Reply to Comment on 'An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales'

2017 Environ. Res. Lett. 12 038002

(http://iopscience.iop.org/1748-9326/12/3/038002)

Environmental Research Letters

OPEN ACCESS

RECEIVED
5 January 2017

ACCEPTED FOR PUBLICATION
16 February 2017

PUBLISHED
8 March 2017

REPLY

Reply to Comment on 'An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales'

Günther Grill[1,6], Bernhard Lehner[1], Alexander E Lumsdon[2,3], Graham K MacDonald[1], Christiane Zarfl[2,4] and Catherine Reidy Liermann[5]

1 Department of Geography, McGill University, 805 Sherbrooke Street West, H3A 0B9, Montreal, Quebec, Canada
2 Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Müggelseedamm 310, D-12587 Berlin, Germany
3 Institute of Biology, Freie Universität Berlin, Germany
4 Center for Applied Geoscience, Eberhard Karls Universität Tübingen, Hölderlinstr. 12, 72074 Tübingen, Baden-Württemberg, Germany
5 Center for Limnology, University of Wisconsin, Madison, WI, United States of America
6 Author to whom any correspondence should be addressed.

E-mail: guenther.grill@mail.mcgill.ca

Compiling global databases of existing or planned dams has been a major challenge for researchers and practitioners due to the lack of quality and availability of dam data for certain parts of the world. This is particularly true for geospatial data, i.e. information about the precise location of individual dams, which for many countries are much less complete than national statistics. In their critique of Grill *et al* (2015), Hennig and Magee (2017) point to regional biases and inconsistencies in the underpinning global dam repositories provided by the Global Reservoir and Dam (GRanD) database (Lehner *et al* 2011) and the database of future hydropower projects by Zarfl *et al* (2015). They focus on a large number of existing or planned smaller dams for China and India. They furthermore argue that GRanD and the database by Zarfl *et al* do not compare well given that GRanD represents dams of all types with large reservoir capacities ($\geq$0.1 km^3) whereas the data of Zarfl *et al* includes only large hydropower dams ($\geq$1 MW) independent of reservoir capacity. Consequently, Hennig and Magee argue that 'the hotspots of future dam construction (and, by extension, river fragmentation) will be in Eastern Europe and Latin America.'

A main design goal of the geospatial databases provided by GRanD and Zarfl *et al* was to create a global record of large dams that is as consistent, comparable, complete, and unbiased as possible given the available data. Despite this objective, the original publications of both databases clearly acknowledge the various shortcomings inherent in the data—including the fact that they miss many dams. But this is the case mostly for smaller dams, and it applies for all regions of the world, not only for Asia. In the case of GRanD, the exclusion of smaller dams was an active process in order to increase global consistency; for example, more than 90% of smaller dams were removed from the data-rich and high-quality repository available for the United States to avoid biases toward North America. Nevertheless, we agree with the observation made by Hennig and Magee that some regional biases remain in global datasets.

Due to similar difficulties regarding data availability and quality, the database of future dams by Zarfl *et al* could not be compiled using the same criteria as the GRanD database and may therefore be perceived as 'incomparable'. Yet, Grill *et al* (2015) do not use the data by Zarfl *et al* for the purpose of comparison; rather they analyze the outcomes of a specific scenario: 'what if all currently planned large *hydropower* dams were built in the future—and beyond the existing large dams of all types?' Obviously this approach neglects other non-hydropower reservoirs in the future scenario, but it does so globally, and the scenario is clearly described as such.

Regarding our conclusions, Hennig and Magee paraphrase Grill *et al* (2015) to 'conclude that much of the increase in the number of dams globally stems from major dam construction in the Amazon Basin, the largest basin by volume worldwide'. We believe that this may be a misinterpretation of the original statement that the global river volume affected by dams would increase from currently 48% to 93% 'largely due to major dam construction in the Amazon Basin.' Our original statement does not imply that we find the greatest number of new dams in the Amazon Basin, which we do not, nor that the absolute extent in fragmentation or flow regulation will be highest in the Amazon Basin. For a correct interpretation it is important to recognize that in the index-based method developed by Grill *et al* (2015) the impact of dams on fragmentation does not simply scale linearly with the number of planned dams, but depends on pre-existing impact levels and on the location of the dams to be built. A basin with low current impact, such as the Amazon, can face strong additional increases of impacts from a few dams on large tributaries (or on the exceptionally large Amazon mainstem). In contrast, even a large number of future dams built in *already* impacted basins, such as the Yangtze Basin, may not lead to a sizeable increase in the basin's impact, especially if these future dams are planned to be built on smaller tributaries. Nonetheless, in addition to the Amazon, our index-based method identifies Asian river basins as hotspots of future dam impacts, including the Ganges/Brahmaputra, Indus, Mekong, and the Yangtze basins.

The observations made by Hennig and Magee on the global databases of current and future dams mainly reflect the limitations that were previously outlined in the original publications of the databases (Lehner *et al* 2011, Zarfl *et al* 2015). We also believe that, in general, GRanD as well as the database by Zarfl *et al* are consistent for the largest of existing and planned reservoirs worldwide; however, we agree with Hennig and Magee that they show significant limitations regarding the inclusion of smaller dams for which a consistent global coverage was not achievable. To this extent, the observations made by Hennig and Magee can be interpreted as confirming that the study by Grill *et al* (2015) is likely a very conservative estimate of global dam impacts. We also strongly support the motivation of Hennig and Magee that methods and data should be further improved, and that experts in specific regions could contribute important information to update or refine existing dam databases. This may be particularly pertinent for rapidly developing economies, such as China and India.

Despite limitations in terms of regional- or location-specific impacts, including due to unintentional biases, the existing global databases and simulations as presented and interpreted in Grill *et al* (2015) can help to create a more holistic perspective of complex water resource demands at large scales. We believe that such global assessment is crucial to point out critical processes, trends, or regions of potential conflict that might have been neglected so far. The reality of dam impacts on people and ecosystems is likely more severe in China, India, and elsewhere than our current simulations show, but incorporating these impacts into global studies will require more data sharing and collaboration. Truly understanding local level impacts in a consistent fashion across the world is a grand challenge for hydrological research, which will depend on an open and concerted exchange of resources and expertise.

References

Hennig T and Magee D 2017 Comment on 'An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales' *Environ. Res. Lett.* **12** 038001

Grill G, Lehner B, Lumsdon A E, MacDonald G K, Zarfl C and Reidy Liermann C A 2015 An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales *Environ. Res. Lett.* **10** 015001

Lehner B *et al* 2011 High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management *Front. Ecol. Environ.* **9** 494–502

Zarfl C, Lumsdon A E, Berlekamp J, Tydecks L and Tockner K 2015 A global boom in hydropower dam construction *Aquat. Sci.* **77** 161–70