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The IHG index for hydromorphological quality assessment of rivers and streams: updated version

Alfredo Ollero[1,*], Askoa Ibisate[2], Laura Elísabet Gonzalo[3], Vanesa Acín[4], Daniel Ballarín[5], Elena Díaz[2], Sergio Domenech[6], Marcos Gimeno[1], David Granado[4], Jesús Horacio[7], Daniel Mora[5] and Miguel Sánchez[1]

[1] Section of Physical Geography, Dept. of Geography and Land Management, University of Zaragoza.
[2] Section of Physical Geography, Dept. of Geography, Prehistory and Archaeology, University of the Basque Country.
[3] Section of Physical Geography, Dept. of Environment and Soil Sciences, University of Lleida.
[4] Ecology and Land (Ecoter, S.C.)
[5] Environment, Land and Geography (Mastergeo, S.L.)
[6] UTE Ebro Basin Hydrological Information.
[7] Section of Physical Geography, Dept. of Geography, University of Santiago de Compostela.

[*] Corresponding author: aollero@unizar.es

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ABSTRACT

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An updated version of the IHG index is presented. The index is based on three appraisal parameters: 1) the functional quality of the fluvial system, including a) flow regime naturalness, b) sediment supply and mobility, and c) floodplain functionality; 2) the channel quality, including a) channel morphology and planform naturalness, b) riverbed continuity and naturalness of the longitudinal and vertical processes, and c) riverbank naturalness and lateral mobility; and 3) the riparian corridor quality, including a) longitudinal continuity, b) riparian corridor width, and c) structure, naturalness and cross-sectional connectivity.

Key words: Fluvial systems, hydrology, fluvial geomorphology, hydromorphological indicators, river assessment.

RESUMEN

Versión actualizada del índice IHG para la evaluación de la calidad hidromorfológica fluvial

Se presenta una versión actualizada del índice IHG, que se estructura en tres grupos de parámetros: 1) calidad funcional del sistema fluvial, incluyendo a) naturalidad del régimen de caudal, b) disponibilidad y movilidad de sedimentos y c) funcionalidad de la llanura de inundación; 2) calidad del cauce, incluyendo a) naturalidad del trazado y de la morfología en planta, b) continuidad y naturalidad del lecho y de los procesos longitudinales y verticales y c) naturalidad de las márgenes y de la movilidad lateral; y 3) calidad de las riberas, incluyendo a) continuidad longitudinal, b) anchura y c) estructura, naturalidad y conectividad transversal.

Palabras clave: *Sistemas fluviales, hidrología, geomorfología fluvial, indicadores hidromorfológicos, evaluación fluvial.*

INTRODUCTION

Hydrogeomorphological river dynamics is the key factor in fluvial systems. It is important not only in functional terms but also in terms of the ecological, landscape and environmental value of the systems (Malavoi and Bravard, 2010). The IHG hydrogeomorphological assessment index is used to implement the 2000/60/EU Directive to reduce the deterioration of fluvial systems, to identify, understand and solve or mitigate the environmental problems of these systems, to improve and conserve their functionality and naturalness, to recognise their hydrogeomorphological values, to train managers and students and to raise awareness in society.

The index was first presented in Barcelona in April 2006 at a workshop on tools for hydromorphological quality assessment in rivers organised by the Water Agency of Catalonia. A first version was published in the journals *Geographicalia* (Ollero *et al.*, 2007) and *Limnetica* (Ollero *et al.*, 2008), and a user guide is available on the website of the Ebro Basin Water Authority (Ollero *et al.*, 2009). The IHG index has been applied to more than 400 river and stream reaches (Gonzalo, 2009; Díaz and Ibisate, 2009; Gimeno, 2009; Acín *et al.*, 2009; Ballarín and Mora, 2010). It has also been considered and applied by other research groups: Raven *et al.* (2010), Álvarez-Cabría *et al.* (2010), and Rinaldi *et al.* (2010).

The experiences obtained from these applications have led the authors to propose some methodological changes to the index. These changes include the assessment of more human impacts and the modifications of some scores. The evaluation of riparian corridor quality has also been restructured. In this short communication, we present the updated version of the IHG index in English, integrating all the changes mentioned above.

UPDATED VERSION

The IHG evaluates nine parameters arranged in three groups: fluvial system functional quality, channel quality and riparian corridor quality. Each parameter has an initial score of 10, corresponding to the natural state and functionality of the system. However, after the impacts and pressures are assessed, points are deducted from this initial value according to different criteria. The full IHG hydrogeomorphological assessment of each river reach is performed by adding the nine values obtained. The highest possible score is 90 points. If the score is between 75 to 90 points, the hydrogeomorphological quality is considered very good. Scores from 60 to 74 points are considered good, scores from 42 to 59 are considered moderate, scores from 21 to 41 points are considered poor and scores from 0 to 20 points are considered very bad. However, the index could also be used to assess the quality of the system based on a single group of parameters: the functionality, the riverbed quality, or the quality of the riparian corridor. In such cases, only the values of the 3 parameters within each of these groups will be added, with a maximum value of 30 points (Table 1). Moreover, before the application of

Table 1. Total and partial scores for each section of the IHG index and hydrogeomorphological quality classes. *Puntuación y calidad hidrogeomorfológica final.*

functional quality		channel quality		riparian quality		total hydrogeomorphological quality	
25-30	very good	25-30	very good	25-30	very good	75-90	very good
20-24	good	20-24	good	20-24	good	60-74	good
14-19	moderate	14-19	moderate	14-19	moderate	42-59	moderate
7-13	poor	7-13	poor	7-13	poor	21-41	poor
0-6	very bad	0-6	very bad	0-6	very bad	0-20	very bad

Table 2. Assessment of the functional quality. *Valoración de la calidad funcional.*

Flow regime naturalness ☐

Water discharge, its temporal distribution and its extreme events respond to natural dynamics; this enables the fluvial system to perfectly perform its role as hydrological mean of transport		10
Upstream or in the functional reach itself there are human pressures (dams, flow diversions, interbasin water transfers, abstraction, returns, urbanization, fires, reforestation, etc) that modify the amount of discharge and/or its temporal distribution	there are either very important flow alterations, which reverse the seasonal regime or there is a constant environmental flow	-10
	if there are noticeable alterations in the amount of discharge during some periods, which entail inversions in the seasonal flow regime	-8
	if there are hydrological regime alterations but the modifications to the seasonal regime are only slightly noticeable	-6
	if there are hydrological regime alterations but the seasonal flow regime remains well characterized	-4
	if there are slight modifications in the amount of discharge	-2

Sediment supply and mobility ☐

The sediment discharge arrives at the functional reach without any retention of human origin and the fluvial system carries out the functions of sediment entrainment and transport without any restrictions		10
There are dams or weirs with the ability to retain sediments in the watershed and further upstream	if more than 75 % of the watershed area upstream the reach presents sediment retention	-5
	if between 50 % and 75 % of the watershed area upstream the reach presents sediment retention	-4
	if between 25 % and 50 % of the watershed area upstream the reach presents sediment retention	-3
	if there are dams or weirs that retain sediments, although these effect less than 25 % of the watershed area upstream the reach	-2
In the reach there are gravel and/or sand extractions and/or dredging which limit sediment supply and mobility	remarkable and frequent	-2
	minor	-1
In the reach there are symptoms or signs of difficulties in the sediment mobility (armouring, embeddedness, alterations of the specific stream power, growth of certain plants…) which can be attributed to human factors	remarkable	-2
	minor	-1
The drainage network and the small tributaries that flow into the reach have human alterations that affect the sediment mobility or their connection with the valley, the floodplain or the riverbed is not continuous	very important alterations and/or disconnections	-3
	significant alterations and/or disconnections	-2
	minor alterations and/or disconnections	-1

Floodplain functionality ☐

The floodplain can exert, without human restrictions, its energy dissipation functions in flood processes, dispersal of peak flows due to sediment overflow and sediments deposition				10
The floodplain has dikes that restrict the natural functions of peak flow reduction, decantation and energy dissipation		if the defences are continuous	if they are not continuous but exceed 50 % of the floodplain length	if they reach less than 50 % of the floodplain length
	if defences directly attached to the channel prevail	-5	-4	-3
	if they are separated from the channel but restrict more than 50 % of the floodplain width	-4	-3	-2
	if there are only far defences that restrict less than 50 % of the floodplain width	-3	-2	-1
The floodplain has cross section alterations (defences, raised communication ways, buildings, ditches…) that modify the hydro-geomorphological processes of overtopping, flooding and flood flows			if there are many obstacles	-2
			if there are few obstacles	-1
The floodplain presents land uses that reduce its natural functionality or it has been kept away from the channel due to dredging or channelisation	if the raised land or the land impervious to water exceeds 50 % of the surface			-3
	if the raised land or the land impervious to water constitute between 15 % and 50 % of its surface			-2
	if there are raised land or land impervious to water, although it constitutes less than 15 % of its surface			-1

FUNCTIONAL QUALITY ☐

Table 3. Assessment of the channel quality. *Valoración de la calidad del cauce.*

Channel morphology and planform naturalness ☐

The channel morphology remains natural, unaltered and its morphology in planform presents the features and dimensions coincident with the basin and valley characteristics, as well as with the system's natural behaviour					10
Artificial morphology changes and direct human modifications of the channel's morphology in planform have been recorded		if they have an effect on more than 50 % of the reach length	if they have an effect on between 25 % and 50% of the length	if they have an effect on a length between 10 % and 25 %	if they have an effect on less than 10 % of the reach length
	if there are drastic changes (diversions, cut-offs, fill-in of abandoned channels, branch simplification…)	-8	-7	-6	-5
	if not drastic changes, minor changes are indeed recorded (setting back embankment, realignment …)	-6	-5	-4	-3
	if not recent drastic or minor changes, there are old changes that the fluvial system has recovered partially	-4	-3	-2	-1
Retrospective and progressive changes can be seen in the reach in the channel plan-form morphology due to human activities in the basin or to the effect of infrastructures				remarkable	-2
				slight	-1

Riverbed continuity and naturalness of the longitudinal and vertical processes ☐

The channel is natural and continuous and its hydromorphological longitudinal and vertical processes are functional, natural and coincident with the basin and valley characteristics, the substrate, the slope and the hydrological behaviour				10
In the functional reach there are cross section alterations that break its continuity		if they dam more than 50 % of the reach length	if they dam from 25 to 50 % of the reach length	if they dam less than 25 % of the reach length
	if there is at least a dam higher than 10 m and with no *bypass* for sediments	-5	-4	-3
	if there are some weirs or at least a dam higher than 10 m with *bypass* for sediments	-4	-3	-2
	if there is a single weir	-3	-2	-1
There are bridges, fords or other minor obstacles that alter the longitudinal continuity of the channel			more than 1 per channel km	-2
			less than 1 per channel km	-1
The topography of the riverbed, the bedform sequences, the granulometry-morphometry of the materials or the riverbed aquatic or pioneer vegetation show symptoms of having been altered by dredging, extractions, floorings or clearances			in more than 25% of the reach length	-3
			in between 5 and 25% of the reach length	-2
			in odd cases	-1

Riverbank naturalness and lateral mobility ☐

The channel is natural and has the ability to move laterally without restrictions, since its natural banks pre-sent a morphology according to its hydrogeomorphological processes of erosion and sedimentation			10
The channel has undergone a total canalization or there are discontinuous bank defences or infrastructures (buildings, communication ways, ditches …) next to the banks	in more than 75 % of the segment length		-6
	in between 50 % and 75 % of the segment length		-5
	in between 25 % and 50 % of the segment length		-4
	in between 10 and 25 % of the segment length		-3
	in between 5 and 10 % of the segment length		-2
	in less than 5 % of the segment length		-1
The riverbanks present non natural elements, garbage or interventions that modify their natural morphology		remarkable	-2
		slight	-1
There are symptoms in the reach that the lateral dynamics are limited or there is not a good balance between margins with erosion or sedimentation. This can be an effect of actions in functional reaches upstream		remarkable	-2
		slight	-1

CHANNEL QUALITY ☐

the IHG index, the river course to be evaluated must be divided longitudinally in reaches. These river reaches should differ according to hydrogeomorphological criteria, such as discharge, valley slope, valley confinement and channel morphology.

The previous version of IHG has been improved in several respects. The updated version includes some improvements in the assessments of sediment supply and mobility and of riparian quality. The assessment of sediment supply and mobility now includes an evaluation of the impact of gravel and sand extractions and dredging. Moreover, the score and calculation of the longitudinal continuity of the riparian corridor have been changed by increasing the score discount for different types of ruptures. The riparian quality assessment has been reorganised to enhance the importance of the riparian corridor width, which has now been included as an independent second parameter within the riparian quality assessment. Additionally, the structure and naturalness and cross-sectional connectivity have been combined to form the third parameter within the riparian quality assessment.

Functional quality assessment of the fluvial system

The functional quality of the fluvial system is evaluated by adding the assessments of the following three parameters (Table 2):

a) *Flow regime naturalness*. This parameter is assessed in relation to the natural state. This standard of comparison implies that the river currently has a natural discharge regime with seasonal flow changes and floods.

b) *Sediment supply and mobility*. This parameter is assessed by examining how dams, dredging and extractions alter and reduce sediment flows. Importance is also given to the lateral inputs of sediment through mass failure processes and the contribution of tributaries.

c) *Floodplain functionality*. This parameter is assessed by considering how the presence of human activities in a floodplain could seriously modify its functionality.

Assessment of the channel quality

The channel quality assessment is obtained from the sum of the scores for the following parameters (Table 3):

a) *Channel morphology and planform naturalness*. Changes in the channel planform are evaluated by considering whether they are direct (channel realignment) or indirect (regulation, deforestation) human alterations.

b) *Riverbed continuity and naturalness of the longitudinal and vertical processes*. This parameter is estimated by considering the impact from dams and weirs (barrier effect, breaking longitudinal continuity, triggering incision processes downstream), and also from other types of human alterations in channels (dredging, gravel extractions, floorings, and vegetation clearcutting).

c) *Riverbank naturalness and lateral mobility*. This parameter considers pressures that confine the lateral mobility of the channel or alter the erosion and sedimentation processes (especially bank defences).

Assessment of the riparian corridor quality

The riparian corridor is the space (vegetated or not) in which the movement of the channel has occurred historically. In this section, the hydrogeomorphological function of the riparian corridor is assessed (Table 4) through the following key features:

a) *Longitudinal continuity*. This parameter is assessed according to the number of discontinuities in the riparian corridor resulting from human occupancy.

b) *Riparian corridor width*. The current width is assessed relative to the optimal width in the past or in a reference scenario.

c) *Structure, naturalness and cross-sectional connectivity of the riparian corridor*. Riparian patches and the internal quality of the riparian zone are estimated by evaluating disturbances and ruptures in the connectivity of the corridor.

Table 4. Assessment of the riparian quality. *Valoración de la calidad de las riberas.*

Longitudinal continuity ☐

The riparian corridor is continuous along the whole functional reach and in both channel banks, as long as the valley's geomorphological conditions allow it				10
There are segments with non-recoverable or permanent land uses (urbanization, factories, farms, gravel pits, stable linear infrastructures, bridges, defences, ditches...) that break the longitudinal continuity of the riparian corridor. There are surfaces with recoverable or non-permanent land uses (poplar plantation, crops, logging, paths…) that mean discontinuities		if more than 70 % of the discontinuities are permanent	if 30 % to 70 % of the discontinuities are permanent	if less than 30 % of the discontinuities are permanent
	if riparian zone is entirely removed	-10	-10	-10
	If the length of the discontinuities are more than 85 % of the riverbank's length	-10	-9	-8
	If the length of the discontinuities are between 75 % and 85 % of the riverbank's length	-9	-8	-7
	If the length of the discontinuities are between 65 % and 75 % of the riverbank's length	-8	-7	-6
	If the length of the discontinuities are between 55 % and 65 % of the riverbank's length	-7	-6	-5
	If the length of the discontinuities are between 45 % and 55 % of the riverbank's length	-6	-5	-4
	If the length of the discontinuities are between 35 % and 45 % of the riverbank's length	-5	-4	-3
	If the length of the discontinuities are between 25 % and 35 % of the riverbank's length	-4	-3	-2
	If the length of the discontinuities are between 15 % and 25 % of the riverbank's length	-3	-2	-1
	If the length of the discontinuities are less than 15 %	-2	-1	-1

Riparian corridor width ☐

The surviving riparian corridor keep all their potential width, so that they play perfectly their role in the hydrogeomorphological system			10
The width of the surviving riparian corridor has been reduced due to anthropic occupation	if the average width of the current riparian corridor is less than 50 % of thepotential one		-3
	if the average width of the current riparian corridor is between 50 % and 75 % of the potential one		-2
	if the average width of the current riparian corridor has been reduced but it remains over 75 % of the potential width		-1
if the ***Longitudinal continuity*** has resulted 0 (totally eliminated riparian corridor)		-10	After applying these scores, if the final result is negative, assess 0
if the ***Longitudinal continuity*** has resulted 1		-2	
if the ***Longitudinal continuity*** has resulted 2 or 3		-1	

Structure, naturalness and cross-sectional connectivity of the riparian corridor ☐

In the surviving riparian corridor the natural stages of vegetation, the complexity of the habitats, the naturalness of the species, and all the transversal diversity is maintained, not existing any internal human obstacle that separates or disconnects the different habitats or environments				10
There are human pressures in the riparian zone (grazing, clearing of vegetation, logging, fires, aquifer exploitation, dead wood picking, oxbow lake filling, garbage, builder's rubble, recreational use…), that cause alterations in its structure; or that cause the riparian zone to became scrubland due to the disconnection of water table (incised channels)		if they extend more than 50 % ofthe current riparian corridor	if they extend between 25 % and 50 % of the current riparian corridor	if they extend less than 25 % of the current riparian corridor
	if the alterations are very important	-4	-3	-2
	if the alterations are slight	-3	-2	-1
The naturalness of the riparian vegetation has been altered by alien species or plantations		if the alterations are significant		-2
		if the alterations are slight		-1
The reach is laterally constricted, generally longitudinally or diagonally, by linear structures such as roads, defences, ditches, trails, paths. These structures alter the transversal connectivity of the riparian corridor		if the discontinuities are distributed throughout the whole sector and the addition of their lengths exceeds 150 % of the reachlength		-4
		if the addition of the lengths of the discontinuities gives a value between 100 % and 150% of the reach length		-3
		if the addition of the lengths of the discontinuities gives a value between 50 % and 100% of the reach length		-2
		if the addition of the lengths of the discontinuities is less than 50 % of the reach length		-1
if the ***Longitudinal continuity*** has resulted 0 (totally eliminated riparian corridor)			-10	After applying these scores, if the final result is negative, assess 0
if the ***Longitudinal continuity*** has resulted 1			-2	
if the ***Longitudinal continuity*** has resulted 2 or 3			-1	

RIPARIAN QUALITY ☐

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