Synergies with other indicators	Synergies with the indicator group *Water quality* indicators
Connection with SDGs	SDGs 6 Sustainable water management, 13 Climate action, and 14 Life below water
Opportunities for participatory data collection	Opportunities for community members to engage in the data collection with assistance
Additional information	
References	European Parliament, Council of the European Union. (2000). *EU Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy*. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02000L0060-20140101 http://www.isprambiente.gov.it/

4.57 Morphological Quality Index (MQI)

Project Name: NAIAD (Grant Agreement no. 730497)

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Morphological Quality Index (MQI)	**Water Management**
Description and justification	The Morphological Quality Index was developed to assess the hydromorphology quality of rivers as introduced in the EU Water Framework Directive (WFD). An extensive review of existing methods to assess the hydromorphology of rivers demonstrated that most methods insufficiently account for physical processes (Belletti et al. 2015). Based on a weighted aggregation of 28 subindicators, the MQI is aimed at an assessment, classification and monitoring of the current morphological state of rivers (Rinaldi et al. 2017). First developed in Italy (Rinaldi et al. 2013), the index was tested and expended on rivers of all Europe (Rinaldi et al. 2015b) during the REFORM EU Project (https://www.reformrivers.eu).
Definition	The MQI is computed by a weighted sum of alteration scores on sub-indicators. The list of sub-indicators is context specific (confined versus partially confined and unconfined reaches). The full mathematical equations are provided in Rinaldi et al. (2015a, p. 99-102). Forms are provided in the appendix of Rinaldi et al. (2015a) as well as in Microsoft Excel spreadsheets that performs the computation automatically

	once filled (available from https://reformrivers.eu/guidebook-evaluation-stream-morphological-conditions-morphological-quality-index-mqi).
Strengths and weaknesses	+ Provide rapidly an aggregated indicator accounting for the state of the art on geomorphology. + Detailed and tried and tested forms and guidelines in the implementation of the method enables quite good robustness considering the complexity of the question. + Very useful indicator to perform a first appraisal of the river reaches' degree of alteration that may guide later on the prioritising of restoration measures, as well as, on which component and process the restoration effort should likely focus (e.g., hydrology, sediment continuity, bank protection, riparian forest) - Relevant at scale of about one kilometre, thus irrelevant for very small measures. In this case, see Rinaldi et al. (2017) for alternative indexes as MQIm or GUS. - Provide one single estimation aggregating numerous different alterations, so it necessarily simplifies the complexity of nature.
Measurement procedure and tool	The whole measurement procedure is described in Rinaldi (2015a). Detailed appendix with helpful advises and precisions are provided. The procedure follows three steps: (i) Segmentation of the river in several homogeneous reaches, one MQI value will be evaluated for each reach. The segmentation procedure should cautiously follow the guidelines. (ii) Estimation of the 28 sub-indicators for each river reach by GIS analysis and field visit; (iii) Computation of the MQI (using the forms provided by the authors or by using the equations) for each river reach. According to the authors and to our experience, a MQI assessment typically takes a couple of days per river reaches.
Scale of measurement	The sub-indicators and the aggregated MQI are computed for river reaches, i.e., homogeneous sections of river that are typically 0.1-10 km long and usually longer than one km. If the relevant scale of analysis would be reaches significantly shorter than one kilometre, the MQIm ("MQI for monitoring" may be more relevant, see Rinaldi et al. (2015a & 2017). MQI (or MQIm) is dimensionless. Comprised between 0 (river totally altered in every component and process) and 1 (wild natural river without alteration).
Data source	
Required data	Estimations of scores of each sub-indicator rely on:

	(i) GIS analysis of aerial photographs and maps (current and a few decade old). Data on reach slope is also required and land use maps (river channel, riparian forest) helps performing the assessment faster. (ii) Field survey to get data on grain size, presence of large wood, vegetation state, evidences of bank erosion, incision, variability of the cross section and inventory of structures (e.g., bank protections, weirs, check dams). (iii) Archives, reports or testimony are required to appraise past and current management practices and alterations (e.g., dredging, vegetation maintenance, large wood removal).
Data input type	GIS data (photographs, maps, land use maps) and field visit to fill the forms.
Data collection frequency	A MQI assessment should first be performed to assess the current status of the river. Prospective applications assuming various strategies to be implemented were tested by Piton et al. (2018) and Gnonlonfin et al. (2019) and proved feasible although more uncertain than for assessment of current status. The MQI forms propose a way to take uncertainty into account which should be used for instance in the case of prospective assessment. After works, e.g., that a NBS strategy be implemented, Rinaldi et al. (2015a, p. 31) recommend waiting at least 5 years before performing a new MQI assessment to enable the river to adjust to the works. After high magnitude flood events (e.g., time return higher than 10-20 years), they also advice waiting a couple of years to let the river recover to its long term geomorphic trajectory.
Level of expertise required	Intermediate: The MQI assessment was tailored to be applicable by river managers, thus it requires a classical background in geomorphology, basic knowledge in GIS software and field visits.
Synergies with other indicators	Complementary with all other indicators on Water Quality
Connection with SDGs	6, 14, 15
Opportunities for participatory data collection	Low: the indicators are quite technical and data collection requires a background in geomorphology.
Additional information	
References	Guidelines for the application: Rinaldi M, N. Surian, F. Comiti M. Bussettini B B. 2015a. Guidebook for the evaluation of stream morphological conditions by the morphological quality index (MQI) - D6.2,

Part 3, . Deliverable 6.2 of REFORM (REstoring rivers FOR effective catchment Management), a Collaborative project (large-scale integrating project) funded by the European Commission within the 7th Framework Programme under Grant Agreement 282656. [online] Available from: http://www.reformrivers.eu/system/files/6.2%20Methods%20to%20assess%20hydromorphology%20of%20rivers%20part%20III%20revised_0.pdf (accessed on May, 19, 2020)

Scientific papers:

Belletti B, Rinaldi M, Buijse A D, Gurnell A M, Mosselman E. 2015. A review of assessment methods for river hydromorphology. Environmental Earth Sciences 73:2079–2100. DOI: 10.1007/s12665-014-3558-1

Rinaldi M, Surian N, Comiti F, Bussettini M. 2013. A method for the assessment and analysis of the hydromorphological condition of Italian streams: The Morphological Quality Index (MQI). Geomorphology 180-181:96–108. DOI: 10.1016/j.geomorph.2012.09.009

Rinaldi M, Belletti B, Bussettini M, Comiti F, Golfieri B, Lastoria B, Marchese E, Nardi L, Surian N. 2017. New tools for the hydromorphological assessment and monitoring of European streams. Journal of Environmental Management 202:363–378. DOI: 10.1016/j.jenvman.2016.11.036

Examples of use:

Rinaldi, M., L. Nardi, B. Belletti, S. Bizzi, K. Brabec, F. Comiti, L. Demarchi, M. Giełczewski, B. Golfieri, H. Habersack, S. Hellsten, S. Kaufman, M. Klösch, E. Marchese, P. Marcinkowski, S. Muhar, T. Okruszko, A. Paillex, M. Poppe, J. Rääpysjärvi, H. Seppo, M. Schirmer, M. Stelmaszczyk, N. Surian, W. Van de Bund (2015b) Final report on methods, models, tools to assess the hydromorphology of rivers, Deliverable 6.2, Part 5, of REFORM (REstoring rivers FOR effective catchment Management), a Collaborative project (large-scale integrating project) funded by the European Commission within the 7th Framework Programme under Grant Agreement 282656. [online] Available from http://www.reformrivers.eu/methods-models-tools-assess-hydromorphology-rivers-part-5-applications (Accessed on May 19, 2020)

Gnonlonfin A., Piton G., Marchal R., Munir M. B., Wang Z.X., Moncoulon D., Mas A., Arnaud P., Tacnet JM., Douai A. 2019. DELIVERABLE 6.3 DEMO Insurance Value Assessment - Part 7: France: Bragues . NAIAD H2020 project (Grant Agreement nº 730497)

Piton G, Philippe F, Tacnet J-m, Gourhand A. 2018. Focus - Caractérisation des altérations de la géomorphologie naturelle d'un cours d'eau Application du Morphological Quality Index (MQI) aux projets d'aménagement du Grand

Buëch à La Faurie. Science Eaux & Territoires 26:58–61.
DOI: 10.14758/set-revue.2018.26.11

4.58 Hydromorphological quality of surface waters

Project Name: UNaLab (Grant Agreement no. 730052)

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Hydromorphological status of surface waters	**Water Management**
Description and justification	Water covers ca. 71 % of the Earth's surface but only 2.5 % of it is fresh, stored as groundwater and in glaciers. Water is vital for living organisms, and it enables a multitude of human activities such as agriculture, manufacturing and transportation of goods. Available water resources are being extensively used for a variety of purposes, and ensuring that the water quality is monitored and the degraded water bodies are enhanced is essential for protecting the water resources. EU Water Framework Directive (2000/60/EC) sets forth the framework for integrated management of surface waters and groundwater resources in the EU Member States, which are presented as River Basin Management Plans.
Definition	Hydromorphological quality of surface waters - rivers, lakes, transitional waters and coastal waters (rated high, good, moderate, poor, bad)
Strengths and weaknesses	+ A comparable EU-wide applied assessment - Requires arrangements on Member State-level
Measurement procedure and tool	The following procedure is based off the requirements set by the Water Framework Directive (2000/60/EC): 1. Characterise water bodies within a river basin area per Annex II: a. Rivers, lakes, transitional waters or coastal waters — or artificial surface water bodies or heavily modified surface water bodies 2. Establish type-specific hydromorphological reference conditions per Annex V 3. Identify and estimate the impacts of significant water flow regulation 4. Identify and estimate significant morphological alterations to water bodies