TWAS-AREP Hybrid Workshop

"Shaping the Future of Science and Research in the Arab Region: AI, Emerging Technologies, and Open Sciences"

Application of AI and modern technologies for smart water resources management in the Arab Region



Prof. Abdin Salih

Director, Arab Water Academy

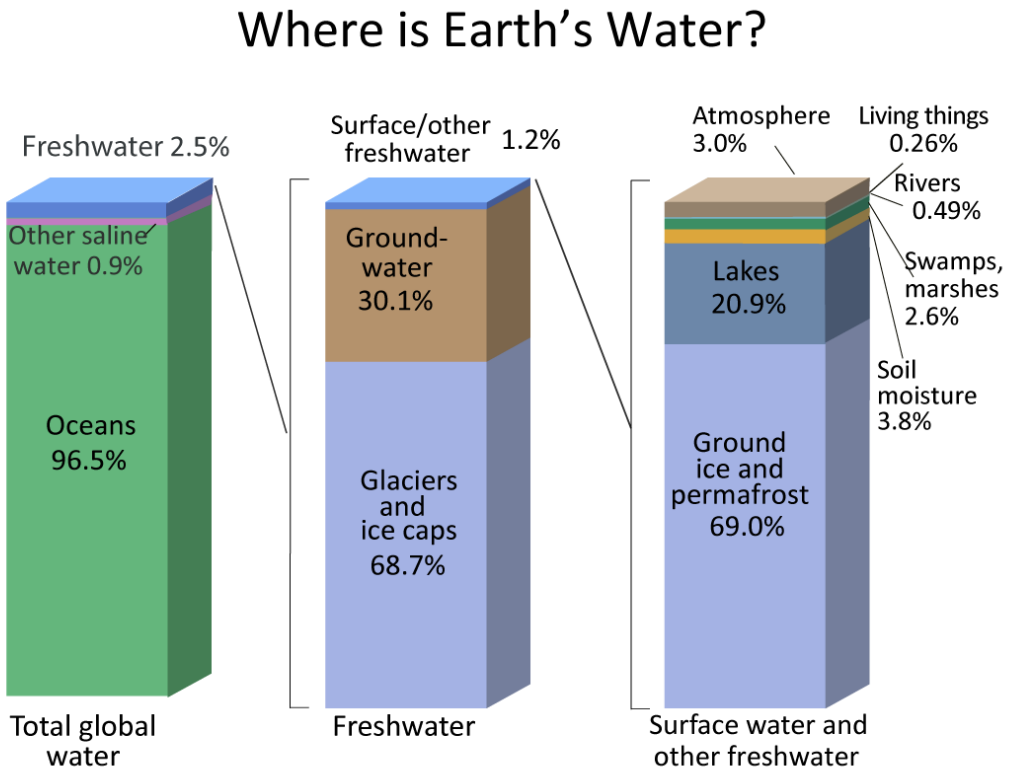
Water is a connector

WATER IS NOT A SECTOR

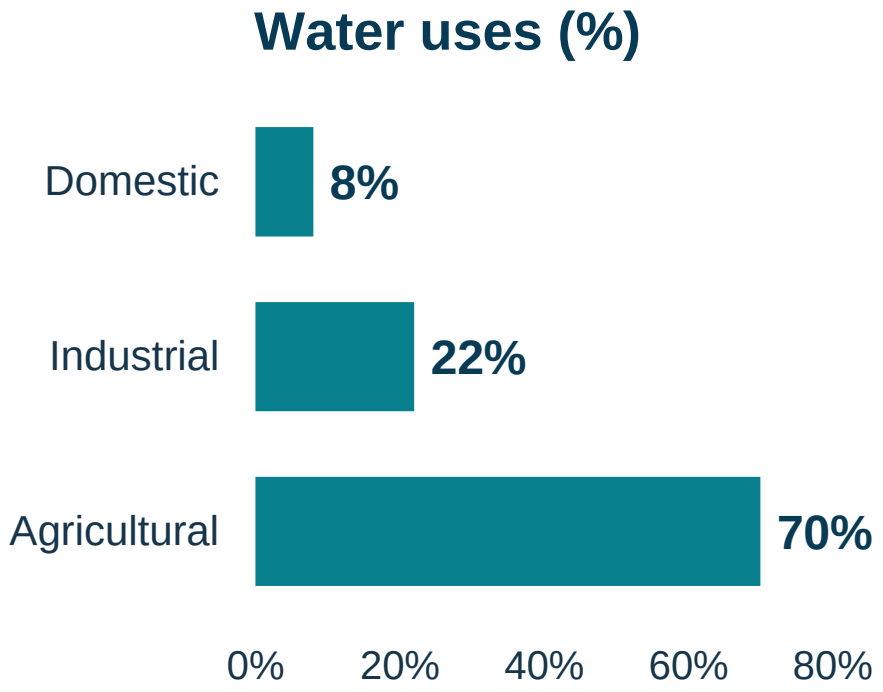
IT IS A CONNECTOR



Water uses across the world



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources. (Numbers are rounded).



Source: USGS. The usage shares follow the original slide.

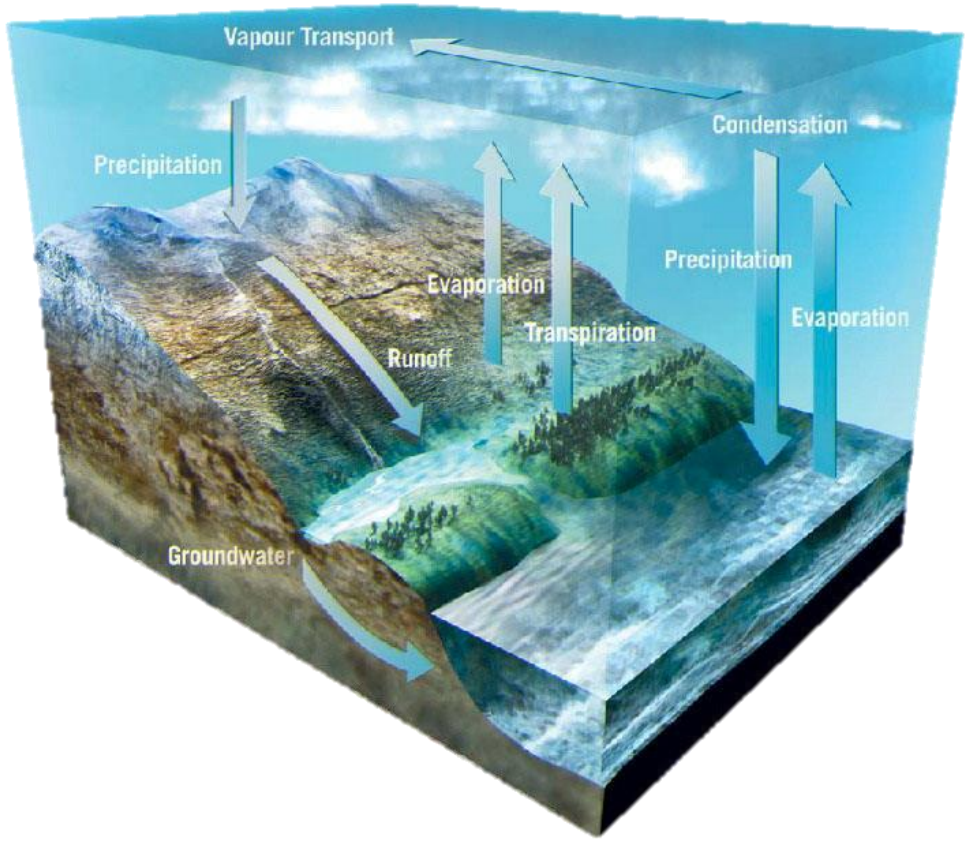


Growing Water Challenges in the Region

Growing Challenges

- Water Scarcity and High Stress.
- Growing Population and Accelerated Demand.
- Inefficiencies in Water allocation.
- Spatial and Temporal Variability.
- Pollution
- Climate Change.
- Problems of Governance and Institutional Arrangement.
- In adequate Capacity Development.
- Poor finance to Research on science, Technology and Innovation
- Cooperation at Basin and Sub-basin Levels

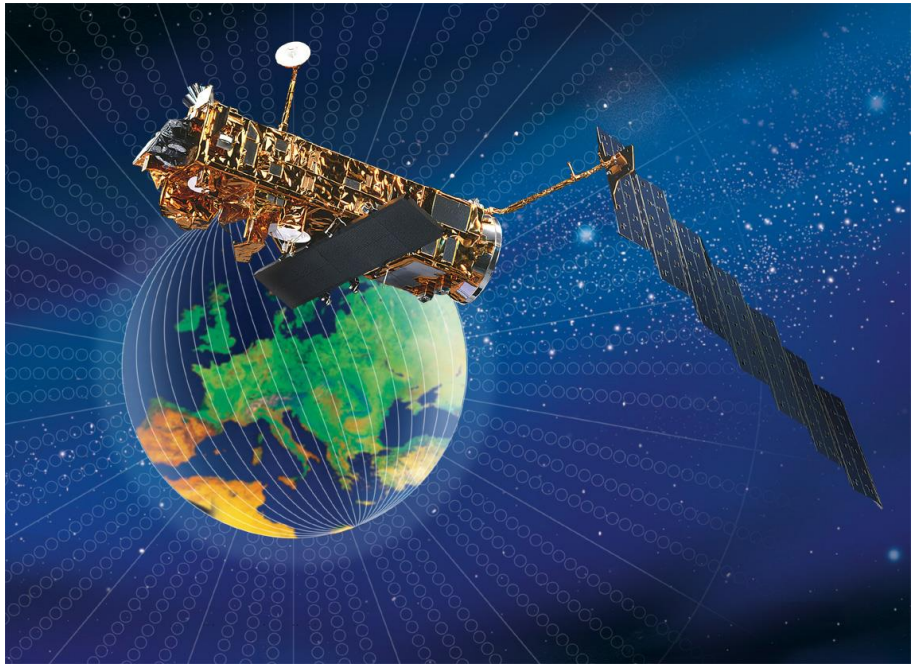
Does the Cycle Accelerate?



Earth observation and a changing water cycle

Global Earth Observation System of Systems (GEOSS)

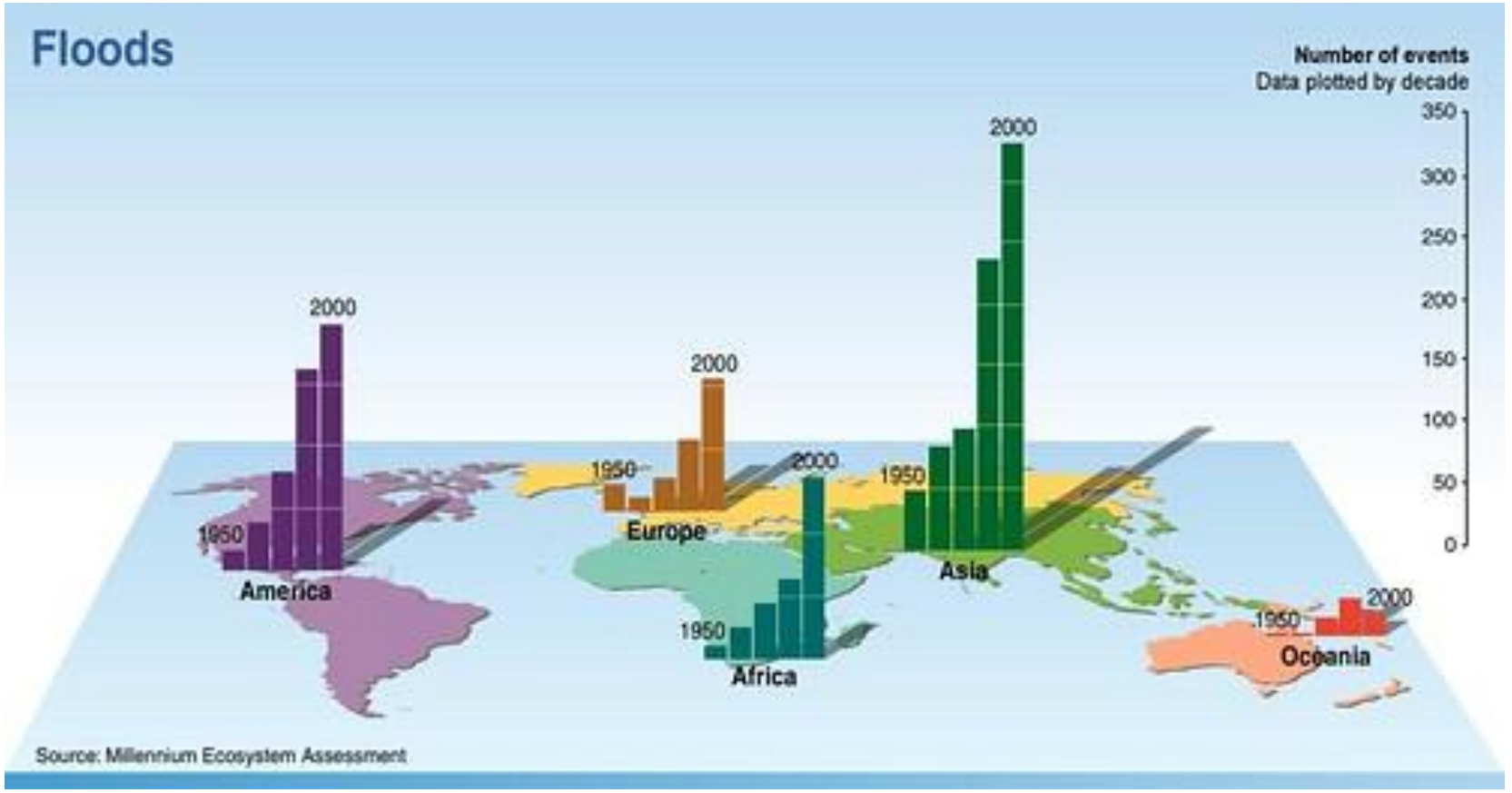
International Hydrological Programme (IHP)



- The cycle is changing?
- Increased risks?
- Growing vulnerability?
- More disasters ?
- Less water for people?
- Crisis is looming?
- What crisis?
- Global or local?

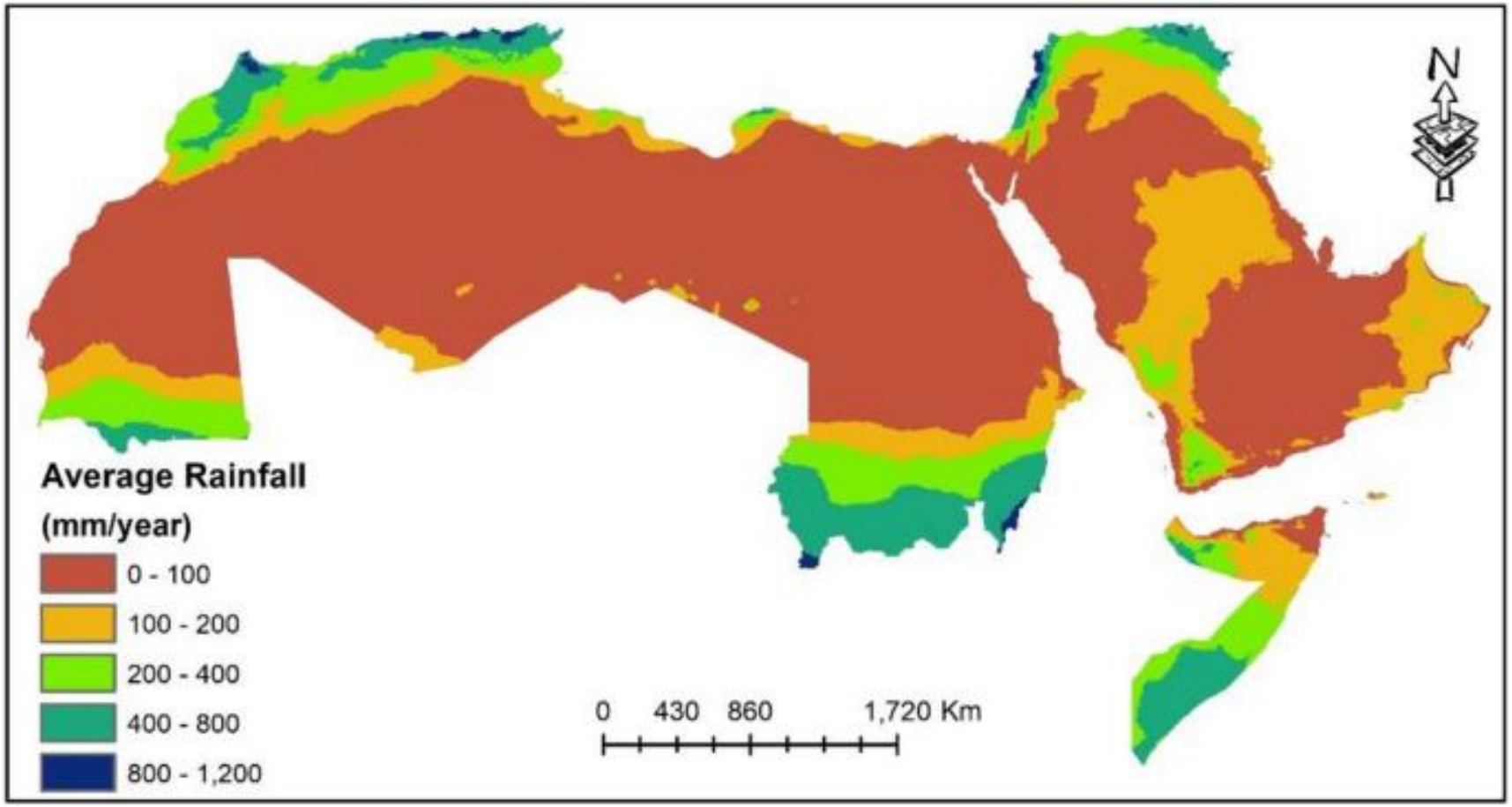
Flood events by continent and decade, 1950–2000

Adaptive water management is crucial, as it adopts an approach based upon flexibility, resilience, and continuous learning

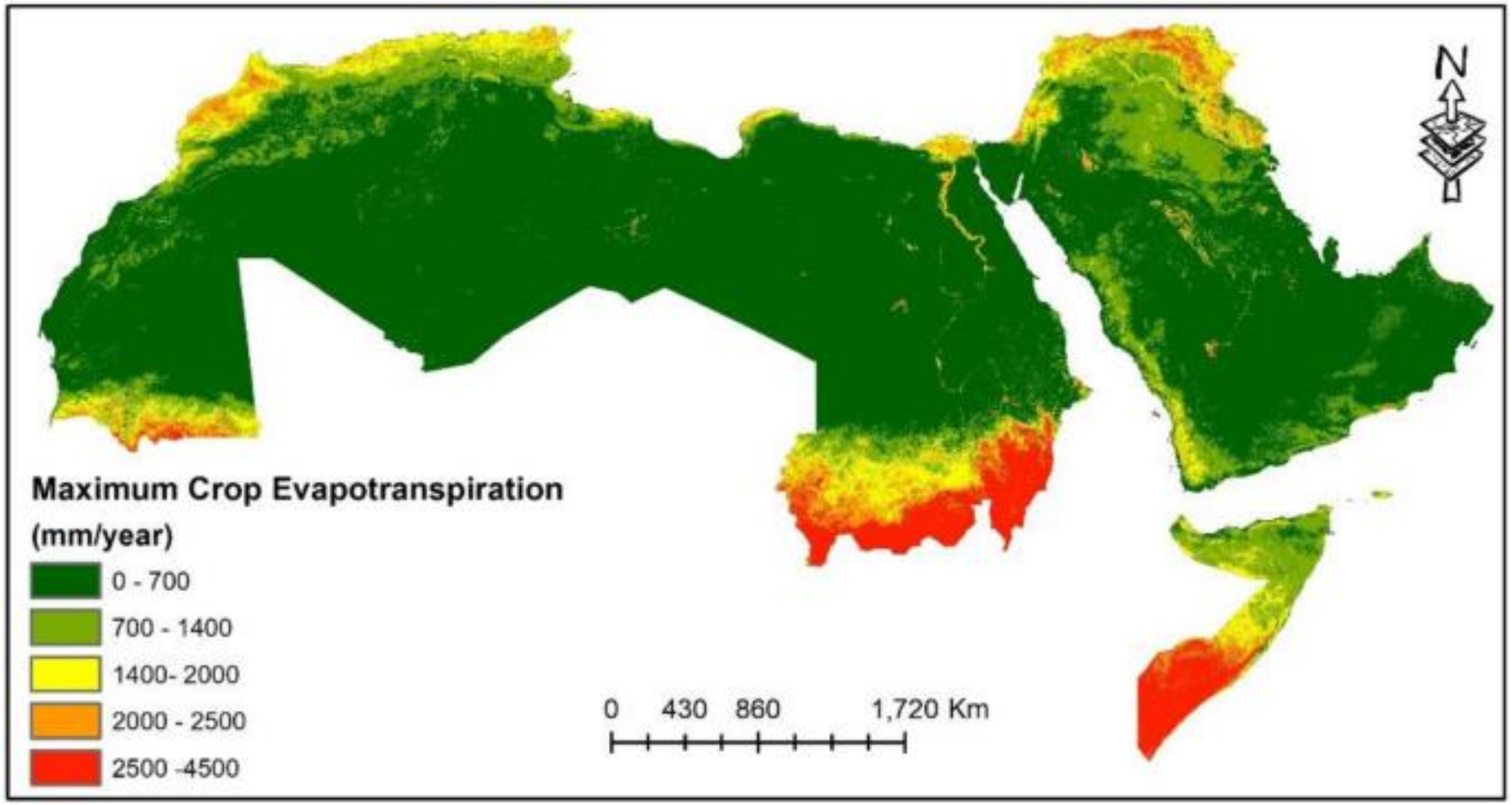


Source: UNEP

Average rainfall in the Arab Region

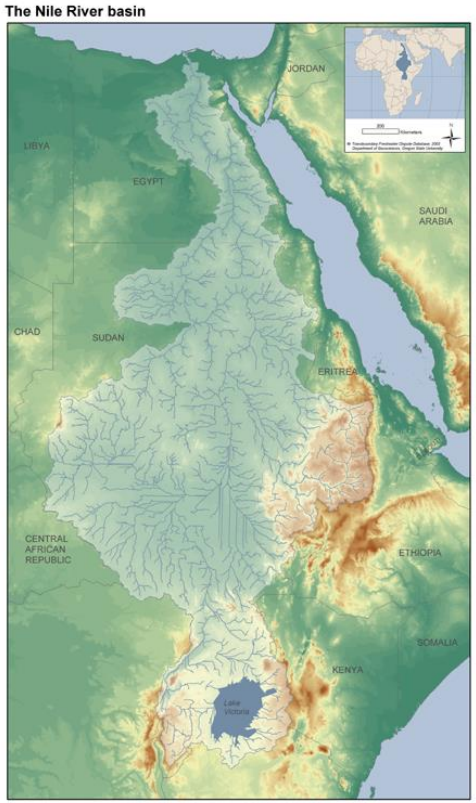


Maximum crop evapotranspiration in the Arab Region

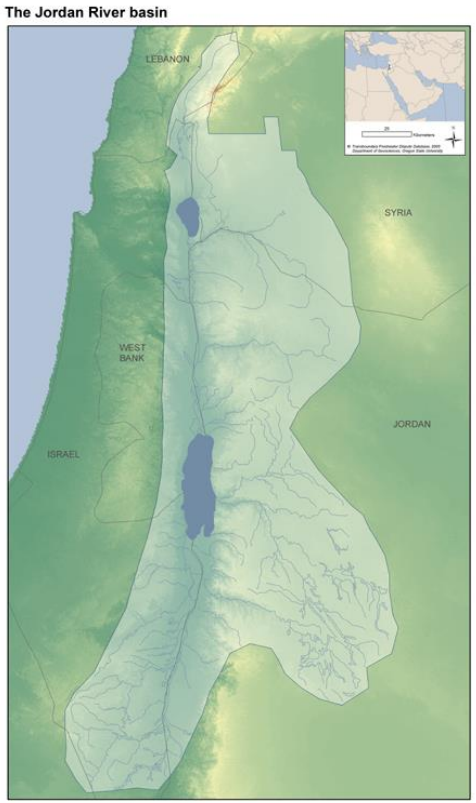


The Nile River basin and the Jordan River basin

The Nile River basin

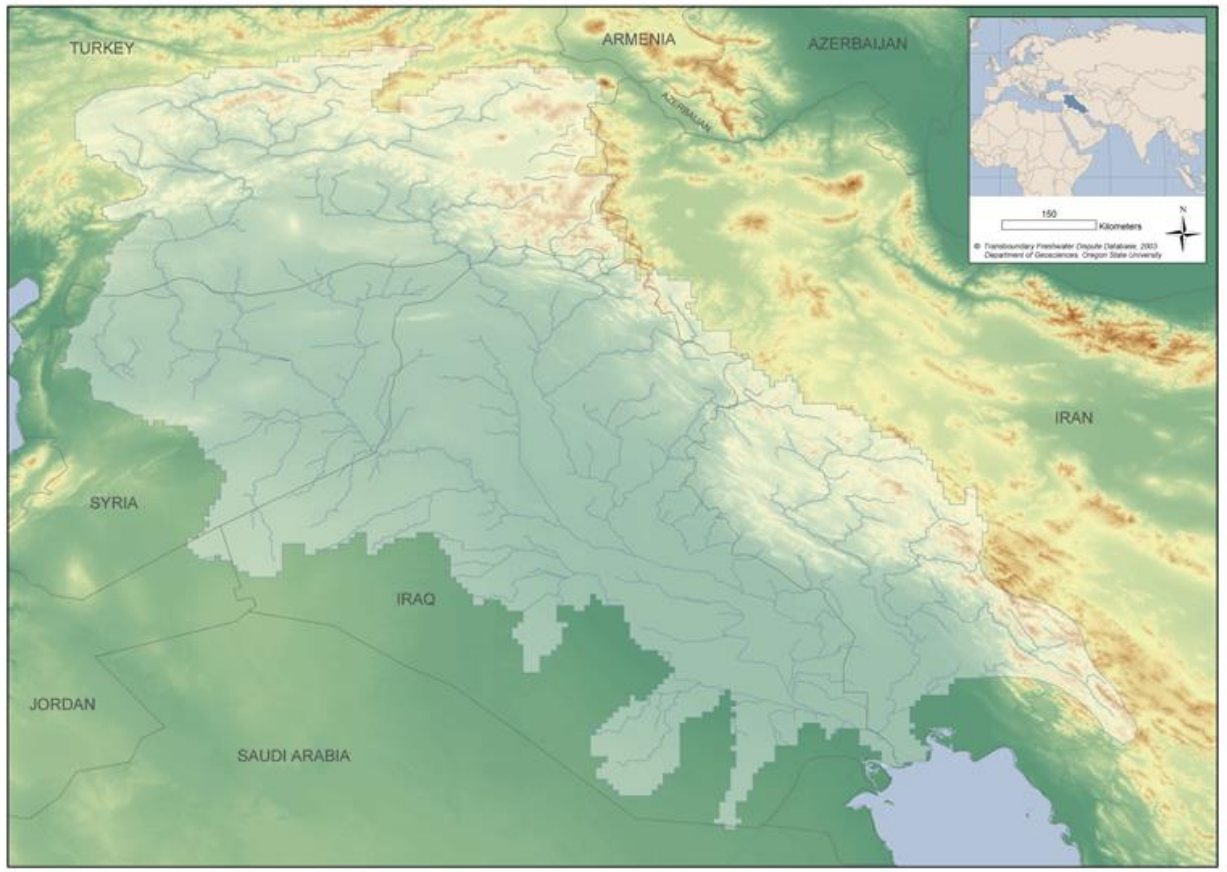


The Jordan River basin

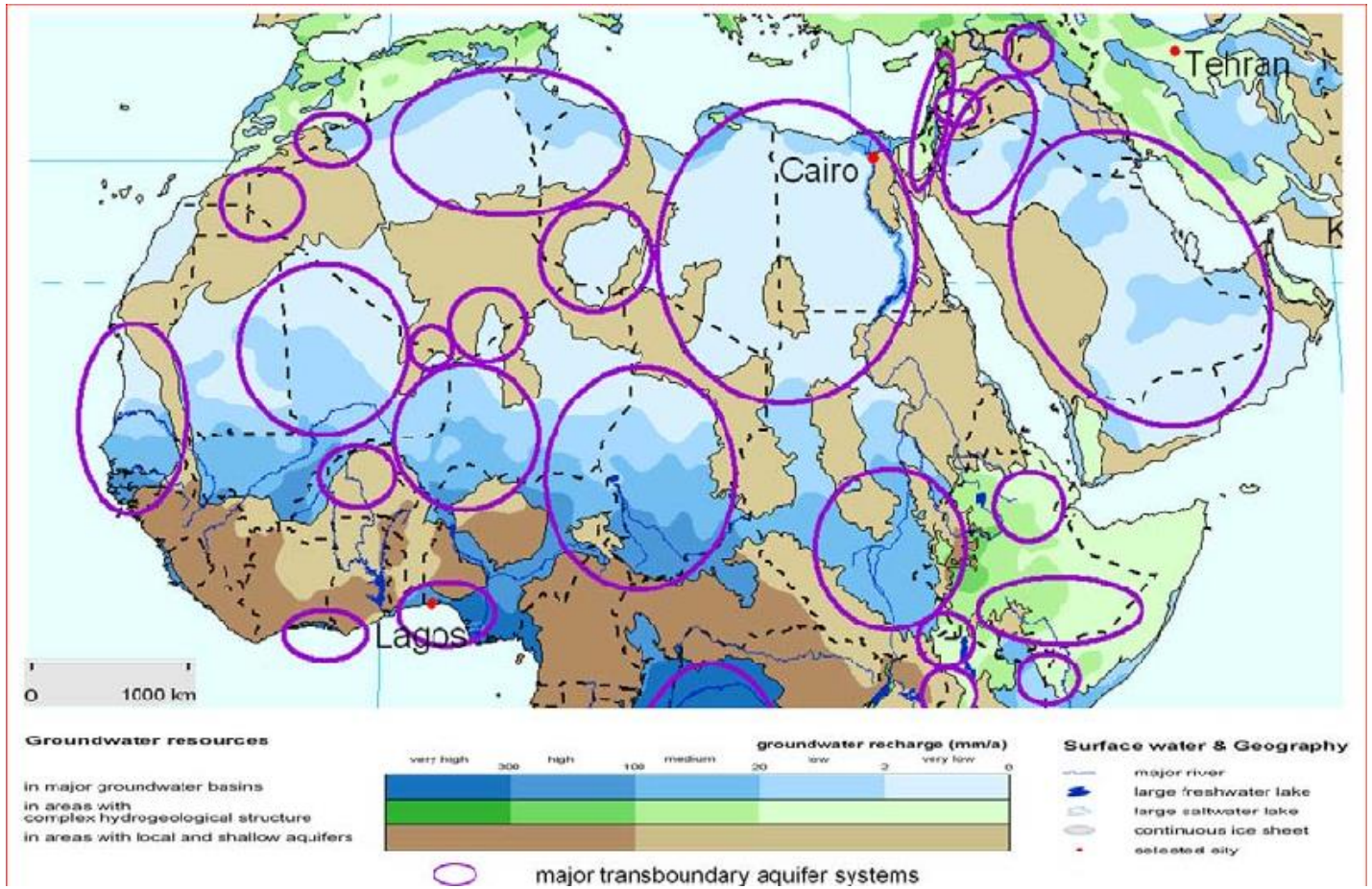


The Tigris Euphrates basin

The Tigris-Euphrates River basin



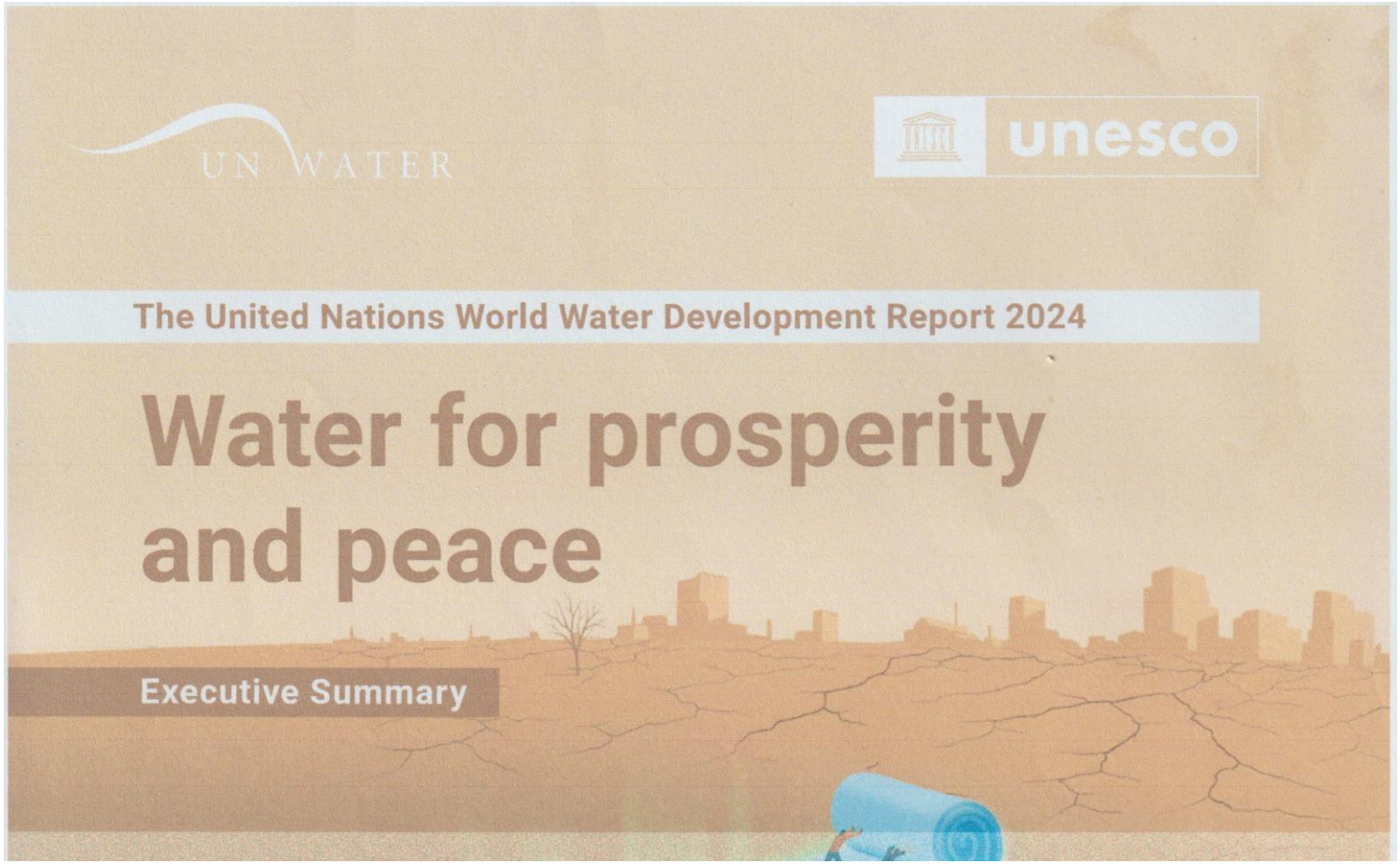
Groundwater map of the Arab Region



Looming Water Crisis



World Water Development Report 2024



Main Outcomes of the World Water Development Report (1)

- Freshwater use growing by about 1% per year.
- Agriculture (70%), Industry (20%), Domestic (10%).
- Half of world population experience scarcity.
- Quarter of world population faces extremely high level of water stress (uses 80% of their annual freshwater supply).
- Climate change is projected to intensify global water cycle, and to further increase the frequency of droughts and floods.
- None of SDG6 targets appears to be on track.
- As of 2022, 2.2 billion people without access to drinking water.



UN World Water Development Report 2024. Data and reference years follow the original presentation.

Main Outcomes of the World Water Development Report (2)

- 3.5 billion people lacking access to safely managed sanitation.
- Water deficits can be linked to 10% of the increase in migration worldwide.
- International water law has developed principles and norms that provide the basis for transboundary water cooperation and can help to solve disputes.
- Water Diplomacy seeks to facilitate the political processes and practices aimed at preventing, mitigating and resolving disputes over transboundary water resources.
- A large proportion of the world's freshwater resources are in transboundary aquifers.



UN World Water Development Report 2024. Data and reference years follow the original presentation.

Main Outcomes of the World Water Development Report (3)

Arab Region

- 19 of the 22 states are below the water scarcity threshold.
- 2/3 of the freshwater resources are transboundary, and 43 transboundary aquifers cover 58% of the region's area.
- Transboundary and x-sectoral cooperation is of crucial importance.
- Main challenges to cooperation lack of data (especially Groundwater)
- In 2021, 7 Arab Countries were in conflict with wide implication for water supply and infrastructure and political cooperation on water related issues.
- Cooperation has a key role to play in breaking through climate and conflict crisis to ensure safe and secure access to water and sanitation for all.



UN World Water Development Report 2024. Data and reference years follow the original presentation.

Main Outcomes of the World Water Development Report (4)

- Recent advances in science and technology benefits sustainable water management (Information & Communication Technologies; Remote Sensing, Sensor Equipment, Citizen Science, Big Data and Artificial Intelligence).
- Education and Capacity Development are key to addressing water challenges.
- The gap in skills and capacity is more pronounced on non-technological aspects (legal, policy, institutional & development).
- Theses skills are essential in transboundary river basins or conflict prone regions, where resolutions may require a process of negotiation and compromise.
- There is a need to make better use of existing sources of finance and to mobilize new capital, including greater international support for developing countries.



UN World Water Development Report 2024. Data and reference years follow the original presentation.

Arid Zone Hyrdrology:

Few wise considerations from

Prof. Howard Wheater

Motivation

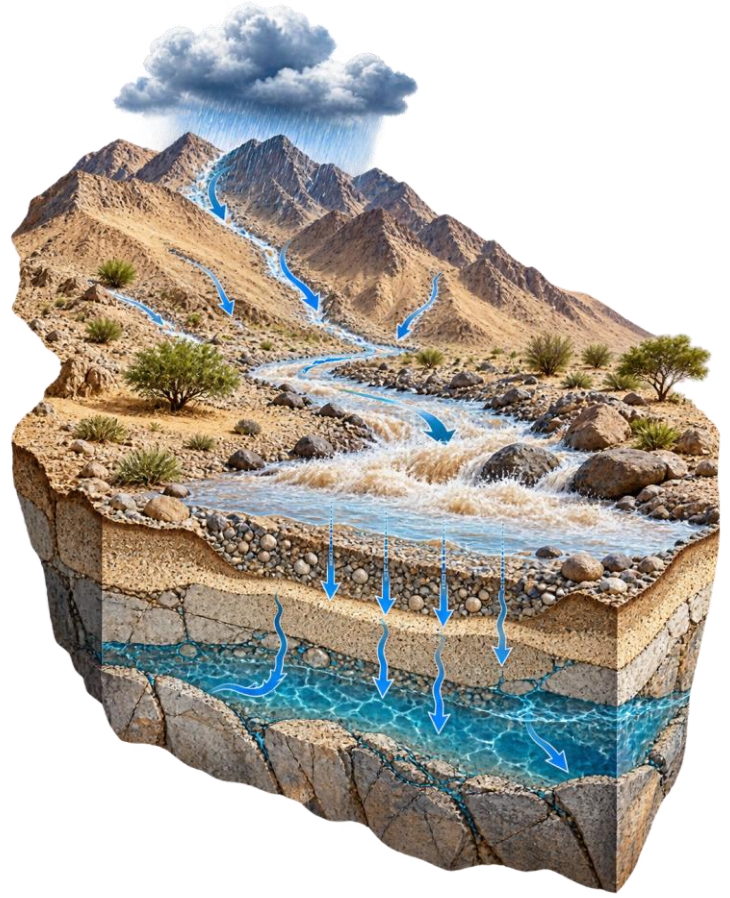
- The hot deserts of the world are, by definition, the regions where water is most scarce, yet they face rapid population growth, increasing pressures on water resources, and increasing threats from extreme events.
- Appropriate water management is crucial, yet arid regions have special hydrological characteristics and suffer problems of limited data and limited scientific understanding.
- Routine use of models for flood design, flood forecasting and water resources management continues to be challenging. Few models are specifically designed for arid areas, and there is limited research to inform model application.
- What are the future science and modelling needs and challenges?



Key science issues

The experimental basins were an invaluable contribution to regional knowledge, giving important data and process insights, e.g.:

- Spatial variability of precipitation is hard to characterize
- Overland flow is a dominant process – but effects of surface processes on infiltration are little studied
- Wadi flows are dynamic (and dangerous), reduce with distance downstream, and are unreliable indicators of upstream flows
- Transmission losses are dominant – but complex streambed processes are variable in space and time and poorly understood
- Groundwater recharge from ephemeral surface flows is a key water resource, yet is uncertain, depending on complex surface processes and heterogeneous subsurface properties



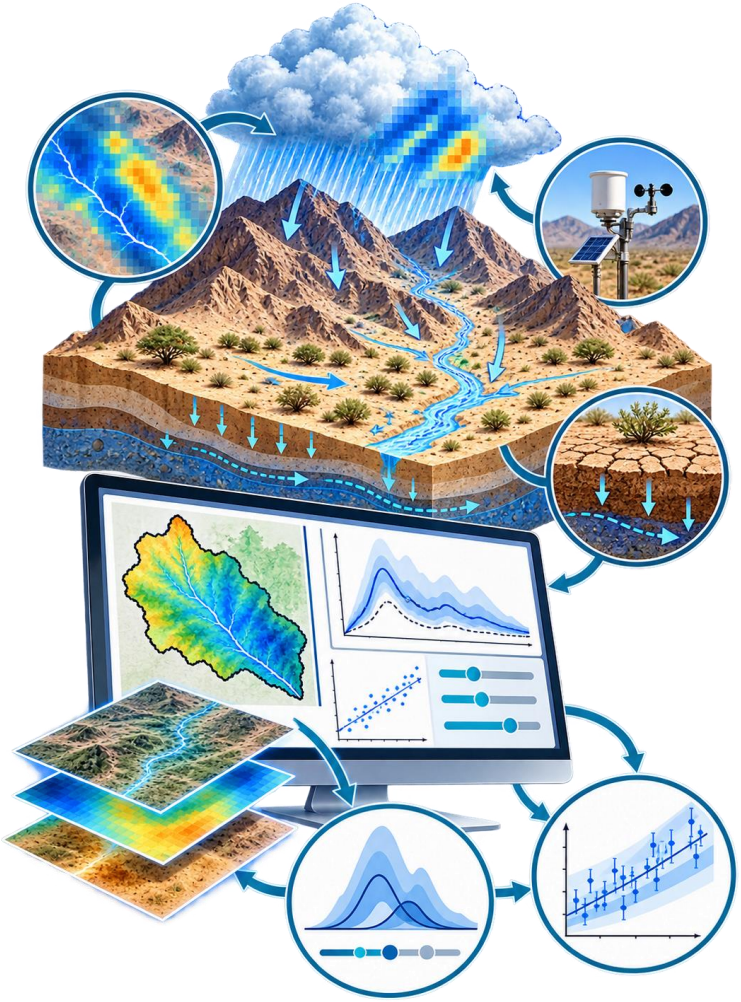
Conclusions - 1

- The need for improved science and appropriate training for arid areas has long been recognized. UNESCO’s arid zone water programme (GWADI, https://gwadi.org) was established in 2003, following an Arab Region initiative. GWADI has established successful regional networks, supports Centres of Excellence and maintains a web-site with data products and information.
- Despite decades of continued activity, major scientific challenges remain. Scarcity of data is a critical limitation, from routine monitoring networks and the intensive, focussed, multi-disciplinary experimental studies needed to unravel the scientific puzzles that remain. Such studies are resource intensive, may require many years (or decades) of support given the infrequency of major events, and fit poorly with established mechanisms for graduate training.



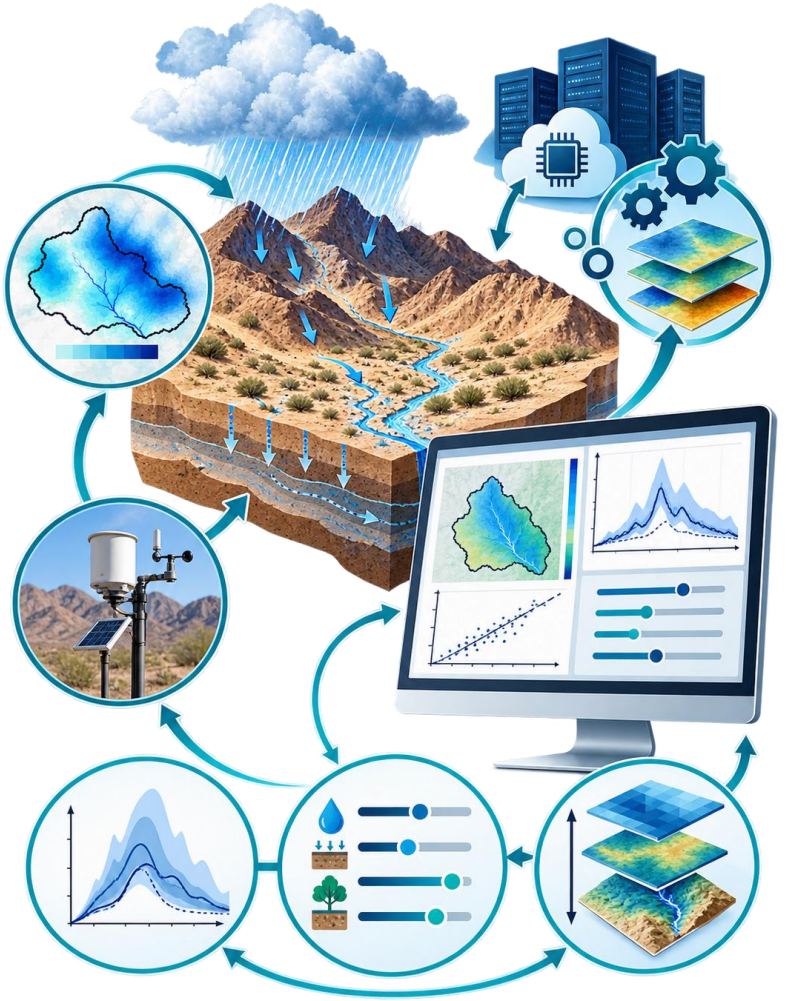
Conclusions - 3

- Over the last 20 years, increased computing power has led to new tools and new insights for model application, but for arid areas, their special characteristics, particularly rainfall spatial variability and transmission loss, add considerable complexity and challenge.
- Little methodological research has been published; commonly models developed elsewhere are used with limited data and critical assessment of their performance.
- The one model that has been designed for these arid areas and quite widely used is the USDA Kineros model.
- More experience is needed of the parameter values needed by physics-based hydrological models, their relationship to catchment characteristics, their scale dependence, their uncertainty and associated model sensitivity.
- And for conceptual models, there is a need to develop local experience of appropriate parameter values.



Conclusions - 4

- Representation of rainfall is a key issue, in particular the definition of uncertainty in precipitation inputs to hydrological models.
- Radar is an exciting possibility to provide spatial rainfall data and is increasingly being deployed for rainfall measurement in arid areas, but high spatial resolution is needed. High resolution atmospheric modelling also offers potential.
- Given inevitable data limitations, for long-term simulation rainfall is probably best handled using stochastic models to generate rainfall sequences that represent spatial and temporal variability. However, modern tools have not been tested for arid areas and all methods need detailed data sets for their development and calibration.



Conclusions - 5

Given the challenges for water management in arid areas, improved science and hydrological modelling are essential. Much work is still needed to build experience to support model applications in arid areas.

This requires:

- dedication to the provision of good quality data
- awareness of the potential of new modelling tools
- the development of a core of expertise at local and regional level
- willingness to share knowledge and experience within and between the world's arid regions.



Opportunities

- Efficient water use
- Non-conventional water
- Demand management



AI applications in the water sector

Flood and drought forecasting

Earlier warnings from rainfall and river observations.

Water supply and distribution

Demand forecasting and network anomaly detection.

Agriculture and irrigation

Irrigation scheduling using weather and field data.

Water quality and wastewater

Anomaly detection and support for treatment.

Groundwater and planning

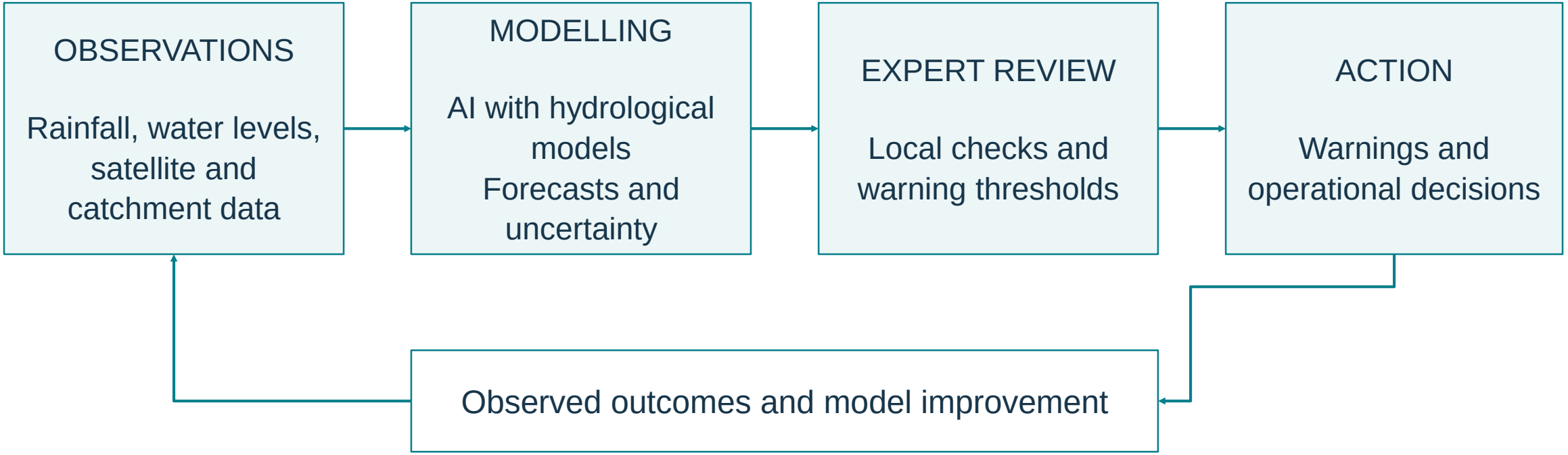
Monitoring patterns and management scenarios.



Conceptual illustration. Applications depend on local data and validation.

AI decision workflow

Illustrative flood-warning workflow for an arid catchment



Conceptual workflow. Local calibration and human judgement support each decision.

Implementation needs in the Arab Region

01 **Reliable observations**

Monitoring, quality control and agreed data sharing.

02 **Local validation**

Test models for arid catchments, transmission losses and rare extremes.

03 **Accountable decisions**

Explain uncertainty. Water professionals retain responsibility for decisions.

04 **Capacity development**

Combine hydrological expertise with data and AI skills.

Machine learning

Prediction and operational analysis

Generative AI

Drafts and explanations for expert checking

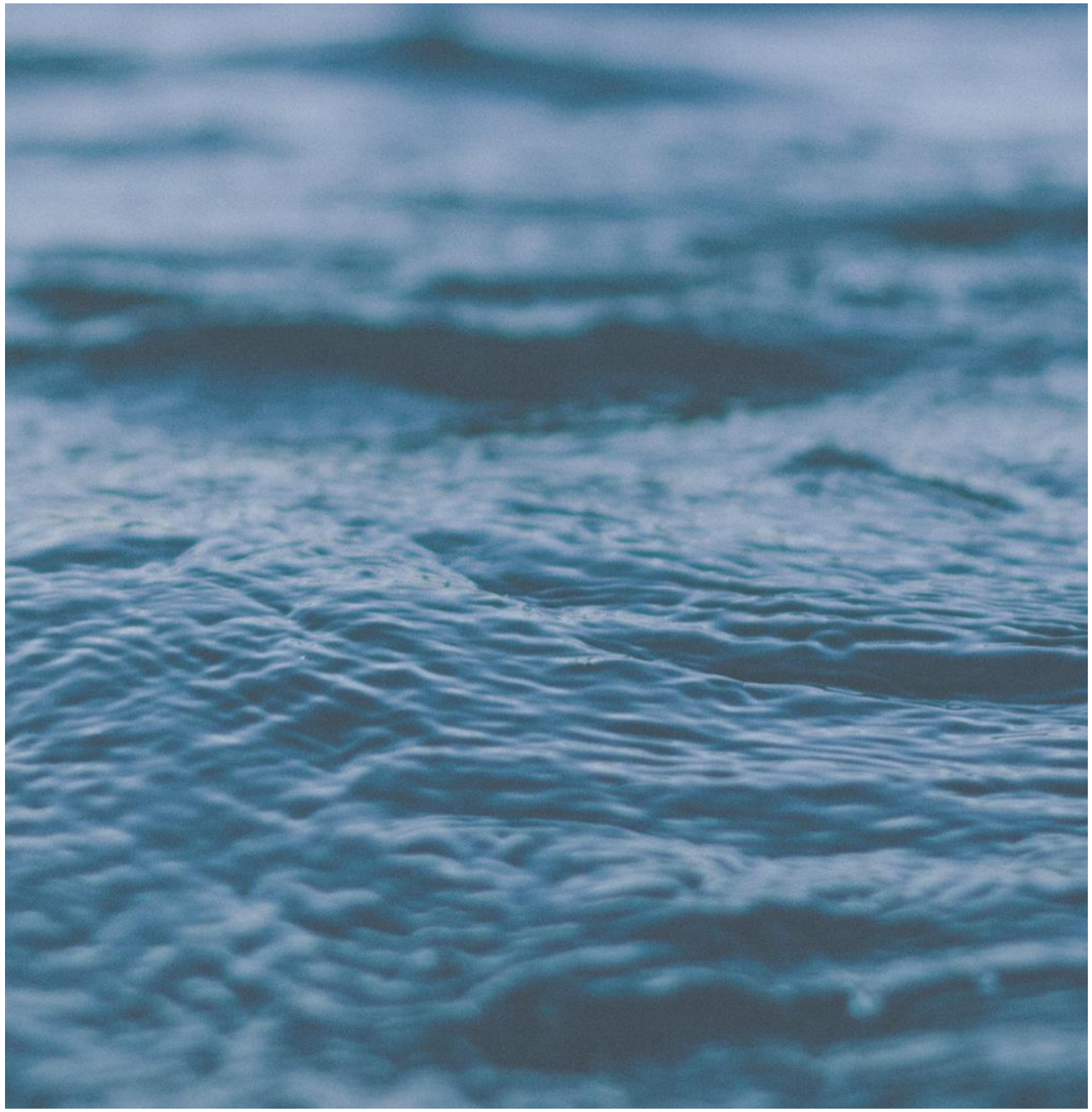
المجلس العربي للمياه

Arab Water Council

The Arab Water Council

An Overview

2026



Mission of the Arab Water Council



The Arab Water Council endeavors to:

- Promote better understanding and management of the water resources in the Arab States in a multi-disciplinary, professional and scientific manner;
- To disseminate knowledge, enhance sharing of experience and information for the rational and comprehensive water resources development of the region for the benefits of its inhabitants.

Objectives of the Arab Water Council

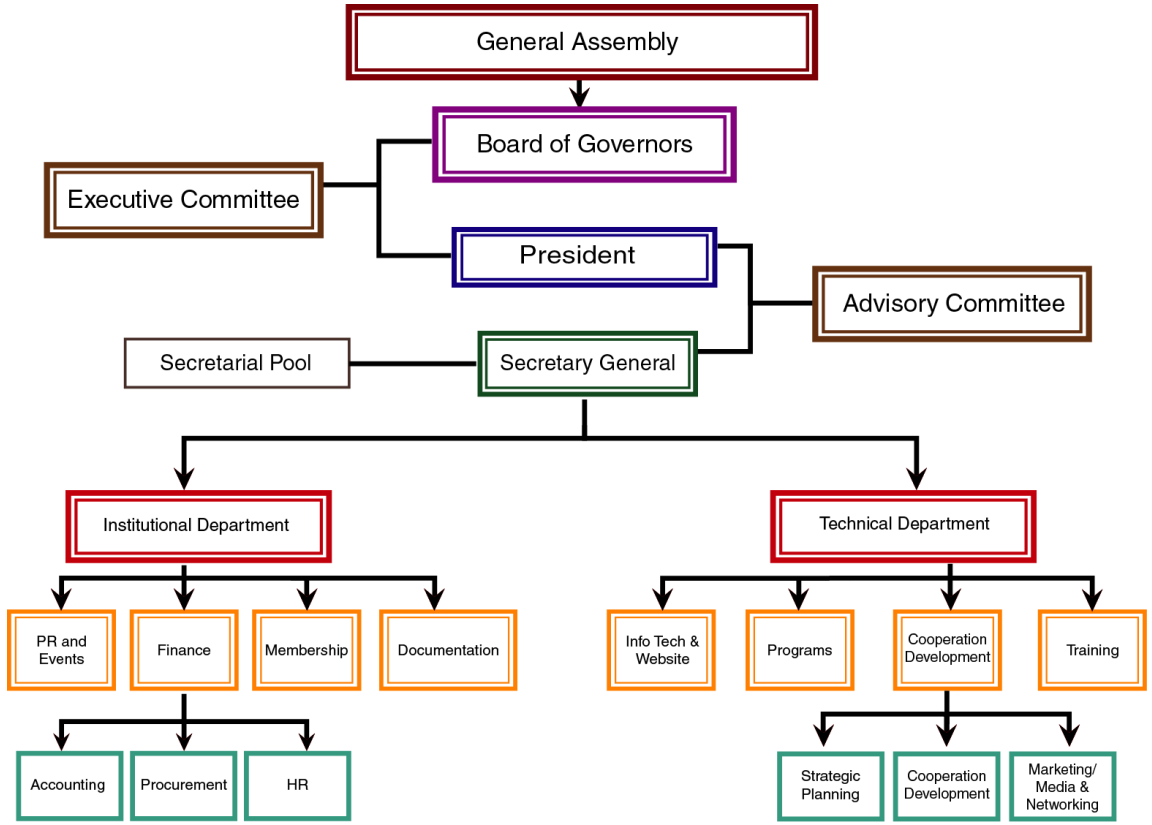
Established 2004

- Shape a strong Arab voice to face the regional challenges and requirements for achieving water security and the Sustainable Development Goals (SDGs).
- Develop regional strategies and providing policy directions.
- Build human and institutional capacities in water- related issues.
- Initiate and strengthen regional and international cooperation and partnerships to tackle water-related challenges, for SDGs agenda 2030.
- Coordinate efforts to incorporate Integrated Water Resources Management, promote sustainable solutions for shared water resources, tackle climate change impacts on water resources and promote Water/Energy/ Food Nexus (WEF).
- Build capacities and disseminate knowledge as well as enhance sharing of experiences and success stories.

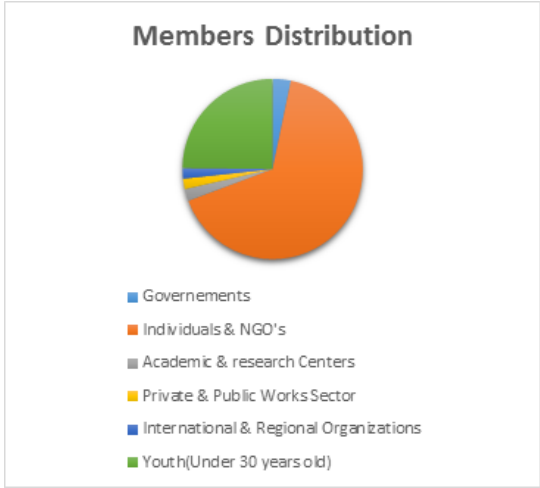


AWC organisational structure and membership

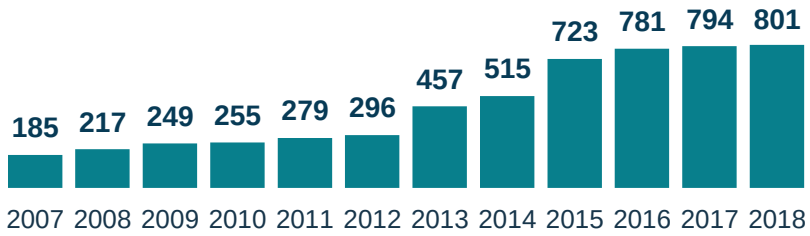
AWC organizational structure



Members distribution



Growth of AWC members, 2007–2018



AWC Thematic Networks



Arab Network for non conventional Water Resources

Arab Women's Water Network

The Arab Children and Youth Network



The Regional Climate Security Network

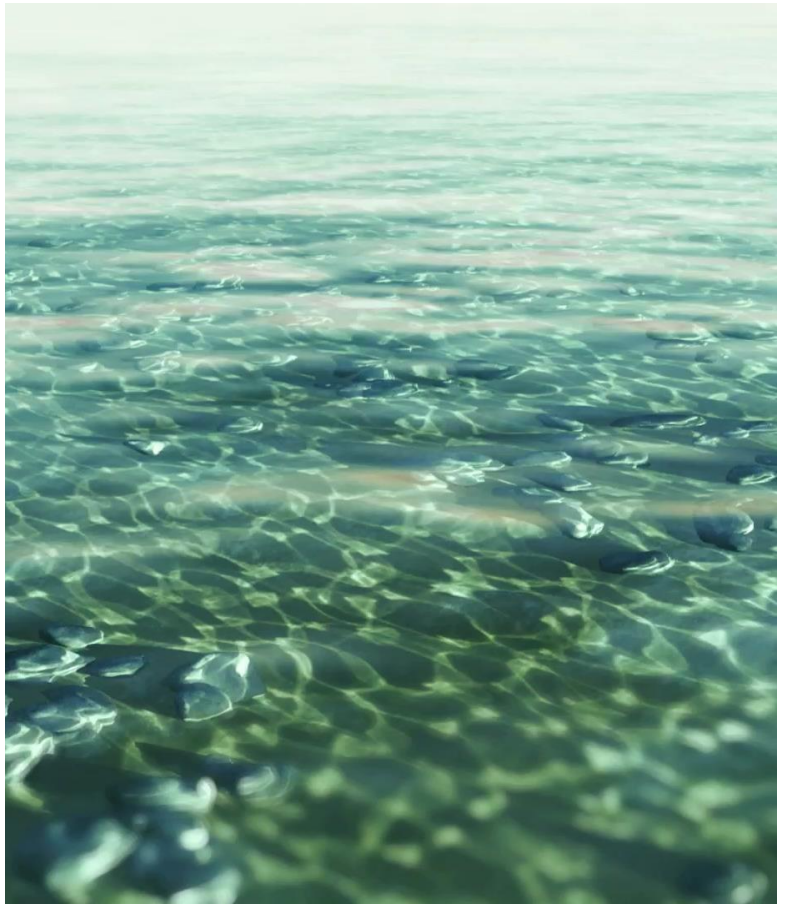
- Establishment of databases (experts, institutions, companies, ...)
- Issuance of publications and periodicals
- Training programs and seminars
- A renewed encyclopedia and electronic libraries

The Arab Water Academy

Established by the Arab Water Council in 2008.

Mission include the followings:

- Enhance skills, knowledge, and tools to develop future water strategies and policies based on integrated thinking across sectors.
- Support active implementation of the learning beyond the Academy by assisting the participants in any moves to develop their enabling environments, institutional frameworks, promote policies, and organizational capacity.



AWA Objectives and Programs

The Academy focuses on training senior and mid-level leaders, preparing future leaders, providing technical and advisory support, and implementing regional and national programs in the following areas:

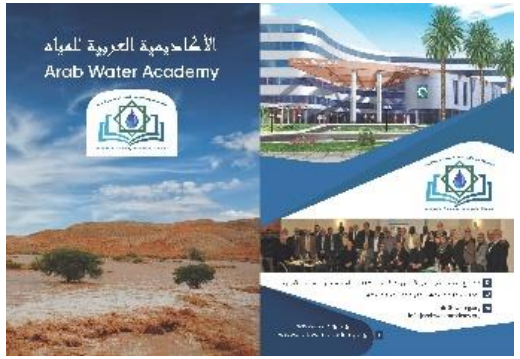
- Water Diplomacy for Transboundary Water Resources Management
- Water, Food, Energy, and Ecosystem Security Nexus
- Integrated Water Resources Management and Governance
- Maximizing the utilization of groundwater in the Arab region
- Non-Conventional Water Resources
- Adapting to the Impacts of Climate Change on the Water Sector
- Crisis and Disaster Management in the Water Sector
- Smart and Technological Management of Water Resources
- Water Production Efficiency and Economic Evaluation of its Uses
- State of the Water Assessment
- Raising Awareness to Address Challenges in the Water Sector
- Artificial Intelligence for Water Resources Management
- Applied Hydrology to Address Water Scarcity in Arid and Semi-Arid Regions
- Water Supply and Sanitation
- Preparing Mid-level and future leaders, as well as youth in the Arab Region, for the Labor Market in the Water Sector.

Arab Water Academy (AWA) and Arab Water Council (AWC)

Established 2008

Objectives

- To develop and provide capacity development programs for leaders, senior professionals , policy-makers and future leaders from the public and private sectors
- To provide technical training services to executive leaders in managing change & reform at organizational, sector and national levels
- To provide a continuous learning environment for alumni and other young professionals in areas of strategic importance in the Arab Region.









AWA activities on artificial intelligence

3 AI webinars Delivered

- Remote Sensing: AI, Open Platforms & Efficient Tools for Water-Resource Intelligence
- “Artificial Intelligent – Driven Discovery and Modeling of Hydrometeorological Extremes”
- “The Role of Remote Sensing (RS) in the Water Sector, by FutureWater-Netherlands”

1 AI training course

- AI for Water, ResourcesManagers:FromData to Decision Applying Generative AI (ChatGPT & DeepSeek) for Smart Water Management

Postponed, Delivery still pending

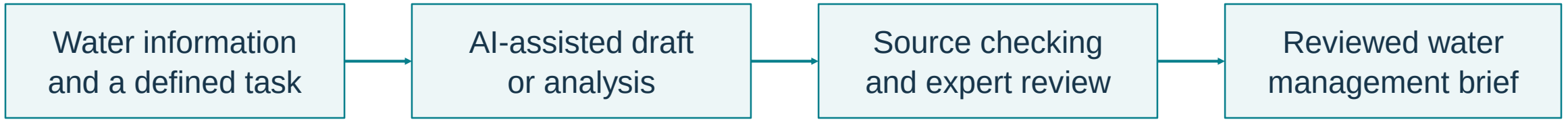


AWA planned AI training course

Postponed. Yet to be delivered.

Proposed practical focus for water resources managers

- Use generative AI to organise water information and draft technical briefs.
- Explore management scenarios and communicate their assumptions.
- Check outputs against reliable sources and professional judgement.



Proposed learning workflow. A revised delivery date is to be confirmed.

“Anybody who can solve the problems of water will be worthy of two Nobel Prizes, one for peace and one for science”

President J. F. Kennedy



Thank You