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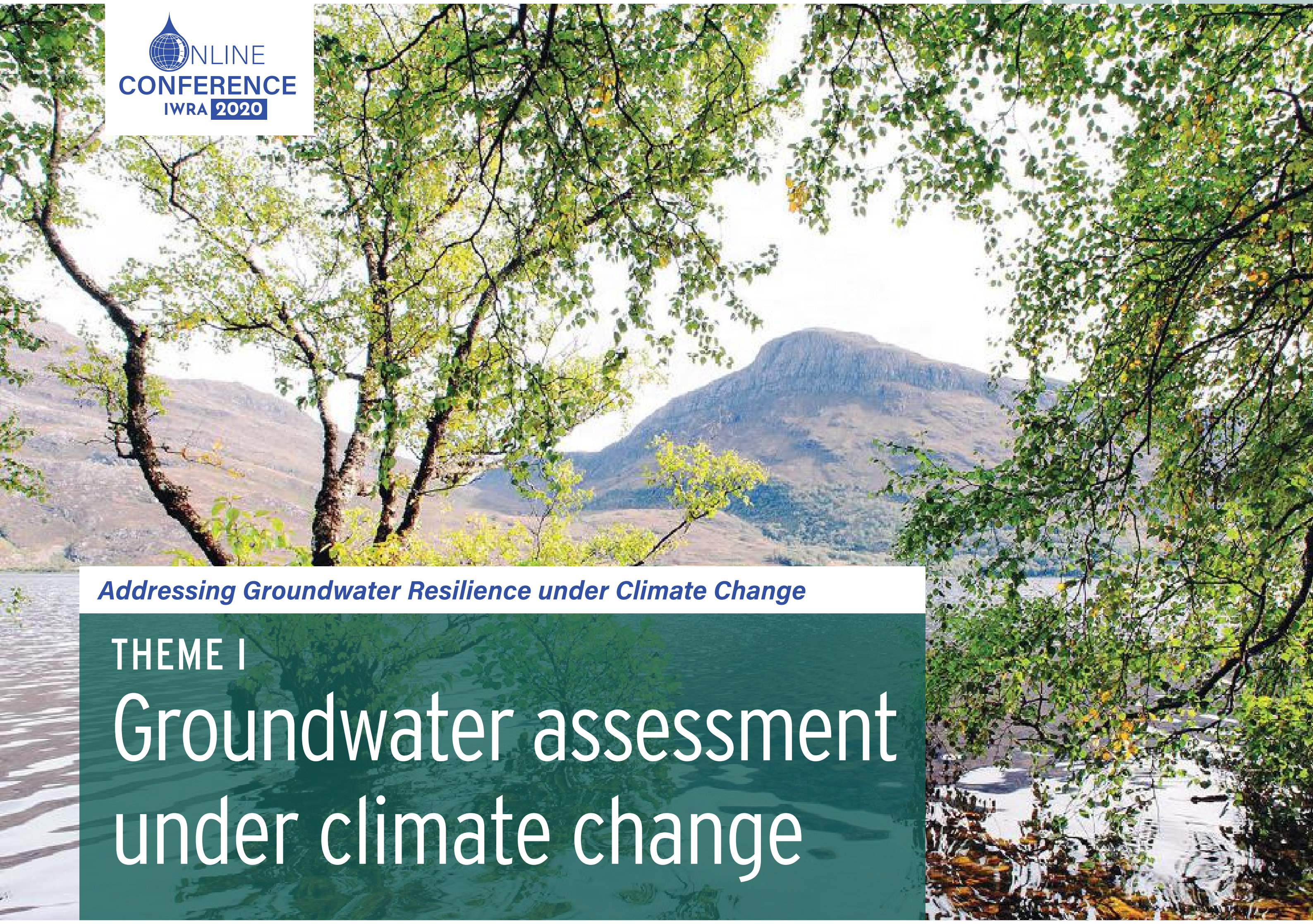

Addressing Groundwater Resilience under Climate Change

THEME I

Groundwater assessment under climate change

Loch Maree, between Garve & Gairloch, Scotland

KEY POLICY MESSAGES

- Legislative, management and knowledge gaps need to be filled urgently.
- Modelling advances seek to improve climate-induced recharge projections.
- Variations in climate change impacts on groundwater require locally-specific approaches.

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United Nations Educational, Scientific and Cultural Organization · Intergovernmental Hydrological Programme

Groundwater is the most significant, but least understood water resource on Earth. 'Out of sight, out of mind' explains the nearly absent legislation and management and persistent gaps in scientific and technical knowledge. Now, climate change is forcing groundwater assessment into focus.

Global volume of groundwater recharge is expected to increase overall by 2070, but some regions will experience declines with serious consequences. Climate-driven model experiments indicate substantial uncertainty in projected recharge values (Mohan) whereas satellite monitoring reveals the multi-level scale of emerging issues such as depletion and pollution (Famiglietti).

Continued intensive groundwater use in drylands is expected to amplify depletion whereas more frequent, intense floods are projected to magnify contamination risks. These insights provide a sense of the scale and nature of the problem as well as requisite management and technological responses. Assessing risks requires dissecting impacts into type (direct or indirect) and aspects (quantity and quality) (Villholth).

Continued intensive groundwater use in drylands is expected to amplify depletion. © DR

UNCERTAINTY COMPLICATES ASSESSMENT

Modelling tools play a significant assessment role, but techniques need to be further developed and refined to reduce uncertainty. At the global scale, recharge estimates become increasingly uncertain, especially in dry areas, as warming levels rise (Reinecke). An assessment of groundwater vulnerability indices proved these indices may not always reconcile well with other related indices such as the climate change index and data from existing reports (e.g., water storages and overexploitation) (Martinez Salvador).

Tools to reconstruct past and project future groundwater levels are needed to quantify climate-driven changes (MacDonald). Simple lumped parameter model and linked simplistic conceptual models indicate large, multi-decadal patterns of groundwater levels similar to those projected for climate.

Future projections show a wide variability of groundwater level changes due to uncertainties in applying climate models, especially in arid regions. Long-term monitoring is necessary to estimate changes in groundwater levels.

GROUNDWATER IMPACTS SHIFT WITH THE CLIMATE

Climate change is generating more frequent heavy rainfalls and fewer light rainfalls; this global shift in precipitation is especially pronounced in the tropics (Taylor) where it is observed to enhance groundwater recharge. The recharge bias towards heavy rainfall events underlines the implications of changes in recharge opportunites in drylands, where groundwater can serve as a vital freshwater buffer for climate change adaptation.

Filtration ponds
© Ivan Bandura

In Russia, an assessment of groundwater recharge considered latitudinal change in seasonal rainfall and temperature from the Black Sea in the south to the White Sea in the north (Grinevskiy). The model indicated no significant recharge change in the south but an increase in the central and northern of parts of European Russia due to rising evapotranspiration. Warmer winters with more rain also led to higher soil moisture absorption during thaws.

A case study in southern China found meteorological droughts were occurring more often than groundwater depletion (Gong), but the timeframes for droughts to start affecting shallow and deep aquifers differed. Regardless, groundwater 'droughts' were occurring in line with meteorological droughts that lasted more than three months. Proglacial groundwater systems play an important role in providing water downstream. Mackay found that glacier retreat could hinder river recharge, but groundwater storage dynamics were nonetheless resilient. Moreover, groundwater buffers proglacial river runoff under climate change.

PUBLIC HEALTH AND AGRICULTURE ARE AT RISK

In Madagascar, researchers explored the relationship between hydro-climatic monitoring data and nutritional and morbidity indicators in young children (Hernandez). Preliminary results indicated a lagged, but not strong impact of hydro-climatic indicators on malnutrition.

Geopolitical tensions complicate the climate change threats to groundwater-dependent agriculture. An analysis of climate information and stakeholder interviews in the Easter Aquifer Basin on the West Bank showed a 30C increase with 20 per cent less rain might lead to a 10 per cent rise in evapotranspiration. This would drive a 30 per cent rise in abstraction to get the same yield (Tuqan), underlining the need to consider the aquifer's transboundary character for future management.

The Beni-Amir Aquifer (Tadla Complex), Morocco, supplies water for drinking, agriculture and industry. Larabi analysed

Geopolitical tensions complicate the climate change threats to groundwater-dependent agriculture.

climate change impacts drawn from evidence provided by the Regional Initiative for the assessment of Climate Change Impacts on water resources and Socio-economic vulnerability in the Arab Region (RICCAR) Data. The model predicted decreasing recharge. Adaptation strategies accounting for such changes are needed to satisfy future water demands.

KEEP SEAWATER AT BAY

Case studies in South Korea and Sri Lanka highlight the challenges of keeping groundwater fresh from saltwater intrusion in coastal regions and island states (Chang; Craig). Shallow aquifers are often the main freshwater source, but threatened by population growth, land use changes and tourism.

Modelling shows that water bodies such as irrigation ponds can serve as pathways for saltwater intrusion, made worse with more frequent storms that delay the return of aquifers to normal salinity levels (Hingst). Studies found distributed abstraction could lower the rate of rising salty 'cones' under bores whereas wellfield management, land development, and groundwater use and recharge could alter islands' vulnerability to saltwater intrusion (DiFilippo).

ACT LOCALLY

Sand dams in drylands can bolster groundwater storage to meet growing freshwater demand (Nyathi). In northern Thailand, artificial injection is not an efficient recharge solution at a regional scale but has potential to increase levels on localised scale if a high volume is applied (Tran).

Drought impact can either be amplified by extensive irrigation use or dampened by integrated surface-groundwater use (Scanlon). Indeed, integrated surface-groundwater use prolongs aquifer lifespan. Other options aiding the sustainable use of groundwater include reduced irrigation pumping, managed aquifer recharge techniques, proper land management, and long-term groundwater-level monitoring.

The impacts of climate change can be minimized by controlling anthropogenic factors such as irrigation through evidence-based and site-specific policy formulation and decision-making.

ADDRESSING GROUNDWATER RESILIENCE UNDER CLIMATE CHANGE
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