Update of hydromorphological assessment in the framework of ICPDR JDS4

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Abstract

For Joint Danube Survey (JDS) 4 the assessment prepared for the JDS3 in 2013 had to be updated by 2019. This concerns the update of the continuous survey of 241 sections of 10 km length, according to the agreed methodology (CEN Standards from 2004 and 2010) and comprises the overall and WFD 3-digit assessment of the hydromorphological features for the navigable Danube from Kelheim (rkm 2,415) to the delta (rkm 0 at Sulina branch).

In total 55 main 10-km-segments have been recorded to be subject of changes (43 improvements, 12 deteriorations). Finally, only 22 changes lead to shifts in the individual assessment groups (channel, banks, floodplain), while only two segments on the Lower Danube shift in overall assessment, from class 3 to class 4. Regarding the WFD 3-digit assessment four segments profit from fish passes in Austria, reconnecting in total seven segments (70 km) for fish migration. In general, improvements prevail on the Upper and Middle Danube, while on the Lower Danube, with exception of some improvements in Bulgaria, slight deteriorations have been recorded. This trend is understandable looking at the previous assessments, indicating many more alterations along the Upper and Middle Danube, while the Lower Danube keeps over long distances – despite of negative influence of sediment balance due to Iron gate dams – a character of fewer alterations (less stabilized banks and rectification of channel, more bars and islands).

1. Introduction

Under the changed JDS4 framework conditions, with a more active role for national authorities and individual countries, the continuous assessment focused on the update of the hydromorphological (HYMO) assessment of the predefined 10-rkm-segments with regard to changes (deteriorations, improvements) of channel, banks and floodplain. The data collection and assessment was performed by national experts (deskwork) supported by a consultant and the ICPDR Secretariat providing a specific data upload tool (Schwarz & Höbart 2021).

2. Approach

For the JDS HYMO assessment 2013 the Danube was divided into 10-rkm-segments assessing channel, banks and floodplains individually before generating the overall assessment for each segment. For JDS4 it was decided to update the HYMO parameters based on the same segments and to shift the assessment only to those segments with significant changes. For the detailed method compare JDS3 documentation (Schwarz, Holubova, et.al. 2015) and for JDS4 see Schwarz & Höbart (2021).

Significant new alterations (occurring for the first time between summer 2013 and summer 2019), as well as restoration activities listed below had to be considered if the level of significance exceeded within one of the 241 10-rkm-segments, namely 0,5 km changes in lengths or 5% change of floodplain areas):

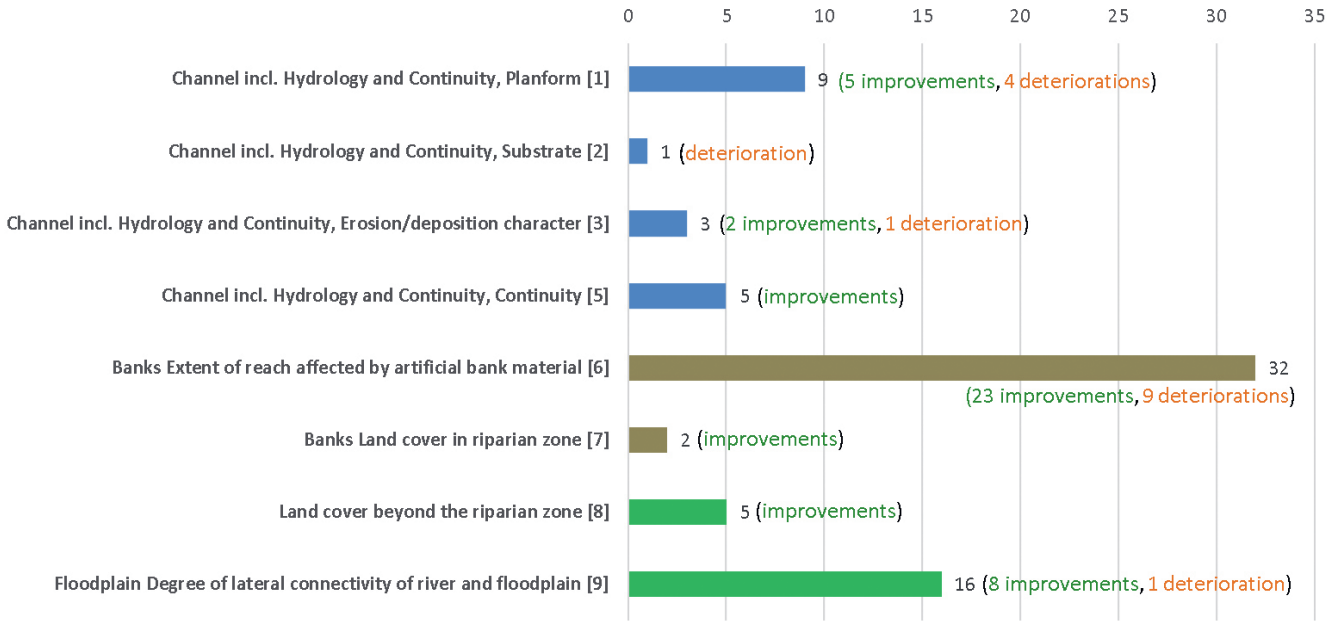

Figure 1: Types of restoration/alteration per all individual changes (blue for "Channel", brown for "banks" and green for "floodplains") and number of improvements/deteriorations per type.

- Channel, including hydrology and continuity: Closure of side-channels, groyne construction/removal, specific, intensive dredging, ongoing, raising or decreasing channel incision, flow regime changes (impoundment length, hydropeaking, water abstraction, particular exposure to ship waves (no thresholds defined), restoration/widening/reconnection of Danube main and side-channels, construction of fish passes or measures to improve sediment transport (gravel feeding, sediment management).
- Banks: New rip-rap, bank reinforcements, change of land use in riparian zone, restoration of riverbanks (removal of rip-rap).
- Floodplain: Further reduction of floodplain areas by cut-off, change in land use or reconnection of floodplains / retention areas.

After the collection and analysis of changes (improvements and deteriorations) the two assessments of 10-rkm-segments as of JDS3, the overall continuous assessment and the WFD 3-digit assesment had to be revised for the reported 10-rkm-segments with changes.

3. Results and discussion

Based on the 241 10-rkm JDS3 segments (navigable Danube downstream of Kelheim, including only the Sulina branch in the Delta), countries recorded changes of the three main assessment groups (channel, banks and floodplains) for the period 2013-2019.

While for the Upper Danube and the Slovak-Hungarian reach of the Middle Danube reported changes are frequent, long reaches on the Lower and Middle Danube segments have no change.

In total, the recorded changes comprise 54 improvements and 19 deteriorations (total number 73). However, several changes occurred in the same 10-rkm-segments for individual parameters, transboundary changes were reported twice (as planned), changes were recorded for two neighbouring segments at once or being recorded for one and the same segment as deterioration and improvement, which is possible. Therefore, only 56 main segments (entire 10-km-segment including all sub segments for channel,

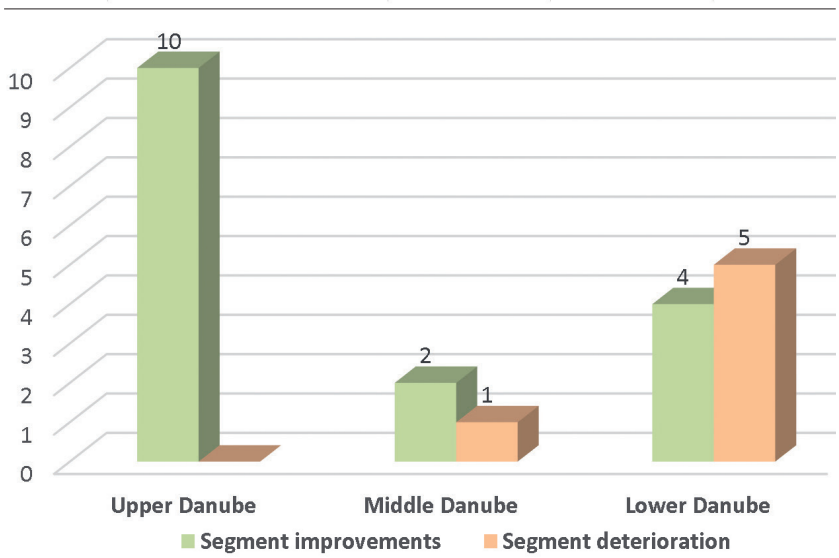

Figure 2: Overview of segments with changes for at least one parameter group (channel, banks, and floodplain) along the three main section of Danube

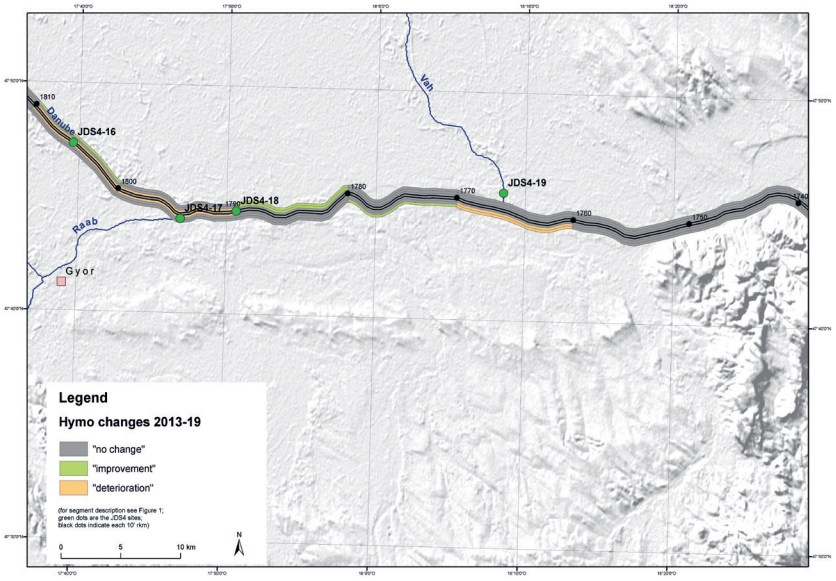

Figure 3: Example for detailed 'change' map: The border stretch SK-HU is characterised by the restoration of two larger side channels in SK and one floodplain improvement in HU. However, the ongoing deepening of the channel downstream of the Gabčikovo dam 'neutralise' from an international viewpoint the development. In Komárom new flood protection reduces the right floodplain area in Hungary.

Figure 4: Example for floodplain restoration near Deggendorf/Germany (Google Earth (2019): Satellite images worldwide. DigitalGlobe 2019. http://www.earth.google.com)

banks right/left and floodplain right/left) have been subject to individual changes. Nine further changes below the threshold of 0.5 km in length have to be allocated with other changes in the same segment (possible aggregation to 0.5 km) or to be excluded from the segment assessment, which are five segments (three improvements and two deteriorations). Finally, changes as required by the methodology can be assumed for only 55 main segments or 23% of all segments.

Aside of many segments with no changes (186 or 77%), most records are improvements falling into 43 main segments or 18% covering mostly the Upper and Middle Danube in DE, AT, SK and HU, while the 12 segments with deteriorations (5%) can be find in HU, RS, BG, RO and UA.

The analysis of changes is based on the total number of recorded changes (73) to keep transparently all records sent by the countries (from data collection tool). River bank changes (restoration or construction) prevail with 46% followed by changes of the floodplain (29%) including the reconnection of side-channels and 25% for the channel.

The total lengths of all changes (73) sums up to 159.69 km. Regarding the length of the changes, rather 'short and small' projects predominate. The exception are fish passes opening entire 10-rkm-segments for migration of biota. Short measures < 2 km comprise 64% of all changes, but only 37.99 km or 24% of all changes by total length. The average length of changes is about 2.2 km, but excluding the full length of 10-km-sections for continuum restoration by fish passes, the average length dropped to 1.7 km.

Most of the changes are related to riverbank development [parameters 6 & 7] with in total 34 changes *(fig. 1).* The removal of rip-rap clearly prevails with 23 cases. Side channel connections [9] as main improvements are rather frequent (8 times, out of other non-structural improvements in floodplains) followed by channel changes [1], which are recorded in junction to side-channel connections on the Middle Danube (five times), but also as deterioration (four times due to infrastructure and dredging activities on the Lower Danube). As already mentioned, parameter [5] for continuum improvements are realised entirely in the Upper Danube. Merely the parameter [4] on changed flow conditions and regime by structures (groynes, dams with impoundments) was not reported at all.

Most of the observed changes cover bank and floodplain segments and show the ambitions of many countries to improve the hydromorphological conditions. However, the length and extent of changes (for structural measures the mean length is 1.7 km) did not lead in all cases to a shift of assessment classes. This has two reasons, firstly the “small size” of changes in relation to the 10-rkm-segment and secondly the previous nearest assessment class boundary.

This lead in total to the class shift of individual assessments for channel, banks and floodplain of 22 out of 55 segments with changes *(fig. 2).*

After screening and comparing the changes in detail (starting with major changes > 1 km length and by overlaying changes within one and the same segment), only two segments changed in overall assessment, two in the worse direction, but already having been close to poor assessments before *(fig. 5).* Those are the segments just downstream of Iron Gate II in Serbia (the bank assessment was reduced from three to class four leading to an overall shift from 3 to 4, however the bank and flood dike construction for Radujevac affect only a small new stretch, in total 2.8 km) and the Danube near Reni in Ukraine (due to recorded dredging in and close to the harbour affecting planform and substrates of channel from 3 to 4 leading to a shift in overall assessment, however the reach of 1.2 km and the amount of dredged material is limited and the dredging started in early 2019, at the end of the monitoring period).

Further several overall assessments for segments fail to shift in a better class due to close boundaries, but being strong candidates for the next cycle of restoration measures (e.g. two segments in the AT reach east of Vienna).

Regarding the fish bypasses in the Austrian Danube the four related segments didn’t shift in assessment as for the 3-digit assessment due to the numbers of sub-parameters for the channel group remaining in the worst class: If planform, flow character, sediment grain size, sedimentation/ deposition character are untouched from the measure the segment remains in the worst class 5, even though the barrier is assessed with as '3' for 'partial passable' (for fish but not for sediment).

The WFD 3-digit analysis for the entire Danube *(fig. 6)* indicates the general alteration similar to the overall assessment (prevailing classes 3-5 for the 241 10-km-segment), in particular for the best documented parameter group 'Morphology', but also the 'Hydrology'. The longitudinal continuity is interrupted by 18 dams (segments). In 2013 for two dams with functioning fish passes and partial sediment feeding (Wien-Freudenau and Melk) the value was '3' according to CEN standard.

The biggest difference now is the restoration of partial continuum (for fish) in the Austrain Danube reach. Four additional hydropower dams are in the meantime equipped with fish bypasses, the ecologically most efficient way to restore fish passability. For the Austrian reach therefore only the dams in Altenwörth and Ybbs-Persenbeug remain, but will be equipped within next years, which will expand the passability towards Wachau and even up to Aschach. For bedload sediment (gravel) the dams are still a considerable obstacle (compare outcomes of the Danube Sediment Project, Habersack et al. 2019 & 2020). For most of the other changes, mainly improvements like the removal of rip-rap for short stretches only on the left or right side respectively, the 3-digit evaluation is not as sensitive as the overall assessment, due to the integration of assessment values for both banks and floodplains.

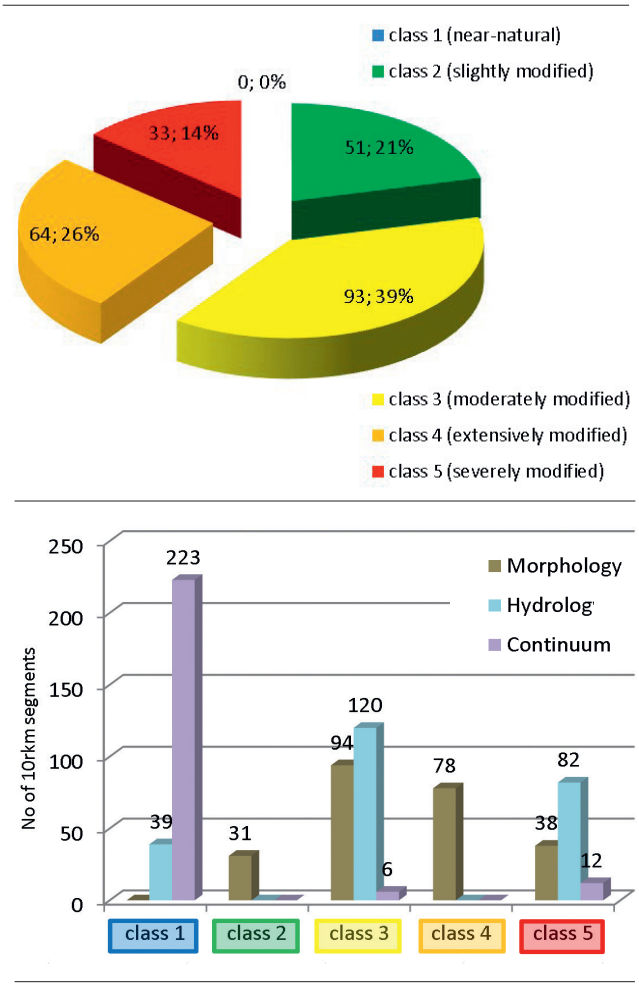

Figure 5 & 6: Above: Overall assessment of JDS4 as based on JDS3 with only slight changes (shift of two segments from class 3 to 4, no change in percentage). Below: WFD 3-digit assessment as based on JDS3, mainly changed for the continuity for fish by the construction of fish passes in AT (hydrology and continuum were assessed only in classes 1, 3 or 5).

In general, the recorded changes imply many improvements in the strongly altered Upper and partial the Middle Danube while on the Lower Danube a few deteriorations prevail, however, based on the much better original JDS3 assessment for the Lower Danube in comparison with the Middle and Upper Danube and the deteriorations are spatially limited. In the total perspective, the positive aspects predominate, regarding the fish continuum the construction of bypass solutions for Austrian dams is an important step. Several side-channel connections including SK and HU are good examples for the proceeding restoration. The reason why more segments on the Upper Danube improved in comparison to the Middle Danube, can be explained with the worse situation before in DE and AT, while the free-flowing SK and HU reach assessment in the third moderate class was closer to class four instead two.

4. Conclusions

In general, improvements prevail on the Upper and Middle Danube, while on the Lower Danube, with exception of some improvements in Bulgaria, slight deteriorations have been recorded for the period 2013-2019.

Several small deteriorations (and renovation of already existing structures) as well as some improvements fall under the thresholds and cannot be considered for the overall assessment. In addition, the limited dredging data for various purposes (navigation, flood, commercial, and restoration) cannot be clearly addressed to obvious changes (compare evaluation by the DanubeSediment project, Habersack et al. 2019 & 2020). Therefore, a general clear trend for the entire Danube cannot be observed for the given period. However, the intensified restoration activity on the Upper and Middle Danube and the slight deterioration of the Lower Danube suggest a positive outlook.

To scope and fulfil the requirements as under the new CEN Standard (CEN 2020) the methodology has to be further developed to keep previous assessments and to apply the new topics, namely the process based assessment of fluvial systems. The DanubeSediment project (Habersack et al. 2019 & 2020) delivered already many extremely valuable quantitative hydromorphological data including longitudinal profiles, channel incision stretches, historical comparisons and morphological river types and made first technical proposals how to assess sediment transport, to improve monitoring, both essential parts of the future hydromorphological assessment. Furthermore, it is recommended to take into consideration the Interreg Danube Transnational Programme Danube Floodplain project outcomes and related solutions for the improvement of floodplain connectivity with the river.

The continuation of restoration measures improving the hydromorphological conditions along the entire Danube is of great importance and monitoring and evaluation of previous restoration projects should be used to improve new projects. However fresh bank revetments and reinforcement or additional groynes should be managed to the absolute minimum and must be compensated by extensive restoration measures (banks and side-channels).

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