BOOK OF ABSTRACTS

This Book of Abstracts provides a comprehensive overview of the session content and is structured into three main sections:

I. Session Description – an introduction to each session, including its objectives and expected outputs
II. Session Program – a detailed schedule for each session, including speakers and timing
III. List of Abstracts – a complete compilation of all accepted abstracts

I. SESSION DESCRIPTION

ID:S5 S5

From mountain water towers to urban rivers: managing water systems as social-ecological-technological systems for climate resilience

Hosts:

	Name	Organisation	E-mail
Host (s):	Blal Adem Esmail	Center for Global Mountain Safeguard Research (GLOMOS), Eurac Research, Bolzano, Italy	blal.ademesmail@eurac.edu
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Abstract:
Water systems are increasingly recognized as social–ecological–technological systems (SETS), where ecological processes, technological infrastructure, and social governance interact in shaping water security. Climate change, with its intensifying extremes—droughts, floods, glacier melt, and shifting

precipitation—adds pressure to already strained water systems. At the same time, urban growth, industrial demand, and lifestyle-driven consumption accelerate scarcity and generate competing claims across scales, from mountain "water towers" to densely populated urban riverscapes. This creates a landscape of persistent trade-offs: hydropower development may secure energy but degrade ecosystems; irrigation expansion may enhance food production but increase conflict and stress on groundwater. Strategic responses must therefore embrace the complexity of SETS, treating water not only as a physical resource but as a nexus of ecosystems, technology, and governance. Water security is inherently political, with hydro-hegemony shaping access, control, and equity across scales.

Nature-based Solutions (NbS) offer a critical pathway within this framework. By leveraging natural processes, they deliver benefits across SETS dimensions: ecological (restoring riparian zones, recharging aquifers), technological (enhancing urban stormwater management), and social (providing co-benefits for health, recreation, and cultural values). Their strength lies in their multi-functionality—addressing climate resilience while advancing biodiversity and social well-being. Yet, NbS also have limitations: outcomes are often less predictable than engineered interventions, and impacts emerge over longer time horizons. This underscores the importance of integrating NbS into governance systems rather than treating them as isolated projects.

A strategic watershed perspective provides the necessary scale for such integration. Linking upstream mountain ecosystems with downstream rivers and urban waterscapes allows for holistic governance that reflects the interconnectedness of SETS. NbS such as forest conservation in mountain water towers, wetland restoration in river basins, and green infrastructure in cities, when strategically aligned, can together enhance hydrological resilience, reduce disaster risk, and strengthen social–ecological equity.

This session will reflect on how NbS can be leveraged to operationalize SETS approaches, demonstrating that water resilience depends not on technological fixes or ecological restoration alone, but on their integration with inclusive governance. By applying an integrated watershed perspective grounded in a SETS approach, we aim to highlight how mountain, river, and urban systems can be reconnected in ways that align climate adaptation with development goals, reduce trade-offs, and contribute to a more resilient water future.

Key themes include:

- Socio-hydrological models revealing feedback between human activities and infrastructures, ecosystems, and water resources.
- Climate change impacts on hydrology and modelling to anticipate future conditions.
- Participatory planning that integrates ecological, technological, and social knowledge.
- Nature-based solutions for enhancing water security and resilience.
- Transboundary governance and upstream–downstream interactions.

Goals and objectives of the session:

The session aims to deepen understanding of adaptive water governance, identify conditions for integrating NBS within SETS, and highlight pathways for resilient, sustainable, and secure water systems across scales.

Some of the questions that we would like to address in this session are:

- In what ways can water security be effectively operationalized across interconnected mountain-to-urban (ridge to reef) systems through a SETS lens, and which actors are most pivotal in this process?
- How can socio-hydrological modelling and ecosystem service assessments be harnessed to inform and strengthen decision-making?
- What institutional reforms or planning innovations are required to embed Nature-based Solutions within SETS for enhanced climate resilience?
- How do policy frameworks, governance arrangements, and market dynamics facilitate—or hinder—the adoption and scaling of Nature-based Solutions?

Planned output / Deliverables:

Draft conceptual framework for SETS-based water management integrating NBS across scales.
In addition, depending on the session participants' interests and the quality of contributions, we could explore the possibility of a collaborative paper, based on the session conclusions and a meta-analysis of evidence gathered therein. The conveners are planning a Special Issue to gather expanded contributions and outcomes from the session; interested participants will be invited to contribute.

Session format:

This will be a standard session featuring up to 10 presentations, each allocated 10 minutes for presentation and 2 minutes for questions and discussion. The session will open with a brief introductory overview (5 minutes) to frame the objectives and conceptual focus on SETS-based water management and Nature-based Solutions (NbS), and will possibly conclude with a moderated synthesis discussion (15 minutes) to draw cross-cutting insights and identify opportunities for collaboration. The total estimated duration is approximately 2 hours.

Related to ESP Working Group:

SWG 5 – ES in Water management

II. SESSION PROGRAM

Room: C1
Date of session: Tuesday, 19 May 2026
Time of session: 11:00 – 12:30

Timetable speakers:

Time	First name	Surname	Organization	Title of presentation
11:00–11:05	Blal	Adem Esmail	Eurac Research, GLOMOS Center for Global Mountain Safeguard Research	Welcome and introduction
11:06–11:15	Hiromu	Okazawa	Tokyo University of Agriculture, Department of Regional Environment Science	Assessing hydropower and flood-mitigation functions of irrigation networks in paddy-dominated regions in Japan
11:15–11:24	Gustavo Adolfo	De la Cruz Montalvo	Universidad Nacional Agraria La Molina, Doctorate in Environmental Engineering and Sciences	Assessing the drivers of irrigation expansion in Peru and its exposure to CMIP6-projected climate change
11:24–11:33	Blal	Adem Esmail	Eurac Research, GLOMOS Center for Global Mountain Safeguard Research	Long-term hydro-climatic trends and simulated water availability (75 years) in Asmara, Eritrea
11:33–11:42	Edyta	Woźniak	Space Research Centre of the Polish Academy of Sciences	Sand Dams for Climate-Resilient Water Security: A SETS-Based Spatial Assessment
11:42–11:51	Valentina	Tomei	University of L'Aquila, Department of Civil, Construction-Architectural and	Operationalizing Nature-based Solutions for urban riverine resilience: a governance-

			Environmental Engineering (DICEAA)	integrated masterplan for Pescara, Italy
11:51–12:00	Anjali	Yadav	Indian Institute of Technology Kanpur, Humanities and Social Sciences	Pollution as Artifact: Adaptive Water Governance, SETS, and the Limits of Nature-Based Solutions in an Urban River of the Global South
12:00–12:09	Agnes	Vari	Ecosystem Research Consultancy	Insights from European freshwater restoration projects and German citizen science on small streams
12:09–12:18	Juan Carlos	Cueva Orjuela	Universidad Nacional de Colombia	Developing indicators of water security from an Indigenous Knowledge perspective in the Amazon River Basin
12:18–12:28				Panel and final Discussion
12:28–12:30	Nidhi	Nagabhatla	United Nations University, Institute on Comparative Regional Integration Studies (UNU-CRIS)	Closing remarks

III. ABSTRACTS

The first author is the presenting author unless indicated otherwise

1. Assessing hydropower and flood-mitigation functions of irrigation networks in paddy-dominated region in Japan

***First author*:** Hiromu Okazawa
***Other author(s)*:** Kiichiro Hayashi, Stefano Balbi, Andrea Antonello, Ferdinando Vila
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In Japan, paddy-dominated agricultural regions are characterized by dense irrigation and drainage channel networks that extend from mountainous headwaters through agricultural valleys to downstream urban areas. These systems, historically developed for irrigation and managed collectively by local communities, play a critical role in sustaining regional water circulation. Recently, increasing attention has been given to their multifunctional role in climate-resilient water management. Agricultural water systems provide a wide range of ecosystem services—such as water regulation, flood control, and energy provision—that can be deliberately enhanced and managed as nature-based solutions (NbS). This study evaluates how these ecosystem service functions can be operationalized as NbS by jointly assessing small hydropower generation and flood-mitigation capacities within rice paddy area.
Hydropower potential is estimated from discharge conditions in irrigation channels during the rice-growing season (May–September), when relatively stable flows are maintained through gravity-driven delivery. At the same time, more frequent extreme rainfall events associated with climate change impose additional stress on these systems, as excess runoff is rapidly conveyed into drainage networks. By examining the capacity of paddy fields to temporarily store stormwater and reduce peak discharge, this study evaluates their role as green infrastructure that reduces pressure on downstream channels and hydropower facilities. Case studies in Japanese hilly and mountainous agricultural areas quantify both available hydraulic head and discharge for energy production, as well as the flood-buffering capacity of paddy fields under heavy rainfall conditions.
The results demonstrate that appropriately managed agricultural water systems can simultaneously support renewable energy generation and reduce flood risk. These findings highlight the potential of rice paddy areas to function as socio-ecological-technological systems that integrate irrigation, energy, ecosystem services, and climate adaptation, thereby enhancing resilience across entire watersheds.

Keywords: paddy fields; irrigation channels; hydropower; nature-based solutions (NbS); green infrastructure

2. Assessing the drivers of irrigation expansion in Peru and its exposure to CMIP6-projected climate change

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Peru's agricultural geography is defined by a critical disconnect: the high-altitude Andes function as "water towers", while water demand is concentrated in the hyper-arid coastal plains. This study analyzes the evolution of irrigation in Peru (1950-2015) as a Social-Ecological-Technological System (SETS), identifying the drivers of expansion and assessing future climate exposure using CMIP6 projections. By reconstructing historical irrigation data and analyzing policy frameworks, we demonstrate that irrigation expansion was driven less by natural availability and more by socio-technological interventions: initially through state-led hydraulic megaprojects transferring water across the Andes, and later through neoliberal reforms promoting high-tech agro-exports. While these "gray" infrastructure solutions expanded the agricultural frontier, our analysis of ISIMIP3b/CMIP6 data (SSP5-8.5 scenario) reveals a looming resilience challenge. Results indicate a projected polarization of the hydrological cycle by mid-century (2036–2065). While the wet season may see precipitation increases of up to 30% in northern regions, the dry season (critical for irrigation) is projected to experience severe drying (>20% reduction) in the central and southern basins. This creates a high-exposure scenario for recently expanded agro-export zones that rely heavily on dry-season river discharge. To achieve true climate resilience, water management must shift towards an integrated governance model that acknowledges these emerging climatic trade-offs, moving beyond infrastructure expansion to incorporate adaptive management and potentially nature-based solutions to safeguard the hydrological services of the Andean headwaters.

Keywords: Irrigation, water security, climate change exposure, water governance

3. Long-term Hydro-Climatic Trends and Simulated Water Availability (75 years) in Asmara, Eritrea: Insights for sustainable water management in data-scarce contexts

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Water scarcity is a mounting challenge for urban areas in semi-arid regions, where rising temperatures and variable rainfall threaten the reliability of limited water resources. In data-scarce contexts, robust, physically based hydrological modelling is essential for understanding long-term water availability and supporting sustainable management decisions. This study presents a 75-year assessment of hydro-climatic trends and simulated water availability for the Greater Asmara Area (GAA), Eritrea, using the GEOframe modelling system to reconstruct daily discharge and water balance components for the Toker and Mainefhi watersheds from 1943 to 2019.
Hydrologic trends reveal a persistent reduction in streamflow for both catchments since the 1980s, despite no major long-term decline in precipitation. This shift is primarily attributed to a robust warming signal (+1.7 °C per century), which has increased evaporative losses and reduced runoff efficiency. The dominance of low and ephemeral flows, with high-flow events becoming increasingly rare, highlights growing hydrological vulnerability for Asmara's water supply.
Hydro-climatic anomalies are evident through drought indices, including the Standardized Precipitation Index (SPI), Standardized Precipitation–Evapotranspiration Index (SPEI), and Standardized Streamflow Index (SSI), which demonstrate recurrent and persistent dry periods, especially in the 1990s and after 2010. Statistical summaries show a predominance of negative anomalies, confirming the chronic vulnerability of the catchments to meteo- and hydrological drought.
Annual water volumes at the catchment outlets averaged approximately 17 million m^3 for Toker and 9

million m³ for Mainefhi, with pronounced interannual variability and multi-year dry phases. Over the 75-year period, cumulative discharge reached about 1.28 billion m³ for Toker and 680 million m³ for Mainefhi. During extended droughts, annual volumes dropped below 60% of the long-term mean, and cumulative water availability was often insufficient to meet even modest per-capita consumption targets, underscoring the need for adaptive management.
These findings highlight the value of physically based modelling for quantifying water resources and guiding sustainable management in data-scarce, semi-arid regions.

Keywords: Hydro-climatic trends, Water availability, Hydrological modelling, Drought indices, Water scarcity risk

4. Sand Dams for Climate-Resilient Water Security: A SETS-Based Spatial Assessment

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We present a comprehensive remote sensing–based assessment of the potential for constructing sand dams within the Grand Sud of Madagascar, a region highly exposed to chronic water scarcity, climatic variability, and socio-economic vulnerability. Sand dams represent hybrid social–ecological–technological interventions that enhance natural hydrological processes while relying on local infrastructure and community management.
The primary objective of this study is to identify and prioritise locations for sand dam construction using exclusively open-access spatial data, enabling scalable and transferable decision support in data-poor contexts. We apply a multi-criteria decision analysis integrating 15 environmental and socio-economic parameters that include rainfall availability, catchment and river morphology, sediment and geological suitability, land use, population distribution, water demand, accessibility, and the presence of alternative water sources. This integrated framework explicitly reflects interactions between ecological processes, technological feasibility, and social needs across the watershed.
Compared to previous assessments, our approach is both more comprehensive and higher in spatial resolution (330 m), allowing for fine-grained screening of sand dam suitability across a large and heterogeneous region. The results highlight spatial trade-offs and synergies in water access, demonstrating where NbS can most effectively enhance groundwater recharge, support local livelihoods, and strengthen drought resilience.
By operationalising sand dams within a SETS and watershed-scale framework, this study contributes to understanding how NbS can be strategically embedded in adaptive water governance. The approach supports evidence-based prioritisation of interventions that align climate adaptation, ecosystem service provision, and equitable water access, offering insights relevant for semi-arid regions facing similar socio-hydrological challenges.

Keywords: sand dams, social-ecological system, water security, Madagascar

5. Operationalizing Nature-based Solutions for urban riverine resilience: a governance-integrated masterplan for Pescara, Italy

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In the context of the European green transition, urban riverine corridors represent critical interfaces where the conflicts between soil sealing, hydraulic risk, and social fragmentation are most acute. This research presents an integrated masterplan for the Pescara River (Italy), developed within the participatory governance framework of the "River Contract" (Contratto di Fiume), to demonstrate how Nature-based Solutions (NbS) can effectively translate high-level frameworks like the EU Nature Restoration Law into local, inclusive action.

Adopting a "Sponge City" and "Living with Water" paradigm, and addressing the urgent need for climate adaptation in a dense, sealed urban fabric, the study identifies three strategic "Action Labs": a brownfield industrial site (Ex Cementificio), an unfinished public infrastructure (Città della Musica), and a degraded green area (Giardino Fluviale). The methodology combines multi-scalar analysis with a co-creation design approach.
The proposed masterplan implements a systemic network of NbS, including radical de-sealing of industrial surfaces, green roofs, rain gardens, vegetated swales, and floodable public plazas for hydraulic management, and the restoration of riparian wetlands. Specifically, the conversion of the industrial brownfield into a permeable park demonstrates how soil regeneration can invert land consumption trends. These interventions are designed to deliver a bundle of Ecosystem Services: primarily regulating services (stormwater management, urban heat island mitigation) and cultural services (reconnecting the community with the river).
The results demonstrate that integrating NbS into urban planning not only mitigates climate risks but actively reverses land consumption. This case study offers a replicable framework for European mid-sized cities, highlighting the River Contract as an essential governance tool to operationalize NbS, bridging the gap between strategic planning and local regeneration to transform marginal barriers into a cohesive blue-green infrastructure.

Keywords: Nature-based Solutions, River Contract, Urban Resilience, De-sealing, Ecosystem Services

6. Pollution as Artifact: Adaptive Water Governance, SETS, and the Limits of Nature-Based Solutions in an Urban River of the Global South

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Water pollution in urban river systems is often addressed through technological and infrastructure-led interventions, including emerging Nature-based Solutions (NBS). Drawing on the middle segment of the Ganga River in India, specifically Kanpur Nagar and Varanasi, this paper conceptualizes pollution as a socio-technical artifact produced and stabilized through social practices, institutional arrangements, and knowledge systems. Using a social–ecological–technological systems (SETS) framework, the study examines how pollution is defined, measured, governed, and experienced over time, and how these processes shape the conditions under which adaptive water governance and NBS can succeed or fail. Empirically, the paper combines long-term analysis of policy documents from the Central Pollution Control Board and the National Mission for Clean Ganga with field interviews and survey data collected among riverine communities. The findings show that pollution persists not only due to technological gaps, but because regulatory instruments, monitoring metrics, and infrastructure interventions operate without alignment with social meanings, collective action dynamics, and institutional capacity. Scientific assessments classify river water as unsafe, while local communities continue to perceive it as purifying, revealing how pollution categories are co-produced and contested within the SETS.
Situated within the context of climate stress, the paper argues that persistent pollution undermines water security and adaptive capacity by eroding trust, coordination, and institutional responsiveness. The analysis highlights why NBS initiatives risk remaining symbolic or underperforming when governance frameworks fail to engage social perception and institutional practice. By offering a diagnostic account from the Global South, the paper contributes to SETS-based conceptual frameworks for adaptive water governance and clarifies the governance conditions required to integrate NBS into resilient urban river systems.

Keywords: Social-ecological-technological systems (SETS), Pollution

7. Insights from European freshwater restoration projects and German citizen science on small streams

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Freshwater restoration has gained traction with the passing of the Nature Restoration Law that targets free flowing rivers and supports restoring waterbodies for biodiversity and ecosystem services. Restoration can take place in many different contexts, from well-funded watershed-scale approaches to minute modifications implemented by volunteering citizens. Both large-scale and small-scale approaches come with different socio-economic benefits, challenges and knowledge needs. Their potential effects do also differ, not only on biodiversity and ecosystem condition, but in their effects on society (engagement, knowledge provision, agency).
We analyzed two sets of surveys and interviews with people involved in restoration and monitoring: a) large-scale projects, with experts involved in restoration projects all across Europe, showcased within the EcoAdvance project, and b) small-scale projects, with volunteers from the German citizen science project FLOW that targeted small streams and explored the potential for restoration. We compared both opportunities as well as challenges and support needs.
Our comparative analysis shows that both sets of respondents experienced bureaucracy as one of the greatest challenges. Knowing the relevant administrative procedures and how to navigate them was seen as crucial. The need for support was especially expressed by citizen science groups. European large-scale projects also experienced acquiring sufficient funding as one of the greatest challenges, whereas respondents from citizen science groups often reported the need for specific expertise regarding river restoration. The challenge to get all stakeholders on board was shared by both groups, while some interviewees from both groups expressed modes and methods of how to achieve this, often reflecting on people's reluctance to accept change.
These two sets of surveys and interviews show that both large-scale and citizen-scale projects have specific knowledge needs where support is needed to be most effective and achieve greatest impact.

Keywords: citizen science, knowledge gaps, social-ecological context as artifact, River governance, Adaptive water governance, Global South

8. Developing indicators of water security from Indigenous Knowledge perspective in the Amazon River Basin

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In the Amazon River Basin, access to water is limited by natural and social barriers, while climate change and human activities increasingly affect water sources. Indigenous communities are among the most affected, which may also contribute to the loss of Indigenous knowledge. Understanding water security from an indigenous perspective can complement Western science approaches, but few studies have explored these views in depth or applied them in other regional contexts. This study develops a water security framework for the Amazon River Basin that incorporates the Indigenous knowledge perspective. A modified version of the Process Analysis Method was applied, including the co-design, co-creation, and co-dissemination steps. Different qualitative methodologies were used, such as interviews, gender-focused focus groups, and workshops with indigenous communities, academics, public officials, and private sector actors. Thematic analysis was used to examine and interpret all data. The study identified, developed and validated a context-specific definition, key topics, dimensions and indicators of water security for the Amazon River Basin. Among the main findings, notable differences emerge between global scientific literature on water security and the indigenous knowledge perspective, particularly due to the Amazonian context. Additionally, there are differences in the perception of water security within Indigenous communities due to their relationship with the environment. These differences reflect diverse worldviews and cultural practices. Indigenous knowledge of water security includes spiritual and ecological connections, contrasting with global frameworks that primarily emphasise access, availability, and quality.

***Keywords*:** Water security, indigenous knowledge, Amazon River Basin