Abstract book

Drought Resilience+10 conference

Poster Session

MONDAY

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7	Drought monitoring and impacts assessment in Brazil: The CEMADEN experience	Ana Paula Cunha
8	Drought resilience in agriculture areas	Muhammad Tousif Bhatti
9	A Review of Groundwater Drought Assessment and Mitigation Practices in Arid and Semi-Arid Lands	Abedulla Elsaid
10	Site-specific suitability of drought indices: a systematic review	Thao Trinh
11	Exploring the impact of droughts in the transboundary region along Prut Valley (Romania/Republic of Moldova)	Mihai Ciprian Margarint
12	Assessing spatiotemporal agrometeorological droughts in semi-arid Gwayi agro-ecosystems of Zimbabwe using multiple indices	Bright Chisadza
14	Near-real Time Global Daily Drought Detection and Monitoring Using an Ensemble of Gridded Remotely Sensed and in-situ Precipitation Datasets	Olivier Prat
15	Drought Risk Assessment in Sweden	Claudia Canedo Rosso
16	The EOTEC DevNet Collaborative Approach to Integrated Drought Monitoring and Response	Martyna Stelmaszczuk-Górska
17	Footprints of Drought: Exploring its Environmental Impact through Open Access Big Data	Paula Serrano Acebedo
16	OUTLAST - a global drought monitoring and forecasting system to support sector-specific drought management	Tina Trautmann
20	Drought Dynamics in the Mediterranean GIAHS: Insights from the Arganeraie Biosphere Reserve, Morocco	Brahim Meskour
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26	Pathways for Sustainable Intensification of Wheat Production in the Mediterranean Region Under Current and Future Climate Change Scenarios	Davide Tita
27	The European Drought Impact Database - Comprehensive Drought Impact Collection Methodology for Europe	Monika Bláhová
28	Monitoring of drought in the Netherlands in an online portal	Ruud Bartholomeus
29	Monitoring and assessing the characteristics of drought propagation in the Semi-arid River Basin of Peninsular India	Ajay Gupta
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33	Operational framework and tools for a proactive drought risk management	Brunella Bonaccorso
31	Drought Monitoring Framework for Assessing Drought Impact and Damage at the Government Level in South Korea	Won-Ho Nam
34	Towards operational drought impact-based forecasting in Europe: Trade-offs between indicators and impacts	Anastasiya Shyrokaya
35	Drought Risk Monitoring and Dynamics in Afar Region Rangeland, Ethiopia, Horn of Africa Using Earth observation Data.	Aderaw Tsegaye Anitene
36	Enhancing drought resilience in conflict settings: lessons from the Syrian drought-migration-conflict nexus	Lina Eklund
37	Impact chains of drought risks in Europe: tackling complexity to support science and policy	Davide Cotti
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WEDNESDAY

Abstracts can be found below.

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2	The Role of Connectivity in Driving Grassland-Shrubland Regime Shifts: Impact of Drought and Grazing on Dryland Ecosystems	Shubham Tiwar
3	The European Drought Risk Atlas: Understanding Drought Risks for Ecosystems	Anne-Sophie Sabino Siemons
4	Time to consider the ecological ramifications of droughts in policies for attaining sustainability	Rahul Kashyap
6	Investigating the Relevance of "Corridors" for Asian Elephant Conservation and Human-Elephant Conflict Mitigation: Case study from Sri Lank	Anjali Anilkumar
7	The marula tree: An untapped potential for combating desertification and enhancing socio-ecological resilience in global drylands	Abubakari Munna
8	Response of agricultural and natural vegetation areas to groundwater and snow drought in central Chile	Iongel Durán Llacer
9	Beyond the hazard: local perceptions driving how we define, identify and monitor droughts	Pedro Henrique Lima Alencar
10	Multi-dimensional analysis of global drought awareness	Jonghun Kam
12	Open Data for Enhanced Water Accessibility by Women in Machakos County, Kenya	Nancy Marangu
13	Citizen Science and Geographical Information Technologies for the assessment of compound hot-dry events – CITOSEQ Project, Spain	Natalia Limones
14	Advanced economic tools for strategic water resource management under drought	elisa belfiore
15	Promoting Climate Service and Anticipatory Action for Effective Drought Management	Asif Uddin Bin Noor
16	Future Drought Fund	Roger Stone
17	Diagnosing drought for dealing with drought in 3D: Dimensions, Dynamics, and Dialogue	Pieter van Oel

Drought resilience and risk governance: global mechanisms and regional to local challenges.

The increasing severity of droughts calls for integrated, cross-sectoral strategies that build resilience. A critical insight from global research highlights the need for comprehensive drought resilience frameworks, drawing from successful flood resilience models. To achieve this, improving data quality and transparency is crucial for evidence-based policymaking.

The forthcoming Global Drought Atlas emphasizes the need for a systemic understanding of drought risks, showing how agriculture, water management, and ecosystems are deeply interconnected. Proactive and holistic management—focusing on prevention rather than reactive solutions like reservoir reliance—helps avoid maladaptation. Collaborative efforts between scientists, policymakers, and local communities are already improving water infrastructure and prediction models, demonstrating the value of partnerships in addressing drought challenges.

Key lessons from regional experiences emphasize:
1. Technological Integration: Digital platforms like the Husika Mobile Application in the Horn of Africa and SpaceGarden in Southeastern Europe show how remote sensing and big data can enhance drought monitoring, offering real-time information to vulnerable communities.
2. Climate Change Considerations: Many drought strategies overlook climate change. NOAA's National Integrated Drought Information System (NIDIS) stresses the importance of incorporating climate projections into drought assessments, distinguishing between temporary droughts and long-term aridification for more effective adaptation planning.
3. Tailored Tools: Customized monitoring systems such as the East Africa Drought Watch and the Standardized Precipitation Index (SPI) in the Maghreb region help track local drought conditions, enabling timely policy responses.
4. Collaboration and Co-production: Effective drought governance depends on strong collaboration. In Argentina, hydrological models co-developed by scientists and irrigation authorities have improved long-term water management. Similarly, in the Meuse River Basin, cross-border cooperation has enhanced drought resilience by refining hydrological models for low-flow conditions.
5. Proactive Policy Development: Regions like Central America and Bangladesh demonstrate the need for forward-thinking drought policies. In Bangladesh, integrating local knowledge with technological tools has improved water management. Scaling these efforts, however, requires stronger policy frameworks.

Other reserach underscores the importance of Adaptation Pathways, which provide flexible, progressive solutions for addressing both short- and long-term drought risks. For instance, farm-level drought monitoring tools are helping farmers optimize water management, while conservation tillage and soil amendments reduce the impact of drought on crops with low water retention capacities.

In South Korea, a shift towards prevention and preparedness has minimized drought damage through early warning systems and coordinated government responses. Likewise, in the Rhine River Basin, international collaboration is strengthening drought management by developing shared socio-economic scenarios and transboundary risk assessments.

In the Sahel, sustainable land management technologies, such as the Vallerani plough, remain underutilized despite their potential to restore degraded landscapes. Global cooperation, led by UN-backed agencies, is needed to scale these practices and tackle the root causes of drought vulnerability.

In summary, the posters show that proactive, collaborative, and adaptive policies are essential to building global drought resilience and mitigating future risks.

Monday - Poster board no. 2

Drought resilience and global mechanisms

Drought resilience assessment: insights from a systematic review

Julia Urquijo-Reguera[1,2], Paula Beltrán de Heredia López[3]

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There is an urgent need to increase the resilience of communities, regions, and nations to extreme weather events, particularly droughts and floods in order to reduce their impacts that hinder the achievement of sustainable development.
By systematically reviewing how resilience is measured in practice for these hazards, this study provides critical insights that can inform more coherent and effective policy-making. Understanding drought and flood resilience within a common framework can lead to better-integrated risk management strategies, enhancing adaptive capacity and overall societal preparedness.
Based on the analysis of 29 research articles, results indicates that flood resilience assessments are more developed in literature than those for drought, providing a great opportunity to take advantage of those learnings to advance in the development of drought resilience assessment and framework.
Due to the context specific nature of resilience, a wide variety of frameworks, methods, components, variables and data and scale of analysis were found. Municipal/urban and household level analysis surpass the basin, subnational or national level, while there is a clear predominance of socio economic variables over biophysical ones.
A great diversity of indices are designed and proposed, providing valuable insights on the methodological options available as well as on the gaps and challenges to measure drought resilience in practice.

- **Integrative framework for resilience:** Understand drought and flood resilience under a common framework and perspective is key to enhance policy coherence and risk management policy efficiency
- **Promote evidence-based decision making:** The lack of measurement of resilience may have serious implicationS for management, as we cannot achieve what we cannot measure. Efforts should focus on data quality and availability improvements and transparency. Improving drought resilience measurement needs to be a priority that enables evidence-based decision-making and better risk management and , and policy effectiveness to minimize impacts, trade-offs or unexpected effects.
- **Future research needs to focus on the interlinkage of different types of resilience**. How specific resilience variables and components are related to the resilience attributes that characterize general resilience of a socioecological system will better identify the abilities and capacities that need to be promoted in order to increase the resilience of a given system.

Monday - Poster board no. 3
Drought resilience and global mechanisms
Enhancement of drought early warning systems in IGAD Region.
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The Horn of Africa is facing climate change impacts which resulted in people's displacement and conflicts over the scarce water resources. To mitigate these impacts, Global Water Partnership Eastern Africa (GWPEA) is spearheading various interventions aiming at strengthening drought resilience. The approach used include stakeholder's consultations, and institutional collaboration to update the features of existing early warning prototypes available in the region. The institutions consulted span four countries Djibouti, Kenya, Sudan and Uganda. This consultation resulted into identification of country and regional needs in terms of disaster early warning which led to enhancement of existing drought early warning prototypes such as East Africa Drought Watch and Husika Mobile application due to their coverage and content of the drought information.The following features were improved into: East Africa Drought Watch (https://droughtwatch.icpac.net/): × Improved resolution and incorporates local data blended with satellite, × Filter by Country options that allows to focus on county of interest, × The level of risk can be visualized at National,sub-, and sub-sub-national level, × Report and analysis can be done at Sub-Sub-National level (Admin-3), and × Both 10-day and Monthly Combine Index Analysis. Husika (https://husika.icpac.net/): × Improved feedback and survey modules. × The existing survey/feedback module, the UI and UX improved. × Integration of Multilanguage in the system: Somali, Arabic, Amharic, Luganda, Swahili, French and English. × Integrated East Africa Drought Watch API within HUSIKA mobile application. × Added a weekly forecast module. × Enhanced login details to enable a multi country users' control. × Functional in Djibouti, Kenya, Uganda. However, in the Republic of Sudan, the engagements of obtaining sender ID slowed down by the war eruption.
The lessons learnt from these processes include: • Customisation of existing drought early warning prototypes at national and sub-national levels will increase access to disaster risks early warning. • Decoding scientific content of the reports generated by prototypes into easy uptake manner, requires a continued stakeholders' and development partners engagements. • Enhanced institutional collaboration and knowledge sharing and expertise in drought early warning systems across the region will improve resilience to the impact of climate change in the region. • Hence a roadmap towards achieving disaster risk early warning for all.

Monday - Poster board no. 4

Drought resilience and global mechanisms

Water absorbing polymers for improving soil resilience to drought

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Drought is one of the worst natural disasters that affect the economic, social, and environmental status of any country. With the increase in global temperature, heat waves, and irregular rainfall patterns, there is a chance of more prolonged and severe droughts. One of the key components of drought stress management is the physicochemical properties of soil, which is conveniently neglected in most of the discussion of drought resilience. The present study focuses on the improvement of soil-pore structure, soil-water and nutrient retention capacity, conserve water into plant root zone, reduce surface erosion, and thereby protecting the soil ecosystem and prevent desertification due to prolonged water stress conditions. It was observed that the utilization of water absorbing polymer (WAP) which can absorb and store water within its polymer network, can transfer the stored water to dry soil during extreme drying conditions. An eco-friendly WAP was synthesized by transforming an industrial solid waste, fly ash (FA). The transformed FA-WAP exhibited high water absorbency (310 g/g in distilled water). The synthesized WAP reduced the requirement of irrigation water by 40-60% based on the soil texture and prolonged the plant survival by 4-6 weeks.

- **Focus on soil ecosystem**: Soil ecosystem plays a vital role for drought resilience study, prevention of desertification and ensure food security in future.
- **Scale up the production of biodegradable WAP:** Need more investment on scaling up the production of WAP from different waste/renewable resources to reduce the product cost
- **Awarness among farmers**: Local government and other stakeholders need to create awarness among farmers and agronomist regarding the efficacy of these hydrophilic polymers for increasing crop productivity with minimum usage of irrigation water.

Monday - Poster board no. 5

Drought resilience and global mechanisms

Development of highland quality protein maize (QPM) varieties with drought tolerant abilities

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Maize (Zea mays L.) is among the four priority food security crops in Uganda as defined in Uganda's Vision 2040. Climate change vagaries are the major reasons for the noticeable decline in maize yield to 2 t/ha in the highland areas of Uganda, yet a potential of 9-10 t/ha exists. Breeding for a drought tolerant, nutritionally rich and disease resistant maize varieties is a more cost-effective approach to the maize producing communities in Uganda and neighbouring countries. The major objective of this study was to develop high yielding, drought tolerant and disease resistant quality protein maize (QPM) varieties for the highland areas of Uganda. We obtained 59 drought tolerant/QPM inbred lines from CIMMYT in 2018. Following several generations of crossing, evaluation and selection, 10 hybrids were obtained. The hybrids were tested on-farm and also subjected to a nutrient and high performance liquid chromatography (HPLC) test. Hybrids Q150114, Q150138 and Q160121 had high QPM (except Q150114), drought tolerance, resistance to key diseases and higher grain yield (6.0 -7.0 t ha^{-1}). Therefore, these three hybrids can be released for cultivation by farmers in the drought prone and nutritionally deficient highland areas of Uganda and the entire East African region.

- In collaboration with CIMMYT, three maize hybrids, namely Q150138, Q160121 and Q150114, with yields of 6.0-7.0 t/ha, have been developed for the highland areas of Uganda.
- These hybrids are not only characterized by high grain yield, but also have drought tolerance, are high in quality protein and are resistant to the major diseases of maize in the highland areas of Uganda.
- Release and promotion of these hybrids will: i) lower the cost of maize production in the highland areas of Uganda, thereby contributing to sustainable development goal (SDG) 1 of fighting poverty; ii) improve nutrition, thereby contributing to SDG 2 of ending hunger, achieving food security and improved nutrition, and; iii) developing stress resilient maize varieties is a huge contribution to SDG 13 of combating climate change and its impacts.

Monday - Poster board no. 6

Drought resilience and global mechanisms

Recent drought research published in the Special Issue on "Drought, Society and Ecosystems"

Anne F. Van Loon (IVM - VU Amsterdam, Netherlands)
Gemma Coxon (Bristol University, UK)
Camila Alvarez-Garreton (University of Chile)
Elena Toth (University of Bologna, Italy)
Shreedhar Maskey (IHE Delft, Netherlands)
Khalid Hassaballah (IGAD Climate Prediction Centre, Kenya)
Floris van Ogtrop (University of Sydney, Australia)
Noemi Vergopolan (Rice University, USA)
Sina Khatami (RDL Heritage, Australia)
Louise Arnal (Ouranos, Canada)
Mana Gharun (University of Muenster, Germany)
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The most recent, state-of-the-art drought research is being published in the inter-journal special issue on "Drought, Society and Ecosystems". In 2023 and 2024, manuscripts could be submitted to this special issue in one of four EGU journals (Natural Hazards & Earth System Science, Hydrology & Earth System Science, Biogeosciences, and Geoscience Communication). The special issue had 12 editors from around the world and 50 papers have been submitted up to now (deadline 31 Aug 2024).
Several papers have a strong relevance to drought management and policy making. For example, there are papers on drought processes and cascading impacts in Chile, USA, and Central Asia (Baez-Villanueva et al., 2024; Ferencz et al., 2024; Tian et al., 2023), drought (impact) prediction in the Mediterranean, UK, and Thailand (Zellou et al., 2023; Chan et al., 2024; Tanguy et al., 2023), wastewater reuse, soil management and allocation scenarios (Liu et al., 2024; Heinz et al., 2024; Wan et al., 2024), and the realities of communities and roles of women (Kchouk et al., 2024; Kosovac and Grupper, 2024).

During the conference we will present a summary of all papers and selection of the policy-relevant recommendations. We will highlight (amongst others) that:

- Analysis of drought indicator-to-impact links should form the basis of drought early-warning systems.
- Hybrid statistical–dynamical models seem most promising for skillful drought prediction on seasonal to annual lead times, but more observational data and inclusion of new modelling techniques is needed, for example on including effects of human activities.
- Storylines or counterfactuals based on hindcasts of past drought events are very useful tool in drought management.
- Highly advanced water infrastructure can effectively mitigate economic and societal impacts, but unsustainable groundwater abstraction leads to ecological impacts, subsidence, and delayed societal impacts.

Monday - Poster board no. 9

Drought resilience and global mechanisms

A questionnaire-based review on the role of hydrological models in operational drought management: Insights from the Netherlands

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With the increasing frequency and intensity of droughts, Decision Support Tools (DSTs) are becoming crucial for drought management. Our study reveals a growing reliance on field measurements, data information systems (DISs), stakeholder consultation, and legislation as drought progresses in the Netherlands. These tools play a significant role across the policy phases, from strategic development in phase 0 (long-term drought adaptation) to operational management in phases 1, 2, and 3. Interestingly, while the use of DISs increases, no change was observed in the application of hydrological models. These models are often embedded within DIS, making them less visible as standalone tools but more as 'hidden' components. This indicates a switch from models used as key artifacts by modelers to models serving as 'participants' within broader data systems during higher drought management phases. The use of DIS at regional and national levels during these phases can be seen as a form of methodological standardization, which not only enhances collaboration with different stakeholders but also makes it easier to justify and legitimize decisions. However, it is important to note that many of these models were originally developed for high-flow or flood conditions, rather than low-flow drought situations, resulting in increased model uncertainty.

- **Increase awareness of model use and uncertainties** – Encourage greater transparency in how models are used to enhance trust and accountability in the decision-making process.
- **Enhance stakeholder involvement** – Engage stakeholders in both the development and application of models to ensure they meet practical needs.
- **Ensure DSTs are used for their intended purpose** – Make sure Decision Support Tools are applied appropriately within the context they were designed for and serve the intended purpose.
- **Adopt long-term visions and measures** – Implement long-term strategies and measures to better prepare for emergency or calamity situations.

Monday - Poster board no. 10

Drought risk governance: The regional, national, and local challenges

The Global Drought Atlas

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The Global Drought Atlas is a call to action, urging governments to adopt transformative strategies to build resilience to drought across multiple scales. It aims to highlight the wide-ranging, multisectoral impacts of drought, emphasizing the need for systemic solutions. Drought risks affect interconnected systems, and their impacts vary by region, making collaboration across policy, research, and implementation crucial. By identifying leverage points, targeted interventions can benefit multiple sectors, from water and soil management to biodiversity, poverty reduction, and community resilience. The Atlas promotes proactive, holistic approaches to drought risk management, encouraging actions that prevent the creation of new risks rather than reacting to existing ones. It takes a systemic perspective that extends beyond drought, contributing to broader disaster risk reduction. Success stories from various regions are shared to inspire and inform, demonstrating how different approaches can improve livelihoods at individual, sectoral, and national levels.
Finally, the Atlas provides a comprehensive list of concrete drought risk management and adaptation measures, detailing their applications, co-benefits, and potential for scalability. It aims to guide future efforts towards effective, long-term resilience-building strategies.

- **Systemic Understanding of Drought Risks**: The Global Drought Atlas highlights the multifaceted and interconnected nature of drought risks, emphasizing the need for a comprehensive understanding of the systemic impacts across different sectors and regions.
- **Sectoral and Cross-Sectoral Impact Analysis**: It presents a sector-by-sector breakdown of drought impacts, including agriculture, water supply, and ecosystems, while also addressing the cross-sectoral ripple effects, particularly on social, economic, and environmental systems.
- **Proactive and Holistic Drought Management:** The Atlas calls for a proactive approach to drought risk management, stressing the importance of early interventions to prevent the escalation of disaster risks rather than reactive responses after the fact.
- **Global Case Studies and Success Stories:** A key component of the Atlas is the presentation of global examples and case studies, showcasing successful drought adaptation and management strategies that can be replicated or scaled in other regions.
- **Concrete Solutions for Policy and Practice:** The Atlas concludes by offering detailed, actionable measures for drought risk management and adaptation, specifying their application across sectors, potential co-benefits, and the conditions necessary for scalability and transfer.

Monday - Poster board no. 11
Drought risk governance: The regional, national, and local challenges
Enhancing Climate Services Through Inclusive Local Knowledge Integration
Sumiran Rastogi
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Find me in person at the conference to chat about this work
A large number of CS today are being co-created, wherein a negotiation between different knowledge systems of CS providers, purveyors and end users continually occurs. However often the LK exploration in CS projects is siloed, conducted solely for research purposes, or selectively includes only certain types of LK. We attribute this to a lack of understanding of what constitutes LK and thereby leading to its selective inclusion. We propose that LK encompasses a range of different knowledges and LK holders can range from indigenous, rural, or urban communities to professionals working at various levels of governance and various positions across the climate services value chain (e.g., service providers and purveyors). Furthermore, meaningful inclusion of LK requires us to understand it in the context of its use. Even without formal climate services, individuals, communities and organisations are continually triangulating between different types knowledges and information. Thus, comprehending the role of LK within decision making by different actors is essential to how it can add value to climate services.
• Integrate diverse knowledge bases, including scientific research and local knowledge (LK), to create comprehensive climate services (CS). • Recognize that stakeholders continually cross-reference different types of knowledge. Develop tools and methodologies that facilitate this ongoing triangulation process. • Leverage the tacit knowledge of national and regional governance processes to enhance the development and implementation of CS. • Establish platforms and frameworks that support continuous negotiation and feedback among stakeholders to ensure the relevance and adaptability of CS.

Monday - Poster board no. 12

Drought risk governance: The regional, national, and local challenges

An evaluation of the drought policy and planning guidelines to improve their alignment with the four priority areas of the SENDAI framework

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Drought is a major global challenge causing significant socio-economic and environmental impacts in several regions of the world every year. A paradigm shift, in drought policy and practice, from crisis to risk management is advocated to reduce the impacts of droughts, and to build the resilience of societies, water and environmental systems against drought. Over the last fifty years, drought policy and planning guidelines were developed and used to support the transition from crisis to risk management and resilience. However, research is lacking on critical reflection, evaluation and update of these guidelines. There is no study on assessing the correspondence of the available guidelines to the contemporary disaster risk reduction agendas and changing needs. This study evaluates twelve drought policy and planning guidelines for their alignment with the four priority areas of the SENDAI framework for disaster risk reduction 2015-2030. A qualitative scoring matrix was developed and used in the evaluation, and each priority area and associated thematic elements were scored at the scale of 0-100 (Very low-0-10; Low: 11-30; Medium-low: 31-50; Medium-high: 51-70; High: 71-90; and Very high: 91-100).

The available guidelines provide a comprehensive coverage on data and information, risk assessment, and communication and dissemination aspects linked to priority 1 (understanding disaster risk). Whereas, more attention is needed to improve coverage on science-policy-practice dialogue, local knowledge and practices, and research and development.

Most thematic elements under strengthening disaster risk governance (priority 2) contain good to very good material for strategies and plans, coordination mechanisms, stakeholder participation and community representation, and policy and governance. The future guidelines can easily build on this wealth of information.

Significant efforts are needed to improve several elements related to disaster risk reduction (priority 3), including financial allocation, risk transfer, mainstreaming drought risk reduction into land use and rural development planning, business resilience and protection of livelihoods, and health and safety.

While most elements under priority 4 (enhancing disaster preparedness) scored under medium to high range, sufficient information was lacking on multi-hazard early warning systems, post-disaster recovery, rehabilitation, and reconstruction, and resilience of new and critical infrastructure.

This study gives an urgent call to the science-policy-practice community to periodically review and update drought policy and planning guidelines to enhance their effectiveness to address contemporary challenges and emerging needs.

Monday - Poster board no. 13

Drought risk governance: The regional, national, and local challenges

Drought policy overview: the case of Central America region

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A proactive risk management approach is needed to effectively tackle drought impacts. This research aims to understand drought policy characteristics across 7 Central American countries: Belize; Costa Rica; Guatemala; Honduras; Nicaragua; Panama; and El Salvador. The analytical framework considers the 3 pillars: Drought monitoring, F&EWS; Vulnerability, risk and impact analysis and Mitigation and response. The results show there is an extensive but scattered set of regulatory tools to deal with drought management linked to water and agriculture, and more recently to climate change and disaster risk reduction policies. There are limited advances on drought monitoring, as only one country has their own drought monitor system. Drought impacts are partially tackled to some extent while vulnerability assessments are very limited. Only 3 countries present advances on drought mitigation and response plans development. To sum up, the Central America region shows limited progress towards the adoption of a pro-active drought risk approach and needs urgent efforts and drought policy development to address drought management gaps and challenges in the region.

An overview on how Central American countries address drought issues under a proactive approach perspective is highly valuable to understand regional efforts to fight drought and climate change and detect current challenges.
There is an urgent need to enhance policy coherence and develop drought management tools at national and regional levels.
Drought monitoring is in its early stages of development but presents opportunities to adopt a common regional approach. It should be also aligned with Mexican Drought Monitor or other Latin American drought monitoring efforts and initiatives.
The analysis of impacts and vulnerability assessment should be promoted to close the information gap on this field of knowledge. This will contribute to develop people-center drought policies and to ensure vulnerable groups are taking into account so no one is left behind.
Drought mitigation and response plans should be developed or improved under a proactive basis to enhance drought management and reduce impacts that hinders sustainable development in the region.

Monday - Poster board no. 14

Drought risk governance: The regional, national, and local challenges

Drought vulnerability in forested cold climates – user-validated perspectives from Swedish water-dependent sectors on governance, policies and plans.

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Water-dependent actors' view of drought vulnerability in their sectors and society, provide valuable insights for designing drought management plans and increasing resilience. Therefore, an online survey was conducted in Sweden, targeting actors from water-dependent sectors working in authorities, research, enterprises, NGOs and trade associations. Respondents rated a large list of vulnerability factors based on their impact on drought risk. All factors concerning governance were found relevant for sectoral and societal drought risk, where factors relating to policies and plans were highly impactful for both several sectors and society. Local water management plans or authority-level coordinated water strategies were particularly impactful, as well as defined water use rights and water-use priority classes. Factors relating to the governing bodies were also impactful, such as their level of drought awareness, coordination and cooperation, and competence to offer drought related support. Differences in ratings for sectoral vulnerability were seen depending on water-type dependency.
This implies that implementation of water- and drought related policies are important measures for decreasing drought vulnerability in water-dependent sectors and society. It also highlights the need for establishing guidelines for competing water-use. As vulnerability differs depending on water-type dependency, drought management in water-dependent societies must be adapted to the primary type of water dependency, as well as the drought type.

Proactive drought management in high latitudes may lower drought vulnerability by:

- Incorporating water priority-classes and having defined water-use rights
- Establishing coordinated authority level water strategies, and local water management plans
- Increasing drought awareness within authorities and the competence level for offering drought-related support
- Increasing the level of coordination and cooperation between authorities when offering drought related support.
- Taking the main water type dependency of the sector into account.

Monday - Poster board no. 15

Drought risk governance: The regional, national, and local challenges

Drought risk reduction measures in Bangladesh: lessons learned and opportunities for scaling out

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Drought risk reduction measures in Bangladesh such as the development and promotion of drought-resistant crop varieties, efficient soil-water management practices, rainwater harvesting, efficient irrigation, mulching and conservation tillage, and crop specific early warning systems have provided valuable lessons and opportunities for scaling out. The adoption of digital technologies, web platforms, and mobile applications, the involvement of local communities, and the integration of indigenous knowledge have proven crucial for the success and sustainability of these measures. These drought management technologies play critical roles in ensuring water and food security, promoting sustainable livelihoods, and reducing the social and economic impacts of drought on communities. To reduce drought risk and scale up these successful drought reduction measures, policy frameworks and governance must be improved, investments in drought risk reduction research and advanced technologies such as soil moisture sensors and drip irrigation must be made, big data and AI tools must be integrated, sustainable land management practices must be implemented, financing must be available, and cross-sectoral and public-private-community partnerships for drought management must be fostered. By leveraging the lessons and opportunities, Bangladesh can strengthen its drought resilience and serve as a model for other drought-prone regions in the world.

- Advocate for policies that encourage the adoption of nature based drought management, smart irrigation systems, locally specific and low cost drought-resistant crop varieties, water and soil conservation, locally specific multi-sectoral and crop specific drought early warning systems, and drought risk financing.
- Create policies that provide financial incentives, subsidies, and insurance schemes to farmers and communities adopting drought-resilient practices, ensuring economic stability.
- Invest in drought research and innovative drought mitigation technologies, and promote institutional and community level capacity building on sustainable farming practices, IoT based drought monitoring, and drought risk reduction techniques.
- Foster south-south collaboration and cooperation between government, private sector, and civil society to pool resources and expertise for large-scale drought risk reduction initiatives.
- Scaling out innovative drought management practices through public-private partnerships, appropriate and low cost technologies, and carrying out monitoring and evaluation of drought risk reduction measures.

Monday - Poster board no. 16

Drought risk governance: The regional, national, and local challenges

Assessing drought risks for transboundary drought management in the Meuse basin

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The Meuse river is an important water resource for people and ecosystems in four European countries, but the basin is vulnerable to droughts. Due to climate change as well as human activities, longer periods of low river discharge, declining groundwater levels and soil moisture deficits may cause environmental and societal impacts, such as limitations for drinking water production, limitations in cooling water for energy production, and damage to agricultural crops and biodiversity. This research aims to increase our shared understanding of the multi-sectoral drought risk and how it may develop in the future, and develop ideas on how to reduce drought risk and improve transboundary drought management. Activities included simulating future scenarios with a coupled rainfall-runoff and river basin water balance model, developing impact functions, explore multiple (open) data sets, carry out desk research and interaction with stakeholders and experts with interviews and a “hackaton”.

- A warmer climate causes 80% of the future change in low flows in the Meuse basin; 20% may be caused by human influence.
- A storyline approach based on an extreme drought event supports a collective understanding of drought propagation, societal impact and the effectiveness of potential measures
- Transboundary drought management requires a new governance structure that integrates water resources management with natural resources management and all water-dependent sectors

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Drought risk governance: The regional, national, and local challenges

Drought resilience and impact monitoring on the Balkans under global change: current picture and possible solutions

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Climate change affects differently the frequency and severity of droughts in various regions of Europe. The South East region is one of the most vulnerable to droughts for two reasons. On one hand, agriculture is crucial here (15 to 20% of the GDP), and on the other, the rate of warming is one of the most intense. A comprehensive study of climate change impacts was made by Koppen-Geiger classification. Between 1991 and 2020, there was a notable shift, thus the area with the Dfb(continental) type significantly decreased and being replaced by the Cfb(temperate) climate. Simultaneously, the Cfa(hot summers) expanded across a wider region, often replacing the Cfb type. Undoubtedly, this shift influences the farmers' choice about which crops are most suitable to local conditions. One of the strategic objectives is to create tools for drought adaptation at the regional scale both for decision-makers and the local community. Thus, the *SpaceGarden platform* (https://spacegarden.cropt.ag/en) was created as an advanced solution for monitoring of agricultural production. By combining soil parameters, land use, vegetation indices, climate data, the platform is giving yield prediction, risk and productivity maps. However, the main advantage is the combination of "ground" data with the most up-to-date analytics.

The main lessons from the co-creation process are:

- Collaboration and co-creation between science, the local community of farmers and businesses can benefit all participants
- Identifying which municipalities are the most vulnerable to weather conditions
- Making balanced decisions supported by spatial and temporal data
- Direct delivery of the latest updates to the business in near real time mode

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Drought risk governance: The regional, national, and local challenges

Climate Change and Pastoralism in the Horn of Africa

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The Societal relevance and Scientific novelty of the Climate Change and Pastoralism in the Horn of Africa lie in the intersection of climate change impacts on vulnerable pastoralist communities within the region.

1. Societal Relevance

- **Human Vulnerability:** Climate Change directly affects pastoralist communities in the Horn of Africa, endangering their traditional way of life and means of subsistence.
- **Conflict Dynamics:** Climate change's resource scarcity could exacerbate existing border disputes and water rights issues, potentially leading to war.
- **Resilience Building:** Understanding the influence of climate change on pastoralism is crucial for developing strategies that enhance community resilience against environmental challenges.

2. Scientific Novelty:

Climate change poses a significant threat to pastoralist communities in the Horn of Africa, posing a significant threat to their traditional way of life and means of subsistence.

Interdisciplinary Research: The relationship between pastoralism, CC, and socio-political issues requires an interdisciplinary approach that combines political science, anthropology, and climatology

Localized Solutions: Research in the region can help develop tailored solutions for pastoralist communities in the Horn of Africa, addressing their unique needs and challenges.

3. Policy Implications:

Scientific discoveries can inform policy decisions at local, national, and international levels to mitigate the effects of climate change and support vulnerable communities.

The best policies to integrate and interpret in the Project of Climate Change and Pastoralism in the Horn of Africa is the establishment of a comprehensive climate-resilient pastoralism strategy. This should encompass the ff key concepts:

- **Sustainable Rangeland Management:** Pastoralist communities will be better equipped to adapt to changing climate circumstances if sustainable rangeland management techniques are put into place. These practices should support biodiversity, soil health, and water conservation.
- **Early Warning Systems**: Pastoralists will be able to prevent future crises and save their livelihoods by creating and executing early warning systems for climate-related calamities like droughts and floods.
- **Climate-Smart Livestock Production**: Promoting climate-smart livestock production practices, such as improved animal breeding techniques and sustainable feeding strategies, will help pastoralists mitigate the impact of climate change on their livestock holdings.
- Capacity Building and Knowledge Sharing: By giving pastoralist communities access to training and opportunities for capacity-building, they can improve their understanding of options for adapting to climate change and become better equipped to make decisions about their livelihoods.
- Infrastructure Development: Pastoralist communities will be more resilient if they invest in infrastructure like market access roads, veterinary care, and water storage facilities. This is because these facilities will increase the communities' capacity to tolerate shocks caused by climate change.

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Drought risk governance: The regional, national, and local challenges

Drought in the Maghreb Region, 2001-2023

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Drought is a disaster with significant societal and environmental impacts, affecting millions globally by disrupting agricultural water supplies, energy resources, and ecosystems. This study is particularly relevant as it focuses on the Maghreb region, a highly vulnerable area due to its low and erratic rainfall patterns. The research evaluates the spatial and temporal distribution of drought across five African countries—Mauritania, Morocco, Algeria, Tunisia, and Libya—using the Standardized Precipitation Index (SPI). By analyzing CHIRPS rainfall data, the study identifies a worsening drought trend, with 2001 being one of the driest years in decades and recent prolonged dry conditions since 2019 causing severe agricultural losses, water shortages, and environmental degradation. These findings are scientifically novel as they provide a comprehensive regional assessment of drought using advanced climate data, highlighting the urgent need for a robust drought monitoring system. Such a system is crucial for proactive drought management and adaptation strategies, which are vital for mitigating food insecurity, displacement, and the broader socioeconomic impacts of climate change in the Maghreb region.

- **Establish a Comprehensive Drought Monitoring System:** Implementing a robust, region-wide drought monitoring system is critical for early detection and response. This system should leverage advanced climate data and tools like the Standardized Precipitation Index (SPI) and Soil Moisture Anomaly (SMA) to provide timely and accurate information to policymakers and stakeholders.
- **Promote Climate-Resilient Agricultural Practices:** Encourage the adoption of climate-resilient agricultural practices in the Maghreb region, including drought-resistant crop varieties, efficient irrigation techniques, and soil conservation methods. These practices can mitigate the impact of prolonged dry conditions on food security and rural livelihoods.
- **Enhance Water Resource Management:** Develop and implement integrated water resource management strategies that prioritize sustainable water use and conservation. This includes improving water storage infrastructure, promoting water-efficient technologies, and protecting vital watersheds to ensure long-term water availability.

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Drought risk governance: The regional, national, and local challenges

Strengthening drought management and resilience from regional science-policy dialogues in southern South America

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The collaborative effort between scientists and decision-makers from the water management and agricultural sectors of central-western Argentina aims to build a drought-resilient region. Following the development and evaluation of regionally-tailored hydrological drought indices, after a capacity development process the irrigation authorities adopted in 2021 a drought monitoring system based on streamflow records and water levels from reservoirs. A calibrated hydrological model considering the complex topography and the impact of cryosphere on streamflow was developed and applied for future hydrological projections, allowing the quantification of a mid-century water availability scenario for long-term adaptation planning. Finally, the impact of water management on the severity and duration of hydrological droughts was quantified using several upstream-downstream approaches to illustrate transboundary water conflicts and wetland degradation exacerbated by human activities

- Science-based decision-making products for drought monitoring and early warning were developed based on hydrological observations, remote sensing products, and hydrometeorological models
- Future streamflow projections based on calibrated hydrological models provided relevant information to the regional water authorities. The hydrological simulations were used for long-term adaptation planning to increase drought resilience and adaptation considering the next 30 years
- The co-production process between scientists and regional water authorities to generate useful information for hydrological drought declaration was embedded in a capacity development process over the last decade
- Human activities related to water management often leave behind aspects such as environmental flows, key for wetlands and ecosystem restoration to achieve many Sustainable Development Goals. Improving water-use efficiency is of paramount importance to avoid upstream-downstream water issues

Monday - Poster board no. 21

Drought resilience and global mechanisms

Understanding & Assessing Drought in a Changing Climate: Addressing the Challenge and its Implications to Drought Resilience with the Global Community

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Significant advances have improved the capacity to proactively manage drought risk by providing those affected with the best available information and resources to diagnose and quantify—or assess—drought conditions. These assessments have a vital role to play in supporting communities in preparing for, mitigating, and responding to drought.

Currently, most common methods for assessing drought conditions do not consistently and deliberately consider drought in the context of climate change. This oversight can unintentionally promote drought response strategies that are limited in building long-term resilience in a changing climate. Consider the case of anomalous drought events, which are expected to recover, versus permanent changes toward a more arid climate. In a changing climate these distinctions are not well known. This limits our ability to disentangle the relative contributions of drought and aridification—a distinction critical to informing both short-term risk management and long-term adaptation.

NOAA's National Integrated Drought Information System (NIDIS) and partners have worked to articulate next steps in progressing towards better characterizing, communicating, and managing changing drought risks. This is an important part of accurate assessments of current conditions that keep pace with the rapid change in our climate. This poster includes a proposal to establish a community of practice to learn and exchange ideas within the community to progress drought assessment science.

- Drought assessment methodologies that account for climate change are key to informing both short-term risk management and long-term adaptation and to avoid maladaptive practices across sectors.
- Disaster relief programs based on drought assessments that do not take into account climate change could be taking on unnecessary financial risk.
- Drought monitoring and assessment methodologies that do not account for climate change could exacerbate inequities in access to information to inform planning and response as well as access to disaster relief.
- Sharing learning and best practices for drought assessment in a changing climate through the global drought community could accelerate needed changes.
- A better understanding of drought in a changing climate will allow key economic sectors and industries better prepare for future conditions.

Monday - Poster board no. 22

From policies into action

A pathways approach for adapting to systemic drought risks

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Short and long-term decision-making that is joined up and anticipates climate and societal change is required to adapt to systemic drought risks. Adaptation pathways are one promising methodology that can achieve this, by considering past and present conditions (climate and societal), to implement adaptation options to manage near term expected drought impacts. Moreover, pathways support longer-term planning by identifying options that can be implemented progressively when there is less uncertainty about future drought conditions. In this poster we integrate an Adaptation Pathways with conceptual risk modeling tools, presenting an approach for adapting to systemic drought risks. Both Pathways and conceptual risk modeling integrate flexibility and multiple perspectives into risk management decision making. Moreover, the visual outputs of these tools are effective adaptation heuristics that can inspire a more interconnected and systemic thinking among decision-makers, which is important if we are to achieve drought resilience. These approaches support identifying co-benefits and trade-offs inherent in adaptation decisions, as well as where synergies can be made for implementing multiple different measures together. This improves understanding of how interventions in one sector can have positive cascading effects in other, interconnected sectors, which is critical given the negative cascading effects that arise from droughts. This poster demonstrates how different clusters of measures can combine and create synergies under conditions of increasing drought risks and uncertainty, aiming to inspire more aspirational thinking about how to strengthen systemic resilience of economies, ecosystems and society to drought and other connected hazards.

- Long-term decision-making is needed that anticipates and is adaptable to climate, societal and environmental change
- Systemic drought risks are dynamic and uncertain
- Conceptual risk models can characterize and assess the interconnected and systemic nature of drought risks
- A pathways approach integrates flexibility into drought risk planning, offering opportunities to create synergies and co-benefits between measures, creating positive cascading effects between sectors and systems

Monday - Poster board no. 23

From policies into action

Implementing Drought Resilience through Strategic Sub-national Climate and Economic Action Planning in India: Challenges and Successes

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At WRI India, we have developed city and region-level climate action plans and growth strategies that balance ecology and economy. This framework informs targeted actions by cities and state governments, integrating systemic, physical, and fiscal strategies that deliver measurable impact. Known as the 'Climate Hazard Vulnerability Assessment (CHVA),' it guides decisions based on local vulnerabilities, enhancing resilience to drought and other climate impacts.

Our approach integrates scientific data and local insights to assess drought risk (meteorological, hydrological, and agricultural), and overall water stress at multiple scales reaching from the regionally appropriate watersheds to the neighbourhood-level.

The analysis of drought risk is further supplemented with study of groundwater exploitation, precipitation change, thermal stress, water (sub-surface and surface) quality fluctuations, soil health, yield, and productivity. We also looked at other urban and environmental pressures such as vegetation change, fire, air quality etc. analogized within socio-economic vulnerabilities and sectoral supply-chains.

These assessments are evaluated for baselines and projected based Representative Concentration Pathways (RCP) scenarios with broad sectoral evaluations for priority economic and development policy scenarios identified by the policy makers.

The evaluation at multiple spatio-temporal scales allows to optimise the water allocation for – human, ecosystems, agriculture, and industry. The drought impacts are assessed based on severity, frequency and extents of the anomalous events and seasonal, and long-term trends to estimate the potential for recovery and relatively permanent change. The framework utilizes periodically updated satellite-derived and government-endorsed datasets, alongside extensive stakeholder consultations, enabling scalable integration into existing policy structures.

Drought declarations in India are rural-centric and inadequately addressed across the country. City disaster governance in India is devoid of droughts that affect not only water supplies, food security, and energy demands but also human and animal health, yields, agricultural supply chain and economy. The CHVA framework integrates applied science and policy, tailored based on publicly available datasets across various scales in India.

- Its application has facilitated dialogue among agencies and stakeholders through evidence-based spatial mapping strategies. The framework offers exhaustive list of indicators, datasets, and suggested methods to approach the analysis that are flexible and can be tailored to for easy replication and scalability.
- Challenges such as data heterogeneity, alignment with legal and policy structures, and capacity gaps within organizations have been addressed through collaborative approaches enabled by the framework.
- It has fostered public-private partnerships, improved water regulation and disaster management policies, and integrated Nature-based Solutions, and thermal comfort into urban and sectoral supply-chain infrastructure in Indian cities.
- The framework has been successfully applied in multiple cities and regions in India such as Mumbai, Bengaluru, Kochi, Nashik, Solapur, Aurangabad, and regions of Tamil Nadu, Uttar Pradesh, Maharashtra, Andhra Pradesh, and Gujarat.

Monday - Poster board no. 24

From policies into action

Drought monitoring and adaptation strategies in agriculture at local scale

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Droughts are becoming more widespread, frequent and severe aggravated by climate change, necessitating the alignment of monitoring efforts and adaptation strategies.Drought monitoring and adaptation strategies together are pillars of a risk-based drought management approach, which is proactive and more sustainable than crisis-driven approach. Agriculture is the largest consumer of earth's freshwater resources, making it the most vulnerable sector to drought impacts spanning from reduced crop yield to complete crop failure. Since agronomic drought adaptation strategies are implemented at a plot scale, it also becomes relevant to integrate drought monitoring at the farm scale. Accordingly, this study adopted and modified the combined drought indicator implimented by the European Drought Observatory at a plot scale for drought monitoring. Additionally, drought adaptation strategies such as deficit irrigation, soil amendment product and tillage methods were evaluated under varying contexts.

- The modified combined drought indicator which integrate in situ soil moisture measurements, captures the influences of local practices. This could enable local stakeholders to adapt their practices to reduce the impact of drought on agricultural crop production.
- Conventional tillage, exacerbates the impact of drought on crop growth by compacting the soil and impeding soil water movement. Therefore, conservation tillage approaches (such as mulching and reduced tillage) should be considered to reduce soil moisture loss during drought periods.
- When soils with lower water retention capacities are exposed to drought, increasing the water supply via irrigation alone might not be a definitive solution. In such cases, the use of soil amendment products that enhance the water retention capacity of the soil could be beneficial by improving water use efficiency.

Monday - Poster board no. 25

From policies into action

Drought Management in South Korea

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Drought policies in South Korea focused on response and recovery before 2014. Extreme drought events have, however, occurred since 2014 as mentioned above. The paradigm of drought management in South Korea changed into prevention and preparedness.
These prevention and preparedness policies enabled the government to response efficiently and timely to the drought in southern region from 2022 to 2023. Drought early warning system detected the extreme drought and thus the government could proactively prepare the response.
MOIS prepared extra budget for drought responses of local governments. MAFRA also supported agricultural drought responses proactively. ME saved residential and industrial water through conjunctive dam operation and decrease in river maintenance flow. Ministry of Trade, Industry and Energy postponed factory maintenance period of national industrial complex.
These proactive efforts to drought in the southern region enabled South Korea to minimize drought damage.

- The paradigm of drought management in South Korea changed into prevention and preparedness.
- Drought early warning system detected the extreme drought and thus the authorities of drought management could proactively prepare the response.
- The proactive responses to drought, especially joint responses among the governmental departments, enabled the authorities of drought management to minimize drought damage.

Monday - Poster board no. 27

From policies into action

Feasible way to regreen the Sahel massively

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The activation of powerful ways to regreen Sahel is urgent. These ways are today in function and well experimented. But they are gravely underemployed. The focus of this proceeding is the "Vallerani" plough, but there are other mediums,like the "Practica Zainer".
The Fondation Reverdir le Sahara promotes radically increase of such practices, in tight collaboration with local inhabitants, particulary the shepherds. Therefore we preconise furniture of technical material and crew, but also the constitution of training courses, and the constitution of an AGENCY depending of the UNO.

This agency would have four main duties:
- sustain concretely and technically the motorised zai
- determine faisable territories, able for this technology
- upkeep relationships with local inhabitants and their earth laws
- control the quality of treated work

These targets are now fulfilled since 20 years by NGOs and private companies. They need to be very largely multiplied and controlled by an international agency. Competent persons are well known by our Fundation. The costs are documented by our Fundation, they are very low by using the Vallerani plough.

The agency would also have scientific goals:
- examine the relationships between greening of the Sahel and increase of the african monsoon toward north
- as formerly mentionned: determine faisable territories

Climate warming increases gradually water convection of the african monsoon towards northern Sahel. Moreover, northern Sahel receives to day so much rainfall as Switzerland. But the water falls in one month and ruins the soil if not absorbed. These opportunities are strong inducements to undertake the work as soon as possible.

These themes are explained in the book "Sahara, planche de salut" by
Jean-Edouard Buchter, Ed. Favre, Lausanne, 2023, 120p.

Fondation Reverdir le Sahara
https://reverdirlesahara.org/

WOCAT-Vallerani
https://qcat.wocat.net/fr/wocat/technologies/view/technologies_1528/

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https://openknowledge.fao.org/server/api/core/bitstreams/4f194ec2-646b-47c6-999d-08497203cb24/content

Monday - Poster board no. 28

From policies into action

Shared strategic drought risk management in the transboundary Rhine River basin

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Although the Rhine basin already has a long tradition of water cooperation in a peaceful environment, more and more frequent extreme drought events introduced by climate change as well as growing water demand due to socio-economic developments challenges current paradigms for drought management in the Rhine river basin, and urgently calls for intensified transboundary cooperation and action.
To develop a common understanding on drought risk and water allocation on the transboundary level, the three Rhine commissions (CHR, CCNR, and ICPR) in collaboration with the EU funded STARS4Water project, are developing three socio-economic scenario narratives for the Rhine basin. The scenarios are modeled using the novel wflow-ribasim tool to perform a drought risk assessment. The project combines state-of-the-art data, information and knowledge from various national, European and global sources, including literature and experts' and stakeholders' input to generate new collective perspectives on the transboundary level. Outcome of the project will be used to update the Rhine River basin climate adaptation plan and make the countries jointly better prepared.

The case of the Rhine river basin shows that transboundary drought policy making and actions on drought can be significantly strengthened by:

- collaboration between representatives from the countries for effective transboundary governance.
- co-creation in producing meaningful information on drought vulnerabilities and impacts through continuous engagement with the stakeholder community
- building a common understanding among experts across borders on drought risk assessments supported by shared data and IWRM modeling tool.
- strengthening the transboundary information and knowledge systems, leveraging all kind of global to local data sources and new data science.
- developing a joint message by policy makers and experts on the impact of future scenarios and uncertainties about socio-economic and climate change on low flows to ensure politicians and stakeholders are informed uniformly and in time.

Monday - Poster board no. 29

From policies into action

Does drought management care about nature? Identifying gaps in the consideration of freshwater ecosystems

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By reviewing drought management instruments from 26 case studies worldwide, our study provides insights into the degree and the manner with which current drought management considers freshwater ecosystems. Results indicate that the consideration of freshwater ecosystems in drought management is as yet at an early stage. This is evidenced by the limited inclusion of freshwater ecosystems across critical elements of the drought management process, including in drought definitions and typologies, indicators, and how exposure and vulnerability are conceptualised. The following scientific advances would benefit drought management in the environmental domain: (i) the development of indicators based on variables that are representative of drought risk exposure and vulnerability in freshwater ecosystems. These should include, besides surface water quantity, groundwater, water quality and habitat variables; (ii) the development of analytical methodologies to systematically assess the exposure and vulnerability of freshwater ecosystems to drought at a scale that is relevant for management. These methodologies could draw from the existing conceptual frameworks on ecological drought, and most importantly, should integrate the knowledge and data currently utilized in environmental risk management; (iii) the improved understanding of the socio-ecological interactions during droughts and their effects on freshwater ecosystems; (iv) the duration, frequency and timing of drought should be considered when designing drought indicators and measures that act on freshwater ecosystems, as the temporal dynamics can significantly influence the severity of the impacts droughts have on freshwater ecosystems.

The following policy relevant recommendations were identified to advance drought management towards risk-based and proactive approaches in the environmental:

- Drought instruments should more explicitly consider the effects of drought on groundwater and water quality. This is currently missing in the indicators to anticipate drought risk in freshwater ecosystems, as well as in the measures to address that risk.
- While reinforcing the monitoring of drought impacts on freshwater ecosystems remains important, there is a need to move beyond observation and address the root causes of these impacts.. For that, analytical methodologies to systematically assess and manage the exposure and vulnerability of freshwater ecosystems to drought need to be implemented.
- It is urgent to incorporate a socio-ecological perspective into drought management, particularly by accounting for the human influences when understanding the (positive and negative) effects of drought on ecosystems. This applies to drought definitions and types, as well as to the methodologies to assess exposure and vulnerability of freshwater ecosystems.

Monday - Poster board no. 30

From policies into action

Drought Monitoring and Forecast, Aridity Management and Afforestation Programs in Saudi Arabia

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The Climate Change Center (CCC) utilizes advanced methods for drought monitoring and predictions, ranging from seasonal forecasts to climate change scenarios. Key activities include an operational drought monitoring system, forecasts predicting climatic anomalies, and downscaling climate scenarios specifically for the Arabian Peninsula. These forecasts provide crucial insights for mitigating the adverse effects of drought on agriculture and water resources. Additionally, the CCC supports afforestation initiatives under the Saudi Green Initiative (SGI) through detailed studies on the impact of vegetation in climate modulation and the efficacy of different afforestation strategies. Research using observations and numerical model simulations indicates that increased vegetation positively influences local and regional climates. This contributes to creating a more stable and resilient ecosystem.

- Saudi Arabia, with its arid climate, faces major challenges like drought and water scarcity. To tackle these, the country has launched initiatives under Vision 2030 to improve environmental sustainability.
- The Saudi Green Initiative (SGI) is a central part of these efforts, focusing on combating desertification, promoting afforestation, and reducing carbon emissions.
- A key element of Saudi Arabia's strategy is the establishment of the Climate Change Center (CCC), which leads drought monitoring and management efforts.
- The CCC collaborates with international institutions such as the Global Drought Observatory of the European Commission, the International Research Institute for Climate and Society (IRI), the National Center of Atmospheric Research (NCAR), the University of Arizona, and Scripps Institution of Oceanography, to ensure best practices.
- These initiatives highlight Saudi Arabia's commitment to addressing climate change and environmental degradation.

Monday - Poster board no. 31

From policies into action

Data Pipeline form raw data to Climate Information

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Since the upcoming challenge of climate change is on a global dimension, it has, therefore, to be addressed on a global scale. The interoperability of data, information, and knowledge, as well as all ready-to-use application packages, is essential to increase the efficiency of knowledge generation. Therefore, the FAIR principles play a special role in designing Climate Services Information Systems (CSIS). Here the data pipeline from raw data to usable information and knowledge on demand will be presented. It discusses concepts of standardization for analysis-ready data and datacubes where developed tools are in place or can be deployed. Realizing FAIR principles for existing datasets in most optimal way and identify opportunities to establish information systems to produce knowledge on demand with the blueprint of the Climate Resilience Application Packages of the CLINT Project as well as findings of the latest OGC Climate and Disaster Resilience Pilot.

Not only does data need to be findable, accessible, interoperable, and reusable, but the entire climate information ecosystem around the data should adhere to the same principles. In case of achieving 'land degradation neutrality' countries are in need of access to the best available data, and tools or generate information on demand to estimate the Sustainable Development Goal (SDG) indicator 15.3.1, Proportion of land that Is degraded over total land area, and monitor progress towards land degradation neutrality (LDN). The United Nation Convention Combat Desertification (UNCCD) is the custodian agency of this indicator and achieving LDN is a strong vehicle for country parties to implement the convention. This results in a worldwide demand on analysis ready data for SDG 15.3.1 to support reporting, monitoring, and verification as well as enhance action strategies and implementation plans.

Monday - Poster board no. 32

From policies into action

Policy-relevant drought research at the Institute for Environmental Studies – VU Amsterdam – the Netherlands

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The drought research group at the Institute for Environmental Studies at VU Amsterdam, the Netherlands, studies the diversity of drought processes from an interdisciplinary perspective; from climate to hydrological, from societal to ecological impacts. We work mostly in Africa, Latin-America and Europe. In this poster presentation, we would like to highlight two regions where we collaborate with water managers, policy makers and NGOs to improve drought resilience on the ground.

In the Horn of Africa, long-term drought impact data collection by the National Drought Management Authority (NDMA) allows understanding the relationship between drought hazard and impacts. Our analysis has shown that these relationships are non-linear because vulnerability factors that change in time and space are important. We are working with NDMA and ICPAC to include these factors in their drought monitoring and early-warning. We also found that low-cost drought adaptation measures can relatively easily be promoted by NGOs with training, but that this is not the case for more expensive adaptation such as water harvesting or sand dams. These measures can also have unexpected consequences, for example increasing flood impacts during heavy rainfall.

In Europe, we are working with water authorities on regional and national level and policy makers on European level to change drought management from a hazard-focus to a more risk perspective. For example, we co-published the European Drought Risk Atlas, in which drought risks were calculated for five different sectors based on impact data. This Atlas was presented to the European Commission. Additionally, we are working with water boards in the Netherlands to assess the effectiveness of their drought adaptation measures. We find that measures that increase storage can be effective, but collective action of landowners and managers from local to national scale is needed in order to upscale these to landscape scale.

Monday - Poster board no. 33

Drought resilience and global action

From systemic drought risks to systemic resilience: a novel framework to guide research and policy

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In recent years, the world has faced extreme droughts with severe direct, cascading and often systemic impacts across communities, sectors, ecosystems, and borders. Droughts also interact with other hazards in complex ways, for example leading to compound heat-drought events, wildfires or aggravated impacts when concurring with other hazards and shocks. At the same time, policy responses to droughts can also lead to response risks/maladaptation, for example when the establishment of reservoirs leads to overreliance and in turn increases vulnerability. Combined, these characteristics pose a challenge to our ability to grasp drought risks in their full complexity, and to manage them in a comprehensive way.
This calls for a paradigm shift in how we look at, assess and manage drought risks: from a predominantly single risk/sectoral to a systemic perspective. Addressing this need, we propose a novel drought risk

framework that highlights the systemic nature of drought risks, and show its operationalization using the 2022 drought in Europe. Our research emphasizes that solutions and policies to tackle growing and increasingly complex and systemic drought risks should not only consider the underlying drivers of drought risks for different sectors, systems or regions, but also be based on an understanding of sector/system interdependencies, feedbacks, dynamics, compounding and concurring hazards, as well as possible tipping points and globally and/or regionally networked risks.
The framework has served as guidance for the 2023 “European Drought Risk Atlas” and the upcoming “Global Drought Atlas”.

Drought risks are on the rise and their effects are increasingly felt across communities, economic sectors, ecosystems, borders and entire societies
To comprehensively assess and manage drought risks, and avoid response risks/maladaptation, a systemic perspective is needed
We propose a novel systemic framework to better inform drought risk research and policy

Monday - Poster board no. 34

Complexity of drought resilience under global change

The 2022 Drought needs to be a Turning Point for European Drought Risk Management

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The 2022 European drought has underscored critical deficiencies in European water management. This paper delves into these shortcomings and suggests a way forward for European drought risk management. Our research focuses on four key aspects: the increasing risk of drought, its spatial and temporal impacts, existing risk management measures, and evolving strategies across the continent. Findings from a Europe-wide survey among water managers reveal a consensus on the growing risk of drought, with organizations showing increased awareness and preparedness. The study highlights the rising frequency and intensity of droughts, stressing the need for continent-wide coordination to manage drought risk.
We observe that droughts, often treated as extraordinary events, instead sould be viewed as complex, long-term crises. This perspective shift is crucial; prioritizing demand reduction and ecosystem health over short-term and supply-side solutions. Additionally, Regional disparities in drought risk management capacity highlight the urgent need for a unified European approach.

This research was carried out by the Drought in the Anthropocene Network.

We advocate for a European Drought Directive to harmonize and enforce drought risk management policies across the continent. This directive should be guided by key principles of Drought Risk Management:
- Managing drought risk holistically (across countries and sectors);
- Recognizing droughts as continuous and systemic events;
- Prioritizing environmental needs;
- Prioritizing water demand reduction over increased supply.

Additionally, a European Drought Directive should:
- Provide guidelines for the definition of drought.
- Provide guidance for international coordination in drought risk management.
- Promote systemic, integrated, and long-term drought risk management;
- Provide guidelines for the development and implementation of national drought risk management policies
- Provide deadlines for key steps in the development of national drought risk management policies:

Drought risk and impact: monitoring, assessment and forecasting.

Drought is a complex and multifaceted hazard, so the poster contributions for the Workstream 3 “Drought impact monitoring, assessment and forecasting” reflect the diverse approaches being taken to monitor, assess, forecast, and reduce its impacts across different regions of the world. These studies underscore the urgent need for innovative tools and strategies to address the growing frequency and severity of droughts and their impacts, exacerbated by climate change.

Drought Impact Monitoring
Effective drought management relies heavily on real-time, accurate monitoring systems, and many of the received contributions showcase advancements in this area. Morocco has adopted a multi-index monitoring approach, integrating indices like SPEI, VCI, and TCI with socio-economic data to create a nuanced understanding of drought impacts on various communities. Brazil's CEMADEN center is using the Integrated Drought Index (IDI) to provide near real-time data, improving drought detection and response across the country. In Switzerland, an innovative drought monitoring and early-warning system, which combines satellite-based and in-situ data, has been developed to track drought conditions on a daily basis. These systems exemplify how cutting-edge technology and big data are enhancing the precision and timeliness of drought information.

Drought Impact Assessment
A key focus in several contributions is the rigorous assessment of drought conditions and their long-term impacts. For example, a study in the Maghreb region analyzed 20 years of rainfall data, identifying trends that point to worsening drought conditions across North Africa, which have severe implications for food security and water availability. In Europe, the European Drought Impact Database (EDID) has been developed to standardize and improve data collection on drought impacts, providing valuable insights for policymakers. Another study emphasized the importance of selecting appropriate drought indices tailored to specific regional climates, ensuring that assessments accurately reflect the severity of drought in different environmental settings, from tropical to arid regions.

Drought Impact Management, Preparedness, and Resilience
Beyond assessment and monitoring, drought risk and impact management involve preparedness, forecasting, and adaptive strategies to build resilience. Forecasting plays a crucial role in improving preparedness, as demonstrated by the seasonal drought impact forecasting efforts in Europe and the forecasting systems in India that track drought propagation from meteorological to hydrological droughts. Switzerland’s early-warning system integrates sub-seasonal forecasts, allowing decision-makers to anticipate and mitigate drought impacts before they fully materialize. Adaptive strategies for resilience were a strong focus in several abstracts, particularly in agricultural contexts. In South Asia, drought-resistant crops and improved irrigation techniques have gained significant acceptance and are helping to protect livelihoods in regions frequently hit by drought. The need for proactive, integrated approaches is echoed in the "EOTEC DevNet" initiative, which aggregates Earth observation tools to support global drought management. Similarly, a study on transboundary drought management in Eastern Europe highlights the importance of cross-border cooperation in tailoring drought responses to socio-economic contexts. These adaptive measures are essential for reducing vulnerabilities and building long-term resilience in regions heavily affected by drought.

Collectively, these studies underscore the importance of an integrated approach to drought risk and impact management, combining advanced assessment techniques, monitoring tools, and proactive strategies that build resilience and help communities minimize the impacts of the growing threat of droughts.

Tuesday - Poster board no. 1
Drought impact monitoring, assessment and forecasting
SPEI, VCI, TCI: A Comparative Study for Drought Monitoring in Morocco
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This research addresses the critical challenge of drought in Morocco, a country where 40% of the workforce relies on agriculture. Our work's societal relevance lies in its potential to safeguard livelihoods, enhance food security, and improve water resource management in a changing climate. The scientific novelty of our approach includes: Integration of multiple drought indices (SPEI, VCI, TCI) tailored to Morocco's diverse ecological zones, providing a more nuanced understanding of drought dynamics. Development of a machine learning algorithm that combines these indices with local socio-economic data, enhancing drought impact predictions at the community level. Incorporation of traditional knowledge from local farmers into the drought monitoring system, bridging scientific and indigenous approaches.. This innovative, interdisciplinary approach not only advances drought science but also provides practical tools for drought management. By linking cutting-edge research with on-the-ground realities, our work paves the way for more resilient and adaptive water management practices in Morocco and potentially other semi-arid regions globally.
• Implement the multi-index drought monitoring system nationwide to enhance early warning capabilities, potentially reducing drought-related economic losses by up to 20%. • Revise agricultural policies to promote drought-resistant crops and farming practices based on the spatial drought risk patterns identified in our study. • Establish a cross-sectoral Drought Task Force that uses our monitoring system to coordinate responses among water, agriculture, and energy sectors during drought events. • Allocate funding for expanding the network of weather stations and satellite data collection to improve the accuracy and spatial resolution of drought predictions, especially in remote rural areas.

Tuesday - Poster board no. 5

Drought impact monitoring, assessment and forecasting

Text as data in drought risk management

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Much of the public discourse and political framing are documented as text. This vast volume of text data, combined with advances in natural language processing (NLP), has opened new ways of extracting actionable insights from texts. Our working group leverages these tools to enhance drought management. For instance, we use texts such as the minutes of meetings of water board committees to extract information on how water allocation decisions are made and who the powerful stakeholders are in these decisions. Furthermore, newspaper text data helps us gauge public perception of the socioeconomic impacts of droughts and assess drought awareness. We also investigate how droughts drive conflicts in Germany, based on both newspapers as well as the text of legal acts. In conclusion, integrating NLP with extensive text datasets holds transformative potential for drought management, providing information on various topics needed to understand human-water interactions.

- Critical information on drought management strategies can be derived from text data, such as reports and strategic plans.
- Near-real time data on perceived socio-economic impacts of droughts can be assessed using media such as newspapers.
- By leveraging NLP to analyze meeting minutes and other textual data, policymakers can gain a deeper understanding of water allocation processes, identifying key stakeholders and their influence on decisions, ultimately leading to more informed drought management strategies.
- Analyzing legal texts and media reports with NLP can help detect early signs of conflicts driven by drought conditions. Policymakers can use these insights to proactively address potential disputes, ensuring a more stable and cooperative approach to water resource management.

Tuesday - Poster board no. 7
Drought impact monitoring, assessment and forecasting
Drought monitoring and impacts assessment in Brazil: The CEMADEN experience
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Brazil has experienced intense droughts across various regions in recent decades. Despite drought being a recurring phenomenon in the Northeast, particularly in rural areas, vulnerability remains high. Prior to the historic drought in the semiarid region, Brazil lacked a federal institution dedicated to drought monitoring and impact assessment. In response, the National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN/MCTI) assumed this responsibility. CEMADEN developed the Integrated Drought Index (IDI), a comprehensive tool that combines data from multiple sources, including precipitation, evapotranspiration, soil moisture, and vegetation health indices. This multi-parameter approach provides a more accurate and nuanced assessment of drought conditions compared to single-variable indices. The IDI is regularly updated, offering near real-time monitoring of drought across Brazil and has been used in the reports of Climate of the WMO.
• Historic Drought: Brazil faces the worst drought in its recorded history (since 1950), severely impacting vital ecosystems like the Amazon rainforest and the Pantanal. • Unprecedented Scale: Drought in 2024 has reached an unprecedented extent in Brazil, affecting regions beyond the historically drought-prone semiarid areas. Approximately 5 million km^2 (60% of the country's territory) is now affected by drought. • Urgent Policy Needs: Comprehensive policies are crucial to prepare for and mitigate drought impacts across all regions, not just the semiarid zone. The climate change is contributing to these changes. • Ecosystem Concerns: The drought's impact on the Amazon and Pantanal raises concerns about carbon stocks, biodiversity, and water availability. • Drought Monitoring: Brazil has already advanced with monitoring and impact assessment systems, such as the CEMADEN operational system. However, the data provided must be effectively considered in the preparedness plans for drought.

Tuesday - Poster board no. 8

Drought impact monitoring, assessment and forecasting

Drought resilience in agriculture areas in Central Asia

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South Asia is one of the world's regions most sensitive to drought (IPCC, 2022), and water and food shortages are expected to become more frequent. Afghanistan and Pakistan, both in south Asia, share nine rivers with a combined population of around 43 million where droughts occur 4 in 10 years, and challenge agricultural production. Work undertaken as part of Water Management for Enhanced Productivity, a USAID funded, IWMI-implemented project, characterizes climate extremes including agricultural droughts and links these events with crop yield using projected climatic data in the agriculturally important Gomal River basin. In Gomal River basin adaptation measures e.g., drought resistant crop varieties, improved irrigation methods and farm practices have shown significant acceptance and uptake. Drought assessment and prediction in agricultural settings, in and beyond south Asia, has high prospects for better planning and implementation of adaptation measures and has global relevance.

- *Drought effects on agriculture, though relatively overlooked, may exceed impacts to urban areas.*
- As cities are on the frontlines of the global climate emergency, systematic assessments of climate hazards for future and adaptation planning are common for large cities. The boundaries of agricultural areas are different from city boundaries. The agricultural areas get much less attention from policy makers with regards to assessments and planning.
- There are many global and regional networks, C40 for example, where leadership of member cities are in action to confront the climate crisis. There is no such network where managers of agricultural districts/areas can unite to develop strategies on drought resilience.
- *Climate shock outlook can be applied to predict and prepare for drought through roll out of adaptation measures.*
- The agricultural drought index considers additional variables than precipitation to comprehensively link drought effects – through crop calendars and models – to crop yield. Policy makers should give more attention to agricultural areas to develop climate shock outlook where agricultural drought indices can be more relevant than commonly used drought indices.
- The climate shock outlook can be used to strategize adaptation options for drought resilience e.g. drought resilient crop varieties, and improved irrigation and farm practices.

Tuesday - Poster board no. 9

Drought impact monitoring, assessment and forecasting

A Review of Groundwater Drought Assessment and Mitigation Practices in Arid and Semi-Arid Lands

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The societal relevance of this research lies in its ability to provide crucial insights into the pressing issue of groundwater drought in arid and semi-arid regions. By understanding the drivers, consequences, and potential mitigation strategies, policymakers, water managers, and communities can make informed decisions to ensure sustainable water resources and protect human health and economic stability. Additionally, the scientific novelty of this study stems from its comprehensive review of the existing literature on groundwater drought, filling a significant gap in research and providing a valuable resource for future studies in this field.

- **Prioritize Groundwater Quality**: Implement comprehensive groundwater quality monitoring and assessment programs to ensure safe and sustainable water use.
- **Foster Regional Collaboration**: Encourage international cooperation to address transboundary groundwater issues and develop joint strategies for sustainable management.
- **Invest in Technology and Innovation**: Support research and development of advanced technologies for groundwater monitoring, modeling, and management, including AI-driven solutions.
- **Promote Nature-Based Solutions**: Integrate nature-based approaches into groundwater management plans to enhance aquifer resilience and reduce water stress.
- **Strengthen Institutional Capacity**: Invest in training and capacity building for water resource professionals to improve decision-making and implementation of sustainable groundwater management practices.

Tuesday - Poster board no. 10

Drought impact monitoring, assessment and forecasting

Site-specific suitability of drought indices: a systematic review

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Over the years, numerous drought indices have been developed for various purposes and applied globally by drought experts. It is essential to understand how important the regional climate and other characteristics are for the appropriate selection of drought indices, as features of each climate type are very different, and the response of indices to climate plays a vital role in drought indices performance. By far, there is a shortage of systematic reviews to evaluate the suitability of drought indices for various environmental settings on a global scale. In this respect, this systematic review addresses the critical gap by providing the simplicity of usage of the 17 common drought indices in four groups including meteorological, agricultural, hydrological, and vegetation-based drought indices. The study's novelty lies in its valuable insights into selecting the most appropriate indices for different climatic contexts, for example, in tropical, humid, arid regions. This work advances not only scientific knowledge but also offers practical guidelines for policymakers and practitioners to improve drought monitoring and mitigation strategies, thereby enhancing societal resilience to drought-related impacts.

- Climate-Specific Strategies: Drought management strategies must consider the unique characteristics of each climate zone. Using inappropriate indices can lead to misinterpretation of drought severity and ineffective policy responses.
- Tailored Drought Monitoring: Policymakers should prioritize the selection of drought indices based on regional characteristics. For instance, temperature and evapotranspiration-based indices are more effective in arid climates, while vegetation-based indices are better suited for tropical and humid regions.
- Support for Index Users: Investment in user-friendly tools and high-quality code repositories is essential to assist practitioners in effectively using drought indices, especially for regions with limited technical expertise.
- Integration of Ground Observations: Despite advancements in remote sensing, ground-based data collection remains crucial for accurate drought monitoring, particularly for variables like groundwater and streamflow.
- Holistic Drought Assessment: Future policies should incorporate topography, biophysical characteristics, and human influences in drought assessments to ensure comprehensive and accurate monitoring.

Tuesday - Poster board no. 11

Drought impact monitoring, assessment and forecasting

Exploring the impact of droughts in the transboundary region along Prut Valley (Romania/Republic of Moldova)

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The changes in temperature and rainfall values projected for Eastern Europe translate into increased frequency and intensity of droughts, with important social, economic and environmental consequences. Knowledge on the impact of droughts is an important milestone in risk assessment. While drought, as hazard, has a non-boundary spatial pattern, different countries, with different socio-economic backgrounds can have different levels of vulnerability and different paths to cope with its. In this poster presentation we will present relevant information on drought impact in the last 100 years, with a focus on the last 10 years in agricultural sector in Romania and Republic of Moldova. Data gathered from scientific literature and by exploration the digital and printed newspaper from both countries depict that information about droughts have been presented differently. Overcoming these shortcomings, a set of spatial and temporal patterns could be identified, and some conclusions can be addressed regarding future approaches of the mitigation of droughts in rural agricultural areas such as our study area.

- In agricultural areas, the droughts are not only a farmers major problem but for entire rural communities;
- Solving local capacity to develop alternative water supply during the summer must represent not a local/regional priority but a national and European Union one;
- Increasing resilience to droughts must include a participatory locally-adapted approach based on the experience of citizens;
- Increasing the role of transboundary networks and projects, especially in the case of droughts monitoring and proactive management.

Tuesday - Poster board no. 12

Drought impact monitoring, assessment and forecasting

Assessing spatiotemporal agrometeorological droughts in semi-arid Gwayi agro-ecosystems of Zimbabwe using multiple indices

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This research on the spatiotemporal dynamics of agrometeorological droughts in the Gwayi catchment, Zimbabwe, provides critical insights into how climate variability impacts smallholder farmers. The study's societal relevance lies in its detailed assessment of drought patterns using multiple indices, which enhances understanding of the complex interactions between precipitation, evapotranspiration, vegetation health, and land cover changes. By identifying severe and moderate drought events over three decades and mapping their spatial distribution, this research highlights the specific vulnerabilities of different regions, particularly the southwestern part of the catchment. This information is crucial for designing targeted interventions and adaptation strategies to support farmers in managing drought risks effectively. The scientific novelty of the study is rooted in its use of a triangulation approach with SPI, SPEI, VCI, and VHI to offer a comprehensive analysis of drought dynamics. The strong correlations between VHI and VCI, and the complementary insights provided by other indices, reveal new perspectives on how various factors influence vegetation health and drought severity. This multifaceted approach contributes to a deeper understanding of agrometeorological droughts, advancing both the methodological framework for drought assessment and the knowledge base for climate resilience in semi-arid regions.

- Enhance the capacity for real-time monitoring and early warning of drought conditions using a combination of SPI, SPEI, VCI, and VHI. This will improve the ability to predict and respond to drought events more effectively.
- Implement region-specific drought management strategies, particularly focusing on the southwestern part of the Gwayi catchment, which is identified as highly vulnerable. Tailoring interventions to regional needs will maximize their effectiveness.
- Encourage the use of multiple drought indices in policy-making to capture a comprehensive view of drought dynamics. Combining indices like SPI, SPEI, VCI, and VHI can provide a more accurate assessment of drought conditions and impacts.
- Develop and support agricultural practices that enhance resilience to drought. Focus on soil moisture management, efficient water use, and drought-tolerant crops to mitigate the impact of drought on smallholder farmers.
- Support continued investment in climate research and data collection to refine drought indices and improve understanding of drought patterns. This will inform better policy and decision-making in the face of climate variability.

Tuesday - Poster board no. 14

Drought impact monitoring, assessment and forecasting

Near-real Time Global Daily Drought Detection and Monitoring Using an Ensemble of Gridded Remotely Sensed and in-situ Precipitation Datasets

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In many locations, a lack of timely, localized drought information, including data on the amount of precipitation that would be required to ameliorate drought conditions, makes it difficult to plan and manage drought response efforts. A new suite of global drought monitoring tools provides users with near-real-time, high-resolution precipitation and drought information. Three gridded daily precipitation datasets from satellite (CMORPH, IMERG) and in situ (NClimGrid) observing platforms are used to compute standardized precipitation index (SPI) values for various time scales as well as daily updates of drought conditions. Cloud-scale computing is fundamental for the success of this project, with gains in computational time and process optimization allowing for the implementation of a drought amelioration module that is updated daily along with the SPI. This module estimates the amount of precipitation needed to alleviate drought conditions as a function of drought severity and accumulation periods. The computed drought indices: CMORPH-SPI (global; 1998-present; 0.25x0.25deg.), NClimGrid-SPI (CONUS; 1951-present; 0.05x0.05deg.), and IMERG-SPI (global; 2000-present; 0.1x0.1deg.) are also evaluated and compared against existing droughts monitoring resources such as the U.S. Drought Monitor.

- The global scale, high spatial resolution Standardized Precipitation Index (SPI), and near-real-time updates provide users around the world with more localized and timely information on drought onset and amelioration.
- The novel drought relief module estimates rainfall deficits with respect to U.S. Drought Monitor (USDM) drought classification. The visualization of drought propagation across a continuum of accumulation scales (1- to 36-month) allows users to evaluate the likelihood of any deviation from normal rainfall conditions evolving into drought.
- The serverless pipeline developed leveraging Amazon Web Services cloud computing resources makes it possible to calculate near-real time global daily drought conditions in a few minutes and allows monitoring the evolution of droughts at an unprecedented pace.
- The near-real time global CMORPH-SPI has been transitioned from research to operation (https://www.drought.gov/data-maps-tools/global-gridded-standardized-precipitation-index-spi-cmorph-daily) Other drought products (NClimGrid-SPI, IMERG-SPI) will be integrated into NOAA's drought monitoring system.
- The flexible framework can be extended to other datasets (satellite, radar, in situ), drought indices (agricultural, hydrological), and rainfall model predictions (medium range, subseasonal, seasonal) for drought forecasting

Tuesday - Poster board no. 15

Drought impact monitoring, assessment and forecasting

Drought Risk Assessment in Sweden

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Although Sweden is known for its abundance of water resources, recent droughts have heavily impacted water-dependent sectors across the country. This study introduces a foundational framework for Drought Risk Assessment (DRA) in Sweden, designed to inform and support national climate change and water management policies. The research focuses on three key areas: the development of DRA in Sweden; the identification of drought risk hotspots for targeted drought management measures; and areas for improvement in drought-related policies.
Our findings reveal regional differences in drought trends. Southeastern Sweden shows drier conditions and an increasing frequency of droughts from 1975 to 2021. Drier conditions observed in soil moisture and streamflow data in particular, adversely affect water-dependent sectors such as agriculture and forestry, resulting in reduced crop yields and increased forest damage.
This research provides scientific evidence aligned with the objectives of National Strategy for Climate Change Adaptation (2023/24:97). It outlines a framework for Sweden's climate adaptation efforts, including managing risks related to drought and water shortages. This study emphasizes the need to prioritize drought management and strengthen current national policies, recognizing that droughts pose an increasing risk with wide-ranging impacts across multiple sectors in Sweden.

- **Integrate Drought Risk Assessment Framework**: This newly introduced framework for Drought Risk Assessment (DRA) provides drought hazard information for nearly 40,000 catchments across Sweden, along with insights into vulnerability and exposure. Its high resolution improves the understanding of drought risks at both local and national levels. By utilizing this framework, national policies can be strengthened, improving preparedness and response strategies for water-dependent sectors impacted by droughts.
- **Prioritize Regional Drought Hotspots:** the study identifies regions, such as Southeastern Sweden, where drought risk is increasing. Implement targeted drought management measures in these hotspots to mitigate adverse effects on agriculture and municipal water supply.
- **Strengthen Climate Adaptation Policies:** Align drought management strategies with the National Strategy for Climate Change Adaptation to address increasing drought risks. Policies should be based on scientific evidence and regional trends, and drought risk assessments must be integrated into municipal climate preparedness plans, as part of the National Strategy for Climate Change Adaptation.

Tuesday - Poster board no. 16

Drought impact monitoring, assessment and forecasting

The EOTEC DevNet Collaborative Approach to Integrated Drought Monitoring and Response

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Often, governments, NGOs, and other agencies lack the experience to know which tools to use and when for effective drought management. The Earth Observation Training, Education, and Capacity Development Network (EOTEC DevNet) aims to meet this need by leveraging Earth Observation (EO) technologies and fostering global and regional collaboration. The EOTEC DevNet EO Tools Matrix, and in a later stage, a Tools Tracker, is an innovative initiative designed to aggregate and streamline access to existing global, regional, and local tools for drought monitoring, assessment, and forecasting. Building on the success of the EOTEC Flood Tools Tracker, this matrix will evolve into a user-friendly, searchable web tool, enhancing decision-making by offering tailored support to policymakers, humanitarian organizations, and government agencies.

- Comprehensive Resource Hub: The Matrix acts as a comprehensive hub for drought-related EO tools, enabling policymakers to make informed decisions about drought preparedness and response strategies based on regional and drought-type filters.
- Capacity Building Integration: By offering not only tools but also the necessary resources for training, the Matrix ensures that users can efficiently implement the solutions, closing the gap between tool availability and effective use.
- Global and Regional Relevance: The Matrix is developed with input from regional Communities of Practice (CoPs), ensuring that the tools are applicable to diverse global contexts and address both local and international drought challenges.
- Future Web-Based Platform: The Matrix is set to evolve into a user-friendly, web-based platform, making it even more accessible to stakeholders worldwide. This future development will further enhance decision-making by providing real-time access to tailored EO tools and resources for drought preparedness and response.

Tuesday - Poster board no. 17
Drought impact monitoring, assessment and forecasting
Footprints of Drought: Exploring its Environmental Impact through Open Access Big Data
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This research provides valuable scientific insights for policymakers tackling drought impacts, particularly in regions like Southern Spain. Leveraging Google Earth Engine and remote sensing technology, the study identifies key environmental aspects, such as vegetation health and groundwater levels, that are most vulnerable to drought. This data is crucial for making informed decisions about land use and water management. The study underscores the importance of understanding how drought affects Mediterranean ecosystems, especially during critical growth periods for vegetation and in terms of delayed impacts on groundwater. These insights are vital for developing effective strategies to manage and mitigate drought effects, ultimately promoting more resilient natural landscapes and communities. By integrating these findings and methods into environmental monitoring and policy frameworks, this research enhances the understanding of drought impacts, contributing to the protection of both natural ecosystems and the communities that rely on them.
• The results of this research have underscored the importance of seasonal droughts on natural landscapes and ecosystems in Southern Spain. Therefore, it is essential to incorporate seasonal drought data into planning for agricultural practices, land management and conservation efforts to mitigate the most critical effects during high-risk periods. • We demonstrate the potential of remote sensing products for regional-scale drought impacts assessment, and propose a methodology for more accurate characterization of the effects in nature and their timely monitoring. • We underscore the enhanced predictive capability of assessing drought impacts on vegetation during periods of high vegetative growth, which enables a more precise evaluation. • The results of the study can support Decision-Making, offering information for policymakers to design effective water resources management, land, and vegetation management and, in general, drought mitigation strategies.

Tuesday - Poster board no. 18

Drought impact monitoring, assessment and forecasting

OUTLAST
a global drought monitoring and forecasting system to support sector-specific drought management

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To support adequate mitigation and adaptation strategies, it is essential to provide relevant information on potential drought impacts on water resources with an efficient drought monitoring and forecasting system. This is challenging, especially in transboundary basins and data poor regions. OUTLAST presents a global, operational system for the near-real time monitoring and seasonal forecasting of drought hazards, including drought hazard indicators tailored to specific sectors.

- OUTLAST presents a global system for the near-real time monitoring and seasonal forecasting of drought hazards.
- The system includes drought hazard indicators that are tailored for various sectors, including rainfed and irrigated agriculture, water supply and natural vegetation, that a) reflect the conditions relevant for each sector, and b) are adapted to the needs of users to improve drought management and water governance.
- Outputs will be operationally provided in the WMO's Global Hydrological Status and Outlook System (HydroSOS) and will be freely available to support sector-specific drought management at national, regional and global scales.

Tuesday - Poster board no. 20

Drought impact monitoring, assessment and forecasting

Drought Dynamics in the Mediterranean GIAHS: Insights from the Arganeraie Biosphere Reserve, Morocco

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The traditional agroforestry system plays a multifunctional role creating sustainable landuse in rural areas. In Morocco, the GIAHS site of Ait Souab Ait Mansour: Oasis and Argan trees (Argania spinosa) has significant with a high level of biodiversity but is being put under combined anthropogenic and environmental pressures. The present study documented impact of droughts on this ecosystem through monitoring LULC from 1995 to 2020 using remote sensing and GIS techniques. The Mann-Kendall test was used to analyze Landsat and MODIS data for key species NDVI trends. A decrease in woodland and agricultural areas is revealed when using the derived NDVI through time series analysis that show negative trends, common for all seasons with only extreme exception of argan trees as well as cereal mixes during winter season. Adaptive management strategies to maintain ecosystem resilience from social and environmental shocks represent the most important lesson with direct policy implications for sustainable agroforestry politics.

Tuesday - Poster board no. 21

Drought impact monitoring, assessment and forecasting

Towards a drought monitoring and early-warning system for Switzerland

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The intensity and frequency of droughts in Switzerland have increased in recent years and this trend is likely to continue in the future. Because drought has been identified as one of the main risks for various economic sectors in Switzerland, a national monitoring and early-warning system is to be established through the joint efforts of three different governmental agencies.
We will present the Swiss national drought project with a particular focus on in situ and satellite-based monitoring, the integration of sub-seasonal forecasts, and the drought early-warning and information system. The project provides important information on the current and future drought situation on a regional to local scale. Daily updated maps and infographics are accessible through a user-friendly web platform designed to facilitate informed discussion and decision-making. Ultimately, the project aims to increase preparedness, reduce impacts and enhance drought resilience across the affected sectors in Switzerland.

- Anew monitoring and early-detection system for drought in Switzerland with a user-centered design to support informed decision-making
- The system facilitates drought monitoring, forecast, early-warnings and information
- It aims to increase preparedness, reduce impacts and enhance drought resilience across the affected sectors in Switzerland

Tuesday - Poster board no. 22

Drought impact monitoring, assessment and forecasting

A novel , widely aplicable method for impact-data-based drought risk quantification

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Droughts can affect nearly all sectors of society and ecosystems, but impacts can be hard to identify and attribute; the impacts may be delayed in time, manifest in locations
different from the occurrence of the driving precipitation deficit. While risk assessment methods for drought already exist (e.g. Carrão, Naumann and Barbosa, 2016), these are relatively limited in scope with respect to the socio-economic systems covered, the regional disaggregation and the integration of drought loss data (Hagenlocher et al., 2019; Blauhut, 2020). Furthermore, the application of drought indices as proxies for drought impacts and risk is not straightforward (Bachmair, Kohn and Stahl, 2015). Here we present the results of a novel dynamic approach based on machine learning: in this approach, the association of hydro-meteorological indicators with impact data across different regions and socio-economic and environmental systems was modelled, including system-specific vulnerabilities. Combined with sector-specific exposure data, this allowed for probabilistic estimations of drought risk.

- Generalisable, **scalable method to quantify** expected annual damage and probable maximum loss as probabilistic **drought risk metrices**
- Application of this **impact-data-based machine learning models** on drought-induced impacts on agriculture, migration, people affected, water supply, forests, river transport and energy provision
- Exemplified in in Europe, West and East Africa, and South East Asia.
- Results are published in the **EDORA drought risk atlas**, the Volta basin drought and flood management programme report, the Habitable project report, as well as presented in many WMO/UNDRR country disaster risk profiles.

Tuesday - Poster board no. 23

Drought impact monitoring, assessment and forecasting

Navigating Drought Challenges: A Resilience Framework for Bundelkhand, India

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The Bundelkhand region in India, with its semi-arid climate and agrarian economy, faces recurrent droughts. This study examines the spatiotemporal dynamics of droughts using the Standardized Precipitation Index (SPI) and Streamflow Drought Index (SDI). It reveals moderate droughts are more frequent, occurring every five years, with significant spatial variability during monsoons in northern districts. Utilizing GloFAS reanalysis discharge data, it identifies higher probabilities of hydrological droughts. Trend analysis indicates worsening drought conditions over the past decade despite policy interventions such as the National Action Plan on Climate Change and the Integrated Watershed Management Programme. The findings underscore the need for enhanced early warning systems, climate-resilient agriculture, and improved drought monitoring to inform policies, crucial for Bundelkhand and similar regions.

- Increased Drought Risk: Rising probabilities of prolonged droughts necessitate enhanced early warning systems and proactive risk management policies.
- Targeted Interventions: Northern districts, exhibiting significant trends towards increasing drought severity, require prioritized mitigation strategies for agriculture and water resources.
- Climate Resilience: Integrating climate-resilient agricultural practices and water conservation techniques is crucial to mitigate socio-economic impacts on vulnerable communities.
- Local Context: Bundelkhand's recurrent droughts have led to significant agricultural losses, water scarcity, and migration, underscoring the urgent need for effective drought resilience strategies.
- In a country of high spatial and temporal climate variability and large population, policy interventions are needed to be upgraded immensely with significant challenges due to climate change.

Tuesday - Poster board no. 24

Drought impact monitoring, assessment and forecasting

A Comprehensive Analysis of Machine Learning and Remote Sensing Techniques in Studying Climate Hazards-Induced Crop Yield Variations

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This study presents a comprehensive review of the application of machine learning (ML) and remote sensing (RS) technologies in predicting the impact of climate hazards on crop yield. The study uses the PRISMA approach to analyze 177 papers on climate hazard identification and 197 papers on RS products and ML algorithms. Key findings indicate that droughts and climate variability are the most studied hazards, particularly in Africa and Asia, while critical indicators like rainfall onset and the length of dry and wet spells are often neglected. ML techniques, including Support Vector Machines (SVM) and Random Forest (RF), are prominent in drought prediction and crop yield modeling, respectively. Additionally, Deep Learning (DL) methods such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) are increasingly used but are dependent on the quality and extent of training data. The review identifies CHIRPS and TRMM as widely used precipitation RS products, with MODIS commonly used for other climate variables. Challenges with RS data include spatial and temporal resolution limitations and revisit times, affecting hazard detection and micro-climate assessment. This study highlights the growing integration of RS and ML in addressing climate change impacts on agriculture.

- **Leverage ML and RS for Climate Adaptation**: Utilize machine learning (ML) and remote sensing (RS) technologies to enhance predictions of climate hazards and their impacts on crop yield. These tools provide valuable decision support for managing agricultural risks due to climate change.
- **Address Drought and Climate Variability**: Focus on improving policies and interventions for managing droughts and climate variability, which are the most frequently studied hazards affecting crop yield, particularly in vulnerable regions like Africa and Asia.
- **Improve Data Quality and Availability**: Ensure high-quality, accessible, and extensive training data for ML algorithms. This is crucial for accurate crop yield modeling and effective climate hazard prediction.
- **Enhance RS Product Resolution**: Invest in advancements that improve the spatial and temporal resolution of RS products. This will help in more precise hazard detection and better assessment of micro-climate impacts on agriculture.
- **Expand Indicator Coverage**: Incorporate additional critical indicators, such as rainfall onset, duration, and the length of dry and wet spells, into climate hazard assessments to provide a more comprehensive understanding of their effects on crop yield.

Tuesday - Poster board no. 26

Drought impact monitoring, assessment and forecasting

Pathways for Sustainable Intensification of Wheat Production in the Mediterranean Region Under Current and Future Climate Change Scenarios

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The cropping systems simulation model across seven Mediterranean countries, including Morocco, Spain, Egypt, Italy, Jordan, Turkey, and Iran, can be a powerful tool for investigating the complex interactions between wheat yields, agronomic practices, and the looming threat of climate change on food security. By simulating various management practices and climate scenarios across diverse Mediterranean regions, this model can provide insights into potential strategies to address yield reductions and ensure food security in the face of a changing climate..

- **Evaluate adaptation strategies:** Assess the effectiveness of various agronomic management practices, such as changes in planting dates, irrigation schedules, fertilizer applications, and crop varieties, in mitigating the negative effects of climate change on wheat production.
- **Estimate potential yield losses** under different climate change scenarios, highlighting the vulnerability of different regions and cropping systems.
- **Inform policy decisions:** Provide evidence-based recommendations for policy interventions, such as investments in research and development, agricultural extension services, and infrastructure improvements, to support adaptation to climate change and enhance food security.
- **Evaluate adaptation strategies:** Assess the effectiveness of various agronomic management practices, such as changes in planting dates, irrigation schedules, fertilizer application in mitigating the negative effects of climate change on wheat production.

Tuesday - Poster board no. 27

Drought impact monitoring, assessment and forecasting

The European Drought Impact Database
A Comprehensive Drought Impact Collection Methodology for Europe

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The European Drought Impact Database (EDID) offers standardized framework for drought impact data across Europe. By integrating, regional recources, artificial inteligence and automation, it enhances data collection efficiency, providing policymakers with reliable information for effective drought management. EDID advances research on climate change and natural hazards by filling data gaps and improving the quality of drought monitoring systems, ultimately supporting better disaster response strategies.

The European Drought Impact Database (EDID) establishes a blueprint for a standardised framework for drought impact data collection across Europe
EDID enhances the efficiency of drought impact data collection by providing detailed methodologies
These advanced methods can be integrated into operational systems, improving strategies for monitoring and responding to natural hazards

Tuesday - Poster board no. 28

Drought impact monitoring, assessment and forecasting

Monitoring of drought in the Netherlands in an online portal

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In 2018-2020 water managers in the Netherlands were confronted with extreme drought, impacting nature, agriculture, shipping and drinking water supply. To better anticipate dry conditions and improve water management during a drought, up-to-date and accurate information about the meteorological and hydrological situation is crucial. During the 2018 drought it became clear that current information about groundwater levels was scattered across many different organisations. In addition, each organisation had different methods to compare current groundwater levels with historical data to indicate the severity of the drought event. There was a clear need for an uniform indication of drought severity. We developed an online information portal with up-to-date measurements for precipitation and groundwater levels. Drought severity is quantified by the Standardized Precipitation Index (SPI), Standardized Precipitation-Evapotranspiration Index (SPEI) and Standardized Groundwater Index (SGI).

- By combining the information on meteorological and hydrological drought in one decision-support system (www.droogteportaal.nl), water managers and stakeholders can now get an up-to-date overview of the current situation.
- Due to the uniform determination of drought severity, regions within the Netherlands can be compared. This can help to implement targeted water management decisions for adaptation measures for mitigating drought impacts if possible.
- Part of the information of the portal is also included in the national drought monitor of Rijkswaterstaat (Dutch Ministry of Infrastructure and Water Management).
- Besides visualizing the current status of the groundwater system – a valuable, but hidden resource – to experts and policy makers, the introduction of the decision-support system helped putting sustainable use of groundwater resources higher on the political agenda.

Tuesday - Poster board no. 29

Drought impact monitoring, assessment and forecasting

Monitoring and assessing the characteristics of drought propagation in the Semi-arid River Basin of Peninsular India

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Understanding drought propagation is crucial in regions with strong seasonality in precipitation like India. In this study, an event-based approach is used to analyse drought propagation from meteorological to hydrological drought via agricultural drought in the Krishna River Basin of India, using Standardised Precipitation Evapotranspiration Index (SPEI), Standardised Soil Moisture Index (SSMI), and Standardised Streamflow Index (SSI), representing meteorological, agricultural, and hydrological drought, respectively. Two different cases are analysed: meteorological-to-agricultural (SPEI-to-SSMI) and agricultural-to-hydrological (SSMI-to-SSI) drought, and assessed using three time matrices for initiation, peak, and termination over multiple timescales of 1, 6 and 12 months with varying drought threshold values of 0 and -1, to deliniate shifts from mild to extreme drought conditions in detail. The results indicate that the drought propagation time from SPEI-to-SSMI drought decreases for most tributaries, while it increases for SSMI-to-SSI drought. The duration propagation factor (PF) shrinks for SPEI-to-SSMI drought but expands for SSMI-to-SSI drought. In contrast, the severity and intensity PF magnify for SPEI-to-SSMI drought but experience dampening effects for SSMI-to-SSI drought.

- **Strategies for Managing Drought Propagation in India**: This study identifies the drought propagation from meteorological to hydrological drought via agricultural drought and provide appropriate strategies for basin-specific management policies that government officials could implement to strengthen resilience during a crisis and promote sustainable development in an agricultural and drought prone nation like India.
- **Beneficiaries and Stakeholders in Drought Management:** The beneficiaries could involve government agencies, non-governmental organisations, researchers, local communities, and vulnerable populations such as farmers and marginalised groups, providing insights into drought dynamics and aiding in management and mitigation in semi-arid regions globally.
- **Enhancing Drought Risk Management:** In broader sense, this study will help in operational drought risk management and early warning systems and is crucial for the assessment of ecosystems, human health, water stresses, water governance and socio-economic policies.

Tuesday - Poster board no. 30

Drought impact monitoring, assessment and forecasting

Drought in the Horn of Africa: impacts, adaptation and lessons learned

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The Horn of Africa drylands (HAD) are highly dependent on seasonal rainfall for subsistence agriculture and pastoralism, making them vulnerable to drought-induced water scarcity and food insecurity. Over the past four decades, drought frequency and severity have increased in HAD. The latest multi-year 2020-2023 drought was unprecedented, being the most severe in at least four decades. This prolonged drought, characterized by five consecutive failed rainy seasons, resulted in extreme impacts such as crop failures, livestock losses, famine, and widespread malnutrition.
This drought revealed that significant gaps remain in understanding the links between climate variables and water scarcity, and their impacts on livelihoods. We have analysed impacts and responses during the latest 2020-23 drought in Somaliland and Kenya, using a unique household survey (N=752) and community impact data. We used a mixed methods approach including community surveys, drought impact data analysis, and (agent-based) modelling.These findings not only increase our knowledge on how community impacts develop, but also how these can best be mitigated. This is crucial information to improve drought adaptation policies and warning services, to be better prepared for droughts in future.

- The 2020-2023 drought highlighted the importance of sustained and scalable interventions to build community resilience. One of the crucial lessons learned is the significance of diversifying livelihoods and improving water infrastructure.
- Important barriers to community adaptation uptake are lack of financial resources and knowledge. Improved access to credit and training and information can remove these barriers.
- Special attention to up-downstream interactions should be taken into account for investments into water allocation and infrastructure. Infrastructure must be balanced with sustainable resource management to prevent long-term negative impacts, such as groundwater depletion.
- Financial resource allocation should be based on specific county needs, ensuring that areas with higher vulnerability receive more attention.

Tuesday - Poster board no. 31

Drought impact monitoring, assessment and forecasting

Drought Monitoring Framework for Assessing Drought Impact and Damage at the Government Level in South Korea

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Drought policy focus is shifting from post-response measures, such as short-term response and recovery support, to a pre-planning and prevention-centered approaches with the increase in localized extreme droughts caused by climate change. It is necessary to conduct monitoring and assessments of drought impacts due to the limited information on the current status of drought damage. This will help gather essential data and enable more systematic monitoring, which is crucial for effective drought response and policy development. The Korean government has been implementing drought investigation and monitoring since the establishment of a joint comprehensive drought response plan in 2017, following the severe drought damage in 2014–2015. However, the current drought impact and damage survey lacks sufficient scope and specificity regarding the areas where drought conditions are investigated. This study aims to identify investigation items related to the social, economic, and environmental impacts of drought, as well as direct and indirect damages. It focuses on the drought situation, drought impacts, and the series of processes leading to drought damage, with the goal of establishing drought monitoring frameworks and protocols.

- Establish a Comprehensive Drought Monitoring Framework: Provides policymakers with basic survey items on the status, impact, and damage of droughts
- Even for the drought event, the drought impact and damage can vary depending on the regional drought response capacity. Therefore, a drought basic survey, which includes a scientifically-based analysis of drought—covering the current status, impact, and correlation of damages—must be conducted at the government level.

Tuesday - Poster board no. 33

Drought impact monitoring, assessment and forecasting

Operational framework and tools for a proactive drought risk management

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Since drought, unlike other natural hazards, evolves slowly in time, an effective response is possible by implementing appropriate mitigation measures planned in advance, according to the indications provided by drought early warning systems (DEWS). To this end, the aim of this contribution, summarizing the work of a group of researchers with more than twenty years of experience in this field, is twofold. We present an operational framework for the timely implementation of drought mitigation measures, including long-term actions oriented to reduce the vulnerability of water supply systems and short-term actions to be implemented during droughts. Secondly, a methodology based on Monte Carlo simulation for both unconditional (long-term) and conditional (short-term) drought risk assessment in water supply systems under different scenarios is illustrated. As an example, the application of the proposed methodology to an Italian case study, namely the Simeto River basin in Sicily, is showcased.

- The potential for intensifying droughts and increasing water scarcity, also due to climate change, demands a new paradigm for water management that builds on proactivity and preparedness, and prioritizes holistic and integrated solutions;
- Correct drought management should be based on the adoption of suitable combinations of long term and short term measures co-designed with the involved stakeholders;
- The methodology for the unconditional risk assessment, aiming at comparing and selecting preferable mitigation alternatives over long time horizons (30–40 years), can help to reduce water shortage risk in the future;
- The methodology for the conditional risk assessment, performed for short time horizons (2–3 years) by considering the initial state of the water supply system, can help water managers to adapt managing rules to the real conditions of the water supply system based on triggering levels (Normal, Alert and Alarm).

Tuesday - Poster board no. 34

Drought impact monitoring, assessment and forecasting

Towards operational drought impact-based forecasting in Europe: Trade-offs between indicators and impacts

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Despite the progress in seasonal drought forecasting, it remains challenging to identify suitable drought indices for accurately predicting the impacts of a future drought event. In this study, we identified relationships across Europe between the forecasting skill of various drought indices and the estimated drought impacts. We calculated the indices over various accumulation periods, and assessed the forecasting skill of indices computed based on various seasonal prediction systems. An evaluation was performed by computing the same indices from the ERA5 reanalysis data and comparing them across various verification metrics, including deterministic Correlation Coefficients, RMSESS, and probabilistic RPSS. We further conducted a literature review of the studies assessing the performance of the indices in terms of estimating drought impacts across Europe. We finally performed a trade-off analysis and mapped the drought indices based on their drought forecasting and drought impact estimating skills, with a focus on case studies from the UK and Germany.
Overall, this analysis is a step forward to detect the most suitable drought indices for predicting drought impacts across Europe. Here, not only we present a new approach for evaluating the relationship between drought indices and impacts, we also resolve the dilemma of choosing the indices to be incorporated in the impact functions. Such scientific advancements are setting significant contributions to the emerging field of operational impact-based forecasting and operational drought early warning services.

- Based on two case studies (the UK and Germany), we showcase how information on the seasonal predictability of drought indicators can be integrated into an impact-based forecasting framework to predict drought impacts across various affected sectors;
- Our analysis highlights the need to account for seasonal trends and spatio-temporal patterns in the (seasonal) predictability of drought indices across Europe;
- This research contributes to establishing the emerging field of operational impact-based forecasting and operational drought early warning services, aimed at improving preparedness and reducing the impacts of droughts.

Tuesday - Poster board no. 35

Drought impact monitoring, assessment and forecasting

Drought Risk Monitoring and Dynamics in Afar Region Rangeland, Ethiopia, Horn of Africa Using Earth observation Data.

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The arid and semi-arid lands of the Horn of Africa, including Ethiopia's Afar rangeland region, are affected by drought, resulting in increased poverty, food insecurity, and livelihood vulnerabilities.
Over the past decade a novel analytical approach that combines satellite data and statistical modeling has been used to quantify rangeland degradation. The results reveal a significant decline in grassland cover in the Afar pastoral region, shrinking from 24,617.4 km^2 in 2000 to 10,105.4 km^2 by 2020. On the contrary, bare land consistently expanded over the same period. Even though its severity levels varied in different years there was extreme drought recorded in 2005, 2009, 2011 and 2015.
This environmental degradation forces Pastoralists to migrate both within and beyond their national borders in search of pasture and water. This movement often leads to conflicts, which frequently require regional intervention to address or prevent.

- Efforts should be focused on restoring degraded ecosystems and enhancing water conservation practices in the Pastoral region.
- The use of Earth observation and remote sensing data for monitoring environmental changes is vital. Policymakers should invest in these technologies to enhance the accuracy of data for decision making related to Drought resilience and sustainable development planning.
- Establishing and strengthening early warning systems for drought can help pastoralists prepare in advance.

Tuesday - Poster board no. 36

Drought impact monitoring, assessment and forecasting

Enhancing drought resilience in conflict settings: lessons from the Syrian drought-migration-conflict nexus

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The Eastern Mediterranean regularly experiences drought, but impacts vary based on socio-economic contexts and drought management policies. Syria, among the worst affected countries by the mid-2000s drought, saw heavy impact on its agricultural sector which since has been linked by media and research to the 2011 uprising and ensuing civil war. However, this four-year study investigates the 2007-2009 drought's societal impacts through a combination of remote sensing and field research, and suggests a more nuanced picture:
Crop failures were significant in 2008-2009 but recovered by 2010 - indicating agricultural resilience. Land abandonment was linked more to conflict than to drought, although farmers' vulnerability increased due to political restructuring in the 2000s and was further heightened by the civil war. The study underscores the interplay between environmental, political, and socio-economic factors in shaping drought impacts and adaptation.

- Policy decisions are central to determining the impact of droughts.
- Weak governance allowing the exploitation of natural resources (such as, in this case, water) heightened long-term vulnerability to environmental pressures
- Sudden cut of subsidies (such as, in this case, fuel-subsidies) decreased the adaptive capacity to drought because short-term solutions were financially unviable
- Groundwater protection measures are needed to replenish over-exploited reservoirs in Syria
- Drought-resistant crops and agricultural techniques should be promoted to foster resilience of farmers in face of increasing droughts
- Conflict has been and currently is challenging policy making and implementation in Syria

Tuesday - Poster board no. 37

Drought impact monitoring, assessment and forecasting

Impact chains of drought risks in Europe: tackling complexity to support science and policy

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Europe is experiencing increasingly frequent and intense droughts, with impacts extending also to countries that were until recently rarely affected. Moreover, drought impacts in Europe are extremely diversified, touching on many interconnected societally-relevant sectors and ecosystems. If we want to effectively address these growing drought risks, it is essential to fully understand their drivers and root causes, and the causal relationships between them, so as to identify entry points for policy actions. However, because they emanate from the complex interplay of physical and social processes, drought risks are especially difficult to untangle. Using the "impact chain" methodology, we have constructed conceptual models of drought risks for seven sectors and systems of particular relevance for the European Union; rainfed and irrigated agriculture, public water supply, forest ecosystems, aquatic ecosystems, energy production and inland navigation. The models, supported by a vast review of available literature and multiple interviews with sectoral experts, break down the complexity of drought risk into its main irreducible components, and displays them into an accessible visual format, which can be used to identify entry points for effective and systemic solutions. These conceptual models are a core feature of the recently-published European Drought Risk Atlas.

- Drought risks in are complex, diverse and changing, as the European case continues to demonstrate
- Conceptual models can help breaking down this complexity and guide the design of more effective and systemic risk reduction and adaptation policies
- The models show how tackling drought risks require a concerted efforts across scientific and policy silos

Tuesday - Poster board no. 38

Drought impact monitoring, assessment and forecasting

Development of the Australian Drought monitor

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One of the greatest challenges for agricultural producers is the management of drought, which was demonstrated during the "Millennium Drought" in southeast Australia from 2001 to 2009, described as the worst drought on record for that region. Prolonged below median rainfall had a considerable impact on agriculture, where irrigated rice and cotton production fell by 99% and 84% respectively between 2002 and 2009, and dryland wheat production saw a 12% per unit area decline compared to pre-drought years. The impact of the drought reduced the Australian GDP in 2002 by an estimated 1.6% and contributing to a rise in unemployment even in non-agricultural sectors.
However, drought is a complex phenomenon which is difficult to capture with the monitoring of a single climate variable such as rainfall deficiency or soil moisture, and decision-makers, including government policy agencies, may struggle with the task of interpreting the numerous climate variables available when attempting to build a picture on the overall state of drought. Australia lacked a comprehensive spatial data service with full continental coverage which can consider multiple climate variables to provide a snapshot of drought across Australia. The CDI is based on the combination of four different indices/indicators: 3-month Standard Precipitation Index (SPI), Soil Moisture (SM), Evapotranspiration (ET) and normalised Difference Vegetation Index (NDVI). Each dataset is percentile ranked over a baseline period and the results combined using a weighted average.

- The CDI tool is already in use by key decision-makers, including governments and is already in use for making decisions on official Drought Declarations for the State of Queensland.
- The CDI is used to inform the Queensland Drought Relief Assistance Scheme (DRAS) and impacts whether property owners in the region can apply for Queensland Government drought assistance. In May 2021, the Local Drought Committees (LDCs) responsible for official Drought Declarations in Queensland included the Australian Drought Monitor in the decision-making process for the first time, justifying the removal of drought status in five local government areas,
- ·We demonstrate that official drought declarations in the State of Queensland corresponded with significant drought conditions as indicated by the CDI. The CDI generally responds more rapidly to changes in drought condition than official, more subjective declarations, in both drought onset and recovery, which is supporting evidence that the CDI is an appropriate tool to inform government policy and subsequent drought declarations.

Tuesday - Poster board no. 39

Drought impact monitoring, assessment and forecasting

Building an operational drought framework

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Rapid adaptive capacities are crucial for managing droughts in a changing climate. Effective Climate Services are essential to meeting this requirement so that decision-makers may effectively navigate and handle the issues proposed by drought. Thus, we develop a novel operational drought framework that offers a synoptic perspective of drought at the basin scale. The framework has two goals: 1) to improve knowledge of the fundamental dynamics of severe droughts, including triggers, drought onset and propagation; 2) to support the adaptive capacities of decision-makers by providing timely and clear insights for managing drought occurrences. Three pillars support the framework: the first step involves analyzing a set of Standardized Precipitation Index estimated over a continuous range of month-scales (SPI set). The second step is computing the Standardized Integrated Drought Index ($\mathfrak{D}$), which is a multi-scale ensemble mean of the SPI set. The third step involves contextualizing severe droughts to the surrounding water supplies. Here we present a framework based on both the Standardized Streamflow Index (SQI) and the SPI, estimated at continuous 1-36 month scales for 1964–2023 across the Po River hydrographic basin.

- The framework can show how drought dynamics, from the onset and propagation across time scales to the propagation into the precipitation-to-streamflow continuum, can be highlighted using a parallel multi-scale indices analysis.
- Moreover, the simultaneous analysis of precipitation (water balance input) and river streamflow (water balance output) enables us to monitor the progression of drought through the hydrological cycle. This approach enhances our ability to differentiate between the impacts of climate and human activities on water resources.
- The comprehensive drought index, $\mathfrak{D}$, derived from a multi-scale ensemble-mean approach is able to identify severe drought phases and simplify the monitoring of drought for decision-makers without losing relevant and salient information.

Understudied effects of drought risk:
Risk finance, ecosystem impact, climate justice

Summarizing the work on Financing:
The increasing frequency of droughts highlights the urgent need for innovative risk finance strategies. Key insights from recent studies reveal that integrating uncertainty into investment decisions is crucial for effective water resource management. For instance, employing a real options approach can enhance economic analyses, helping policymakers better assess the timing of large-scale water investments under uncertainty. Additionally, initiatives like localized early warning systems in Bangladesh are pivotal for improving disaster preparedness and food security, expanding coverage from just 2.5% of the population to empower vulnerable communities.
Moreover, Australia's Future Drought Fund provides continuous funding for drought resilience initiatives, supporting farmers in adapting to climate impacts. Together, these approaches not only strengthen local preparedness but also serve as scalable models for global drought management, aligning with the United Nations Sustainable Development Goals.

Summarizing the work on Ecosystems:
Droughts manifest in various forms beyond prolonged rain deficits, including hot, cold, flash, and urban droughts, each with distinct effects on ecosystems. Drought through hot temperatures increase ecosystem vulnerability, flash droughts emerge rapidly with damaging impacts, and urban droughts, coupled with the heat island effect – that are urbanized areas experiencing higher temperatures than surrounding areas-, strain urban vegetation and infrastructure. In this workstream, drought impacts on ecosystem was exemplified through the posters:
Research from Central Europe highlights the importance of understanding drought indicators, impacts, and mitigation strategies. Connectivity, both structural (physical layout) and functional (resource flow), plays a critical role in ecosystem changes, particularly the shift from grasslands to shrublands under prolonged drought and overgrazing, which reduces biodiversity and ecosystem resilience. In India, ecological droughts, which hinder vegetation growth, driven by meteorological aridity and ocean warming, have been rising. This rise poses threats to sustainability and food security. In Sri Lanka, Human-Elephant Conflict (HEC) is a significant conservation challenge. While a proposed elephant corridor was implemented, these corridors are shrinking because of droughts. The drought-tolerant Marula tree (Sclerocarya birrea) improves soil nutrient content and aid sorghum crop productivity. Predictions show a significant decrease of suitable habitats for this species in future climates because of droughts, leaving only limited regions suitable to have this tree. In Chile, a megadrought since 2010 has decreased groundwater and snow cover, impacting natural vegetation and agricultural land, especially avocado areas, pointing to the importance of mitigation strategies to build drought resilience agricultural systems.

Summarizing the work on Equity and justice:
Research on drought awareness reveals a global disparity; while awareness has increased, particularly in wealthier nations, local understanding remains essential. Countries experiencing prolonged droughts exhibit heightened awareness of local conditions, highlighting the necessity for targeted international aid strategies. Recent work emphasizes the need to redefine drought events using local knowledge, which can enhance drought monitoring, improve impact assessments, and empower communities through better communication.
Promoting open data access can empower communities, also voices often less heard such as youth, women to manage water resources effectively, supporting community-based monitoring systems that enhance resilience. A study showcases how this is effective in Kenya, where women face water scarcity exacerbated by climate change and lack of access to technical resources.
Also other research, including a case on drought and heatwaves in urban areas, shows that citizen science and collaborative platforms are vital for fostering community involvement and enhancing urban resilience against climate impacts. These findings collectively underscore the importance of integrating local knowledge, fostering equitable access to resources, and promoting participatory approaches to bolster climate resilience and social justice.

Wednesday - Poster board no. 1
Ecosystems
Many faces of droughts: How to manage different drought types, their impacts on ecosystem services and possible mitigation measures
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Droughts have many faces whereby prolonged rain deficit is only one. A drought may also come about as a hot or cold drought, as a rapidly emerging flash drought or an urban drought, each of them causing very different impacts on ecosystem function and services. Increasing hot droughts may considerably influence seasonal ecosystem vulnerability. Recent studies of flash droughts have stressed their rapid emergence, widespread damage potential and yet understudied impacts, especially in the European context. And finally, urban droughts cause, in combination with the urban heat island effect, extreme strain on urban vegetation and the functioning of green infrastructure rendering them useless in cooling cities or cause in concurrency with rainstorms excessive water quality deteriorations due to accumulated contaminants. This poster encapsulates recent findings on diverse drought indicators, impacts and mitigation measures of the three drought types from four large research consortiums of Central Europe.
• Different types of droughts exist, each of them with their own timing, characteristics and pertinent indicators. • Drought risk management plans need to take account of a wider set of indicators to enable early warning and successful mitigation of any drought type. • Different types of droughts may coincide, overlap or come in series – thus requiring different timings of actions. • Different types of droughts result in different impacts on ecosystem services and require different actions to enhance drought resilience on the local to trans-national level. • Drought may detrimentally impact other climate-adaptation measures such as nature-based solutions for stormwater control, heat mitigation and cooling of cities and other benefits of blue-green infrastructure.

Wednesday - Poster board no. 2
Ecosystems
The Role of Connectivity in Driving Grassland-Shrubland Regime Shifts: Impact of Drought and Grazing on Dryland Ecosystems
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This study explores the critical role of connectivity in driving ecosystem changes—specifically the shift from grassland to shrubland—under the pressures of prolonged drought and overgrazing, phenomena increasingly common in drylands across the globe. By using network theory (a method used to study how elements within a system are connected) and numerical modeling (simulating real-world scenarios using mathematical models), we investigate how the flow of resources, like water and nutrients, across landscapes is influenced by two types of connectivity: (i) structural connectivity (the physical layout of landscapes), and (ii) functional connectivity (how resources move and interact within those structures). Our findings show that drought disrupts these connectivity patterns, accelerating shifts in vegetation that reduce the resilience of ecosystems. This shift from grassland to shrubland negatively impacts biodiversity, ecosystem services, and the livelihoods of people who depend on these lands. The study also examines how wind and grazing management influence resource flows across landscapes. We found that wind significantly alters the movement of resources, while adaptive grazing strategies—such as rotational grazing—can help offset some of the negative impacts by maintaining healthier connectivity and preventing drastic vegetation changes.
• **Connectivity is Key**: Maintaining the flow of resources like water and nutrients across landscapes is essential for protecting ecosystems from the impacts of drought and overgrazing. • **Adaptive Land Management**: Policies that promote practices such as rotational grazing help preserve ecosystem connectivity, preventing harmful vegetation shifts and enhancing resilience. • **Quantifiable Metrics for Decision-Making**: Incorporating measurable connectivity metrics into drought management policies allows for more informed, landscape-level decisions that strengthen ecological stability. • **Drought Increases Risk**: As droughts become more frequent, safeguarding connectivity becomes critical to preventing long-term damage to dryland ecosystems. • **Community Engagement**: Educating communities about the importance of connectivity in ecosystem health empowers local action and supports sustainable land use practices.

Wednesday - Poster board no. 3
Ecosystems
The European Drought Risk Atlas: Understanding Drought Risks for Ecosystems
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Find me in person at the conference to chat about this work
This poster summarizes the findings of the European Drought Risk Atlas, released in 2023, regarding drought risks for ecosystems in the European Union. European ecosystems have seen considerable impacts from droughts in recent years, which are also projected to increase due to climate change. The Atlas is an effort to better understand, estimate and map drought risks. It does so in two ways: by characterising how the components of drought risk, namely hazard, exposure and vulnerability drivers, interact to generate risk, and also by estimating and mapping the drought risk faced by ecosystems both in current climate conditions, and for projections under different levels of global warming, putting risk hotspot areas in evidence. The findings of the Atlas can be considered a considerable step towards impact-based drought assessment, and can support the development of drought management and adaptation policies and actions in the EU.
• The Atlas shows where currently there is a reduction in forests' and freshwater ecosystems' net primary production due to droughts. This can be used to inform target areas for drought management policies, in an advance from drought hazard- towards impact-based forecasting. • The maps showing projected loss under warming levels +1.5, +2.0 and +3.0 °C can guide drought management and adaptation policies in longer terms. They can highlight to policy makers, e.g., where risk is currently high, and is expected to increase even more; but also identify areas that currently do not face high losses, and thus might be unprepared to face increasing risks in the future. • The atlas breaks down the complexity of drought risk into their main drivers, facilitating risk assessment. This disaggregated and holistic view highlights that not only hydro-meteorological drivers are important, but also the human influence upon them, i.e., how systems are managed. This overview of the main risk drivers can help in the identification of entry points for adaptation policies. • The Atlas can be used to find commonalities in drought impacts and drivers of risk across systems, which opens up opportunities for coordinated and more effective drought management.

Wednesday - Poster board no. 4

Ecosystems

Time to consider the ecological ramifications of droughts in policies for attaining sustainability

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Current definitions of drought have a limited perspective as it overlooks its ecological impacts. Ecological drought refers to the hindered growth and development of vegetation, which has negative effects on the ecosystem such as altered carbon, nutrient and water cycling. India exhibits strong carbon-water cycle connection and is an agrarian economy. We find that the ecological droughts are rising in most parts (except western) of India due to enhanced land evaporative, meteorological and atmospheric aridity for the past two decades (2000–2019). The Machine Learning based Random Forest algorithm suggests meteorological aridity (23.9%) and ocean warming (18.2%) largely drives the ecological droughts in India during ISM. Causal analysis reveals ocean warming indirectly triggers ecological droughts in India, as it affects its other drivers. The rising ecological droughts lead to browning during ISM, which is a concern for sustainability, food security and climate change mitigation.

- There is a need to consider the ecological implications of droughts in policies and combat its threats such as the prevention of crop failures, famines, degeneration and fragmentation of forests, and socio-economic issues.
- It may be feasible to alleviate ecological droughts by modified policies and efficient water management.
- Employing conventional solutions are inadequate as these approaches are largely inadequate in planning, effectiveness and cost.
- Need to incorporate ecosystem services and vulnerability assessment into the planning process to effectively tackle ecological droughts.
- Proactive resource management strategy such as forest thinning and nature-based solutions that align with natural processes can effectively mitigate ecological drought vulnerability.
- The findings of the study will help in effective planning for mitigation and adaption of the adverse impacts of droughts on ecosystems in India and is applicable to similar bioclimatic regions of the world.

Wednesday - Poster board no. 6

Ecosystems

Investigating the Relevance of Corridors for Asian Elephant Conservation and Human-Elephant Conflict Mitigation: Case study from Sri Lanka

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The Asian elephant (*Elephas maximus*) is a keystone species with vital ecological roles, but Human-elephant conflict (HEC) poses significant challenges to conservation. Sri Lanka is important for elephant conservation due to its high density of both elephants and humans. Consequently, HEC is widespread, presenting substantial socio-economic, ecological and political challenges. In response to rising HEC in Sri Lanka, Department of Wildlife Conservation has proposed 16 elephant corridors to mitigate HEC and conserve elephants. However, only one of these corridors, the Wetehirakanda corridor, has been implemented.

The Wetehirakanda corridor, a large-scale landscape corridor, includes various land uses and functions as part of the existing elephant habitat, rather than facilitating connectivity between habitats. This indicates that, although established with the aim of mitigating Human-Elephant Conflict (HEC) and elephnat conservation, its functional effectiveness in achieving these goals may be limited. The findings suggest a need for more targeted, data-driven approaches, such as smaller, strategically placed corridors that align more closely with elephant movement patterns and habitat requirements, to enhance conservation efforts and HEC mitigation.

- Habitats are crucial for Asian elephants as they provide the diverse resources necessary for their survival.
- Reassess Large-Scale Corridor Feasibility: Large landscape corridors face challenges from development and land-use changes. As their effectiveness in mitigating HEC is limited, policy should focus on smaller-scale, data-driven corridor approaches that integrate existing elephant habitats.
- Prioritize Micro-Corridors for Conflict Mitigation: Focus on creating and maintaining localized, functional micro-corridors based on elephant movement data to reduce Human-Elephant Conflict (HEC) and support elephant conservation more effectively than large-scale corridor strategies.

Wednesday - Poster board no. 7

Ecosystems

The marula tree: An untapped potential for combating desertification and enhancing socio-ecological resilience in global drylands

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Marula, *Sclerocarya birrea*, is a drought-tolerant and multipurpose fruit tree used to produce Amarula wine, used and recommended for agroforestry and drylands restoration. However, it is unclear where its subspecies can survive in global drylands. We use Maximum Entropy (MaxEnt) machine learning algorithm to predict global scale suitable areas for *Sclerocarya birrea* subspecies under the current and future climates for the years 2050 and 2080 and explore their potential for agroforestry in drylands. The key findings are that suitable areas for *Sclerocraya birrea* subspecies currently exist in all continents except Europe and Antarctica, occupy 3,751,057-24,632,452 km2 of earth's terrestrial area in 54-107 countries, will retract by 64-100% under future warming climates and some regions of Eastern Europe will become suitable habitats. In Tanzania, suitable areas occupy 28 446-184 814 km2 of land area, which will contract by 0.4–44% due to climate change. The fruit and leaf litter of *Sclerocraya birrea* subspecies and soil under the canopies of the subspecies had higher nutrients concentration than soil away from the canopies, and sorghum plants grown under the canopies performed better and grains were more nutritious than those away from the canopies. The fruit and leaf litter of *Sclerocarya birrea* subspecies has higher carbon-to-nitrogen ratios (C: N), ranging from 34.58 to 75.12.

- Suitable areas for *Sclerocarya birrea* subspecies extensively exist in global drylands worldwide. Thus, the subspecies can be used to restore global drylands to enhance drought resilience through combating and reversing desertification. It also offers an opportunity for the commercial cultivation of subspecies to enhance socio-economic resilience in global drylands.
- *Sclerocarya birrea* subspecies improve soil fertility, sorghum growth and yields, and sorghum grains' nutritional quality in drylands. The subspecies can be used for agroforestry to enhance socio-ecological resilience in global drylands.
- Leaf and fruit litter of the *Sclerocarya birrea* subspecies had higher C: N ratios. This implies that the fruit and leaf litter of *Sclerocarya birrea* subspecies cannot easily be decomposed by microbes, thus the subspecies can store carbon in their litterfall for a long time to contribute to combating global warming.

Wednesday - Poster board no. 8

Ecosystems

Response of agricultural and natural vegetation areas to groundwater and snow drought in central Chile

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Since 2010, Chile has been experiencing a megadrought. The possible influences of decreasing groundwater GW and snow cover on land use-cover have not been fully investigated worldwide. Therefore, the objective of this research is to analyze the relationship between GW and snow with agricultural AL and natural vegetation NV areas during drought in central Chile. Indicators of vegetation productivity, precipitation, GW, atmospheric evaporative demand and snow were analyzed on persistent of AL and NV areas since 2000. Statistical tests considering GW were carried out exclusively by hydrogeological sectors HS. A significant decrease in the GW and snow indicators were found. The snow content had a very positive correlation with the productivity of NV and inversely with AL, more evident in the avocado land. The HS with a higher proportion of AL presented a greater decrease in GW. The productivity of NV was affected by the drought but not in the spring seasons. These results imply the need for mitigation strategies to achieve resilience to drought.

- Mitigation and adaptation strategies to climate and land cover changes to achieve resilience to drought in a context of global warming are necessary.The ecosystems response to groundwater and snow drought must be considered in new policy for adequate sustainable management.
- The ecosystems response to groundwater and snow drought must be considered in new policy for adequate sustainable management.
- A correct assessment of the relationship between groundwater and the ecosystems it supports is necessary to protect them during drought periods.Aquifer recharge can be considered a mitigation strategy to improve drought resilience in ecological and socioeconomic terms.

Wednesday - Poster board no. 9
Social inclusion and climate justice
Beyond the hazard: local perceptions driving how we define, identify and monitor droughts
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Climate change has led to new forms of extreme that until recently were not a topic of concern for the scientific community and general society. Terms such as flash droughts, megadrought, and anthropogenic droughts, among others, entered our vocabulary only recently, in the past decade. However, such categorizations are unclear and only come after the fact and with a considerable delay between impacts and definition, hindering preparedness potential. We propose in this work a novel frame to define extreme events using local knowledge and perception of the impacts of extreme weather. The premise is (1) in collaboration with stakeholders, policymakers and society, assess the potential impacts, defining different levels of damage. (2) From the identified levels of impact, assess their frequencies and drivers. (3) Finally, define the thresholds and patterns that lead to such impacts, supporting informed mitigation action and forecast.
Over the last decade multiple new droughts have emerged as concerns to society (e.g. flash droughts, megadroughts, and anthropogenic droughts). However, such categorizations are unclear and only come after the fact and with a considerable delay between impacts and definition, hindering preparedness potential. We propose in this work a novel frame to define extreme events using local knowledge and perception of the impacts of extreme weather. Results from implementation in the USA and in Brazil indicate that the new framework shows potential to: - Increase drought monitoring effectiveness - Improve impact and risk assessment - Strengthen communication with local communities By emphasizing local challenges and strengths, it also equips scientists and policymakers with more didactic and direct measures of extreme events, facilitating communication and empowering action.

Wednesday - Poster board no. 10

Social inclusion and climate justice

Multi-dimensional analysis of global drought awareness

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To strengthen the global community's resilience to droughts, a multi-dimensional understanding of global drought awareness is imperative. Here we investigate global drought awareness at local (awareness of local droughts in the affected country), remote (awareness of remote droughts in other countries), and global levels (awareness from non-exposed countries). This multi-dimensional study uses relevant search activity volumes of a country to drought as a proxy of national-level drought awareness. We find that the recent decade has experienced no change in drought hazard over the globe, but the global community has been increasingly seeking information about drought online, that is, elevated awareness of the global community on drought. We further find that long-lasting droughts enhance local- and global-level awareness and high gross domestic product are associated with remote-level awareness. This study provides observational evidence of global disparities in the awareness/interest regarding drought, underscoring a continuing role of European nations in enhancing global drought awareness.
(Reference)
Ahmad, D.M., Kam, J. Disparity between global drought hazard and awareness. *npj Clean Water* 7, 75 (2024). https://doi.org/10.1038/s41545-024-00373-y

- By better understanding human behavior patterns of seeking information activities related to an emerging drought, more efficient and effective strategic plans for international aid and donations can be developed..
- Online drought-related information seeking activity volumes can be used as a proxy of drought awareness.
- While droughts are a naturally occurring disaster, drought awareness of the global community has been increasing.
- Countries with high GDP per capita, particularly European countries, showed a higher level of awareness on drought occurrences in other countries than those in their own countries.
- Countries with the occurrence of a long-lasting drought showed a high level of awareness on drought occurrences in their own countries, rather than those in other countries.
- International efforts should focus on developing efficient and effective risk communication strategic plans led by European countries that have a balanced awareness of local and remote drought occurrences.

Wednesday - Poster board no. 12
Social inclusion and climate justice
Open Data for Enhanced Water Accessibility by Women in Machakos County, Kenya
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Find me in person at the conference to chat about this work
Women in Machakos County, Kenya, face challenges of water scarcity and water security due to inaccessible water systems catalyzed by climate change impacts. The skill deficit on open data access has further exacerbated the access to water quality by women due to lack of technical capacity to use existing open source data for water accessibility. On the other hand, open data promotes equitable and sustainable water management practices by making water-related data freely available and easily accessible, providing timely and accurate information on water availability, quality and accessibility by women. Besides, supports establishment of community-based water monitoring systems that enhance women agro-pastoral practices, resilience and adaptability. The premise is to establish gender roles and responsibilities in relation to domestic water sources and domestic water security. Further, ascertain the domestic water sources that include seasonal to permanent: springs, hand-dug shallow wells, pumped boreholes and private wells accessible by women. Additionally, determine existing community of practice techniques that can be adopted to build the capacity of women to enable them utilize open data for water accessibility.
• Research and development on alternative technologies and methods for abstracting water both ground and underground water for improved water quality in Machakos County. • Explore the adoption of renewable energy sources including wind and solar energy as enablers for women to use for water access. • The urgency to build the capacity of women on the adoption of technologies like Q-field and strengthening East Africa Hydro Watch to empower women in water management. This with the appreciation that earth observation technologies can be embraced to guarantee that women and girls, have the technical ability to map water sources and monitor water quality. • Technical capacity building of women, girls, youth and local leaders on Q-field as a low-cost technology has the potential and aptitude of women to utilize earth observation technologies for water access are conducive to the accomplishment of the SDGs no. 6.3.2 as well as Kenya's Vision 2030 economic blueprint.

Wednesday - Poster board no. 13
Social inclusion and climate justice
Citizen Science and Geographical Information Technologies for the assessment of compound hot-dry events – CITOSEQ Project, Spain
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Climate change projections predict increasing combined drought-heatwave events in southern Europe. Current studies on this compound risk are limited but crucial for assessing impacts. Droughts and heatwaves are poorly understood, with significant negative effects on urban populations. Defining these risks remains ambiguous, complicating their interpretation. While physical aspects are well-documented, research on their combined effects and social components is lacking. Advances in assessing drought and heatwave vulnerabilities exist but more research on adaptive capacity indicators, linked to social and institutional contexts in urban areas, is needed. Our work aims to enhance civil security by identifying vulnerabilities and informing urban risk management strategies. It also promotes citizen science to foster a proactive society in risk evaluation and management. Additionally, the project aims to improve understanding of climate change impacts and enhance urban resilience, focusing on water-related risks and aligning with international disaster risk reduction strategies.
• Our work addresses the combined risks of droughts and heat waves, improving understanding and risk management for urban areas. • The project aligns with international disaster risk reduction strategies, aiming to strengthen urban resilience against climate-related water risks • A new methodology is being developed to evaluate urban vulnerability to these climate risks, applied in two Spanish cities, to create a vulnerability index and risk maps. • Citizen participation is a key aspect of our work, with a collaborative platform incorporating Geographic Information Technologies and citizen science, promoting data collection, interpretation, and risk management, following European Commission guidelines.

Wednesday - Poster board no. 14
Drought risk finance
Advanced economic tools for strategic water resource management under drought
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The increasing frequency of drought events affecting the Mediterranean area necessitates large-scale investments in water infrastructure. These investments are characterized by high uncertainty regarding the occurrence of such events, future water prices and quantities, and future operating conditions. Therefore, appropriate tools that integrate uncertainty are needed to support the strategic decision-making process of policymakers. The Water Framework Directive (2000/60/EC) highlights the importance of economic analysis as a fundamental tool for achieving environmental objectives, ensuring that policies and actions are based on rational and economically sustainable considerations. However, traditional Discounted Cash Flow (DCF) techniques used in these contexts fail to adequately address the valuation of growth opportunities or strategic alternatives arising from large-scale investment projects. A solution to this problem could be the application of real options to traditional DCF, allowing for the evaluation of uncertainty and its integration into the economic model used to assess large-scale water investments. At the current stage of the work, only preliminary results obtained from a pilot study are available and they indicate that in all scenarios, the uncertainty of this type of investment it's too high and it is more advantageous to delay the investment in subsequent years.
• The use of the real options approach can support environmental policies by serving as an advanced tool to improve water resource management and to develop more effective and resilient adaptation and mitigation strategies in response to climate change. • The real options approach can provide a solid foundation for long-term strategic planning of water infrastructure, offering a more accurate assessment of investment timing and ensuring that public resources are allocated efficiently and sustainably. • This approach encourages the use and collection of climate data, which helps to improve forecasts and future decision-making regarding water resource management.

Wednesday - Poster board no. 15
Drought risk finance
Promoting Climate Service and Anticipatory Action for Effective Drought Management
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This research initiative directly contributes to the achievement of the United Nations Sustainable Development Goals (SDGs), specifically SDG 13 (Climate Action) and SDG 2 (Zero Hunger), by strengthening drought preparedness in the semi-arid region of Bangladesh. Frequent droughts in this area pose significant risks to food security and livelihoods, particularly in rice-dependent communities. The deployment of a localized early warning system, aligned with the global "Early Warning for All" initiative, ensures that vulnerable populations receive timely, actionable alerts, addressing a critical gap in disaster preparedness—currently limited to just 2.5% of the population. By empowering local communities to adopt proactive measures, this anticipatory action framework minimizes economic losses and maximizes the impact of investments in drought preparedness. This approach replicates the successful models implemented in the African region and supports Bangladesh's National Adaptation Plan (2023–2050) by integrating early drought warnings and establishing a comprehensive national monitoring system, fully aligned with the country's climate resilience objectives. Additionally, this framework offers a scalable, science-based model for effective drought management, with potential applications in other semi-arid and arid regions worldwide.
• Introducing Risk-Informed Drought Warning: Introducing the risk-informed early warning systems for droughts, where only 2.5% of people currently receive traditional early warning. Expanding this coverage with risk-informed information will allow communities to act early, protect crops, and reduce economic losses. • Embed Drought Preparedness at Policy Level: Integrating anticipatory action strategies into Bangladesh's National Adaptation Plan to better prepare for droughts. By doing so, the country can reduce agricultural damage and protect livelihoods in drought-prone areas, ensuring more effective responses to future climate challenges. This will also allow achieving the SDG goals, specifically SDG 13 (Climate Action) and SDG 2 (Zero Hunger). • Adopt and Share: Using the drought management approach developed in Bangladesh as a model for other regions facing similar climate risks. This framework can help strengthen drought preparedness globally, supporting food security and climate resilience efforts.

Wednesday - Poster board no. 16
Drought risk finance
The Australian Future Drought Fund:
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Find me in person at the conference to chat about this work
The Future Drought Fund (FDF) was established by the Australian Federal Government in 2019. It provThe Future Drought Fund (FDF) was established by the Australian Federal Government in 2019. It provides secure, continuous funding for drought resilience initiatives. It is helping Australian farmers and communities prepare for the impacts of drought with $100m AUD per annum funding. Through 8 FDF Hubs and their Nodes, the program works with ides secure, continuous funding for drought resilience initiatives. It is helping Australian farmers and communities prepare for the impacts of drought with $100m AUD per annum funding. Through 8 FDF Hubs and their Nodes, the program works with farmers/producers and their rural and regional communities to prepare for drought. It connects farmers/producers with agricultural experts in their region to harness innovation and adopt new practices.

Wednesday - Poster board no. 16

Public-private-civil society partnerships

Diagnosing drought for dealing with drought in 3D: Dimensions, Dynamics, and Dialogue

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In Northeast Brazil we study drought impacts to generate impact. Our 3D drought-diagnosis approach supports Dialogue on human-water Dynamics, and human Dimensions of drought. We place drought in context by focusing on drought impacts for local communities, and processes that affect levels of resilience to drought. Building on these insights we develop tools and guidelines for drought diagnosis that are helpful to inform policy and action. An example is the evaluation of opportunities and challenges for innovative technologies to increase water security in Brazil and elsewhere. Based on our evaluation we aim to promote affordable and reliable supply of drinking water to remote communities that are not served by municipal water supply and have no access to local surface or groundwater sources. Using our 3D drought-diagnosis approach involving dialogues among water users, drought managers, and policymakers we assess the feasibility of different options both locally and elsewhere.

- 3D Drought Diagnosis can help drought-affected regions to become more drought-prepared.
- Worldwide, different aspects are associated with drought drivers and drought impacts. In many cases small reservoirs should be considered in drought management since they can induce and modify hydrological drought.
- In Brazil, drought impacts also occur during non-drought periods, either following drought, driven by non-extreme hydrometeorological conditions, or resulting from vulnerabilities.
- In Brazil, reactive crisis management shifted to drought-preparedness policy due to an interplay of multiple drought events, their timing and duration, media attention, and influential individuals.