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ABSTRACT
Addressing global water crises demands effective communication across diverse audiences, especially in initiatives such as the scientific decade HELPING by the International Association of Hydrological Sciences (IAHS). This study synthesizes insights from the hydrological community, gathered through interviews, workshops and a digital survey. We identify key challenges and best practices across three inter-related domains of communication: science–society interactions, policy–science interfaces and transdisciplinary research communication. Effective science–society interaction depends on community trust-building, transparent communication of uncertainty and inclusive engagement strategies. Strong policy–science interfaces benefit from bridging institutions and dedicated knowledge brokers. Transdisciplinary work improves when disciplinary siloing is reduced through common language and co-production. We summarize our findings in the FUSS framework, which promotes messages that are few, unambiguous, short and well-structured. We argue that advancing hydrological science in the face of water crises requires moving beyond one-way communication towards more dialogic, inclusive and context-sensitive approaches.

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1 Introduction

Effective science communication is a cornerstone of the third scientific decade of the International Association of Hydrological Sciences (IAHS), HELPING (2023–2032), which aims to address global water crises by integrating hydrological knowledge across scales through diverse, inclusive and actionable perspectives from different actors.[1] The acronym HELPING – Hydrology Engaging Local People IN one Global world (Arheimer *et al.* 2024) – captures the idea of deriving insights from comparing challenges and solutions in different contexts, ranging from coping with increasing water scarcity in drylands and flooding in coastal areas to groundwater depletion in agricultural hotspots.

Given the diverse nature of water crises, it is vital that all voices are heard to ensure that solutions are adapted to local and regional settings and to integrate existing knowledge across scales and geographies. This includes contributions from researchers at different career stages and from different disciplines, community actors such as decision-makers at multiple governance levels, private-sector representatives, professionals involved in water management projects and non-governmental organizations (NGOs) (Marshall *et al.* 2020). Considering these diverse perspectives is essential as inclusivity increases trust, allows the integration of local and indigenous knowledge with formal scientific knowledge and ultimately leads to more effective and actionable outcomes (Reed *et al.* 2014, Arheimer *et al.* 2024). In all of this, science communication is crucial in facilitating collaboration among actors within the HELPING community, ensuring more equitable and balanced decision-making and enhancing the legitimacy and acceptance of results (for further details on the organization of the new scientific decade, see Supplementary Materials A).

Casting a spotlight on science communication at the start of the HELPING decade is particularly relevant because of the evolution in communication practices and technologies over the first two IAHS scientific decades, PUB (Predictions in Ungauged Basins) and Panta Rhei. PUB (2003–2012) primarily aimed at reducing prediction uncertainty for hydrological variables such as streamflow, water quality and sediment transport, marking a shift from reliance on traditional statistical analyses toward a deeper focus on process understanding (Pomeroy *et al.* 2013). Panta Rhei (2013–2022) focused on understanding the constantly-shifting interactions between hydrological systems and society, with a name inspired by ancient Greek philosophy and the belief that "everything flows"[2] (Montanari *et al.* 2013). Over the two decades that PUB and Panta Rhei spanned, the way hydrologists communicate has shifted dramatically. During PUB, the first smartphones, widely-used video-conferencing platforms and major social networks (such as LinkedIn, Facebook, Twitter and Instagram) became available. During Panta Rhei, communication technology evolved further, to the point that smartphones became ubiquitous, and social media focused heavily on visual content, particularly short-form videos. This development was accelerated during the COVID-19 pandemic, when online meetings became a new standard of professional communication. As Panta Rhei drew to its close in 2022, a new generation of generative AI tools became widely accessible, marking an important turning point in communication practices. These tools are already reshaping how scientific information is created and shared, raising questions about accuracy, ethics and inclusivity in water-related communication.

In the literature, science communication in hydrology and its rapidly evolving facets have long been explored, from highlighting water utility communication practices (Bishop 2003) and discussing the role of values and emotional appeal (Dietz 2013, Abu Bakar *et al.* 2024) to tackling the challenge of helping actors visualize and prepare for the impacts of ("impossible" or mega) floods (Bertola *et al.* 2021, Montanari *et al.* 2024, Ommer *et al.* 2024). Some studies have addressed questions similar to the ones posed in this paper, but at more regional or

[1] We have consciously opted against using the word "stakeholder" in this context to avoid the perpetuation of colonial narratives (Reed *et al.* 2024).
[2] Its name was inspired by ancient Greek philosophy and the belief that "everything flows". The full phrase is "Everything flows, and nothing stays still", which means everything is in flux and nothing remains the same: "Τα πάντα ρει, μηδέποτε κατά τ'αυτό μένειν". Essentially, Heraclitus was emphasizing the constant state of change in the universe. He used the metaphor of a river to illustrate this idea: even though the river looks the same, the water is always moving and changing. This concept applies to everything in existence. According to the "everything flows" concept, he reminded us that "you cannot step into the same river twice" because the river is changing at every moment, so it is never the same river.

local scales (e.g. Hundemer *et al.* 2022, in the Southwest United States). However, to our knowledge, no recent publication has provided a comprehensive assessment of the global hydrological community's perception of communication challenges and strategies to overcome them, particularly within the context of IAHS scientific decades.

This paper aims to provide a comprehensive, community-based exploration of perceived science communication challenges and to develop more effective and inclusive communication strategies within HELPING. We define "*science communication*" as the practice of translating complex scientific concepts into meaningful information tailored to different actors' needs, including an iterative assessment of the appropriateness and effectiveness of the chosen approach (Fischhoff 2013). Our basis for this paper is a broad community perspective gained through in-person and online workshops, interviews with IAHS members who were involved in the two previous IAHS scientific decades, interviews with diverse actors involved in science communication outside IAHS and an online survey. Our methods combined and cross-verified quantitative and qualitative data to ensure validity, explore key themes and examine the same phenomenon from multiple perspectives (Creswell *et al.* 2003, Kabo *et al.* 2023).

Broadly, we focus on three dimensions of science communication: (i) science–society interactions, by which we mean the broad set of engagements between hydrologists and societal actors – particularly trust-building and inclusive engagement with communities affected by water crises, (ii) the policy–science interface, concerning how hydrological knowledge is conveyed to, and taken up by, decision-makers and (iii) transdisciplinary research communication, which we use to denote communication with research collaborations that deliberately integrate hydrological science, other academic disciplines and non-academic actors in the co-design and co-production of knowledge and solutions. While transdisciplinary research represents one specific form of science–society interaction, we treat it separately here because it involves distinct internal communication challenges with such collaborative projects. These three domains were consistently highlighted across interviews, workshops and surveys, and they frame our synthesis of challenges and best-practice strategies.

We emphasize that this article is an opinion paper and does not claim to provide an exhaustive review of past science communication approaches in hydrology. Rather, it is a snapshot of what the HELPING community perceives as the current major challenges and potential solutions. It follows on from a series of thought-provoking opinion papers written during Panta Rhei (https://www.tandfonline.com/journals/thsj20/collections/panta-rhei-opinion), alongside HELPING perspective papers such as Castelli *et al.* (2025).

2 Methodology

The overall methodology for gathering insights into the experiences of community members is presented in Fig. 1. Each step is described in more detail below. In-person and online workshops fostered real-time dialogue and collective problem-solving, interviews captured the subjective and nuanced perspectives of individual actors and the online survey offered more quantitative insights. We aimed to explore how: (i) science–society interactions promote two-way communication between local communities and hydrologists and other societal actors, build trust and foster engagement with those affected by water crises; (ii) policy–science interfaces help prevent top-down instrumental approaches from water decision-makers that lack local understanding; and (iii) communication within transdisciplinary research collaborations provides diverse perspectives and facilitates collaboration among hydrologists, other disciplines and non-academic partners. We hypothesized that, together, these forms of communication support more normative, deliberative modes of engagement, leading to novel solutions based on shared values and emerging norms.

2.1 Vienna workshop

As a first step, we organized a splinter meeting at the EGU24 General Assembly[3] (14–19 April 2024, in Vienna, Austria). The hybrid workshop included 18 attendees on-site and two online. Workshop discussions helped to frame the further workflows of the information-gathering process for the community paper, as well as four main sets of science communication challenges (Supplementary Materials B).

2.2 Collaborative documents to prepare interviews and online workshops

Following the Vienna workshop, we embarked on a non-systematic collaborative literature review, based on a shared spreadsheet, in which contributors identified useful sources and summarized their main points.[4] This review formed the basis for synthesis by the lead authors. Simultaneously, we drafted collaborative documents with questions to structure the online workshops, and the interviews with long-term IAHS members, and other actors. Based on the IAHS privacy guidelines, we developed a data privacy statement for the interviews and the workshops (Supplementary Materials C).

[3]EGU24 had over 20,000 attendees from 109 countries and therefore offered a valuable opportunity to gain a diverse range of perspectives. Splinter meetings are open to anyone attending – online or in-person. This splinter meeting was promoted in the run-up to the conference via social media (including the IAHS accounts) and different mailing lists to generate engagement.

[4]Volunteers carried out searches for publications on science communication in the water space in Web of Science, SCOPUS and Google Scholar, then entered the citation and a note on its pertinence for our research in a shared table. In total, our collaborative literature review provided in-depth coverage of 36 immediately relevant, peer-reviewed articles about science communication in hydrology, published between 2003 and 2024. While a broader body of literature exists on science communication more generally, we intentionally restricted our synthesis to hydrology-specific studies in order to maintain direct relevance to IAHS scientific decades. This was not intended as an exhaustive review, but rather as a focused synthesis of the most directly relevant contributions.

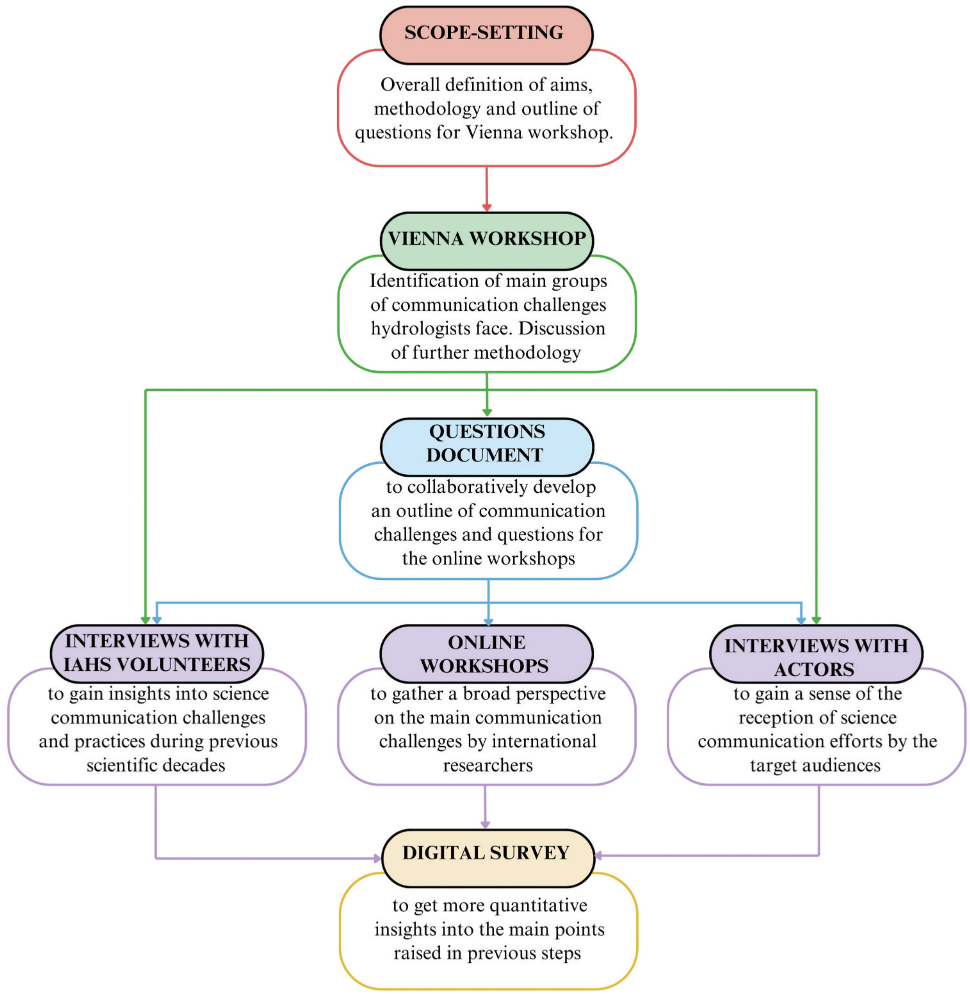

Figure 1. Flowchart of the information-gathering approach adopted for this paper and the interconnections among its components.

2.3 Interviewing long-term IAHS members

Next, 12 long-standing IAHS members who had held active leadership roles in the past two IAHS scientific decades were interviewed to elucidate the science communication challenges they faced, their temporal evolution and how they were addressed. Interviewees were chosen through purposive sampling, in which we deliberately selected participants likely to be knowledgeable about the aspects of interest (Johnson and Waterfield 2004). Of 25 long-term IAHS volunteers who were contacted, 11 completed interviews and one responded to questions in writing (for more details, see Supplementary Materials D). Among these 12 interviewees, half were based in Europe, with two each in Asia and South America and one each in North America and Africa. Despite efforts to include diverse IAHS volunteers (via representation from regional and Early Career Scientist (ECS) committees), European researchers remained in the majority, resulting in interviews skewed in terms of both geographic and gender representation. Only one of the twelve interviewees was a female researcher, which may reflect the typical gender imbalance in senior research positions. Several recent studies have shown that, although there has been a slow increase of female researchers in senior positions in the geosciences (Agnini *et al.* 2020, Ranganathan *et al.* 2021), a significant gender imbalance remains. This is particularly striking as the same studies also show a relative parity of female and male PhD students. An anonymized list of interviewees – both of IAHS members and non-IAHS actors (see Section 2.5) – is provided in Supplementary Materials D. Direct quotes used for illustrative purposes in the text are accompanied by each interviewer's ID from this list. For IAHS members, the ID begins with "V" (denoting Volunteer), while the IDs for non-IAHS actors vary by sector: "C" for NGOs/civil society, "G" for government, "P" for private sector and "R" for research institutes. For the analysis of the interviews and workshops conducted for this study, a thematic analysis (following Terry *et al.* 2017, Braun *et al.* 2019) was conducted, albeit in a simplified form due to the heterogeneity of the data. For more details and an overview table of main themes, see Supplementary Materials E. In the results outlined below, themes are in bold.

2.4 Online workshops

As a fourth element in our methodology, we collected a broader set of perspectives from the HELPING community through three focus group discussions during online workshops. Focus groups (Amir *et al.* 2024) are a qualitative research method that aims to generate ideas and an understanding of a wide array of opinions. Participants included researchers at different career stages as well as non-scientific actors from the private and public sectors. These two-hour online workshops were staggered across time zones to maximize international accessibility. One workshop was coordinated by regional leads for North and South America, a second one by researchers based in Europe and Africa and a third by volunteers from Asia and Oceania. This followed the example set by the IAHS leadership during the topic-finding process for the new scientific decade (Supplementary Materials F). Overall, 47 participants contributed their opinions on science communication during these workshops.

2.5 Interviewing non-IAHS actors

Next, we conducted interviews with a broad range of water sector actors, such as engineers working in river rehabilitation, mayors of small towns facing flood hazards, government officials in water management agencies and leaders of NGOs that organize around sustainable water use in arid regions. They were chosen through both purposive and convenience sampling, with working group members contacting actors deeply involved in science communication with whom they had come into contact through their own work. The aim of these interviews was to understand the place of science communication in their mental models (Bruine De Bruin and Bostrom 2013). In total, 22 actors were interviewed: eight were based in Asia, six in Europe, three each in North America and South America and two in Africa. Of these, 48% were involved in the governmental sector, 30% in the private sector, 17% were employed at research institutes and 9% worked for NGOs. Interviews were carried out in the native languages of the interviewees or with English as a lingua franca. Details are given in Supplementary Materials D.

2.6 Digital survey

Another component of our approach was a digital survey, which was promoted on social media (amplified by the IAHS main account), the mailing lists of the IAHS and the EGU Hydrological Sciences Division, and the personal efforts of working group members. The aim was to gain a more quantitative understanding of some of the main communication challenges and related questions that emerged during the previous steps in our methodology. This component also contributed to the triangulation and complementary aspects of the mixed-methods study. The questionnaire began with an anonymous respondent characterization (age group/sector/geographical origin/career stage), which was followed by a series of 17 multiple-choice and open-ended questions on science communication (details in Supplementary Materials G). In total, 100 respondents participated in the survey, with response rates analysed based on promotion channels (social media platforms and e-mail lists).

2.7 Reflections on the making of this paper

Finally, we used the experience of organizing the community paper itself to reflect on the wide range of communication challenges involved in successfully motivating a section of the hydrological community to take part in a new initiative, as well as coordinating a global group of volunteers and workshop participants. Following Van Hateren *et al.* (2023), we conducted an anonymous internal survey of the authors of this paper – their gender, country of origin and career stage – to gain insights on its global representativeness and to raise awareness of any implicit biases. Overall, 59 volunteers from 23 different countries contributed to the making of this paper. The largest share of them came from Europe (38.6%), followed by Asia (36.4%), Africa (9.1%), South America (6.8%), North America (6.8%) and Oceania (2.3%). Most of them (52.3%) were ECS,[5] followed by mid-career stage scientists (27.3%), senior researchers (11.4%) and students (9.1%). Regarding gender, 68% of authors identified as male, 27% as female and 4% as non-binary or other.

A more detailed reflection on the science communication challenges involved in the making of this paper – from coordinating volunteers based in numerous time zones to engaging community members through the online survey – is presented in Supplementary Materials H. Here, it can be noted that the major challenge was finding ways of being truly inclusive and ensuring that as representative a group as possible could participate in the making of this paper. In some ways – such as holding online meetings tailored to different regions – we succeeded. In others, we failed, as evidenced by the fact that, despite our efforts at inclusivity, the majority of volunteers in this effort were still male and based in Europe. Consequently, there is also a pronounced bias towards European respondents in the digital survey, as many participants were recruited through internal mailing lists and personal networks of working group coordinators and senior researchers. This limitation needs to be kept in mind in interpreting the results outlined below, especially with a view towards their worldwide validity.

3 Results and discussion

3.1 A look back: science communication in PUB and Panta Rhei

One prominent theme that emerged during interviews with long-term IAHS volunteers was the change in **target audiences** for the scientific decades. "*Panta Rhei was so much more complex than PUB*", one interviewee (V10) noted. "*PUB had a particular focus limited to hydrological sciences research. But Panta Rhei wasn't science for hydrology's sake. It was linked to the development we needed, the collaboration we needed, and to climate change. And how everything changes over time.*" Interviewees noted that Panta Rhei broadened its scope beyond PUB's, engendering systems thinking and interactions both within and outside the hydrological research community. HELPING aims at going a step further, making knowledge co-creation and interactions with non-scientific actors an explicit goal (Arheimer *et al.* 2024).

[5]Early career scientists as defined by the European Geosciences Union – up to 7 years after the completion of their last degree. Data as of February 2025.

Another common theme was the increased range of **choice in communication channels**, especially team collaboration tools and social media,[6] particularly during the COVID-19 pandemic. However, most interviewees stated that their preferred communication channels for managing working groups have been, and continue to be, e-mail and in-person meetings. E-mail was valued because of its generational and geographical accessibility. Several interviewees noted that senior community members are often reluctant to adopt social media or team collaboration tools, and that some of these tools are not universally accessible. For example, in China, platforms such as Facebook or Google products can generally be accessed only within higher education institutions or through virtual private networks (VPNs).

In addition, several interviewees remarked on the theme of **communication overload**. With the proliferation of different communication channels, the level of noise is nearly unmanageable. One interviewee (V2) noted: "*I'm already so overwhelmed reading my e-mail that I avoid using Slack or other tools like that*." While the preference for internal communication via e-mail remains strong, interviewees noted that e-mails must fulfil a certain number of criteria in order to be effective in reaching researchers. Specifically, they must be personalized, concise and sent at the right frequency. Interviewees noted that engagement on many e-mails is low, and sending them to large, self-managed e-mail lists can feel like "screaming into the void". It was through "learning by doing" that most of them fine-tuned their communication strategies. "*I send e-mails on a monthly basis. Too often is not good because people ignore your messages*", one of them (V4) noted. "*Sending personalised e-mails to a few individuals worked much better than emails to the entire community*", another one (V1) emphasized.

Another theme raised frequently during interviews was **choosing the right format for meetings**. Interviewees agree that face-to-face meetings are indispensable for effective communication in general and for trust-building in particular. Before the pandemic, during PUB and much of Panta Rhei, these meetings happened regularly at large conferences such as the annual General Assembly of the European Geosciences Union (EGU) and the American Geophysical Union (AGU) Fall Meeting, as well as smaller, more specialized events. Since 2020, online and hybrid meetings have become far more frequent, supplementing but not fully replacing in-person interactions (Kang and Van Ouytsel 2024). In terms of accessibility, the advantages and drawbacks of both variants were outlined by several participants. On the one hand, online meetings save time and are accessible to those lacking resources to travel. "*In former years one was away the whole day just because of a 3-hour meeting in Munich*", one researcher (V2) noted, for instance. On the other hand, the accessibility constraint most frequently highlighted for online meetings is the matter of time zones and scheduling across time zones that often privileges Europe or the US. "*Physical meetings are no problem because we travel to one place. But for the online meeting it's a challenge to find a common time*", one interviewee (V4) pointed out.

A further major theme was the question of providing the right **incentives for science communication**. With respect to communication within PUB and Panta Rhei, senior researchers noted that success principally relied on the motivation of key people – working group leaders, the chairs of committees, or the coordinators of individual initiatives. One interviewee (V6) noted: "*This means that you need to find leaders that are willing to put in a lot of work on that*." This has especially been the case in the absence of official guidelines for communication, which were sparse in previous decades. In general, communication guidance from the IAHS office has increased over the years. When PUB was launched, for instance, a volunteer independently created a website for the new scientific decade, which was only later integrated into the IAHS website (www.iahs.info).[7] For members of PUB and Panta Rhei working groups, the most effective motivator to become active was the prospect of contributing to community and opinion papers, many of them published in *Hydrological Sciences Journal*, a pivotal outlet for IAHS. "*You have to look at the way the academic activity and academic recognition is organised*", one interviewee (V6) noted. "*Researchers try to look for an outcome that can be included in their CV, when you ask people to get involved in activities that are not recognized by the institutions hiring them. It's not a matter of will or personal interest, it's just a matter of what one can do*." As a result, especially engaging in communication efforts beyond the scientific community can be tricky. "*For instance, if you invite people to write a blog, you won't find people willing to do that*."

Finally, several interviewees touched on the theme of **ensuring equity in science communication** – noting that, over the past 10 years, engagement with IAHS in general and with scientific decades in particular has increased. One interviewee (V7) highlighted that their impression had been of a shift towards a more bottom-up structure, with young scientists in particular making their voices heard. Another interviewee (V9) also pointed out that it is crucial that different regional and national challenges are recognized and integrated when it comes to developing guidelines for HELPING, with a view towards "*decentralising communication beyond the Global North*"[8] and an approach of defining goals rather than mandating procedures, ensuring that solutions remain locally relevant while contributing to a cohesive global framework. This can be facilitated by the IAHS committees for ECS and regional committees for Africa and Latin America.[9]

[6]It must be noted that the perception of the role of social media might have changed since the Vienna Workshop and the online meetings were held in spring and summer 2024, given the shifts that followed the 2024 US presidential election.

[7]In contrast, the office now maintains a professional presence on an extensive website as well as several social media platforms, which has been noted as an asset for communication by several interviewees.

[8]We acknowledge that the terminology "Global South/North" is not clearly defined in a geographical or political sense, that it may perpetuate mental models of colonial hierarchies and that efforts on decolonizing the language used in hydrology are ongoing. We have nevertheless chosen to keep the terms for this article as they were frequently used by both interviewees and workshop participants.

[9]https://iahs.info/Initiatives/committees/

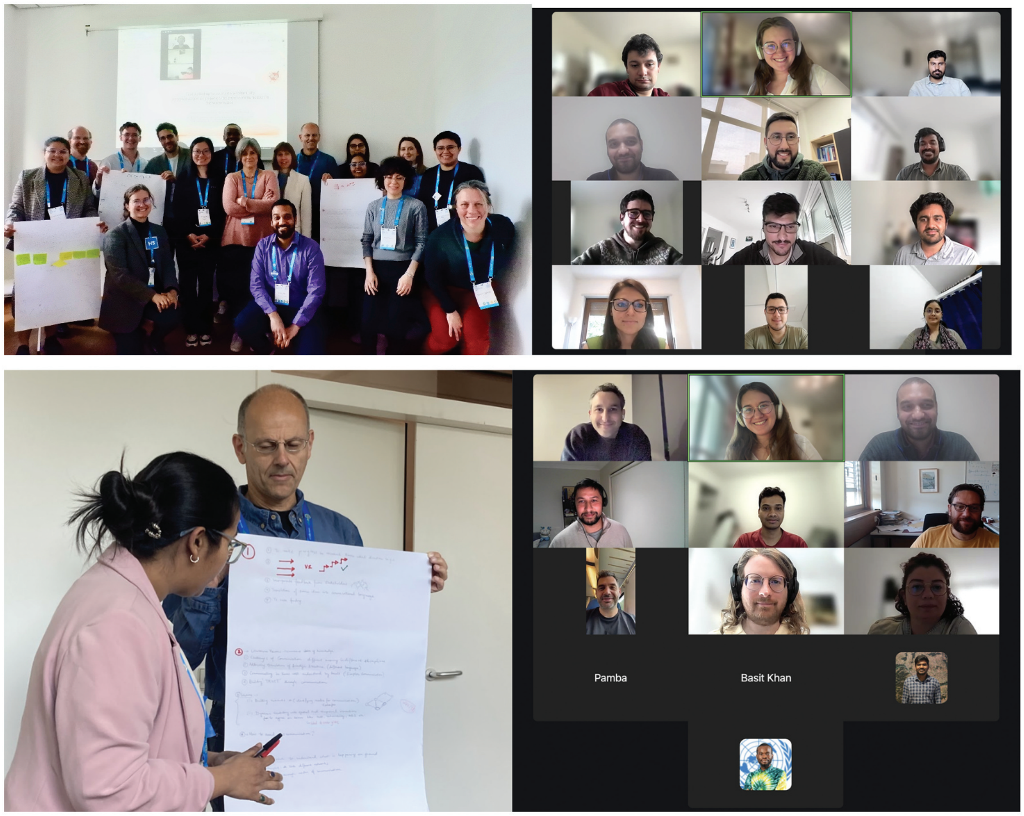

Figure 2. Images from the Vienna (April 2024, left) and online (July 2024, right) workshops.

3.2 The main challenges of science communication in HELPING as perceived by hydrologists – outcomes of the participatory online workshops

Workshop discussions (Fig. 2) highlighted several key communication challenges, centred particularly around the themes of **building bases of trust** in the communities hydrologists work with through science communication, how to **tailor messages to different target groups** (both within hydrology and more broadly), how to **deal with the information overload** that is often brought about by modern technology, and how to tackle practical challenges like **finding funding for science communication activities**, and active efforts for **diversity and inclusion**. Several of the themes touched upon overlapped with those that appeared in interviews with IAHS volunteers and non-IAHS actors, as detailed further below.

In terms of **building bases of trust through science communication**, several groups shared their experiences of encountering scepticism or even hostility towards water professionals that led to a lack of engagement and difficulties in local communities during projects. In some places, this was due to a historical divide between scientific data and local experiences (Abbott and Wilson 2015). One participant gave the example of fieldwork conducted in the Mekong River Basin, which highlighted how past elitist attitudes hindered community engagement; scientific experts did not believe in the possibility of the diurnal water level variations reported by the community. In other contexts, such as Chile and India, participants noted that memories of governmental mismanagement of disasters had created long-term trust deficits. One group emphasized that community organization is the most effective when it is led by the communities themselves, in line with communitarian principles. Several groups also observed that communities tended to place greater trust in individual researchers than in institutions, while political involvement often introduced power dynamics that worsened community engagement. Several participants mentioned immersion programs (participant observation) at educational institutions to build trust with communities over longer time periods, while others highlighted the advantages of involving community facilitators (Eaton *et al.* 2021). Science communication was seen as a key instrument in overcoming public mistrust (Bultitude 2011). A consensus among participants was the need for early and sustained investment in trust-building and communication (Reed *et al.* 2014). They advocated workshops as essential tools for co-production, and leveraging interdisciplinary and external expertise, for instance, by collaborating with third-party experts to facilitate brainstorming sessions (Moallemi *et al.* 2021) as well as involving knowledge brokers (Miller *et al.* 2014). Another group emphasized iteratively engaging with and gathering feedback from communities, also through open-access tools of limited complexity that allow for local knowledge to be taken into account. One suggestion to increase community trust was to involve community members as authors in reporting.

Related to the challenge of trust-building is the theme of **tailoring messages to different audiences**, which broadly encompasses navigating multiple ontologies relating to scientific concepts. This includes the need for sensitively navigating intercultural differences and translation between languages, the latter of which has been facilitated by the use of AI translation tools. It also encompasses tailoring scientific terminology and units to local relevance. One participant gave the example of a project in which they stopped providing discharge values in m^3/s because the community was more interested in rainfall thresholds that triggered urban flooding. Similar ontological challenges apply in interdisciplinary communication. While participants advocated working with colleagues from other fields – to avoid "reinventing the wheel" – this process is complicated by the fact that the same terms can have different meanings or interpretations across different domains (e.g. water-related "efficiency" terms for irrigation engineers versus plant physiologists; Van Halsema and Vincent 2012). In the context of interdisciplinary projects, participants highlighted the need for early terminological discussions to establish a common understanding.

An important related point brought up by several groups was the need to reduce **the complexity of hydrological information** and wrap it into storylines (Fischer *et al.* 2022). Information may be ineffective if it is overly complex, misaligned with actors' objectives, or presented with excessive reminders that could be perceived as patronising (Fabregas *et al.* 2019). Clear messaging that leverages relevance through past experiences, even via videos, was suggested. However, several groups cautioned against over-simplification that risks erasing important nuances. One participant quoted Mencken (Prejudices: Second Series, 1920): "*There is always a well-known solution to every human problem – neat, plausible, and wrong.*"

In particular, participants stressed the need to **communicate uncertainty** that is inherent to hydrology (McMillan *et al.* 2016), especially in areas such as probabilistic flood forecasts (Arnal *et al.* 2020). In line with Gustafson and Rice (2020), workshop participants found that expressing uncertainty in the form of quantified error ranges and probabilities largely had beneficial effects.

In summary, participants stressed that effective communication requires clear, audience-specific messaging, the use of appropriate formats such as visual aids in the form of graphics and videos, and sensitivity to both linguistic and emotional nuances. To convey complex information, several participants advocated the merits of a two-tiered approach similar to that used by the Intergovernmental Panel on Climate Change (IPCC): a brief executive summary accompanied by a full report co-produced with the community to build trust and ensure bottom-up representation.

Another considerable challenge that groups outlined centred around the theme of **navigating modern communication channels**, especially social media. The advantages they pointed out included increased access to diverse global audiences, real-time updates and asynchronous engagement. Workshop participants agreed that social media can be a way to reach people and generate engagement, especially when researchers employ targeted content strategies (Martin and MacDonald 2020). At the same time, they expressed concerns about biases, incomplete messaging, as well as active misinformation and the pitfalls of "feeding the trolls" (Golf-Papez and Veer 2022). Social media's brevity often led to oversimplification or misinterpretation of complex issues like water management. The issue of personal views overshadowing institutional credibility also emerged, with multiple groups stressing the importance of maintaining neutrality and clarity when using social media platforms. Attention was also called to accessibility issues resulting from the lack of infrastructure or restrictive governmental regulations. Regarding internal communication, participants pointed out the risk of bias by a few overrepresented individuals, which could lead to discontent among the silent majority (Long and Zhong 2023). Overall, participants expressed a favourable attitude towards blending traditional and modern communication methods, depending on the target audience. In internal communication, team collaboration platforms were seen as having a certain value, but most participants preferred direct personal communication, such as e-mails, phone calls or one-on-one interactions.

Finally, one theme discussed in detail was the challenge of **ensuring equity in science communication** through active efforts for inclusivity and representation. Participants agreed that inclusion and representation are key to overcoming hydro-hegemony (Menga 2016). The current lack of diversity among hydrologists makes it difficult to integrate regional, cultural and social differences, which was also highlighted in a recent survey of UK hydrologists (Environment Agency 2024). Several groups underscored the importance of creating leadership roles for individuals from marginalized or underrepresented backgrounds, as this would help bridge the gap between different power structures and amplify the voices of communities traditionally excluded from hydrological research. However, to reach this goal, it is crucial to address the practical barriers underrepresented hydrologists face. To do so, funding is needed – from scholarships to travel grants, which make attendance possible at events such as conferences and public dissemination events. Practical solutions suggested by participants included leveraging online video conferencing platforms to increase accessibility for those unable to travel, as well as applying for funding through mechanisms like the EU's COST Action program (https://www.cost.eu), the PRIMA foundation (https://prima-med.org/), which is co-funded by the EU framework research programmes, the Fulbright Scholarship Program or the IAHS SYSTA Grants (https://iahs.info/About-IAHS/SYSTA-Grants/). These strategies aim to mitigate the financial and logistical hurdles that prevent full participation in the global hydrological community.

3.3 Perception of hydrology science communication by non-IAHS actors

The main themes raised by actors in the private sector, research institutes, NGOs and governmental departments showed considerable convergence with the main challenges outlined during the workshops and interviews with IAHS volunteers, though they also presented some differing perspectives, particularly in comparison to the volunteer interviews.

Similar to the workshop participants, actors pointed to the pivotal theme of **building bases of trust through science communication** with local communities, a process that takes time and is difficult to measure. Several interviewees highlighted the value of spending as much time as possible on-site to establish rapport and gain a sense of how people perceive the hydrological systems that frame their lives, by exploring them together in the spirit of "water walks" (Holstead *et al.* 2025). Another recommendation was to rely on community facilitators, such as trusted local leaders (e.g. mayors or village chiefs) or doctors. "*Communication is effective when you anchor it to the closest trustworthy person to the community members – and that is your challenge*", one interviewee (C1), who works in an NGO specialized in water quality and health, noted. "*When they become your communicator, communication percolates to everybody*." The same interviewee also emphasized the value of enabling communities to generate and trust their own data. "*People trust data with a location and a photograph more than a datapoint alone. They visually mark [safe] water sources using locally meaningful color-codes. This data, generated locally rather than by an outsider, fosters trust when promptly shared back*."

A further theme that was stressed by multiple actors was the necessity of **making the purpose of communication clear**, especially given the differing priorities of communities and researchers. While the former are primarily concerned with finding practical solutions to water crises, the latter are often driven by the pressure to publish quickly in an academic environment of ever-increasing competitiveness (Aprile *et al.* 2021, Mills and Inouye 2021). As a result, interviewees noted, communities often feel exploited as sources of information. Past research (Kessler *et al.* 2022) has shown that scientists in precarious working conditions, such as temporary employment, tend to internalize the mental model of strategic science communication geared towards making themselves as relevant as possible. Actors advocate for user-centric, result-oriented approaches, which place the needs of communities at the heart of research and prioritize engagement and continuous sharing of data and progress. In this, a "pull" approach (accessing, interpreting the right scientific evidence for practice) combined with design thinking principles was emphasized as being more impactful than the predominant "push" approach (increasing the rate of implementing research findings into practice) (Boaden 2020). A recurring recommendation was for hydrologists to be clear about assumptions, limitations and uncertainties and to explain them in plain language rather than the technical formulations often used in peer-to-peer communication. Within the theme of **tailoring messages to audiences**, interviewees emphasized the value of the multi-tier strategies established by the IPCC and the World Bank, already highlighted in the online workshops. One interviewee (P2) with expertise in stakeholder engagement underlined the value of building a concise narrative targeted towards a particular audience, as well as the value of straightforward visuals:

> Good, simple graphs that clearly convey something the audience cares about – that's key. If they have to spend time figuring out the X- or Y-axes, you're going to lose their attention. Even I find my attention span is shorter than it used to be. I try to frame communication in a way that an 18-year-old today could easily understand, especially since they're the future generation of decision-makers.

An important point touched on by multiple interviewees was the necessity of adjusting language and avoiding jargon, both in public-facing communication and in peer-to-peer publications (Venhuizen *et al.* 2019, Altman *et al.* 2022). One interviewee in particular emphasized the merits of plain-language abstracts in scientific journals, as they facilitate interdisciplinary collaboration. With respect to community engagement, the effectiveness of positive rather than negative priming was noted. "*Initially, we approached communication with a scientific, 'enlightened engineer' mindset, focusing on risks and hazards like skeletal fluorosis, warning people about dire consequences, such as disabilities in children*", one interviewee (C1) working in the context of health and water quality with communities in the Global South explained. "*While effective for some, it caused friction with many who felt overwhelmed by yet another hazard amidst various existing struggles, such as chronic indebtedness. Good communicators advised shifting from negative priming ('this water will cripple you') to positive priming ('better water, food, and nutrition, lead to a better life'). For marginalised communities, combining occasional negative messages with a broader positive framework proved more effective and avoided distrust [. . .]*."

Another point raised by multiple interview participants was the theme of being aware of the **political dimensions of science communication and the power structures involved**. They highlighted that hydrologists need to factor broader discourses about topics such as climate change and natural hazards into their own communications. Climate change, for instance, has entered popular consciousness, and many people are now more willing to listen. At the same time, however, the topic has become highly polarized and politicized, amplified by targeted misinformation campaigns and social media echo chambers. This latter can lead to disconnects between scientific evidence and the personal beliefs of community members (Hundemer *et al.* 2022) and further undermines the old adage that science literacy is a panacea to societal conflicts (Nisbet and Scheufele 2009). As such, water science communication is increasingly becoming political communication (Scheufele 2014; Morovati *et al.* 2026). Actors pointed out that, frequently, the dissemination is controlled by an establishment whose first priority is to stay in power, rather than address systemic issues. As a result, hydrologists and community members are often prone to self-censorship, classifying their own discourse out of deference to the sensibilities and ingrained opinions of political actors, many of whom have control over factors such as funding. With respect to power structures, participants noted that communication often fails due to established hierarchies, particularly within research institutes and government agencies, with information of ground-level engineers not being taken into account by their superiors. The latter are also frequently perceived as figures of authority to such a degree that their judgements are not called into question. "*[Engineers with BSc degrees] tend to trust hydrologists with PhDs or consultants who have higher qualifications*", one interviewee (G6), an engineer in a governmental agency in the Global South, pointed out. "*Even if they suspect something might be wrong, they assume that the experts know better than them because they have higher degrees*." In the same context, the same interviewee also highlighted the value of offline meetings because they force the attention of people in positions of power, who ultimately make decisions: "*Online is not effective at all. Higher authorities don't listen, not because they don't want to, but because they're busy*." The same interviewee also noted that senior decision-makers rarely have time to attend talks by visiting hydrologists or actively engage in science communication, which aligns with Watts (2016) and his emphasis on the importance of the bridging function of organizations and consultants for successful knowledge transfer (Morovati *et al.* 2026).

Another systemic issue that has a major impact on science communication in the water domain is the crucial theme of **finding funding for science communication**. In particular, actors underlined the value of having funding that is explicitly dedicated to science communication. For instance, one interviewee, working in an environmental engineering firm, was involved in one of the first river restoration projects in Europe in the early 2000s. Financed partially by the EU's Natura 2000 programme, the project came with a dedicated communication budget. "*It was a first for us*", interviewee G1, head of an engineering office, recalls. "*We'd never done outreach like this for any of our previous projects. But with this budget, we funded town halls and information panels, educational paths through the riparian forests, and local photo exhibitions*." As a result, large sections of the population, who had originally been critical of the rehabilitation programme, gradually came to see its effectiveness both in terms of biodiversity conservation and flood protection. Another interviewee, a government official in Cambodia (G9), emphasized the role of in-house graphic design and video editing specialists who help the officials frame information targeted at the general public in a visually engaging and broadly accessible way. Accessibility and engagement-boosting visuals are also at the heart of projects by another interviewee (R2), who works with art to gain insights into communities' lived experience – from creative workshops and community-engaged artwork to infographics targeted at schoolchildren. Though funding for such projects is often difficult to obtain, and publishing results of such inter-disciplinary research is a challenge in itself, these art-based approaches help reach the community in an interactive way and provide chances to connect with people's personal experiences. This value of bringing creativity and art into the conversation was also emphasized by a researcher–artist interviewee (R4) who blends hydrology with *Bharatanatyam* to highlight how rivers are depicted and celebrated as emotional beings in traditional Indian dance forms, leveraging anthropomorphization to build empathy (Harrison and Hall 2010). In the literature, creative and playful approaches have proven equally effective in gaining insights into communities' lived experiences and attitudes – from developing tabletop and board games (Illingworth and Wake 2019, Stephens *et al.* 2019) to leveraging virtual reality (Skinner 2020).

Across the interviews conducted with different actors, several aspects stood out. First, many individuals working in engineering offices or governmental departments assumed by default that "science communication from hydrologists" referred mainly to the provision of data such as water levels and discharges, rather than broader outreach activities. This gives an important clue about how the knowledge produced by hydrologists is perceived by many of its end-users. Second, the substantial variety of contexts in which hydrologists and other water-sector actors operate was striking. For instance, one interviewee (P3), head of a governmental agency dealing with disasters in a country in Asia, was concerned with the implementation of an AI-driven flood management system, as well as the related challenges of transparency and communication with the programming team. In contrast, a government official from North Africa (G1) described difficulties with data collection still reliant on hand-read gauges, alongside communication pathways that continue to depend on fax and postal services. Together, these examples highlight the wide range of lived experiences among actors in the water domain that HELPING seeks to engage during this new scientific decade.

3.4 A quantitative view: the results of the digital survey

Finally, the digital survey provided a broader, quantitative view of many of the issues raised during both the workshops and interviews with long-time IAHS members and actors. (See Supplementary Materials I for a detailed breakdown of the demographics of respondents.) The total number of respondents was 100.

Regarding preferred communication channels, 84 respondents replied that e-mail was their primary choice for receiving updates about initiatives such as HELPING (cf. Fig. 3). This preference is also confirmed by the fact that the vast majority of respondents – 81 of them – found the survey via e-mails sent to mailing lists, and only 19 came across the call to participate on social media. At the time of the digital survey, among those who used social media, the preferred platform was LinkedIn (64). The largest section of respondents (45) preferred monthly updates, followed by weekly (18) and bi-monthly (14). Among the target audiences that respondents engaged with, academic experts (94) and non-academic experts in the private sector (63) were predominant. Correspondingly, the majority of respondents (55) said that the largest part of their science communication activities fell into the professional category (between them and their peers), followed by deficit-based (from them to non-scientific actors/"the public" with the broad purpose to inform them of scientific outputs) and consultative (iterative between them and non-scientific actors incorporating actor inputs into scientific knowledge) communication, with 17 respondents each. Only eight respondents said that the majority of their science communication activities fell into the deliberative category (iterative between them and non-scientific actors, with local and scientific knowledge democratically influencing each other in a deliberative process). In terms of specific science communication activities respondents engaged in, participating in in-person workshops and community events was the most common activity (76 respondents), followed by publishing in scientific journals (61) and holding online workshops and webinars (47). Only 12 respondents listed contributing commentary in traditional media (newspapers, TV, etc.) as part of their science communication activities. This is striking, as Peters *et al.* (2008) found that 39% of surveyed researchers at the time had had contact with the mass media, and because both journalists and hydrologists agree that it is crucial to build a joint narrative around

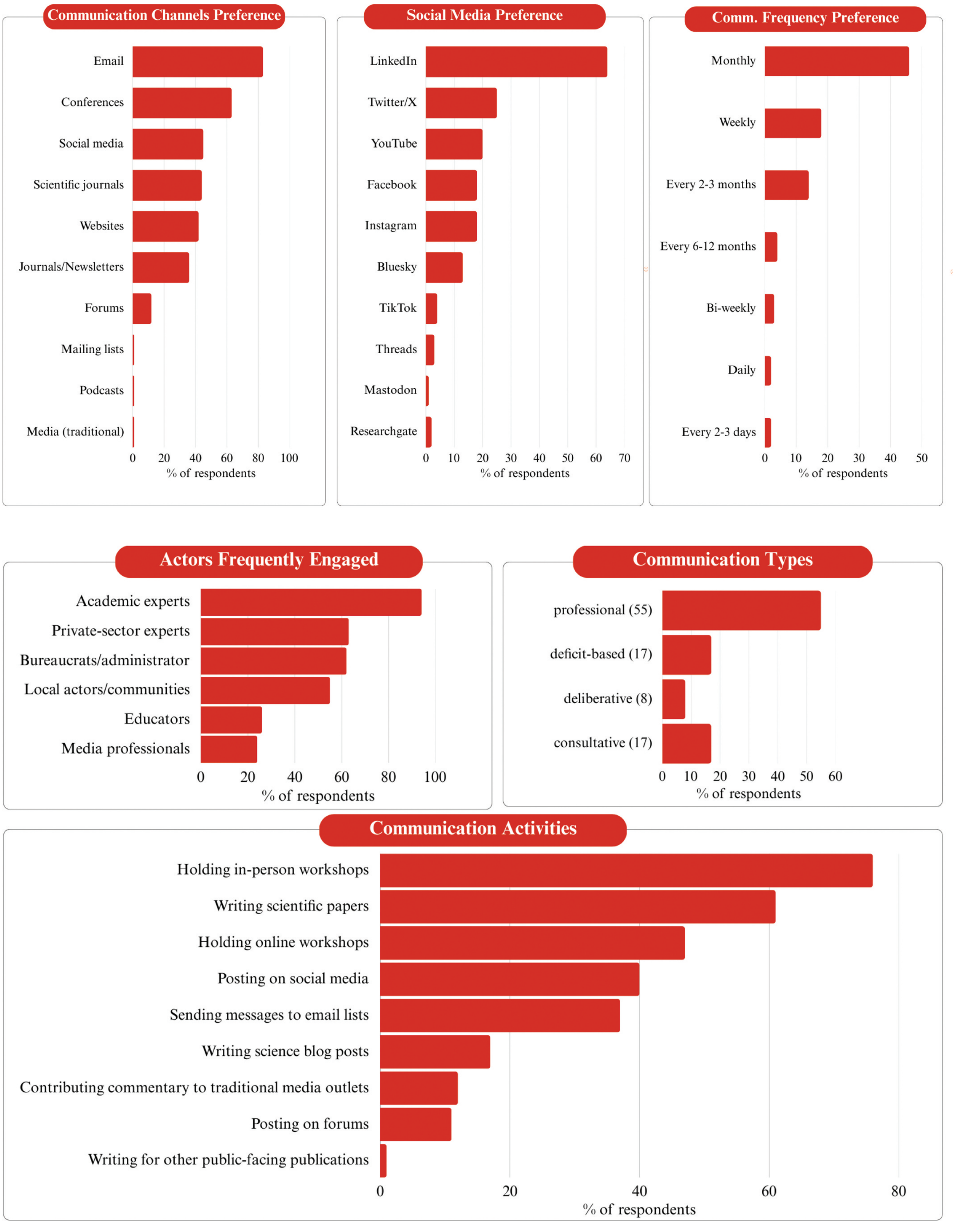

Figure 3. Science communication practices of survey respondents. Communication types are derived from Schibeci and Williams (2014).

scientific facts and leverage personal stories for information transmission (Lutz *et al.* 2018).

Concerning perceived challenges, the single most highlighted issue was the overwhelming volume of incoming communication (46), followed by terminological and language barriers (cf. Fig. 4). Out of all respondents, only 22 had received training on science communication to a broader audience, while 33 had received training on peer-to-peer communication and 41 had received no communication training at all. A clear North–South gradient is observed, whereby only four respondents from the Global South had received training for communication with a broader audience and only seven had received peer-to-peer training. For those who had received training, most of it was provided by their institution (49), followed by international associations such as IAHS or EGU (13) and free online resources such as webinars or

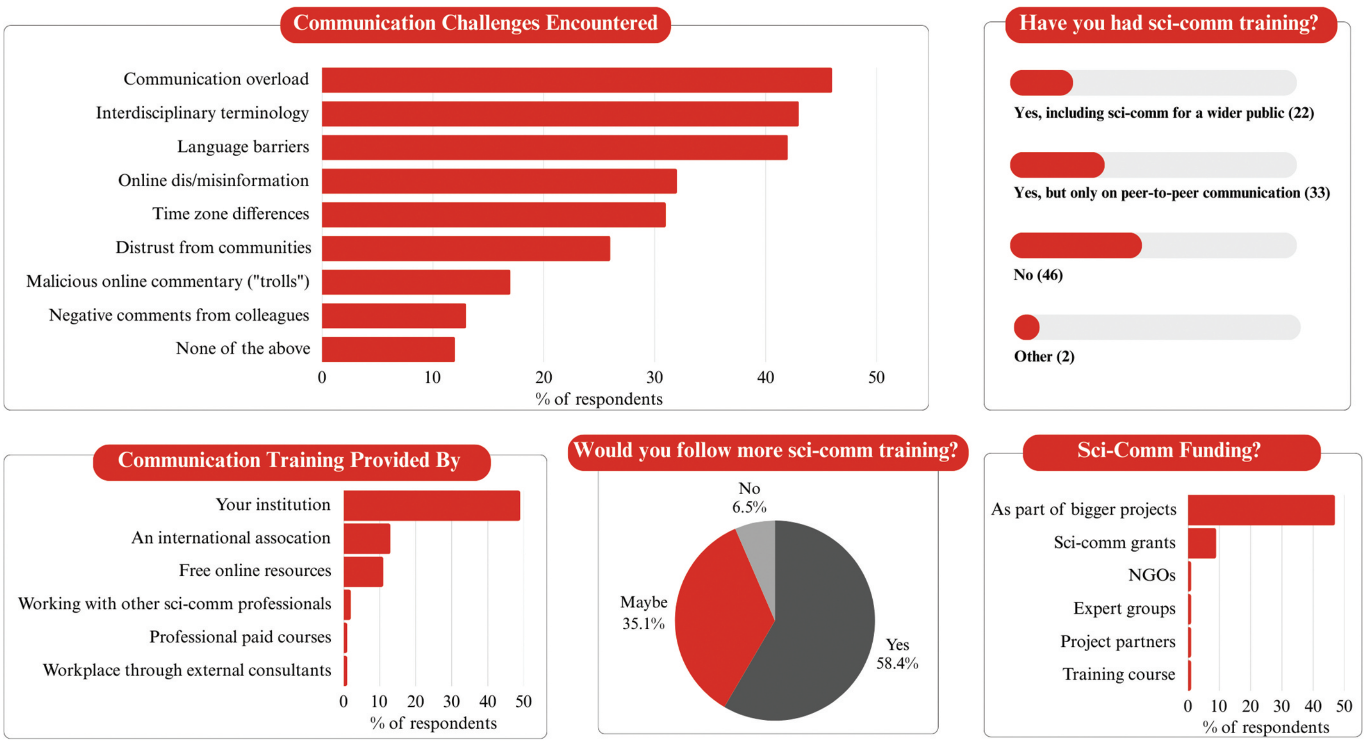

Figure 4. Science communication challenges as perceived by survey respondents, and experiences with and opinions on science communication and funding.

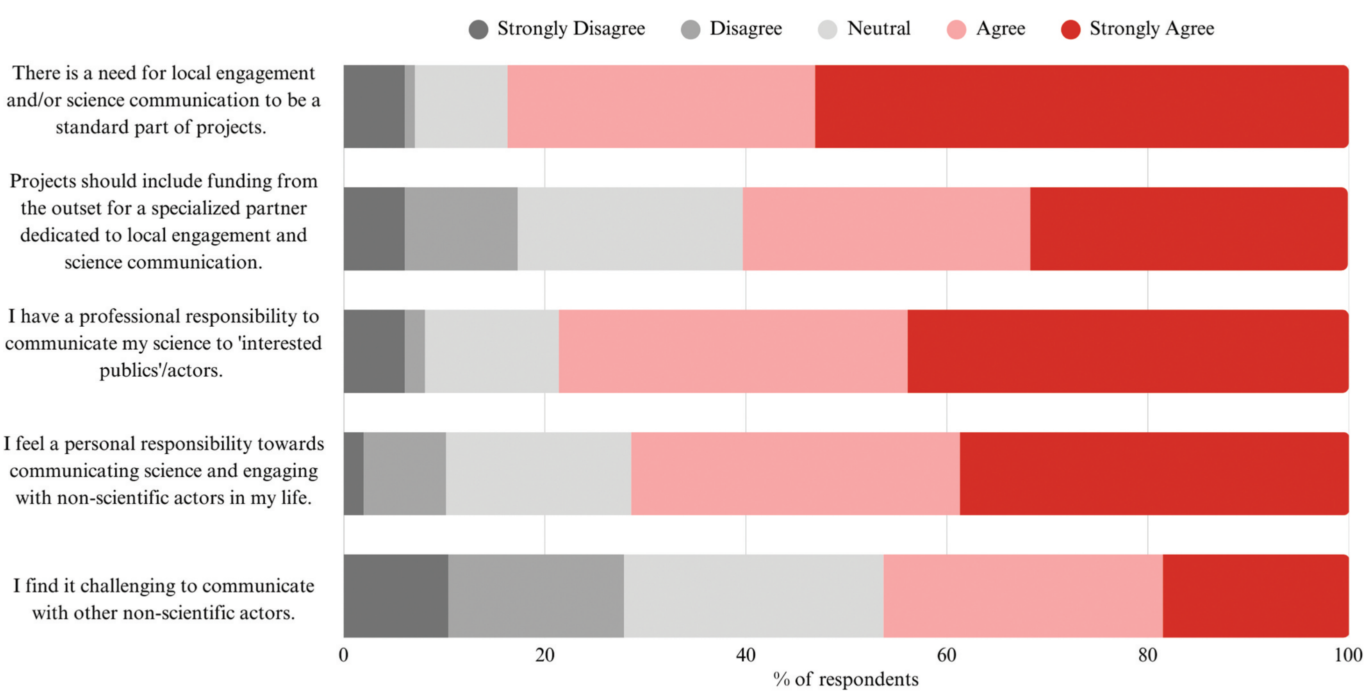

Figure 5. Attitudes and feelings of personal responsibility to science communication by survey respondents.

tutorials (11). Overall, 45 respondents said that they would follow additional science communication training if offered, and 27 said they might. Regarding funding for science communication activities, 46 respondents replied that they had received some in the past, mostly as a part of bigger projects and only nine as specific science communication grants.

Generally, respondents believe that science communication deserves a high priority in the professional lives of hydrologists (cf. Fig. 5). A total of 82 respondents either agree or strongly agree that there is a need for local engagement and/or science communication to be a standard part of projects. Likewise, 77 agree or strongly agree that they have a professional responsibility to communicate their science to interested publics/actors.

In open-ended responses, the survey respondents largely echoed the interviewees and workshop participants. They called for a reduction of jargon and acronyms, as well as for simplicity and conciseness in communication. Several also emphasized the importance of patience when iteratively adjusting communication strategies to target audiences. The need to involve local actors was also evoked by multiple respondents. One response emphasized the effectiveness of "*making space for non-experts to give their local expertise in ways that makes them much more receptive [. . .], especially in political climate science spaces*". Several responses echoed the call from actors to put the needs of communities at the heart of communication efforts and to involve them in the research process from the start: "*First, engaging audiences toward common win–win goals and objectives. Second, asking them to contribute and populate with methods/ideas to attain those goals/objectives. Third, agreeing on a common strategy to work with audiences and stakeholders.*" In this context, the value of knowledge brokers was also highlighted. Finally, several respondents also highlighted the fact that their science communication efforts were not being recognized.

The majority of respondents agreed that science communication should be more central to their activities (first four statements in Fig. 5). However, almost 50% find it challenging to communicate with non-scientific audiences, indicating that many who wish to engage more effectively lack the necessary expertise or confidence. This highlights a significant gap that HELPING can help address.

4 Synthesis: recommendations and outlook

Our findings resonate with established theoretical models of science communication. Much of the communication within hydrology has historically relied on a one-way, deficit-oriented model, in which scientists transmit knowledge to policymakers or communities. However, the perspectives gathered in this paper consistently emphasize the necessity of two-way, dialogic processes in which trust, co-production and iterative feedback are central. In practice, the three classic rationales for public participation (Stirling 2008, Wesselink *et al*. 2011) can also be translated into communication aims. Instrumental approaches treat communication as a means to influence decisions or behaviours, e.g. policy briefs, technical reports). Normative approaches emphasize communication as a process of mutual understanding and inclusion, e.g. participatory workshops with communities. A substantial rationale highlights that dialogic, co-produced forms of communication can improve the substantive quality and relevance of hydrological knowledge and decisions, for instance by integrating scientific analyses with local and indigenous understandings of water systems. The added theoretical value of our study lies in outlining how community members feel these communication models must be adapted to hydrology's specific challenges – including uncertainty, interdisciplinarity and hydro-political contexts – and in illustrating that effective communication in the HELPING decade requires hybrid strategies that bridge these models across different domains.

Table 1 synthesizes the science communication challenges as perceived by the hydrological community, gathered during the interviews with long-term IAHS members and non-IAHS actors, participatory workshops and the online survey. They aligned closely with the framework proposed by Hutchins (2020), which categorizes communication challenges into four main areas: audience, purpose, format and significance. The "audience" category addresses the complexities of tailoring messages to diverse groups (answering the question: "With whom do we communicate?"). The "purpose" focuses on the goals of communication (answering: "Why communicate?"). "Format" refers to the challenges of selecting and adapting communication channels (answering: "How to communicate?"), while "significance" is the research narrative which translates to impact and relatability (answering: "What is the significance of the work for the audience?"). Additionally, "meta-challenges" capture the communicators' reflections on their own roles and capacities in science communication.

Effective science communication in hydrology requires a multi-layered approach that incorporates both individual practices and broader systemic changes, while also considering the specific goals of the IAHS HELPING decade. Table 2 lists direct and derived recommendations based on the inputs collected from different actors in this study, categorized according to different communication aspects (Hutchins 2020), as well as suggestions for systemic change.

For individual hydrologists, a crucial step is to embrace effective, audience-centric communication practices. Communication should be tailored to specific groups – such as policymakers, local communities, or fellow scientists – with particular attention paid to avoiding jargon and using language that resonates across disciplines and geographies. Starting collaborations with a co-produced understanding of terminologies will improve cross-cultural and interdisciplinary projects. It is also essential for hydrologists to prioritize their audiences' preferred communication channels and frequencies, thereby reducing information overload and enhancing engagement. Among IAHS members, these preferences tend towards monthly email communications. In terms of communication formats, we propose the FUSS framework of communication (Fig. 6):

- **F**ew communications, sent at people's preferred frequency
- **U**nambiguous text with clear action items
- **S**imple phrasing instead of complicated jargon
- **S**hort, well-structured messages that leverage bullet points, sub-headings and other visual markers to highlight key information

Table 1. Key challenges or recommendations pertaining to science communication in the water sector, based on inputs from different actors. Grey cells indicate that the challenge was mentioned, white that it was not. Challenges are categorized into science communication aspects of audience, purpose, format and significance (Hutchins 2020) as well as meta-challenges.

Communication Challenge Identified	IAHS Volunteers (Y/N)	Online Workshop Participants (Y/N)	Actors Beyond IAHS (Y/N)	Online Survey Respondents (Y/N)
Audience-centric communication: With whom am I communicating?				
Expanding communication beyond the scientific community requires tailoring messages to diverse audiences, including interdisciplinary, intercultural, and local communities. A shift towards bottom-up engagement and regional inclusivity requires decentralized, locally relevant communication strategies on water management.	**Y**	**Y**	**Y**	**Y**
The complexity of adapting scientific terminology and concepts to be jargon-free across languages, disciplines (e.g. hydrology, environmental engineering, agriculture, hydrosocial) and sectors (e.g. private, public, non-profit) leads to ineffective communication.		**Y**	**Y**	**Y**
Trust-building with communities takes time and is difficult to measure.		**Y**	**Y**	**Y**
Purpose: Why am I communicating?				
Differing priorities: Communities seek practical solutions, while researchers face pressure to publish, leading to perceived exploitation of local knowledge.		**Y**	**Y**	**Y**
The complexity and uncertainty inherent to hydrology make it difficult for water professionals to communicate assumptions, limitations, and uncertainties in an accessible and actionable manner.		**Y**	**Y**	**Y**
Effective format selection: How am I communicating?				
Online and hybrid meetings improve accessibility but present challenges, such as time zone issues and reduced personal engagement. Especially senior decision-makers tend to engage more effectively in offline settings.	**Y**	**Y**	**Y**	**Y**
The overwhelming volume of incoming communication via a diversity of channels can lead to message fatigue, causing individuals to avoid additional tools or updates and making it difficult to maintain effective communication.	**Y**	**Y**		**Y**
Traditional media engagement has decreased in public science communication. Simultaneously, technology gaps create communication barriers – some regions struggle with outdated methods (e.g. fax, postal transmission).		**Y**	**Y**	**Y**
Social media and public communication tools can enhance outreach but pose risks of mis/disinformation, oversimplification and credibility issues in communicating water management and policy efforts.		**Y**	**Y**	**Y**
There is a significant gap in effectively engaging and communicating with non-scientific actors; plain-language summaries, concise narratives and clear visuals are often underutilized.		**Y**	**Y**	**Y**
Creative and artistic approaches (e.g. dance, games, community art) effectively engage local communities and bridge knowledge gaps. Unfortunately, they are not as widely accepted.			**Y**	**Y**
Compelling research narrative: What is the significance of my (research) work for the intended audience?				
Translating global issues into local contexts is a prerequisite for scientifically robust solutions relevant to communities facing concrete issues.	**Y**	**Y**	**Y**	**Y**
Science communication is increasingly political – climate change narratives are polarized, misinformation is widespread and hydrologists may self-censor in politically sensitive contexts.		**Y**	**Y**	**Y**
Meta-challenges in science communication in the water sector: How do I see myself as a communicator?				
Representational diversity and inclusion across genders and regions in both scientific and non-scientific actors in the water sector is required for more impactful and relevant science communication.	**Y**	**Y**	**Y**	**Y**
Lack of funding limits science communication efforts in the water sector, particularly for underrepresented groups. Dedicated funding enables outreach activities (e.g. training, art-based engagement, travel, organizing events like town halls).	**Y**	**Y**	**Y**	**Y**
Academic incentives drive engagement toward publishing, while informal communication (e.g. blogs) and community engagement are deprioritized.	**Y**		**Y**	**Y**
The perception of science communication differs across sectors – some actors view it primarily as "professional" (e.g. articles) or "deficit" knowledge provision (e.g. water levels) rather than broader "consultative" or "deliberative" efforts.			**Y**	**Y**
Many scientists feel a professional responsibility to engage in science communication but lack formal training and wider recognition for their efforts.				**Y**
Open-access publishing fees prevent actors such as independent institutions and researchers – particularly from the Global South – from sharing their hydrological insights.			**Y**	

At a systemic level, science communication needs to be more widely incorporated as a standard part of project proposals, with funding agencies allocating dedicated sections (e.g. "dissemination and exploitation") for these activities. This inclusion will ensure that communication is not merely an afterthought but a core component of scientific projects. Additionally, dedicated funding made available for communication activities beyond large projects would better support long-term outreach. Dedicated science communication activities can provide invaluable ways of generating engagement in local communities, gaining insights into people's lived experiences and enhancing the acceptance of new projects and measures. Yet many such activities are difficult to fund – and to publish in scientific journals. This relates to another necessary systemic shift in the publishing landscape, which not only makes transdisciplinary research – that is, studies co-designed and co-produced by academic and non-academic partners – difficult to publish, but also poses significant barriers in the

Table 2. Recommendations for science communication in the water sector, derived (in)directly from actors' inputs. These are divided into individual recommendations (pertaining to audience, purpose, format and significance aspects of communication) and systemic recommendations (related to funding, publishing and institutional aspects) to improve the effectiveness of communication efforts.

Category	Recommendations
Audience-centric Communication	(1) Tailor communication to specific audiences (e.g. policymakers, local communities), considering their priorities and knowledge levels
	(2) Adapt scientific terminology and concepts to make them jargon-free across languages (via translation), geographies, disciplines and sectors. Early project discussions can establish a common terminological understanding.
	(3) Spend as much time as possible on-site (individually or via institutional immersion programs) to establish rapport with local communities and understand the way they perceive the hydrological systems that shape their lives.
	(4) Use locally trusted actors for community outreach. Strategies like "water walks" and anchoring communication in trusted local facilitators (e.g. village chiefs, mayors, doctors) can enhance trust in and support for initiatives.
Purposive Communication	(1) Emphasize mutual knowledge exchange between scientists and local communities to co-develop solutions. A user-centric, results-oriented approach is needed to implement water science for solutions.
	(2) Transparency is crucial – communicate assumptions, limitations and uncertainties clearly in plain language.
Significance of the Communication	(1) Shift from deficit-based to consultative and deliberative communication to co-develop scientifically robust and locally relevant solutions.
	(2) Focus communication efforts on engaging communities from the start, involving them in defining common goals, contributing ideas, and collaborating on strategies to achieve those goals.
Improving the Communication Format	(1) Balance online, hybrid and offline meetings, and consider accessibility and engagement levels, particularly when involving senior decision-makers.
	(2) Communicate through people's preferred channels and respect preferred outreach frequencies.
	(3) Minimize jargon when collaborating across different specializations or disciplines, as it can hinder communication beyond narrow contexts. Use concise messaging (e.g. FUSS framework to send messages: Few, Unambiguous, Simple, Short).
	(4) Use social media and public communication tools to engage audiences by sharing clear, simple and relatable content. Explore partnerships with subject-matter experts and communicators to fact-check and provide context. Regularly update content to stay relevant and address common misconceptions, ensuring both engagement and credibility.
	(5) Use plain-language summaries, concise narratives, balanced (positive & negative) priming and clear visuals (inspired by IPCC, World Bank formats). They are more effective when engaging with non-scientific actors. Plain-language abstracts facilitate interdisciplinary collaboration.
	(6) Leverage creative formats like art, animations, infographics and interactive maps for better engagement.
General recommendations (systemic)	(1) Funding for science communication.
	(2) Projects should integrate communication funding from the start (e.g. in planning and resources, including specialized partners for local engagement and in-house communication specialists; creative participatory workshops).
	(3) Funding agencies should prioritize dedicated budgets for outreach. Funding for science communication activities should be made available also for smaller, non-project-based activities.
	(4) Collaboration between national and international funding channels can enhance support for these efforts.
	(5) More inclusive and community-centric publishing.
	(6) Advocate for fee waivers and interdisciplinary publications accounting for community engagement, to increase accessibility for historically underrepresented, independent (scientific and non-scientific) actors in the water sphere.
	(7) Standardize the implementation of plain-language abstracts to facilitate the accessibility of hydrological studies and interdisciplinary collaboration.
	(8) Institutional encouragement of science communication.
	(9) Recognize and promote science communication as a valid part of a hydrologist's CV and value it during the hiring processes and career progression.
	(10) Offer science communication training alongside technical skills for hydrologists, including aspects such as audience-specific, jargon-free communication; using traditional and modern media channels; shifting from deficit-based to more consultative or deliberative communication with communities, etc.). Interdisciplinary doctoral training programmes could provide a way forward (Wallen *et al.* 2019).

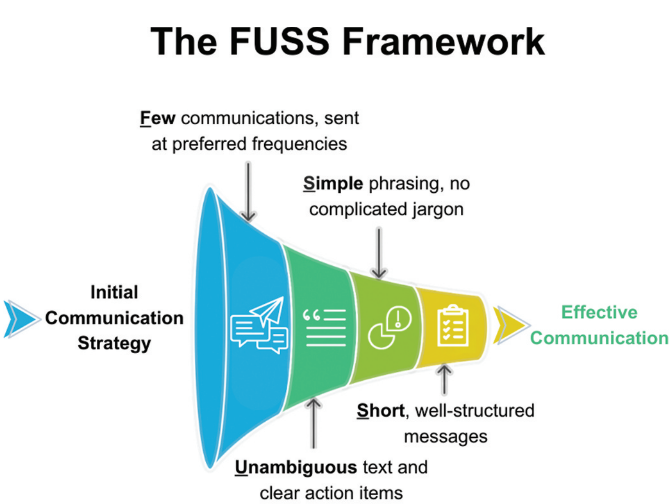

Figure 6. The FUSS Framework.

form of open-access publishing fees. These often prevent actors such as independent researchers and other water professionals – particularly from the Global South – from sharing their insights. Furthermore, the immense pressure to publish shapes the priorities of many hydrologists, especially those in early-career stages, often creating a disconnect from the communities they work with. Targeted measures, such as a greater openness of journals to interdisciplinary work and fee waivers for non-academic or Global South actors, could help address these issues. Plain-language abstracts need to be encouraged to make research more accessible across disciplines and to non-scientific actors. Furthermore, institutions need to recognize science communication as a legitimate and valuable part of a hydrologist's CV, particularly during the hiring process and career progression.

Beyond necessary shifts in the publishing and funding landscape, as well as systematic recognition of science communication activities by institutions, effective science communication in hydrology does not require a drastic overhaul but rather a series of incremental, complementary and sustainable measures to drive overall impactful change. These efforts, when combined, can help make hydrology more accessible, actionable and societally relevant. The goal is not just to communicate scientific findings, but to build long-term relationships with diverse audiences, grounded in mutual trust and respect. Good science communication must be bidirectional and deliberative, with a focus on inclusivity and sensitivity to the local context, ensuring that hydrological science reaches its target audience and resonates with communities across the globe. Especially in the face of recent political shifts and new challenges in many parts of the world, striving for good science communication and the trust that it inspires is more important than ever, both in HELPING and beyond.

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