Critical research in the water-related multi-hazard field

To the Editor — We believe that the transdisciplinary studies on water-related multi-hazards are innovative and critical research by the water community, thus answering the call of the recent *Nature Sustainability* Editorial 'Too much and not enough'[1] for water science ideas that are not derivative or stagnant. This domain of water studies focuses on the specific contexts where water-related hazardous events occur simultaneously, in cascade or cumulatively with other events. Characteristic of the field is the intensive collaboration of scientists and practitioners from different disciplines working together to better understand, assess and manage water-related multi-hazards. At the recent Asia Oceania Geosciences Society–European Geosciences Union Joint Conference on New Dimensions for Natural Hazards in Asia, we discussed the statement 'Too much and not enough'[1] and here suggest three reasons why transdisciplinary collaborations have led to many new ideas and notable advancements in the field of water-related multi-hazard research in recent years.

First, collaboration across different natural hazard fields led to approaches for structured comparative analyses that allow general results to be drawn from the assessment of multi-hazard events presented in case studies that can be applied to other contexts. For example, a systematic examination identifying which natural hazards can trigger or amplify the probability of floods (or vice versa) revealed interactions with the following hazards: earthquakes, volcanic eruptions, landslides, regional subsidence, storms, hail, extreme hot temperatures and wildfires[2]. Flood and drought experts developed the paired-event approach for undertaking detailed analyses of the contribution of different drivers to changing impacts from floods and droughts[3,4]. They also identified processes whereby flood or drought risk reduction measures can have (unintended) positive or negative impacts on the risk of the opposite hazard (and vice versa), with important implications for practical flood and drought risk management[5].

Second, collaboration across natural and social sciences revealed the strong influence of human behaviour dynamics on multi-hazard risks. In addition, the use of novel data and data science approaches support the assessment and modelling of these complex multi-hazard events and their impacts. For instance, one study[6] developed a new framework for assessing the two-way interactions and feedbacks between water-related multi-hazards, decision-making processes and conditions of socio-economic systems. The field of compound flooding (describing combinations of multiple flood drivers and/or flood types that contribute to a hazardous event) showcased the integration of several new data science methodologies — including the use of convolutional neural networks and data fusion techniques — for the assessment of local and regional compound flooding[7], and the joint influence of riverine and coastal drivers of flooding in close to 3,500 deltas[8]. Probabilistic multi-risk scenarios facilitate quantitative assessments and improvements of risk mitigation measures, such as tsunami evacuation facilities[9]. The utilization of novel data science approaches for multi-risk research needs improved interdisciplinary education, an example is the HEIBRiDS graduate programme that provides joint PhD supervision by a domain and a data science expert.

Third, collaborations between scientists and practitioners are addressing the challenge of the increasing frequency and intensity of water-related multi-hazards due to climate change; these collaborations show that it is neither efficient nor possible to protect potentially affected areas from the impacts of all events, including the most extreme ones. As a result, new robust, adaptable risk management strategies are being developed. An example is the new coastal risk management strategy in Japan, where 'tsunami level 1' determines the height of coastal protection against frequent tsunamis and other coastal hazards, while 'tsunami level 2' is intended to ensure safe evacuation before extreme events[10]. Another example is the World Bank's improved financial risk management framework to better respond to sequential or compound events, such as the occurrence of natural hazards during the COVID-19 pandemic[11].

Still, we share some of the concerns raised in the *Nature Sustainability* Editorial[1]. Funding plays a major role in water-related multi-hazard research. We welcome the efforts of many funding bodies, such as Horizon Europe, to promote the translation of scientific results into practice by integrating it into research projects. However, we agree that it is impossible to develop and implement new interdisciplinary approaches in three-year projects. High publication pressure, exacerbated by easy-to-apply citation metrics used in many types of evaluation, is particularly problematic in interdisciplinary fields. Metrics, such as the *h*-index, do not illuminate insightful and innovative aspects of published work and are not useful for comparisons across disciplines, due to differences in publishing traditions and academic databases in use.

Overall, intensive transdisciplinary collaboration in the field of water-related multi-hazard research has resulted in many new ideas in recent years that have already improved practical risk management of natural hazards for the benefit of society. The creation of new ideas can be supported in many ways, for instance, by providing adequate mid- to long-term funding for transdisciplinary research, supporting improved interdisciplinary education, improving the processes to assess the value of scholarly work and — last but not least — broadening the scope of research deemed interesting by leading journals such as *Nature Sustainability*. ❐

Heidi Kreibich[1]✉, Marleen C. de Ruiter[2], Katsuichiro Goda[3], Margreth Keiler[4,5], Anawat Suppasri[6] and Bruce D. Malamud[7]

[1]Section Hydrology, German Research Centre for Geosciences, Potsdam, Germany. [2]Institute for Environmental Studies, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands. [3]Department of Earth Sciences, Western University, London, Ontario, Canada. [4]Department of Geography, University of Innsbruck, Innsbruck, Austria. [5]Institute for Interdisciplinary Mountain Research, Austrian Academy of Sciences, Innsbruck, Austria. [6]International Research Institute of Disaster Science, Tohoku University, Sendai, Japan. [7]Department of Geography, King's College London, London, UK.

✉*e-mail: heidi.kreibich@gfz-potsdam.de*

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Competing interests

The authors declare no competing interests.