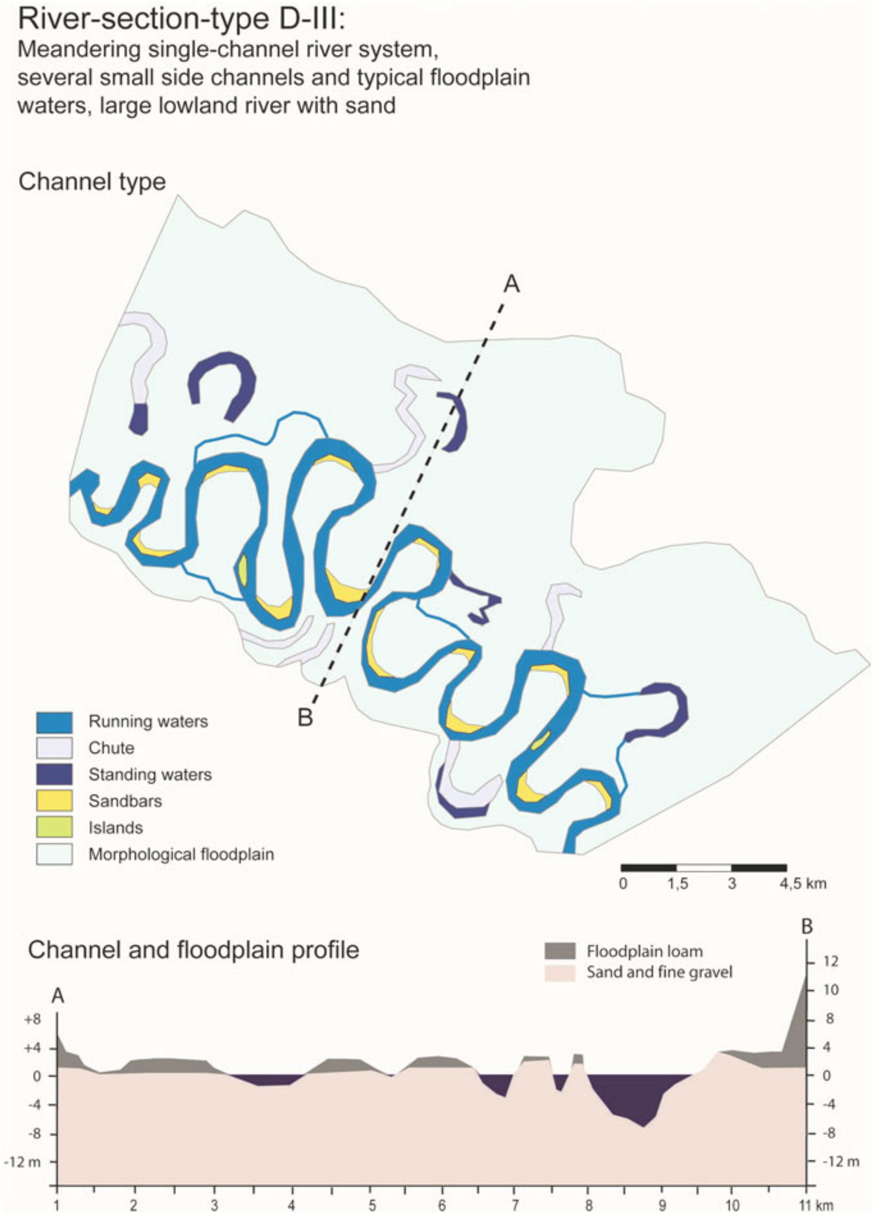

Fig. 5.5 Visualisation of the main river section type for lower Drava (Schwarz 2007)

5.3 Hydromorphological Assessment

For the International Association of Danube Research (IAD) a first pilot survey and physical habitat assessment based on the CEN Standard from 2004 (CEN 2004) was conducted between 2005 and 2007 (Schwarz 2007). For this assessment, the Lower Drava downstream the Mura confluence was surveyed by boat and over land. A GIS database was developed to allow an easy and fast analysis of about 400 longitudinal assessment stretches of individual length, for which channel, each left and right bank and floodplain was assessed (Table 5.1).

Table 5.1 Main hydromorphological parameter groups and subparameters to be assessed in a five-class scoring system. The first class (near-natural) serves as reference condition

Main parameter groups	Main parameter	Subparameters, description
Channel	Planform and cross-section (width and depth)	(a) Bankfull width (b) Entrenchment depth (to bankfull) (c) Average stream width (c) Mean depth of water body (d) Maximum depth of waterbody
	Average velocity (littoral, channel)	Flow classes: no flow (stagnant), low flow (just visible—approx. 0.3 m s^{-1}), medium flow (0.35–0.65 m s^{-1}), high flow (>0.7 m s^{-1})
	Channel type	Single thread, parallel channels, braided/meandering, braided, sinuous, constrained (natural/artificial)
	Navigation channel	No navigation channel, <1/3 of the bottom area, 1/3–2/3 regarding width and depth, 2/3–3/3 with strong impact (waves, ship propellers)
	Riverbed features	Bars, islands, riffles; accretion between groynes; large woody debris
	Channel substrates	Undisturbed, dredging, groynes/rip-rap, bed reinforcement, navigation
	Grain size of sediment (littoral, channel)	Inorganic: bedrock, boulder, cobble, gravel, sand, silt, clay, concrete and other artificial material
	Composition of channel substrates	No artificial changes, no changes in >70% of the evaluated section, reduction of grain size due to backwaters, backwaters with mostly changed flow velocity and grain size, totally impounded sections
	Channel stabilisation	Artificial material and extent
	Migration barriers (longitudinal)	Type of barrier such as dam or weir
	Longitudinal continuity	(a) Height of structures (b) Channel substrates (c) Migration barriers (for the migration capacity of biota and sediment)

(continued)

Table 5.1 (continued)

Main parameter groups	Main parameter	Subparameters, description
	Impoundment	Length
	Lateral connectivity	Whole floodplain area is connected, >50% of the floodplains are connected, 50–75% disrupted, 75–90% disrupted, <10% are connected
	Hydropeaking	To be defined for large rivers, it seems to be important to record daily changes above 15 cm
Banks/Riparian Zone	Bank profile	Type, extent natural, remaining, bank structure: fine substrate/flat (to medium) slope, versus (very) steep slope
	Extent of natural vegetation	Percentage of assessment reach
	River engineering on banks (rip-rap)	Natural > 75%, 50–75%, 20–50%, < 20%, 0%
Floodplain	Width	Active floodplain, loss of floodplain (percentage)
	Land use	Artificial, agricultural, forest/near-natural areas, wetlands, water bodies
	Oxbows/side channels, tributaries	Connection type: main channel, tributary, small side-arm, open-end oxbow (lower end open), oxbow, near-separated (no permanent plant growth on the connecting zone, gravel), large secondary channel, floodplain lake, reservoir

The second CEN Standard on the scoring (evaluation) was published after the study in 2010, but basically the parameters were assessed in a five-class system using arithmetic means, individual assessments for channel, banks and floodplains as well as an overall assessment based on the arithmetic mean of all parameters.

The CEN Standard from 2004 is currently under substantial revision moving from the pure physical habitat description towards process-based approaches (sediment, morphology, hydrological conditions considering river scaling approaches from catchment down to river reach) following the outcomes of the REFORM project (http://www.reformrivers.eu/—Rinaldi et al. 2017).

5.4 Results

5.4.1 *Basic Fluvio-Morphological Parameters*

In a first step, basic fluvio-morphological parameters and the assessment of river-banks should illustrate the current conditions before summarizing the hydrological assessment by the CEN method (see Table 5.2 and Fig. 5.6). In comparison with

Table 5.2 Major fluvio-morphological parameters in comparison with reference conditions derived from historical maps for the Lower Drava River

Parameter	Drava D-II (reference state/current situation)	Drava D-III (reference state/current situation)
Reach length (km)	68/50	295/185
Channel width (m)	100–1500/80–450	200–400/120–300
Meander wave length (km)	4/6.2	3.8/5.3
Meander amplitude	3.1/1.1	4.5/2.2
Sinuosity	1.5/1.2	2.2/1.5
Number of islands	90/15	45/6
5 meander development stages (in percent of the reach length, compare Fig. 5.6)	II (20%)/(70%)	II (15%)/(50%)
	III (60%)/(30%)	III (45%)/(50%)
	IV (20%)/(0%)	IV (35%)/(0%)
		V (5%)/(0%)

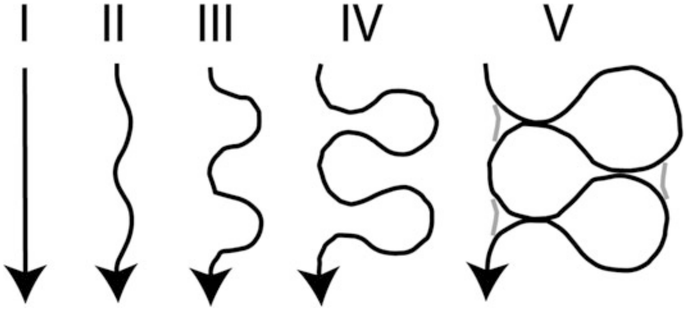

Fig. 5.6 Different stages of meander development used for the morphological characterization after Lászlóffy (in: Bognar 1990)

reference length, the reduction of the lower meandering Drava (D-III) is considerable, and reaches nearly 40%. Average channel width was reduced to up to one-third of original size for D-II and lost most of its variability in channel width.

The sinuosity (the ratio between channel length and valley length) and meander parameters, including the five stages of meander development (Fig. 5.6), clearly indicate the considerable reduction of meander activity for all sections. Only selected subsections such as D-IIIa and D-IIId (cf. Fig. 5.4) still host typical and vital meander sequences. The detailed evaluation of the distribution of meander development stages indicates mostly initial stages of meanders and very few reaches in the fifth stage (with completed cutoffs). This is the expression of the main 19th-century regulation and slow re-formation of meanders within reaches of low maintenance after World War I (declining navigation from Osijek upstream to Barcs, part of the iron curtain border between Hungary and the former Republic of Yugoslavia).

Table 5.3 Assessment of banks

Highly dynamic banks (steep banks with erosion)	41 (7%)
Shallow banks (associated with point bars)	29 (5%)
Others (mostly nearly natural banks)	266 (43%)
Old structures (collapsed rip-rap and groynes)	34 (5%)
Major bank revetments and structures (rip-rap, groynes, side-arm closures)	247 (40%)

A total length of 617 km banks of the Drava include along the studied 235 rkm stretch both riverbanks plus all major side channels and hydraulic structures such as groynes (Table 5.3). Nearly 12% of all banks are highly dynamic steep banks and shallow point bars. Together with the group of invariant banks, showing no clear trend to erosion or accumulation, over 50% of all banks are not systematically stabilized by rip-rap, which is of high value compared to western European rivers of similar size. However, the group of old collapsing structures (rip-rap and groynes) can be counted along with the major bank revetments (together 45%) as they stabilize the river over decades.

The morphological floodplain in the respective section spreads originally over 240,981 ha and only 53,693 ha has been retained as active floodplain, which is a loss of 78% (in general, length reduction in Hungary is about 82% and only 70% in Croatia).

This hydromorphological overview may reflect a too poor overall hydromorphological situation along the Lower Drava. But looking at the given river continuum (no dam within the reach) and on reach scale considering all in-channel features, banks and floodplain vegetation of the shrunken but still continuous active floodplain, a better situation can be presented.

5.4.2 CEN-Based Hydromorphologcial Assessment

As described above, the river was subdivided into about 400 reaches, allowing a precise description and assessment of all in-channel features, banks, and floodplain on both banks in a five-class assessment scheme.

5.4.2.1 Channel Assessment

At least a few scattered reaches of the lower Drava (together about 45 km out of 235 km) could be attributed to the best (blue) quality class, showing all features of a near-natural channel in comparison to the reference condition. On the other hand, only about 7% are extensively and severely modified (orange and red classes, see Fig. 5.7). About 38% belong to the quality class 2 (green), indicating a still high potential to provide most of the hydromorphological functions of reference reaches.

Fig. 5.7 Overall evaluation of the lower Drava (left) and for all rivers in the Drava and Mura river system (right) (Schwarz 2007)

The remaining 34% are rated as third (yellow) class, mostly regulated with stabilized banks. The two most significant human pressures are flood protection and hydropower generation (upstream from the studied section) (see Chaps. 9 and 10 in this volume). But for the Lower Drava in particular, the conditions maintained for the nearly non-existing navigation (mean and low water regulations) and the commercial gravel and sand extraction are significant pressures (the latter was considerably reduced since 2010).

5.4.2.2 Assessment of Banks and the Riparian Zone

Less than 20% of the surveyed banks reflect natural conditions such as steep and very shallow banks at point bars (indicating lateral erosion, accumulation and channel shifting). From the remaining 80% about the half are neutral banks without continuous bank protection, but the other half is reinforced by rip-rap. Compared to reference conditions, the potential total length of erodible steep banks is estimated 2–3 times higher compared to the current situation. The riparian vegetation shows whether the banks are intact or not, but neophytes are spreading along regulated and less frequently flooded banks.

5.4.2.3 Floodplain Assessment

Today about 78% of the morphological floodplain is cut off or excluded from the regularly flooded area. The remaining area still hosts most of the typical softwood and hardwood habitats in particular along the Lower Mura and Drava. However, flood dynamics along strongly regulated reaches are affected by incision of the main channel and aggradation of fine sediments on the floodplain (increasing disconnectivity).

The overall assessment results obtained in 2005 for the lower Drava (arithmetic mean of the channel, banks and floodplain assessments) indicate that more than the

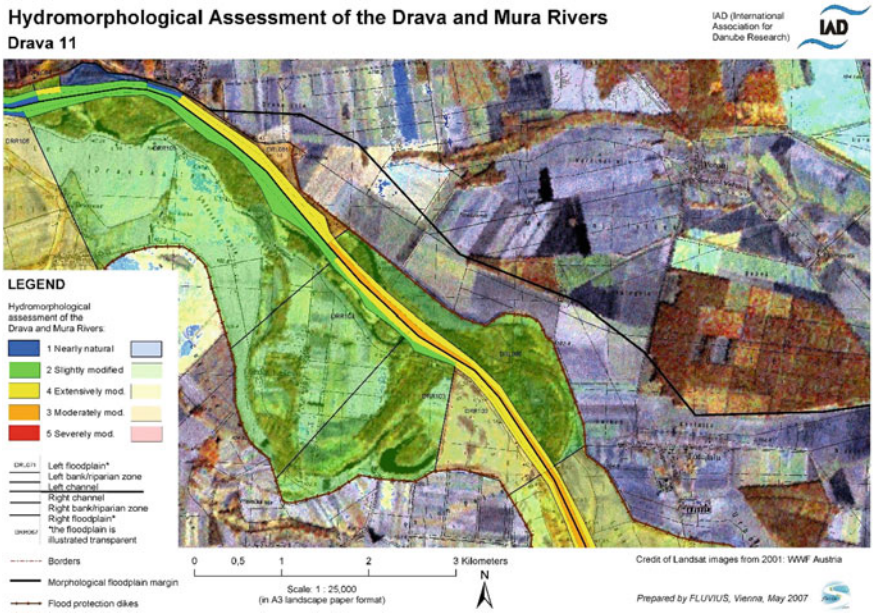

Fig. 5.8 Map example indicating the individual assessment of channel banks and floodplain as colour ribbon and segment visualisation

half of the river belongs to the first and second class and one third is in the moderately modified class three (see the left pie chart in Fig. 5.7 and the map in Fig. 5.8). This result, excellent in comparison with many other European rivers of similar size, however, should be critically viewed. The long-term processes driven by the chain of hydropower plants upstream alter the sediment balance and hydrological behavior at least for the minor but ecologically important flood events. The impact of continuous sediment deficit (channel incision) in regulated reaches, lowering of groundwater on the one side and disconnection of the active floodplain areas should lead to degradation on the long term. Looking at the catchment scale (right pie chart in Fig. 5.7), the significant alterations due chains of hydropower plants in Austria, Slovenia and Croatia are evident in the 37% ratio in the two poorest classes.

Regarding the official national classifications for the 2015 River Basin Management Plans for the Lower Drava (Hungary and Croatia), the results are not comparable for different reasons. First of all, the Water Framework Directive is based on water bodies which comprise much longer assessment units (in the case of the Drava over dozens of km for one water body) and different methods (in the case of Croatia only based on pressure related risk assessments and not on a particular hydromorphological survey and assessment). *Hungary*[1] established its own

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[1] https://www.vizugy.hu/index.php?module=vizstrat&programelemid=149.

methodology fitting the CEN standard, which refers the entire Lower Drava to the second (good) class. No significant quantitative hydrological alterations were designated (same results are stated regarding ecological status). For the 2015 report, *Croatia*[2] only uses a single pressure—impact risk assessment applying the "one out–all out" principle—as applied for biological quality elements. In other words, the worse parameter defines the final assessment. The Lower Drava was assessed to be in the third class and only the lowermost 20 km downstream Osijek (utilized by navigation) was assessed in the fourth class (being another heavily modified water body). Ecological status was mainly in class 3, hydropower reach class 4 and downstream of a most polluted tributary on Lower Drava west of Osijek to the mouth class 5. (This was the situation before 2009.)

5.5 What Happened Since 2005?

Hydromorphological inventories are time consuming and the six-year monitoring cycle (as proposed in the WFD) is very ambitious. Moreover, there are no systematic approaches how to update the extensive inventories. However, it is extremely important to observe and record all changes and developments in the following periods, even to upgrade methodologies with the new CEN standard as intended, from the pure physical habitat descriptions towards process-based approaches which also consider sediment and hydrological behaviour. For lack of space, only the most important changes and trends are presented below.

In *Austria* about 20 km of the river length of at least class 3 (yellow) (Fig. 5.7, right pie chart) were affected by hydropower impoundments and turned into the red class (two plants built downstream of Graz on the Mura). On the Upper Drava and Mura, however, several river restoration projects were carried out, not only creating continuity by fish passes, but also improving the morphological situation (e.g. between Lienz and Spittal) and locally on the Upper Mura in Styria. But the length of new impoundments exceed the length of restored river reaches.

As of particular interest in the upper catchment, climate change is most visible in the mountain ridges of the upper headwaters. At a first glance, those reaches are still in close-to-natural conditions (the glacial headwaters of the Isel, Möll and Mura). However, the retreat of glaciers and melting processes will make their discharge regimes alter considerably in the future, when glaciers will disappear or retain a minimum extension. Therefore, such river section types are under high pressure from the climate change. Since all geomorphic processes are driven by the freezing and melting of water, their discharge and sediment regime controls all processes downstream.

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[2] http://www.voda.hr/sites/default/files/plan_upravljanja_vodnim_podrucjima_2016._-_2021_0.pdf.

Although in *Slovenia* there is a new initiative to construct further hydropower plants on the Mura, no significant change has taken place yet. (Mota is under planning, six other dams have been designed, e.g. on the transboundary reach with Austria.) Local restoration projects (Life projects on the Mura, mainly side channel connections and bank improvements and along the residual Drava branch downstream of hydropower plant in Maribor), outreach additional and new bank stabilization efforts on other sections.

In *Croatia,* too, further hydropower plants were intended but are not physically in the planning stage. Water management agencies currently work on the first large-scale Life project of the country concerning river restoration. However, some additional bank stabilization works for the protection of infrastructure (bridges and flood-control dykes) and housing enlarge the length of modified banks. In particular, the most downstream reach from the Danube confluence to Osijek and further upstream to Belišće (rkm 53) was improved for navigation, by introducing low-water correction, but mainly stabilization of erodible steep banks, leading in total to a reduction of class 2 (and even some class 1) stretches. Also on the Lower Drava two new bridges north of Osijek were built (the highway is now close to completion) deteriorating the Lower Drava corridor. At the same time, commercial dredging has been significantly reduced. The general trend, strategic planning (for instance, for the reconnection of oxbows) as well as the management of flood-control dykes and stakeholder involvement are promising.

In *Hungary,* the Danube-Drava National Park stretches all along the river course. Commercial dredging was reduced within the past decade and several small improvements as side-arm reconnection and some bank removal are evident and concepts how to reconnect oxbows are under implementation (see Chaps. 19–21). A detailed mapping of the current channel centerline of the river compared to the old official rkm from the early 1980s shows discrepancies of the overall river length by meander cutoffs on the one hand and natural processes (lateral shift) on the other (see Chap. 11). Finally, the loss of about 10 rkm since the beginning of river regulation has been almost fully compensated by lateral shifting (Schwarz 2017).

In summary, further slight degradation can be observed for the Drava and Mura in general (new hydropower plants in Austria, additional bank reinforcements/regulation in Croatia) and the problem of ongoing channel incision and disconnection of active floodplain by aggradation is still unsolved. But keeping in mind the very special situation of the Lower Drava, for long decades part of the iron curtain and now dividing Hungary and Croatia, EU countries facing complicated transition processes, the establishment of the Transboundary Biosphere Reserve Mura-Drava-Danube can be seen as a positive step to preserve and restore the river corridors and their functions for the benefit of next generations.

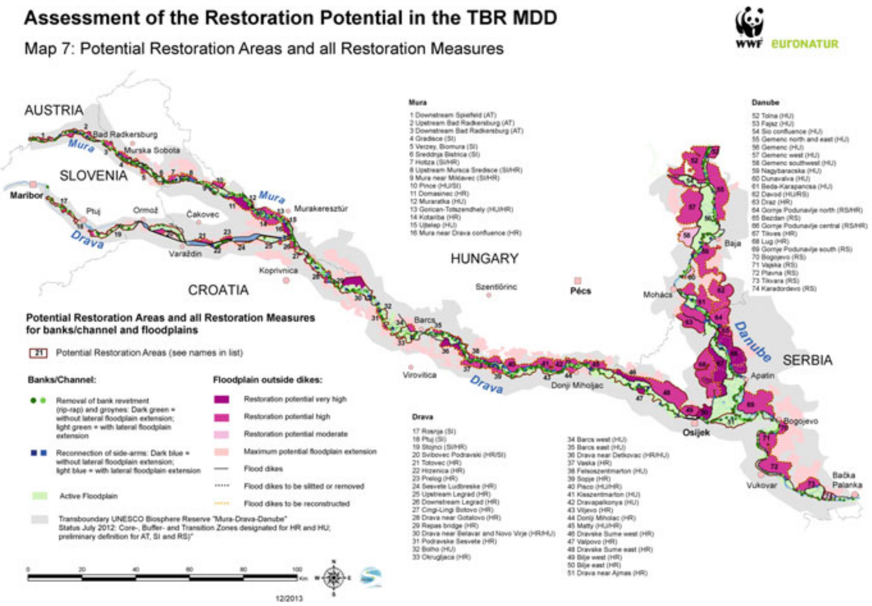

Fig. 5.9 River and floodplain restoration potential along the entire river corridors

5.6 Proposals for Restoration Since 2012

Regarding the Lower Drava stretch (rkm 0–235), a long-term (maximum) river and floodplain restoration potential was identified (Schwarz 2013), also confirmed by Croatian Waters regarding potential side-arm and oxbow reconnections and studies for several Hungarian projects, mainly within the national park. EU Life projects in both countries are under implementation (DravaLife in Croatia[3] and an oxbow reconnection project in Hungary,[4] a transboundary project).

For the respective reach 205 bank sections with a total length of 201.6 km (each 980 m long on the average) could be subjected to rip-rap and groyne removal and 46 major side-arms with a total length of 146.8 km (average 3.2 km) could be reconnected. Together with the 48 proposed areas (in total 207,557 ha) for floodplain restoration (147,027 ha to be reconnected outside the flood-control dykes), these impressive figures clearly confirm both the need and opportunity to improve the hydromorphological conditions by river and floodplain restoration (Fig. 5.9).

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[3] http://www.drava-life.hr/en/home/.

[4] http://www.olddrava.com/.

5.7 Conclusions

Since the mid-1990s the lower Drava (from the Mura confluence to the Danube confluence, 235 rkm) was investigated repeatedly and 2007 the first hydromorphological assessment for a large river in the middle and lower Danube basin, based on the first CEN standard, was published (Schwarz 2007) and delivered important findings for the approach to the mapping of the entire Danube (Schwarz 2015; Schwarz et al. 2015).

The Lower Drava is influenced and altered by upstream hydropower plants in Austria, Slovenia and Croatia, the various river regulation works (bank stabilization, some groynes and former meander cutoffs) as well as the loss of floodplains by constructing dykes. However, it still retains nearly all features of the original riparian landscape along several reaches and the whole course was designated a Biosphere Reserve containing two Ramsar areas and one riparian National Park, which underline the ecological importance of the river corridor.

However, the initial investigations and the hydromorphological pilot study should be viewed as a substantial baseline work only to follow up the middle and long-term processes and alterations along the Lower Drava. Sediment flux, the prevailing reaches with incision and also the short accumulational reaches and their associated channel features such as gravel and sand bars have to be surveyed and monitored jointly and data exchanged. Hydrographical analysis should underlie the investigation of flood dynamics (amplitude, magnitude, duration) considering all effects of the hydropower chain upstream (discharge distribution, role of reservoirs during low to annual flood discharges, hydropeaking which is observable at least 50 km downstream of the last barrage).

Finally, both the pressures and responses (impacts) should be evaluated at different scales providing the basis for understanding the cause-effect linkages that govern the observed river system variation. The developments within the last 10–15 years partly indicate further deterioration along some river reaches, but also initial restoration activities reflecting a slow paradigm change in river management as well as a better transboundary cooperation.

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