Flood risk regulation

Responsible partner: IGB

Actuality: November 2021

Interpretation

Flood risk regulation is assessed as the average of two indicators that refer to the retained water volume and to the slowing of flow velocity. As a first sub-indicator, the ratio of the flood volume of the active to that of the former floodplain is used (Gleason & Labhan 2008, Mehl et al. 2018, Mehl et al. 2020). This sub-indicator thus shows to which degree the actual area available in a floodplain segment for flood retention has been reduced in comparison to its original extension. In case there are no dykes, embankments or impairments due to infrastructure (e.g. road embankments) present in the floodplain, the flood volume remains unaffected. In the case potential flooding areas have been already calculated e.g. for flood hazard maps, these can be used directly for the determination of the water retention volume in the floodplain. The second sub-indicator consists of the results from the hydro-morphological survey of the river segment, which are included are as the average value of the hydro-morphological assessment scores for the river bed, river bank and riparian zone. This sub-indicator is used as a proxy for the hydraulic roughness of the river corridor at high water level, which is effective on the flattening of the flood wave (peak attenuation) (Mehl et al. 2018, Mehl et al. 2020). Hence, averaging both sub-indicators enables to consider both the amount of retained water and the mitigation of the flood wave (Mehl et al. 2018, Mehl et al. 2020). For scenario calculations (e.g. construction of diked marsh areas) please see RESI Handbuch (Podschun et al., 2018).

References

Gleason, R. A. & Labhan, M. K. (2008): Chapter A: Background and Approach to Quantification of Ecosystem Services, in: Gleason, R. A., Labhan, M. K. & Euliss, N. H. Jr. [eds.]: Ecosystem Services Derived from Wetland Conservation Practices in the United States Prairie Pothole Region with an Emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs. Professional Paper 175, U.S. Department of the Interior, U.S. Geological Survey: 3-14.

Mehl, D., Hoffmann, T. G., Iwanowski, J., Lüdecke, K. & Thiele, V. (2018): 25 Jahre Fließgewässerrenaturierung an der mecklenburgischen Nebel: Auswirkungen auf den ökologischen Zustand und auf regulative Ökosystemleistungen. Hydrologie und Wasserbewirtschaftung 62 (1): 6-24.

Mehl, D., Hoffmann, T. G., & Iwanowski, J. (2020). Quantifizierung und Bewertung regulativer Ökosystemleistungen: Rückhalt von Treibhausgasen/Kohlenstoffsequestrierung, Hochwasser-, Niedrigwasser- und Sedimentregulation, Bodenbildung in Auen sowie Kühlwirkung der Gewässer und terrestrischen Böden. In C. Fischer, H. Fischer, D. Mehl, S. Podschun, B. Stammel, M. Pusch, & M. Scholz (Eds.), River Ecosystem Service Index (RESI)—Methoden zur Quantifizierung und Bewertung ausgewählter Ökosystemleistungen in Flüssen und Auen. Leipzig: Helmholtz-Zentrum für Umweltforschung—UFZ.

■ Original approach according to River Ecosystem Service Index (RESI) (Podschun et al., 2018)

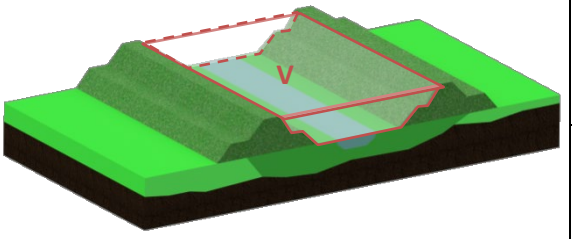
Class	Abbr.	Description	Spatial reference
Regulating	FRI	Reduction of the flood discharge and lowering of the flood peak: wave flattening (retention volume is used by overflow/flooding, river/floodplain morphology influences roughness)	Floodplain segment or compartment ☒ former floodplain ☒ active floodplain ☒ river

Variable	Abbr.	Unit	Variable description	Data basis
Volume of the active floodplain	V_{act}	m³	Volume between mean and high water level (full active floodplain)	-dikes and longitudinal structures -digital terrain model (DTM10) -Flooding area of HQ100
Volume of the morphological floodplain	V_{morph}	m³	Volume between mean and high water level (height of the stop line of the morphological floodplain, transition from valley bottom to valley border)	-dikes and longitudinal structures -digital terrain model (DTM10) -Flooding area of HQ100
Flow length of the relevant mapping section	L_i	m	Length	-hydro-morphological assessment (river structure quality mapping)

within the river-floodplain segment				
Ratings for riverbank (RB), floodplain (FP), riverbed (RB)	*RBai* *FPi* *RBei*	Ordinal 5 … 1	rating class of hydraulic roughness	-hydro-morphological assessment (river structure quality mapping)
Total length	L_{tot}	m	Length	-hydro-morphological assessment (river structure quality mapping)

Calculation

Assessment of the volume



Sub-Indicator FRI_1

Calculation of the volume ratio of the active floodplain to the morphological floodplain:

$$FRI_1 = \frac{V_{act}}{V_{morph}}$$

FRI_1	> 80 %	> 60 % … ≤ 80 %	> 40 % … ≤ 60 %	> 20 % … ≤ 40 %	≤ 20 %
FRI_1	5	4	3	2	1

Sub-Indicator FRI_2

Calculation of the length-weighted mean overall classification of the watercourse:

$$FRI_2 = \sum_{i=1}^{n} \frac{L_i}{L_{tot}} * \left(\frac{RBa_i + FP_i + RBe_i}{3}\right)$$

FRI_2	≤ 1,5	> 1,5 … ≤ 2,5	> 2,5 … ≤ 3,5	> 3,5 … ≤ 4,5	> 4,5
FRI_2	5	4	3	2	1

Indicator

Calculation of the overall indicator **FRI** as the average of the results of the sub-indicators **FRI_1** and **FRI_2**:

$$FRI = \frac{FRI_1 + FRI_2}{2}$$

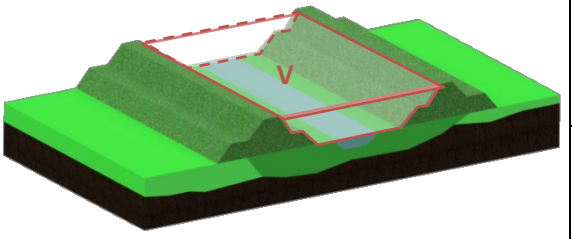
Scaling ☒ **national** ☐ **local**	**FRI**	≥ 4.5	< 4.5 … ≥ 3.5	< 3.5 … ≥ 2.5	< 2.5 … ≥ 1.5	< 1.5
Evaluation Class		**5**	**4**	**3**	**2**	**1**
Qualitative Evaluation		**No or very little loss** of active floodplain volume, **very high** wave reduction	**Little loss** of active floodplain volume, **high** wave reduction	**Moderate loss** of active floodplain volume, **moderate** wave reduction	**High loss** of active floodplain volume, **little** wave reduction	**Very high loss** of active floodplain volume, **no or little** wave reduction

■ Adaption for Danube-wide application

Class	Abbr.	Description	Spatial reference
Regulating	FRI	Reduction of flood discharge (by retaining water) and lowering of the flood peak (by slowing down flow velocity), resulting in a flattening of the flood wave in downstream sections	Floodplain segment or compartment ☒ former floodplain ☒ active floodplain ☒ river

Variable	Abbr.	Unit	Variable description	Data basis
Volume of the active floodplain	V_{act}	m³	Volume between mean and high water level (full active floodplain)	-digital terrain model (DTM25) -Active floodplain delineated by Danube Floodplain Project
Volume of the morphological floodplain	V_{morph}	m³	Volume between mean and high water level (height of the stop line of the morphological floodplain, transition from valley bottom to valley border)	-digital terrain model (DTM25)
Reference areas (segment- or compartment)		ha	Determination of area of active floodplain, potential floodplain per floodplain segment	- Floodplain segment - Floodplain compartment
Flow length of the relevant mapping section within the river-floodplain segment	L_i	m	Length	-hydro-morphological assessment (river structure quality mapping)
Hydro-morphological status ratings for riverbank, floodplain, riverbed	*HyMo*	Ordinal 5 … 1	rating class of hydro-morphological integrity and hydraulic roughness	-hydro-morphological assessment (river structure quality mapping)
Total length	L_{tot}	m	Length	-hydro-morphological assessment (river structure quality mapping)

Calculation

Assessment oft he volume	Sub-Indicator FRI_1
	Calculation of the volume ratio of the active floodplain to the morphological floodplain: $$FRI_1 = \frac{V_{act}}{V_{morph}}$$

FRI_1	> 80 %	> 60 % ... ≤ 80 %	> 40 % ... ≤ 60 %	> 20 % ... ≤ 40 %	≤ 20 %
FRI_1	5	4	3	2	1

Sub-Indicator FRI_2

Calculation of the length-weighted mean overall classification of the watercourse:

$$FRI_2 = \sum_{i=1}^{n} \frac{L_i}{L_{tot}} * (HyMo_i)$$

FRI_2	≤ 1,5	> 1,5 ... ≤ 2,5	> 2,5 ... ≤ 3,5	> 3,5 ... ≤ 4,5	> 4,5
FRI_2	5	4	3	2	1

Indicator

Calculation of the overall indicator **FRI** as the average of the results of the sub-indicators **FRI_1** and **FRI_2**:

$$FRI = \frac{FRI_1 + FRI_2}{2}$$

Scaling ☒ **national** ☐ **local**	**FRI**	≥ 4.5	< 4.5 ... ≥ 3.5	< 3.5 ... ≥ 2.5	< 2.5 ... ≥ 1.5	< 1.5
Evaluation Class		**5**	**4**	**3**	**2**	**1**
Qualitative Evaluation		**No or very little loss** of active floodplain volume, **very high** wave reduction	**Little loss** of active floodplain volume, **high** wave reduction	**Moderate loss** of active floodplain volume, **moderate** wave reduction	**High loss** of active floodplain volume, **little** wave reduction	**Very high loss** of active floodplain volume, **no or little** wave reduction

■ Data sources

Data set	Data type	Spatial reference	Spatial resolution	Source	Creation date	Comments
L_i, HyMo, L_{tot} Hydro-morphological assessment (River structure quality mapping - RSQM)	Line	Danube catchment		https://www.danubegis.org/	2015	In case of availability of data on floodplain condition, these can be directly applied for a more accurate or alternative determination of the indicator, for example, the assessments of the land, bank and bed of the river.
V_{AFP}, V_{FFP} Copernicus European Digital Elevation Model (EU-DEM, Version 1.0) EU-DEM25	Raster	Pan-European	25 m	https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-eu-dem	2000-2011	
Segmentation	Polygon	Floodplain		river-floodplain segments (1-10 km)	2021	

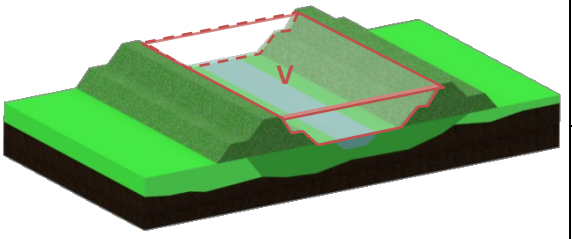
■ Adaption for the Austrian Pilot Area

Class	Abbr.	Description	Spatial reference
Regulating	FRI	Reduction of flood discharge (by retaining water) and lowering of the flood peak (by slowing down flow velocity), resulting in a flattening of the flood wave in downstream sections	Floodplain segment or compartment ☒ former floodplain ☒ active floodplain ☒ river

Variable	Abbr.	Unit	Variable description	Data basis
Volume of the active floodplain	V_{act}	m³	Volume between mean and high water level (full active floodplain)	-digital terrain model (DTM10) - Floodplain compartment
Volume of the morphological floodplain	V_{morph}	m³	Volume between mean and high water level (height of the stop line of the morphological floodplain, transition from valley bottom to valley border)	-digital terrain model (DTM10)
Reference areas (segment- or compartment)		ha	Determination of area of active floodplain, potential floodplain per floodplain segment	- Floodplain segment - Floodplain compartment
Flow length of the relevant mapping section within the river-floodplain segment	L_i	m	Length	-hydro-morphological assessment (river structure quality mapping)
Ratings for floodplain (FP)	*FPi*	Ordinal 5 … 1	Rating class (5 ≙ class 1 1 ≙ class 5)	-Land Cover Model
Ratings for riverbank (RB), riverbed (RB)	*RBai* *RBei*	Ordinal 5 … 1	Rating class of hydro-morphological integrity and hydraulic roughness (5 ≙ class 1 1 ≙ class 5)	-hydro-morphological assessment (river structure quality mapping)
Total length	L_{tot}	m	Length	-hydro-morphological assessment (river structure quality mapping)

Calculation

Assessment oft he volume



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Sub-Indicator FRI_2

Calculation of the length-weighted mean overall classification of the watercourse:

$$FRI_2 = \sum_{i=1}^{n} \frac{L_i}{L_{tot}} * \left(\frac{RBa_i + FP_i + RBe_i}{3}\right)$$

FRI_2	≤ 1,5	> 1,5 ... ≤ 2,5	> 2,5 ... ≤ 3,5	> 3,5 ... ≤ 4,5	> 4,5
FRI_2	5	4	3	2	1

Indicator

Calculation of the overall indicator **FRI** as the average of the results of the sub-indicators **FRI_1** and **FRI_2**:

$$FRI = \frac{FRI_1 + FRI_2}{2}$$

Scaling ☒ **national** ☐ **local**	**FRI**	≥ 4.5	< 4.5 ... ≥ 3.5	< 3.5 ... ≥ 2.5	< 2.5 ... ≥ 1.5	< 1.5
Evaluation Class		**5**	**4**	**3**	**2**	**1**
Qualitative Evaluation		**No or very little loss** of active floodplain volume, **very high** wave reduction	**Little loss** of active floodplain volume, **high** wave reduction	**Moderate loss** of active floodplain volume, **moderate** wave reduction	**High loss** of active floodplain volume, **little** wave reduction	**Very high loss** of active floodplain volume, **no or little** wave reduction

■ Data sources

Data set	Data type	Spatial reference	Spatial resolution	Source	Creation date	Comments
RBai, RBei, L_i, L_{tot} Belastungen Oberflächengewässer - Morphologie	Line	Austria	50000	NGP-DB (BML-FUW), Ämter der Ländesregierungen	01/2016	
FPi Copernicus riparian zones, Corine Land Cover LCLU (MAES_4)	Polygon	International / Active FP	Minimum Mapping Unit: 0.5 ha Minimum Mapping Width: 10 m	https://land.copernicus.eu/local/riparian-zones/land-cover-land-use-lclu-image	2012	Land use in the active floodplain is categorized for this ES in terms of the flow resistance of the vegetation that is effective on the flattening of a flood wave (peak attenuation). Hence, an **FPi score of 1** is attributed to land use 3110 - Natural & semi-natural broad-leaved forest **FPi score 2:** 3000 - UA Forest, and 3410 - transitional woodland and scrub For the remaining land use categories, a **score of 5** is assigned.
V_{AFP}, V_{FFP} Digital terrain model of Austria, based on airborne laserscanning	Raster	Austria	10 m	https://www.data.gv.at/katalog/dataset/dgm/resource/b347b029-3fd5-448a-8c2c-07f483c2c56e	20.01.2015	
Segmentation	Polygon	Floodplain		river-floodplain segments (1-10 km)	2021	