Dams, do we need them?
Their Pros, Cons, Safety, and Impact
An Introduction to the Main Issues

Prof. Dr. Ragab Ragab,

Fellow, UK Centre for Ecology and Hydrology, UK CEH

rag@ceh.ac.uk

President, International Commission on Irrigation and Drainage, ICID

ragab@icid.org

International Conference on Hydropower and Dams Development for Water and Energy Security – Under Changing Climate on 7-9th April 2022 at Rishikesh, India

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Words of welcome to the participants of International Conference on Hydropower and Dams Development for Water and Energy Security Under Changing Climate Rishikesh, India

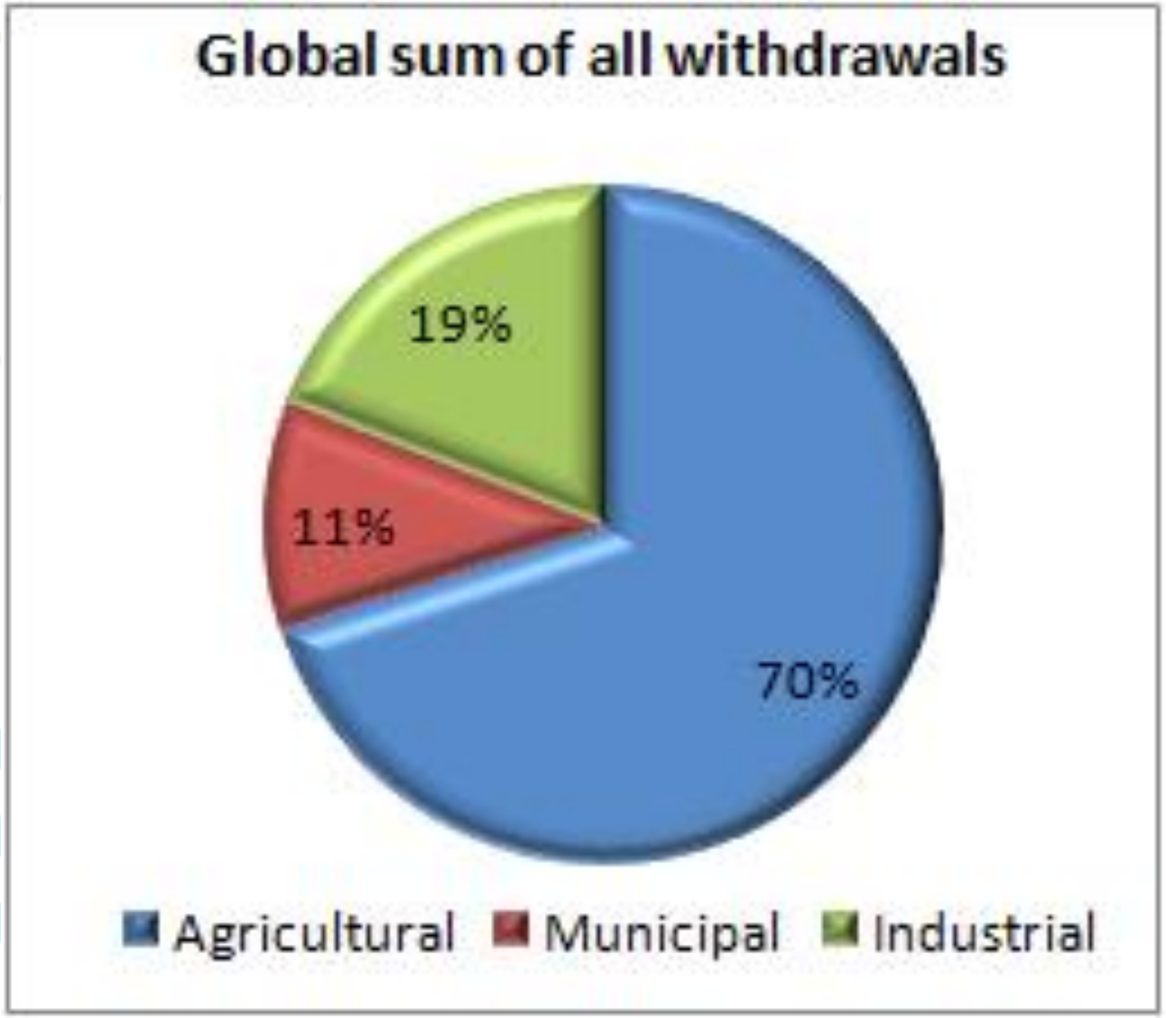
Good morning & Good afternoon Excellences, Distinguished Guests, Dignitaries, friends, colleagues, professionals, practitioners and the Large Dams community. I am honoured to be invited to address your conference on behalf of the International Commission on Irrigation and Drainage, ICID.

ICID interest in Dams and Reservoirs

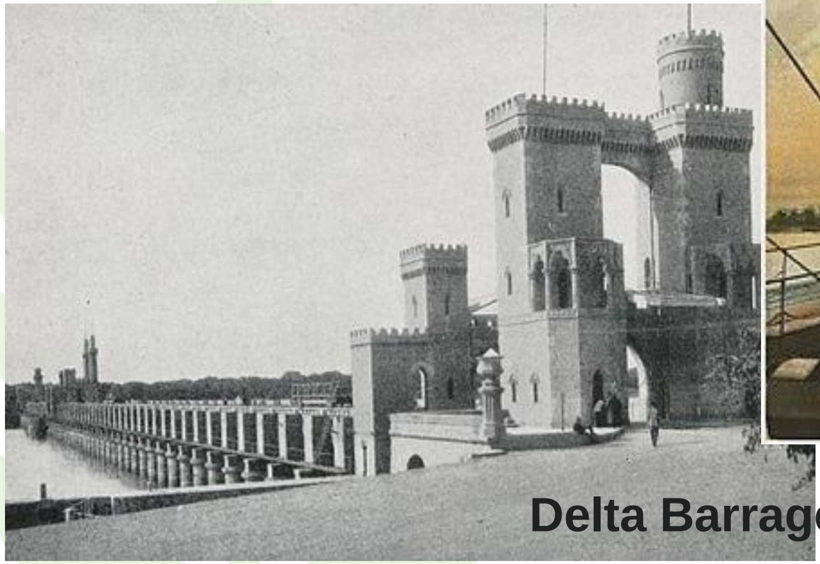
ICID has a register of Historical Water Structures including dams & reservoirs and has interest in dams and reservoirs as they provide:

- **Steady water supply for drinking and irrigation all over the year.**
- **Protection against extreme events such as Flood.**
- **Guarantee steady water supply during extreme events of droughts.**
- **Hydropower for irrigation systems, abstraction pumps, dairy farming and agricultural production in general.**
- **Fish, wildlife and natural healthy and rich habitat.**
- **Steady flow for the whole year enabling us to apply integrated water management.**

Dams ad Reservoirs are of great importance to ICID as Irrigation consumes 70% of Global Fresh Water Resources.

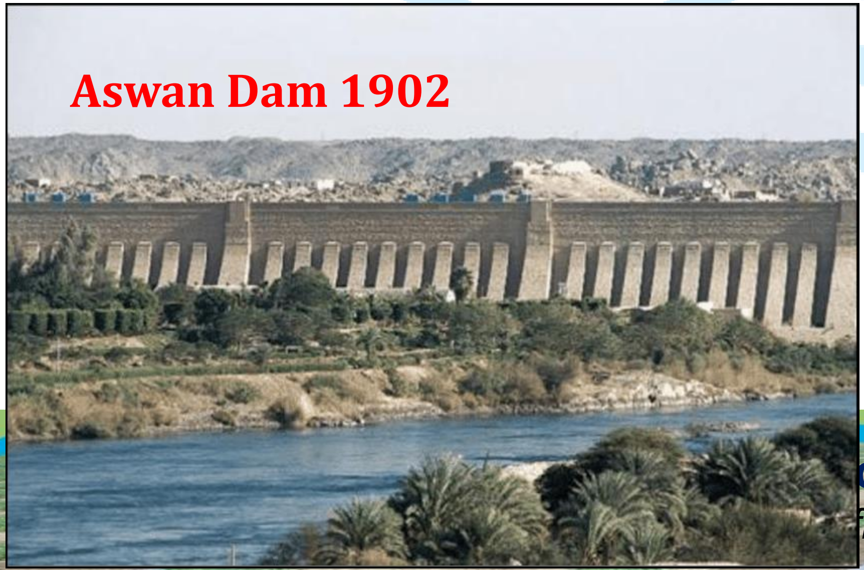


Sadd el-Kafara, 2700 - 2600 BC

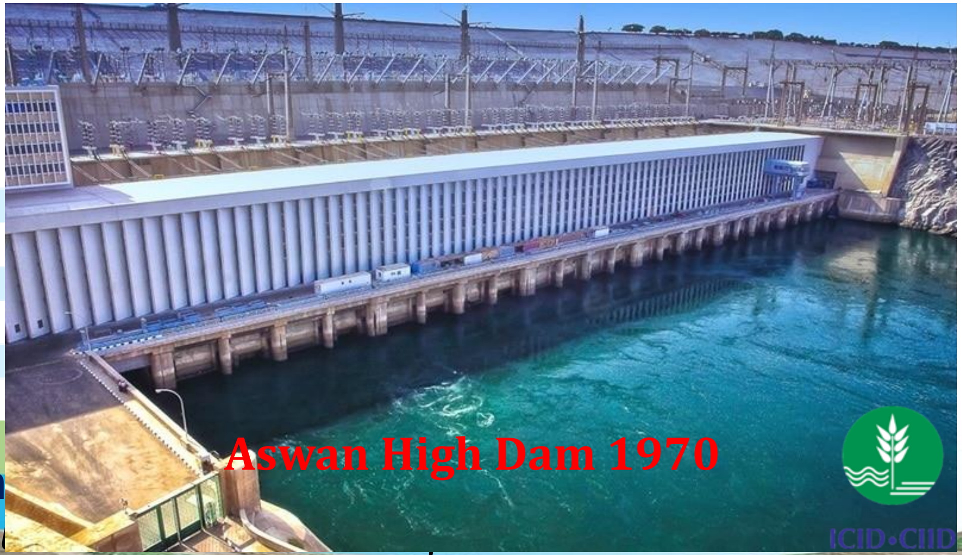


Delta Barrage Dam 1862

Time in History: Dams Development in Egypt


Aswan Dam 1902

For thousands of years dams were built by early civilizations & have ensured adequate supply by storing water in times of surplus (high flows and flood) and releasing it in times of scarcity, thus also preventing or mitigating floods


Aswan High Dam 1970

Time in History

Japan's WHIS

Mannou-ike Reservoir 701

Kumedaike Reservoir 738

Gorobe Irrigation Canal 1631

Irukaike Reservoir 1633

Asuwagawa Irrigation Canal 1710

Asakasosui Irrigation System 1882

The current challenges

By 2050, world population is expected to increase from 6 to 9 billion, subsequently:

1. The food demand is expected to increase by 100% requiring more irrigation water (globally, on average, irrigation consumes 70% of fresh water resources).
2. Water consumption is expected to increase by 50%.
3. Increase global energy demand by 30-40% (irrigation requires energy).
4. Climate change predicted increased & reduced rainfall in different parts of the world, subsequently, reduced runoff, river flow and groundwater recharge.
5. The future climate change predicts more frequent extreme events of flood and drought. Irrigation requires a steady water supply throughout the year.
6. Currently, there is an increasing gap between water demand and supply. By 2030, a 40% overall gap between global water supply and demand is expected.

Do We Need More Dams and Reservoirs to Meet the Challenges?

To answer this question, we need to ask ourselves:

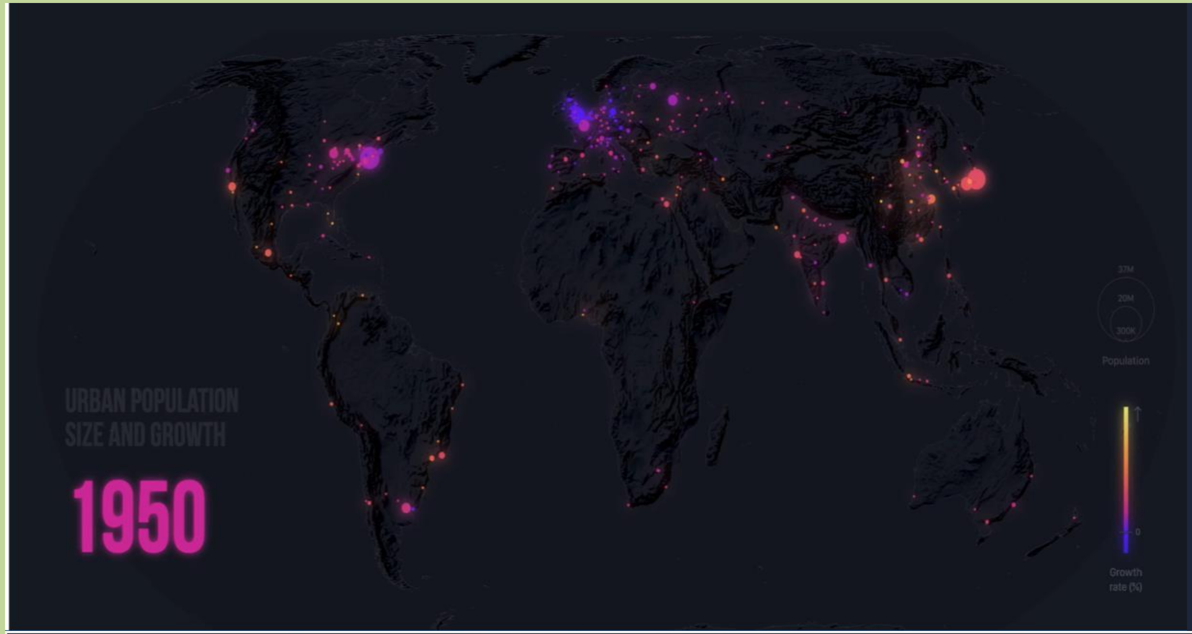
- **Do we have adequate water supply to meet the demand now and in the future without extra Dams and Reservoirs?**
- **Can we cope with the climate change extreme events of flood and drought now and in the future without more Dams and Reservoirs?**
- **Can we meet the energy demand now and in the future without extra Dams and Reservoirs?**

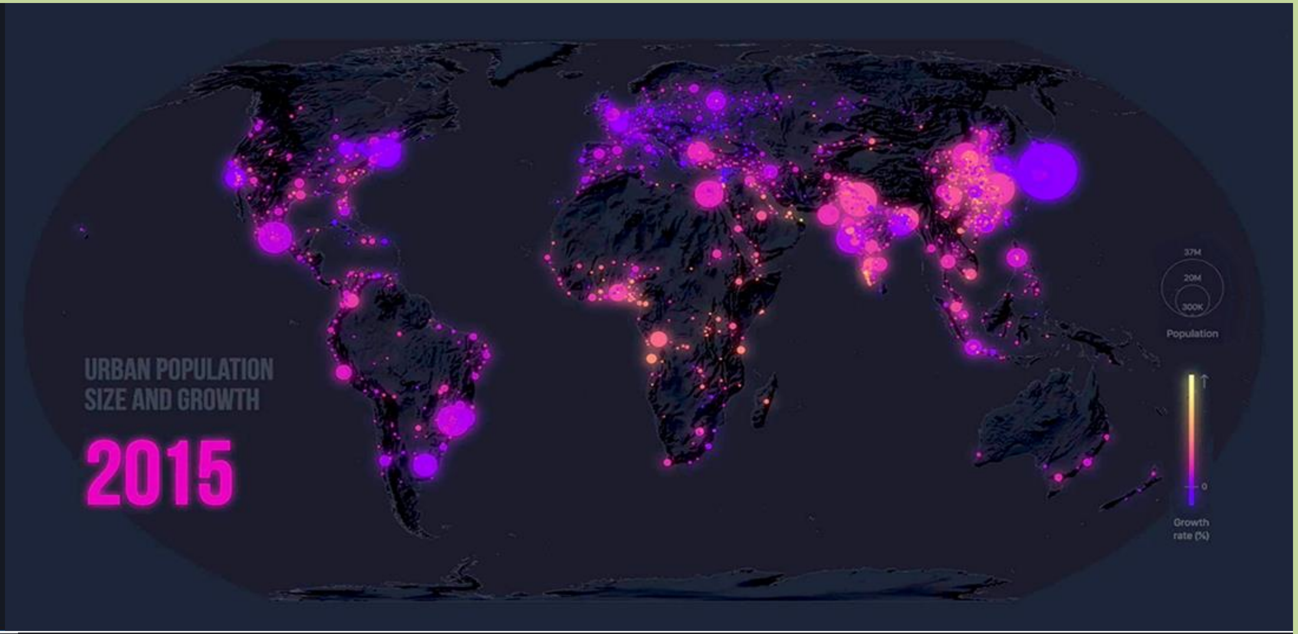
Before answering those questions, let us have a look at the impact of population increase, climate change & others on water resources.

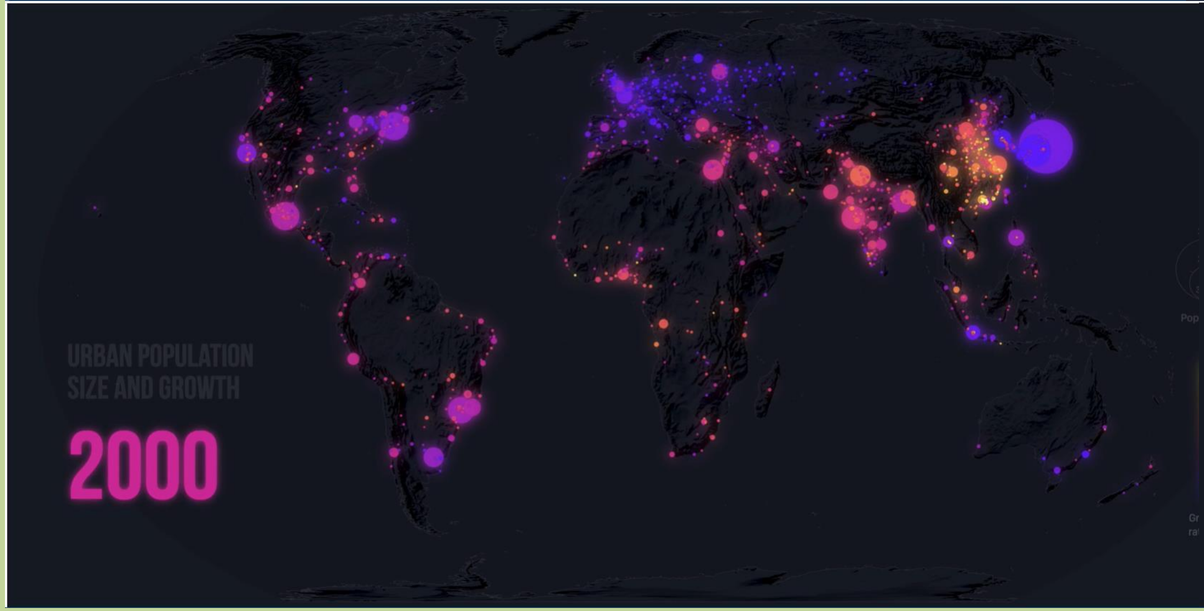
Population Increase Impact On Water Supply and Demand

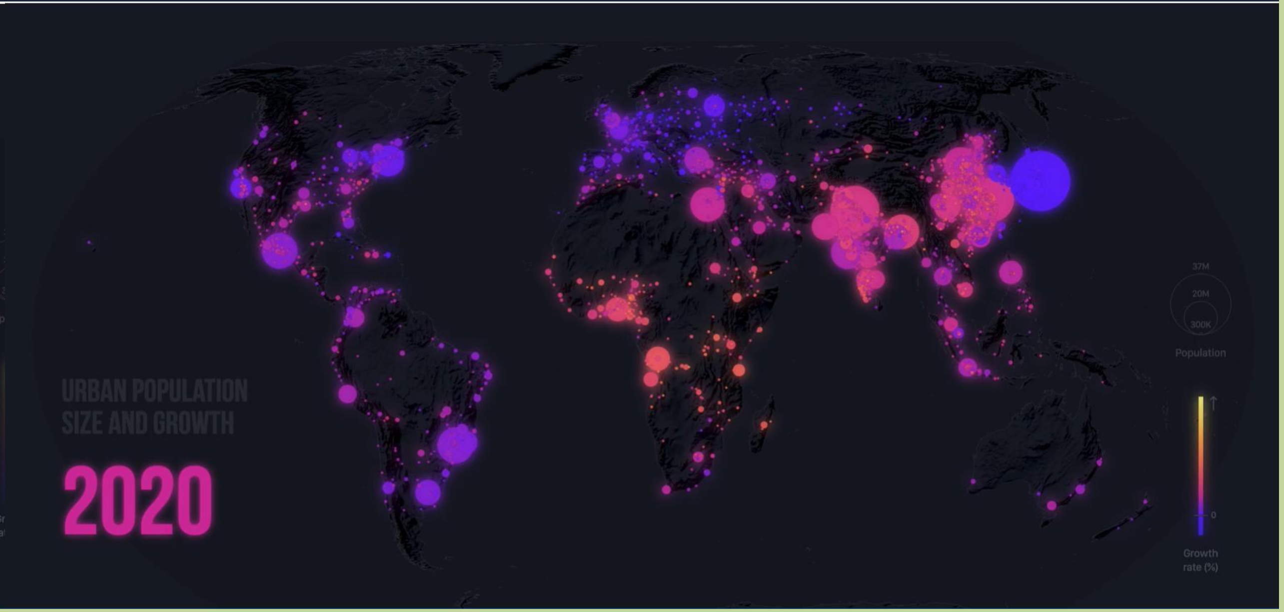
Urban Population increase

https://www.visualcapitalist.com/map-global-rise-of-urbanization/



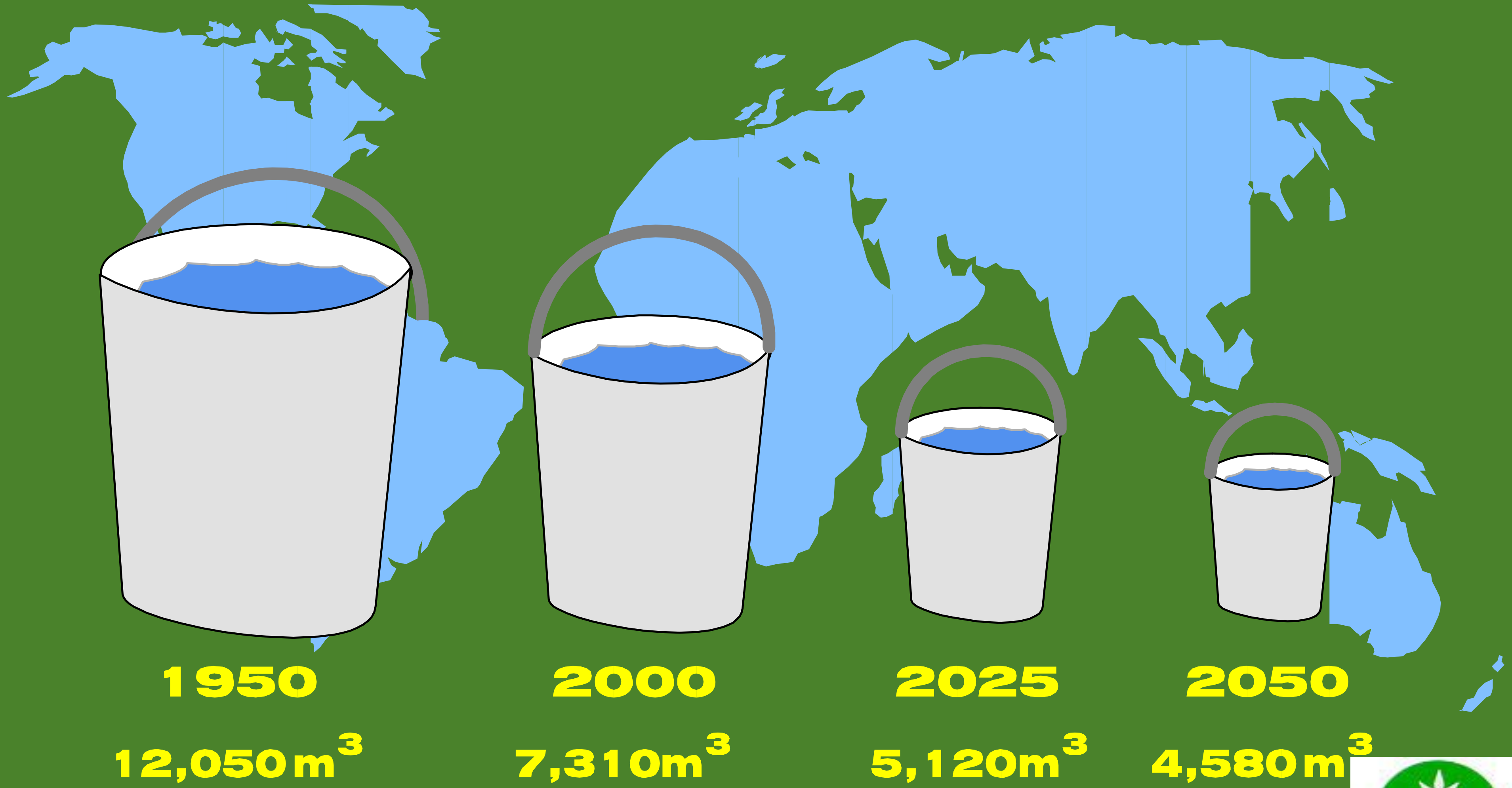






Freshwater Availability Per Capita 1950 - 2050

When water supplies drop below 1,000 cubic metres per person per year, the country faces "water scarcity".



Increasing population in the next 50 years combined with increased consumption will greatly stress water availability.

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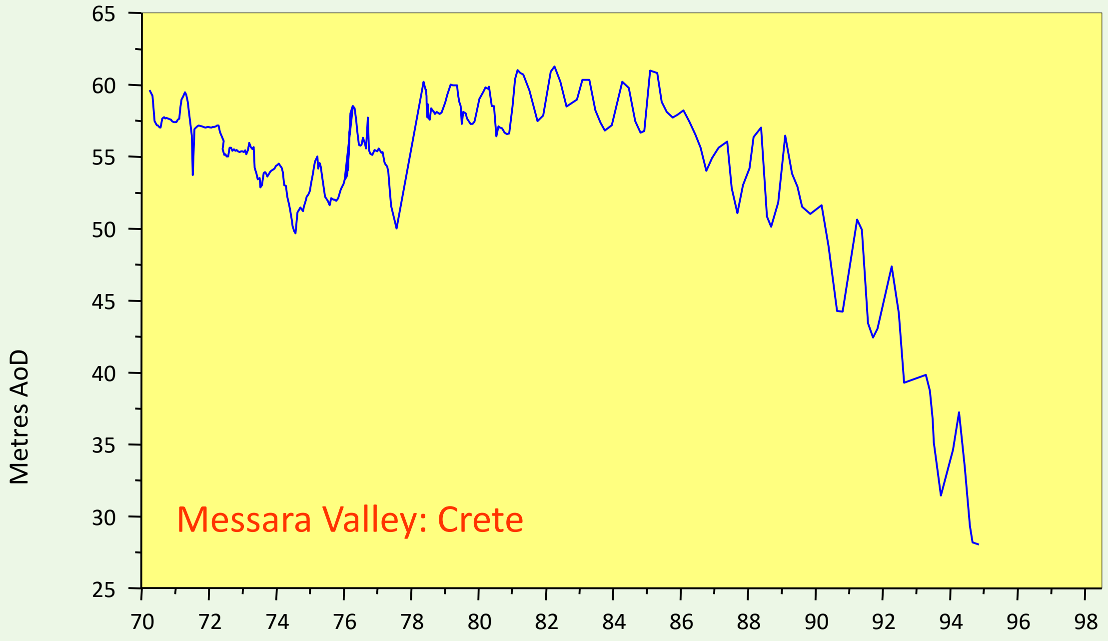
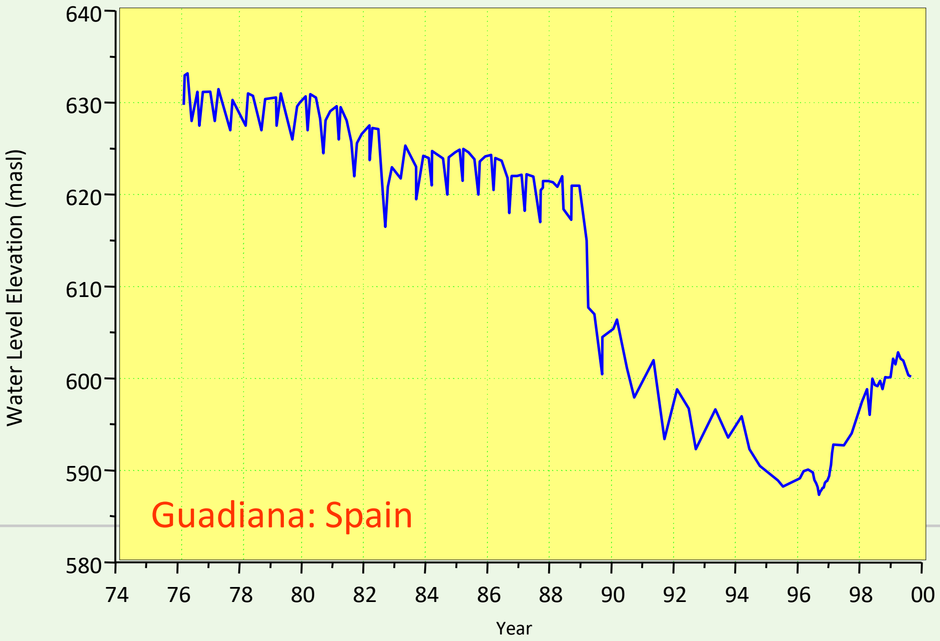
Over Exploitation of Groundwater

Need to better estimate the groundwater resources and its renewability to avoid over exploitation.

1-2m/year drop
in GW level





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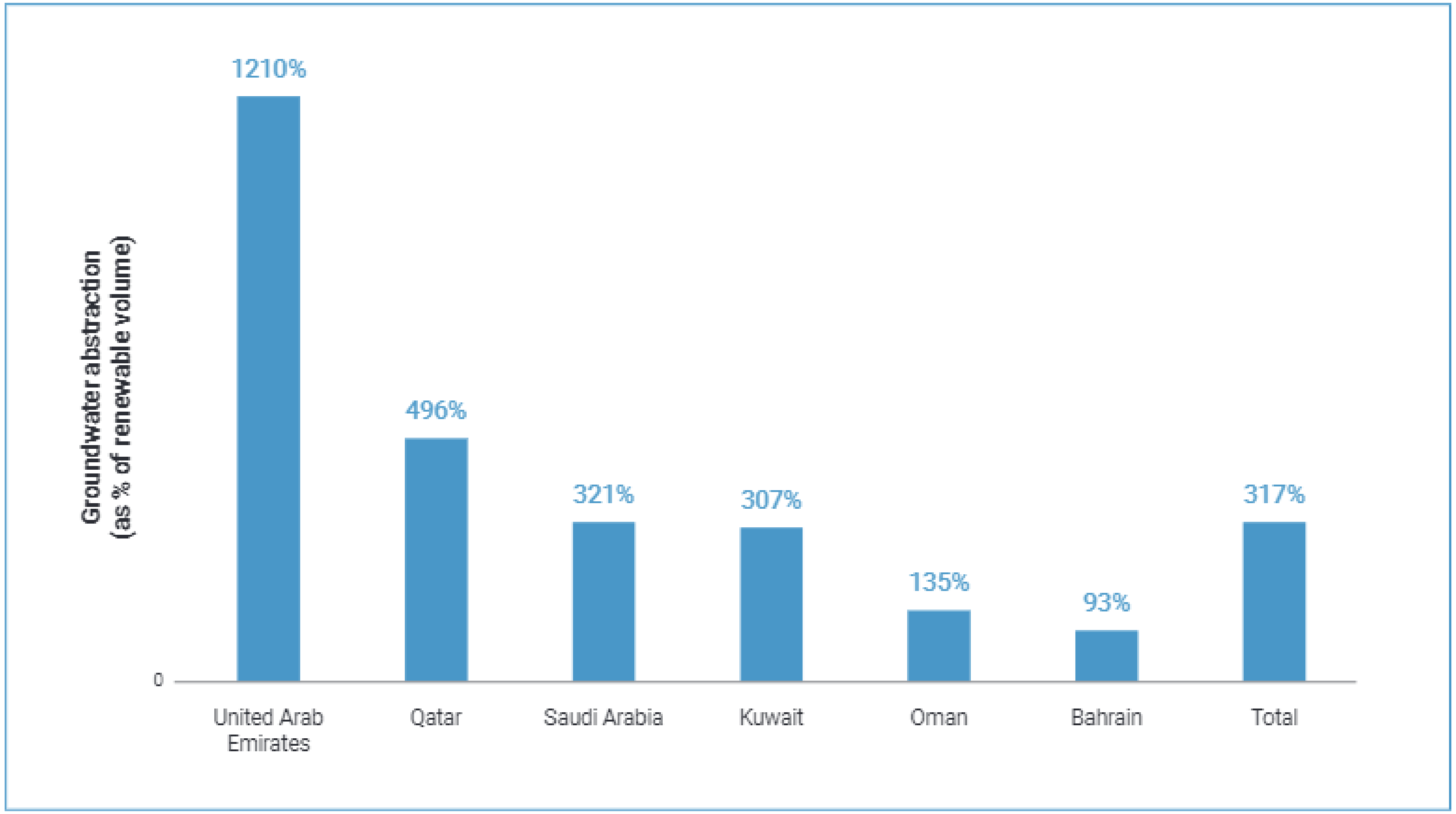
project

Groundwater over-abstraction

Figure 8.3

Over-abstraction of groundwater resources in the Gulf Cooperation Council States



Source: Based on data from Al-Zubari et al. (2017, Table 2, p. 3).

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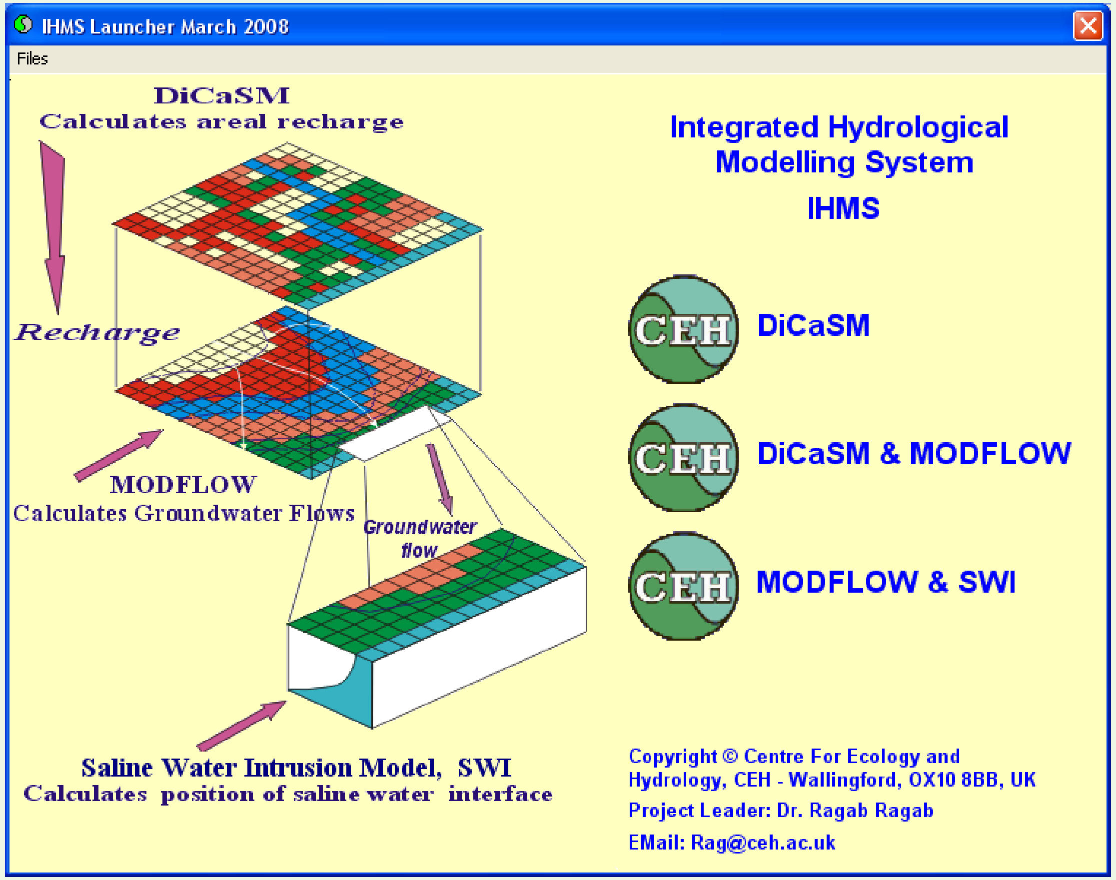
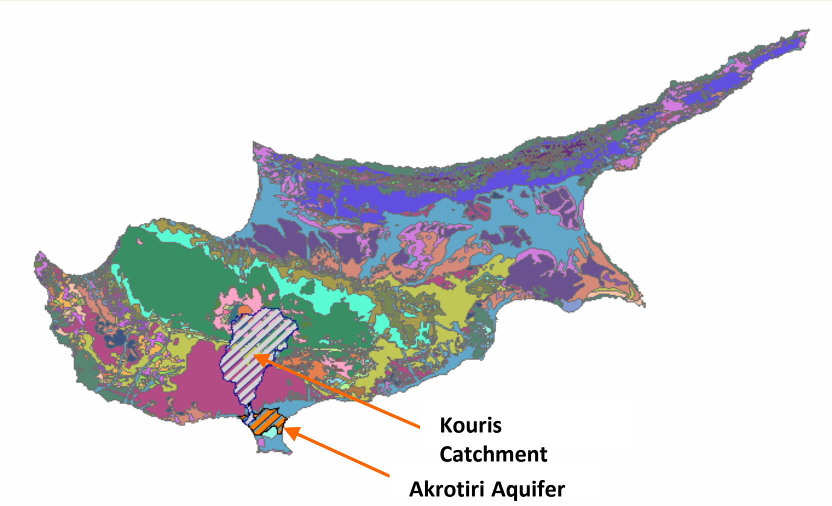
Climate Change Impact On Water Supply and Demand





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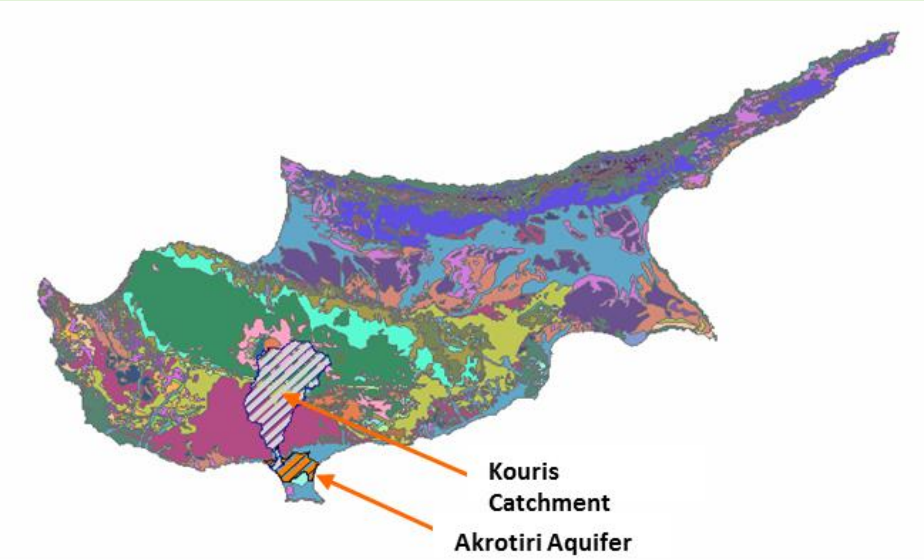
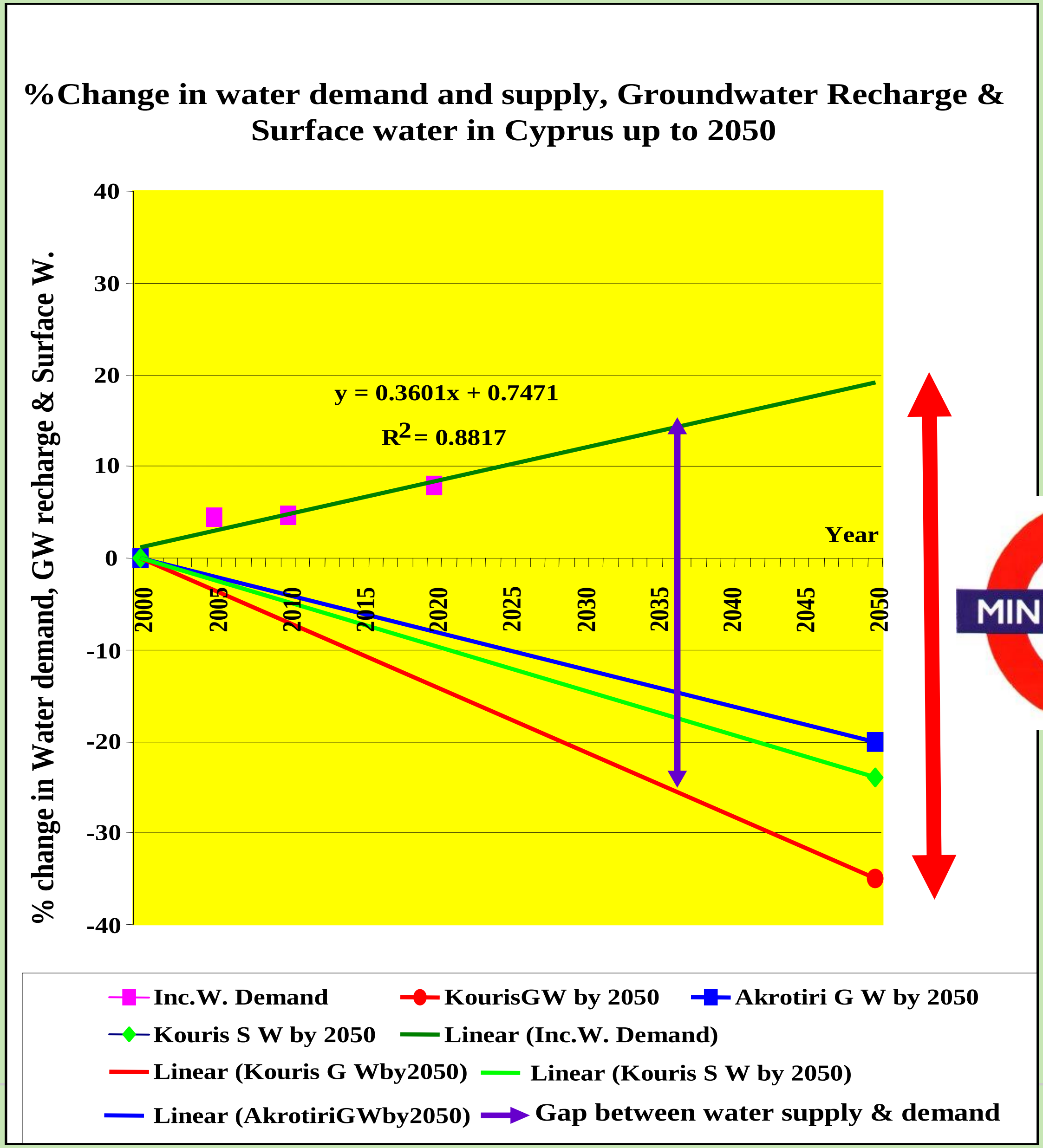


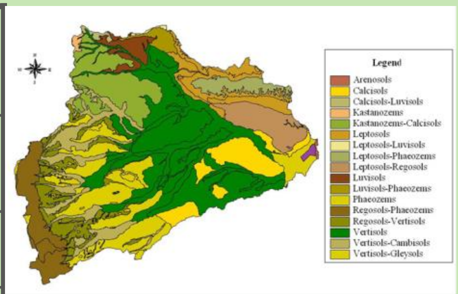
Ragab et al. 2010

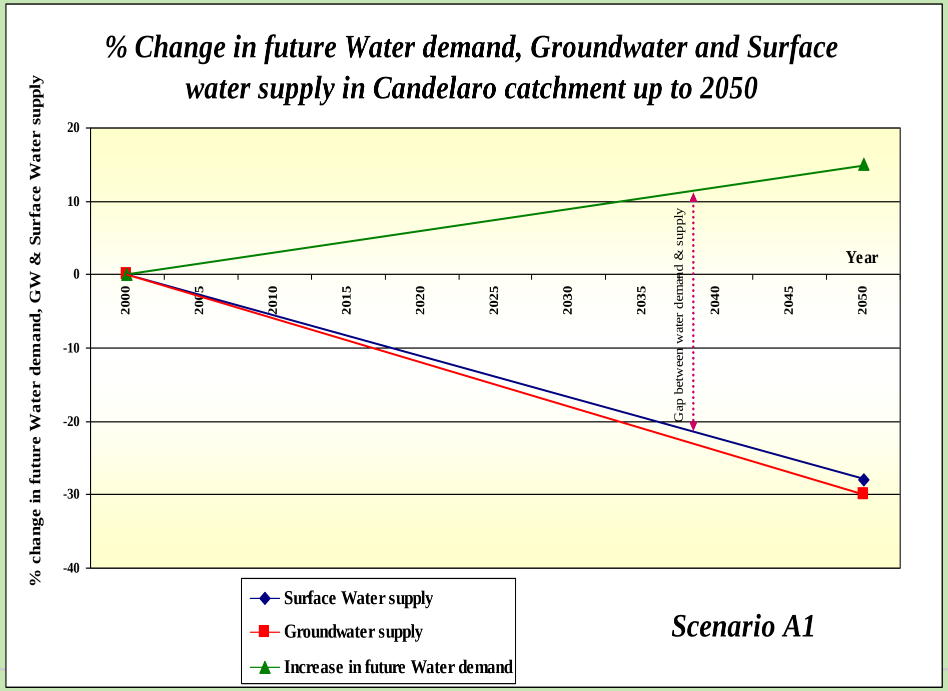


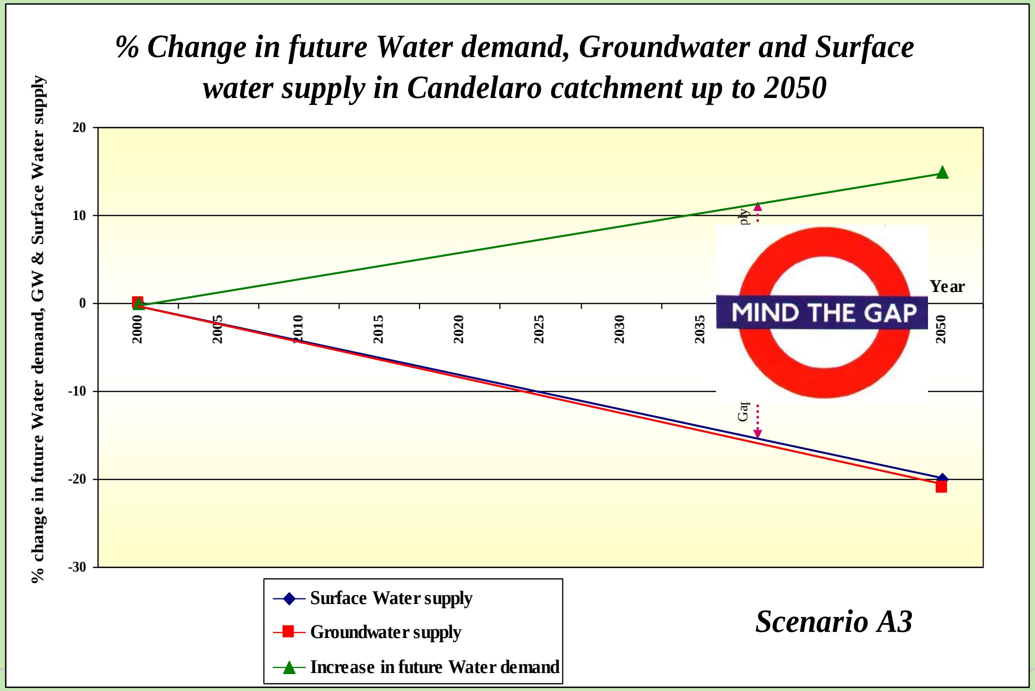
The future gap between water supply and demand in Candelaro catchment, Italy.

Scenario A1	Factors	% variation
	Future Water demand	+ 15%
	Groundwater supply	- 30%
	Surface water supply	- 28%

Scenario A3	Factors	% variation
	Future Water demand	+ 15%
	Groundwater supply	- 21%
	Surface water supply	- 20%







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Scenario A1

Scenario A3

Daniela R. D'Agostino et al. 2010

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Case-study Catchments

Key climatic and drought experience gradients (south-north/ west-east)

Rural/urban/peri-urban

Wide-ranging stakeholder representation

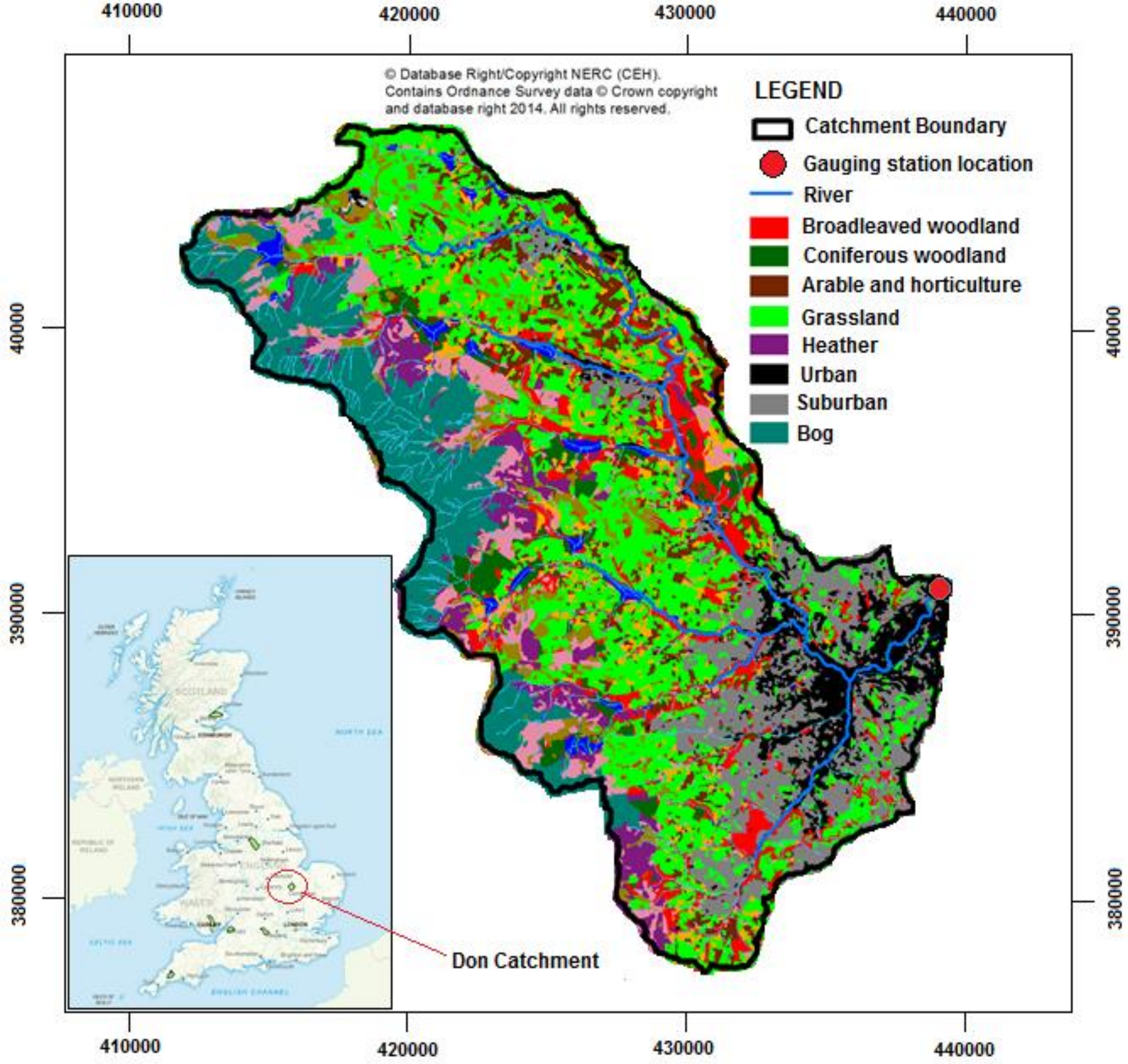
Wales/Scotland/English governance represented

Fowey catchment as a Pilot for narrative enquiry

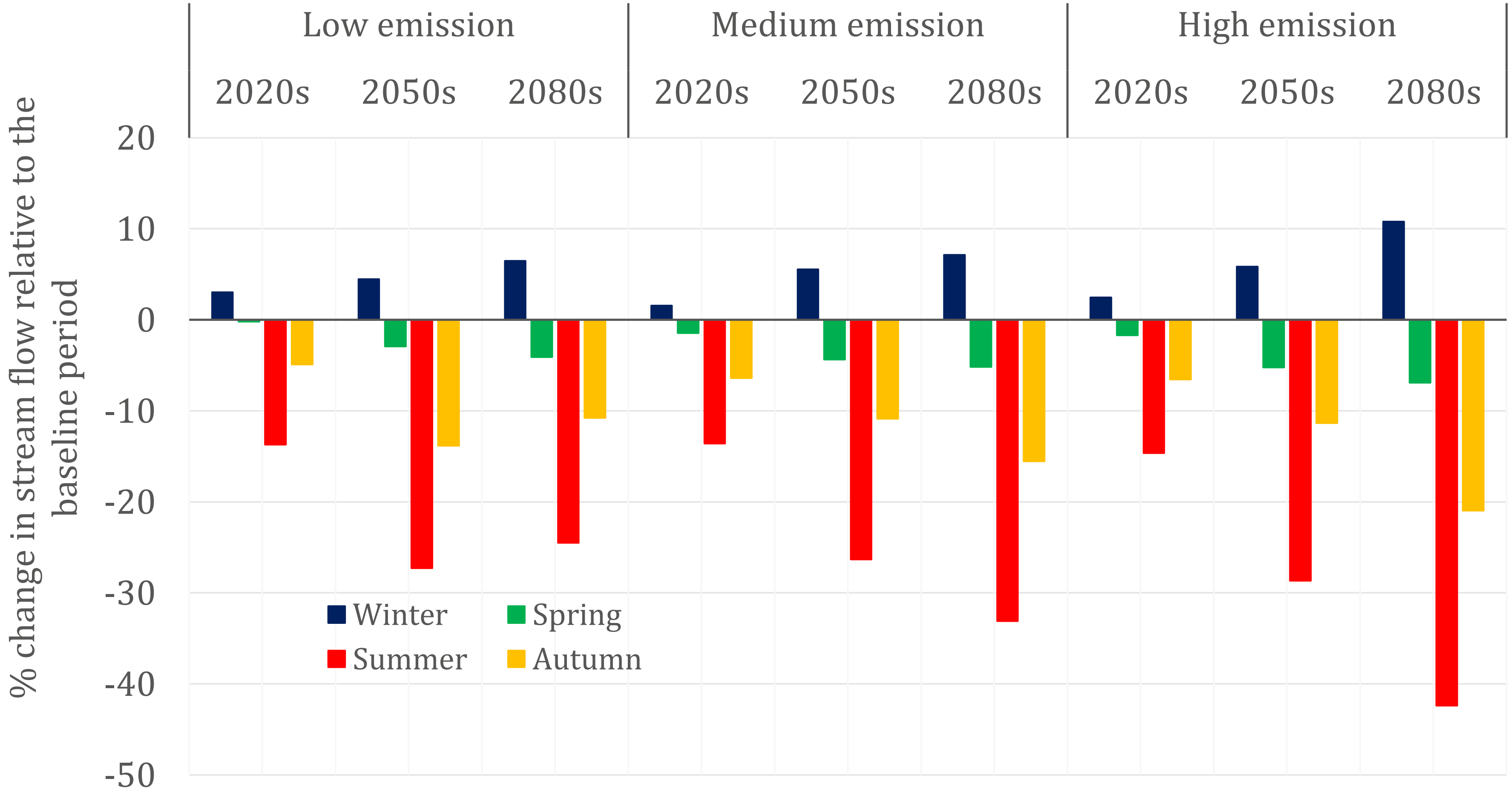
South - North	West -East
Fowey 1506 mm	Fowey 1506 mm
Ebbw 1501 mm	Frome 817mm
Don 1009 mm	Pang 707mm
Eden 799 mm	Bevills Leam 580 mm

Figure 1 Case study catchments overview map

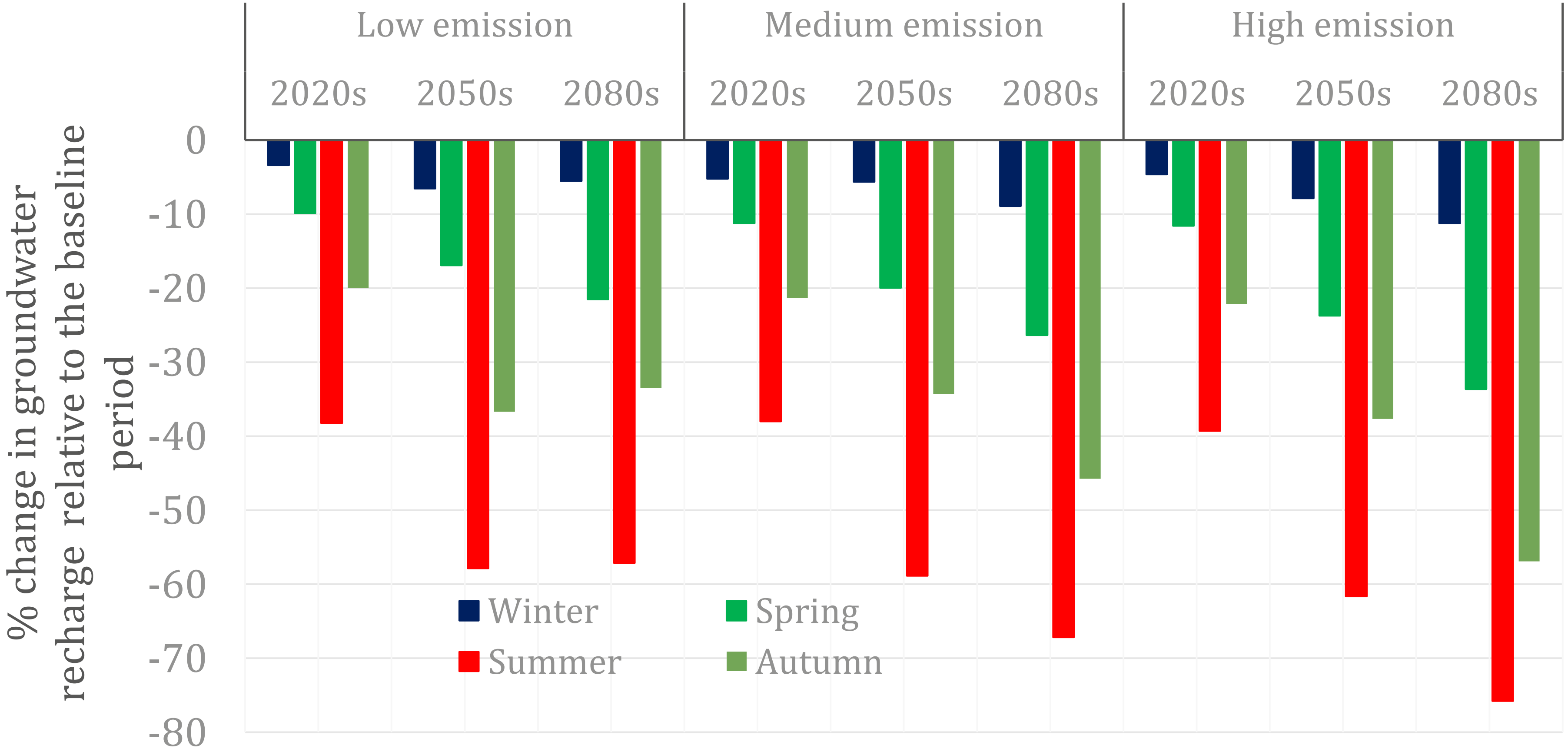
Don catchment main land use



Don: Stream flow using Joint Probability DATA



Don: Groundwater recharge using Joint Probability DATA



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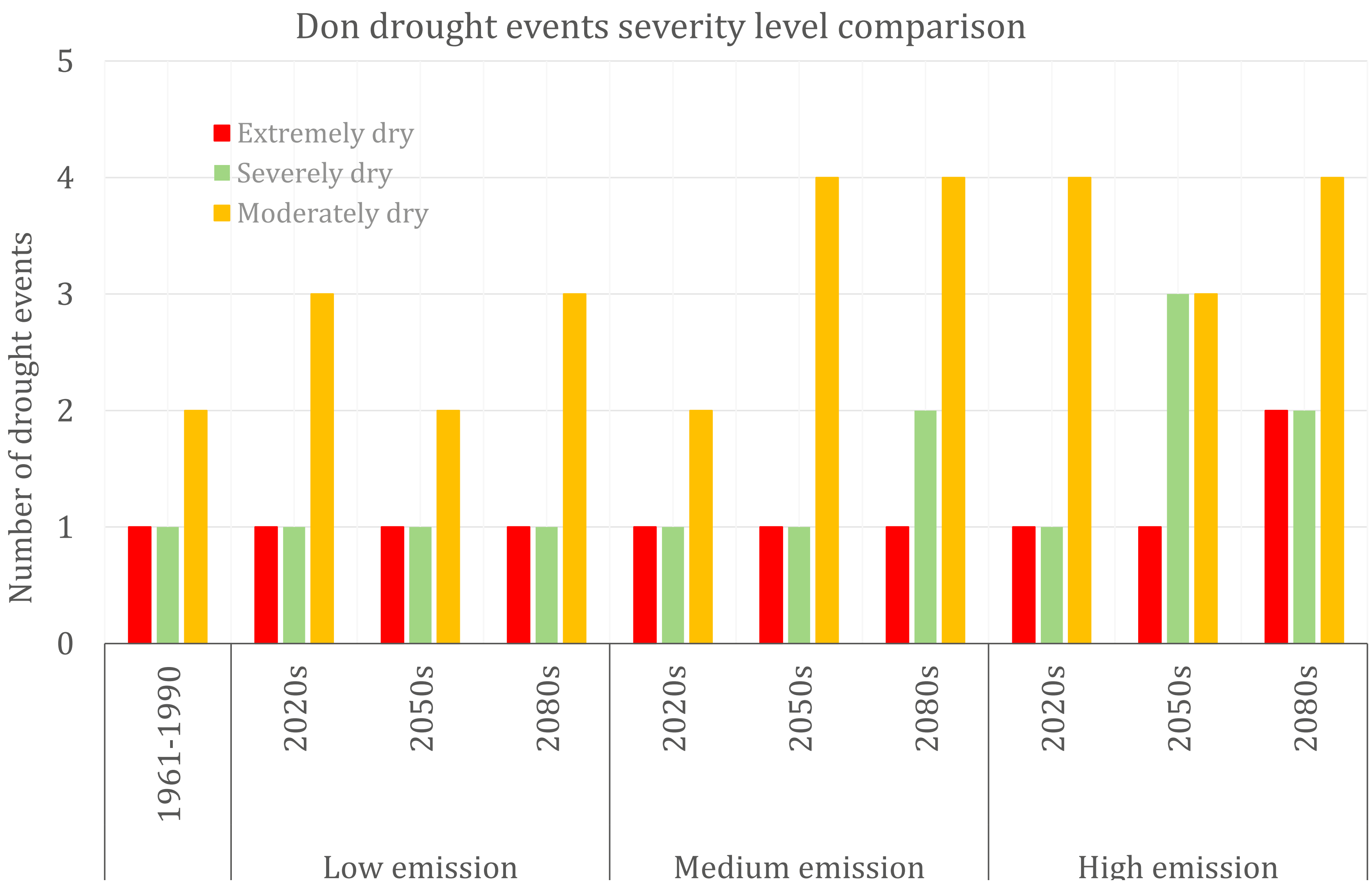
Don: Reconnaissance Drought Index, RDI (using Weather Generator data)



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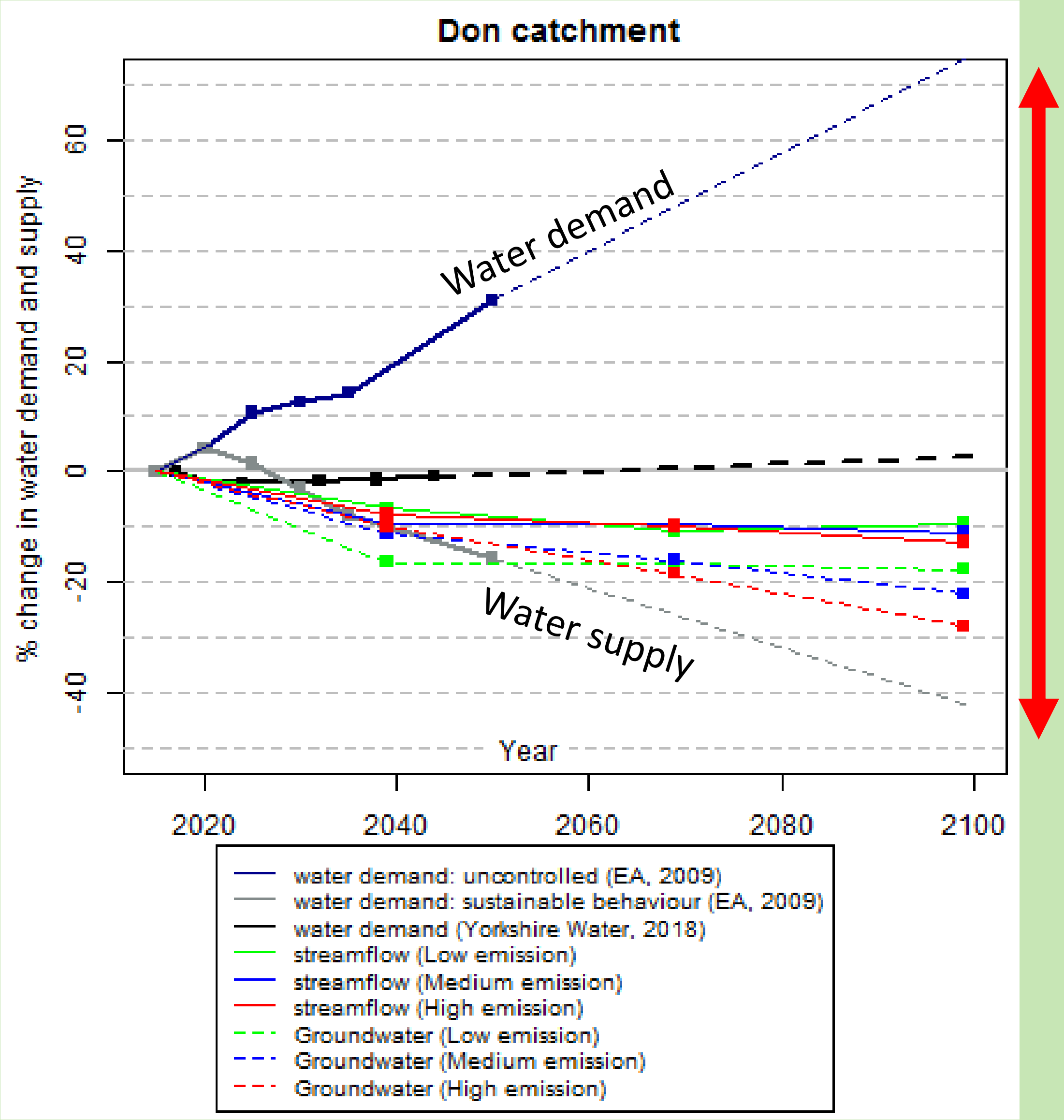
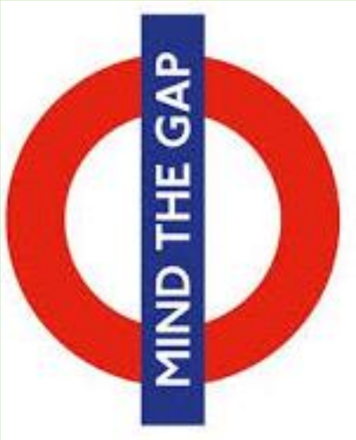
Extremely dry RDI ≤ -2 , Severely dry RDI -1.5 to -1.99, Moderately dry RDI -1 to -1.49

Don future supply vs demand under climate change





The gap between future water demand and future water supply

- **In all 7 catchments apart from Eden in Scotland, there will be a gap between future water supply and future water demand and that gap is widening over time up to 2099 if water demand is not sustainably managed and controlled.**

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How to narrow the Gap between Water Supply and Demand

How to Narrow the Gap between Supply and Demand

Increasing Water Supply to meet irrigation demand

There are a number of solutions, few examples:

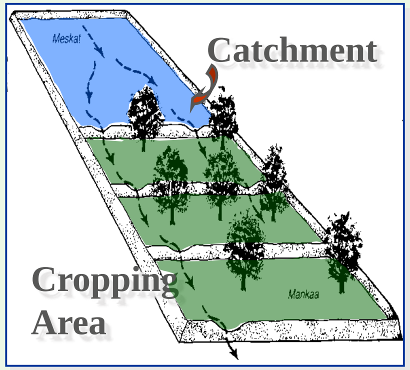
- **More surface storage (new reservoirs & dams)**
- **More Groundwater recharge**
- **More wells**
- **Use of treated wastewater and brackish/saline water**
- **Desalination (for cash crops - costly for field crops)**

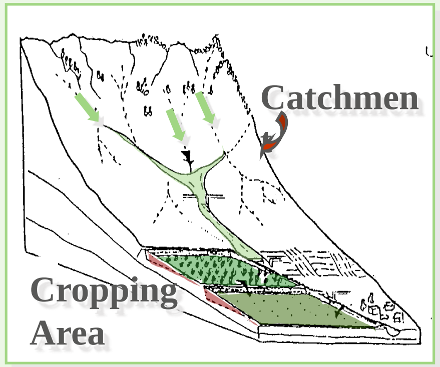
Other solutions include enhancing water use efficiency, efficient irrigation systems, crop selections &rotations

Increasing water supply

RAINWATER HARVESTING

Rooftop & Courtyard Water Harvesting	Micro-catchment Water Harvesting	Macro-catchment Water Harvesting





Time in History Water Harvesting Structures Development

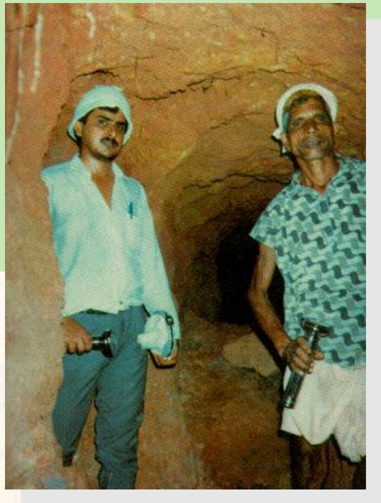
Water Harvesting structures, India

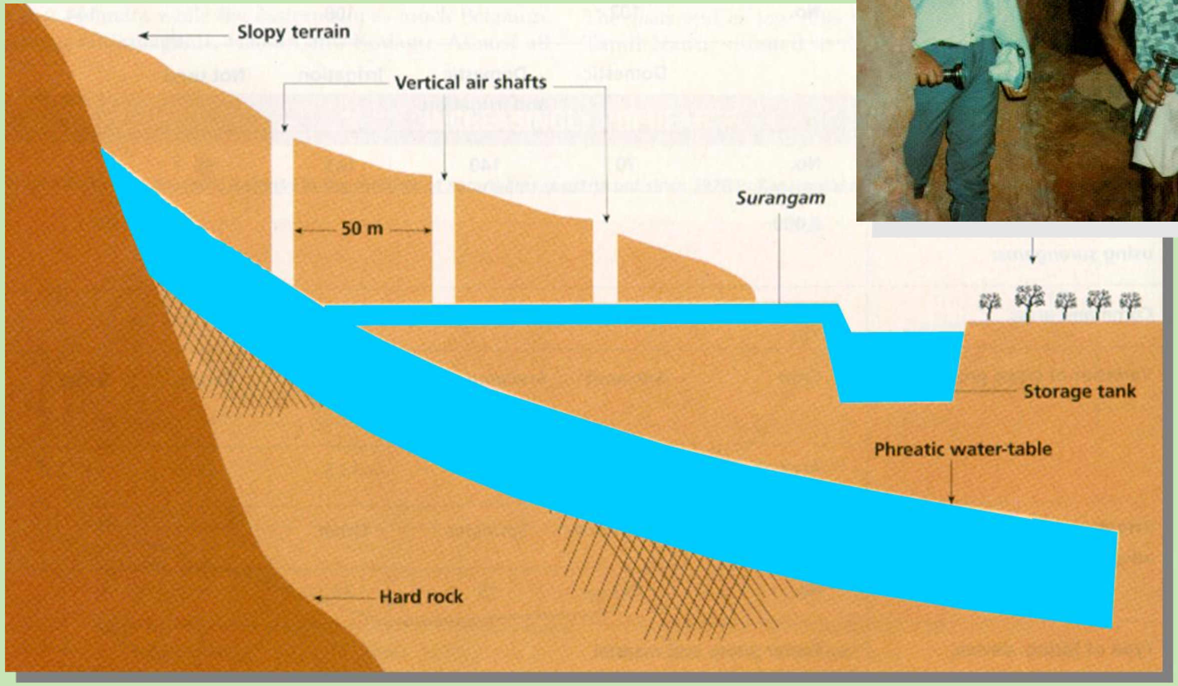
Mountain Lake, Tunisia

The Three Gorges Dam, China

Rainfall – Runoff Harvesting into subsurface reservoirs

The Inside of a Surangam (Tunnel) in Kerala.





Groundwater recharge points, North Malabar, Kerala, INDIA

Underground Dams – Brazil

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Issues related to Dams and Reservoirs

The Main Issues of Concern

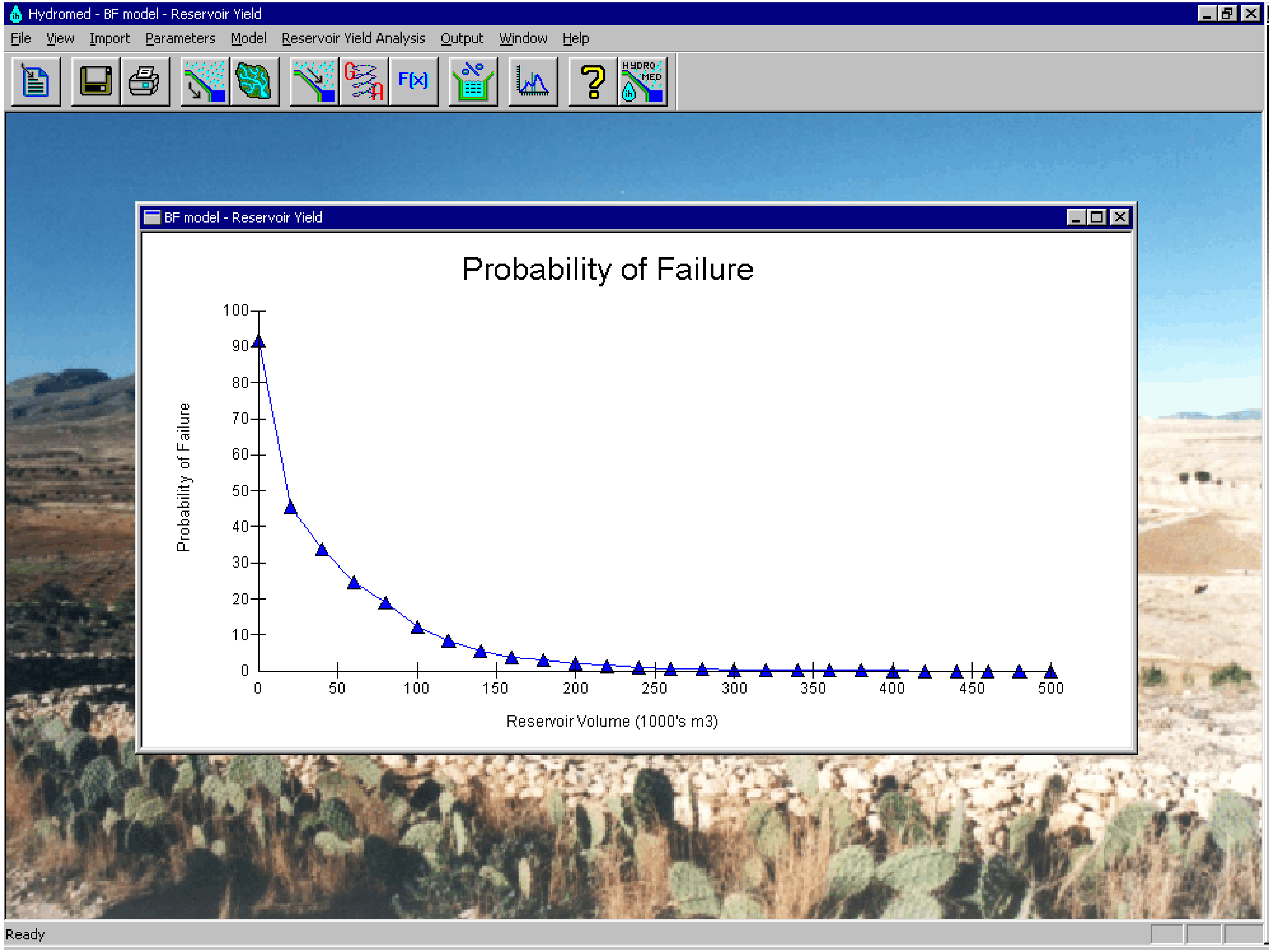
- Safety of dams/reservoirs
- Societal impact during and after building the dam/reservoir
- Environmental and ecological impact
- Impact on local climatic conditions (cloud formation)
- Impact on downstream riparian countries in shared rivers
- Impact on river flows and navigation
- Evaporation Losses

Safety Factors in designing Dams & Reservoirs

Building dams and Reservoirs is not only a civil engineering construction business only. It requires good knowledge about the Hydrology, Economy, Environment and Societies.

In terms of Hydrology, we need to consider a long term historical records of flows, understand the temporal variations and avoid using long term mean values if extreme events are frequent or expected.

1. Estimate accurately the volume of the reservoirs that has minimum risk and low probability of failure (conduct probability of failure test analysis).
2. Conduct Uncertainty Analysis for River Flow (uncertainty level varies from daily to monthly to seasonal to annual).



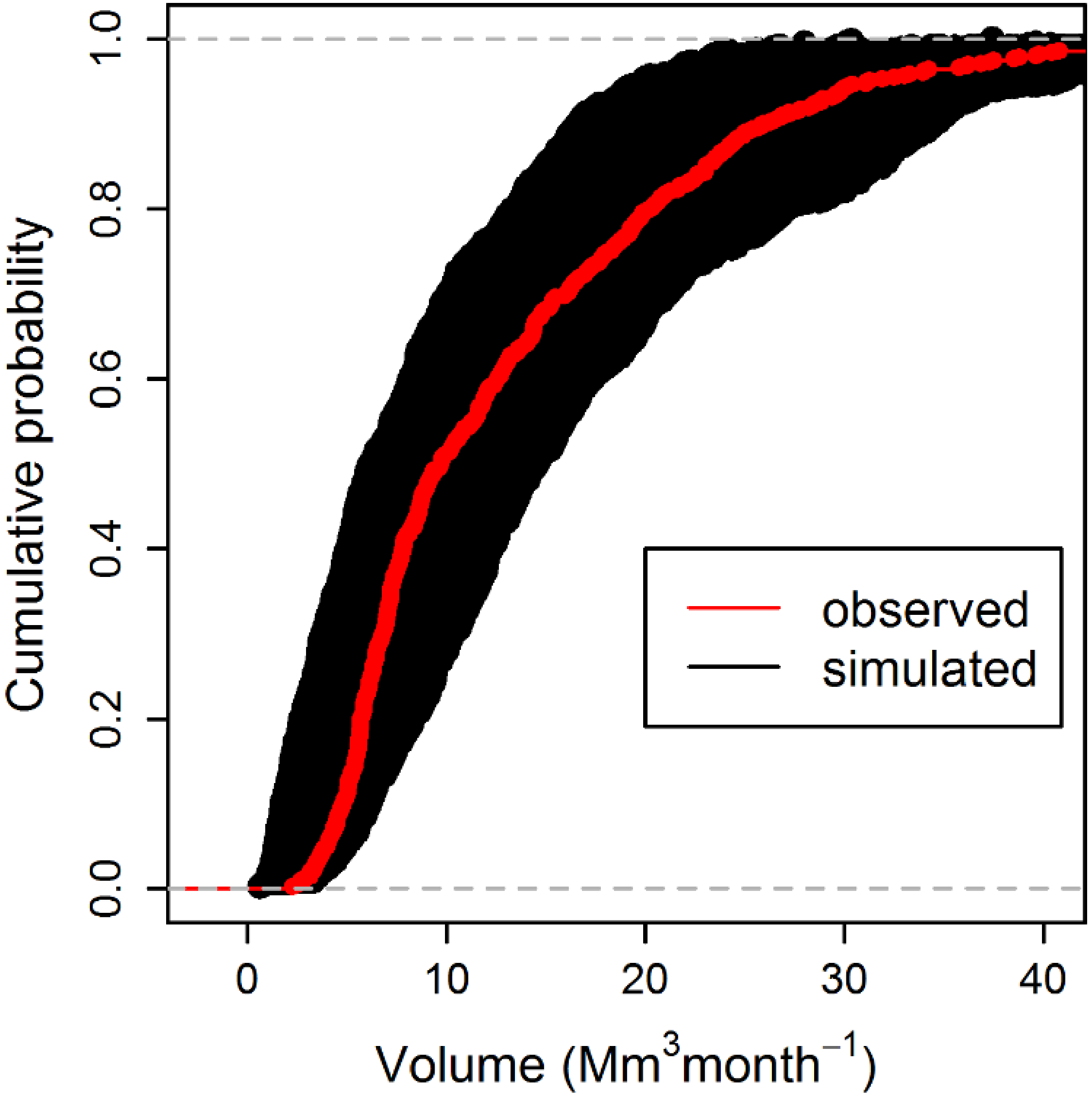
Ragab et al. 2001

Reservoir storage capacity using the HYDROMED model

The Uncertainty analysis of river flow prediction

- Generalized Likelihood Uncertainty Estimation, GLUE indicated that the model captures above 70% of the observed river flow (Containment ratio CR) i.e. 70% of the monthly observed values are included in the 5%-95% likelihood-weighted quantiles envelope.
- CR for Don : Eden
- Daily 57% 66%
- Monthly 70% 69%
- Seasonal 76% 69%
- Annual 85% 93%

Don: Model uncertainty monthly plots – river flow

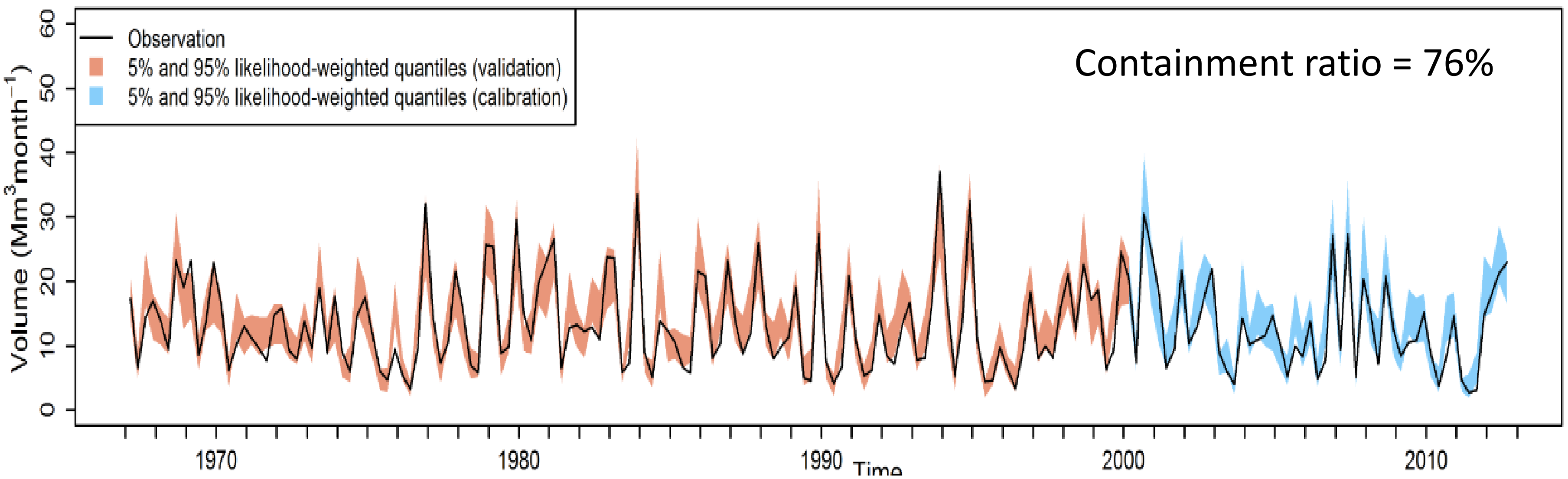


Ragab et al. 2020

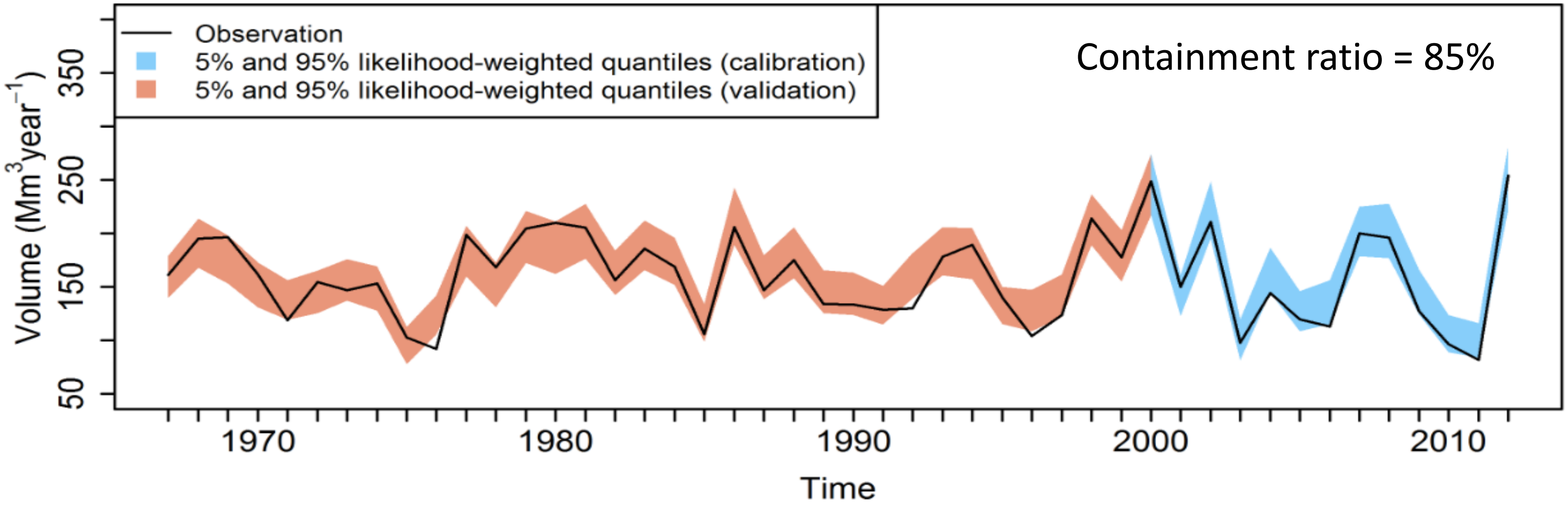
Don: Model uncertainty plots - river flow

Don Catchment CR
Daily: 57%
Monthly 70%
Seasonal 76%
Annual 85%

Monthly flow



Annul Flow



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Ragab et al. 2020

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Sedimentation

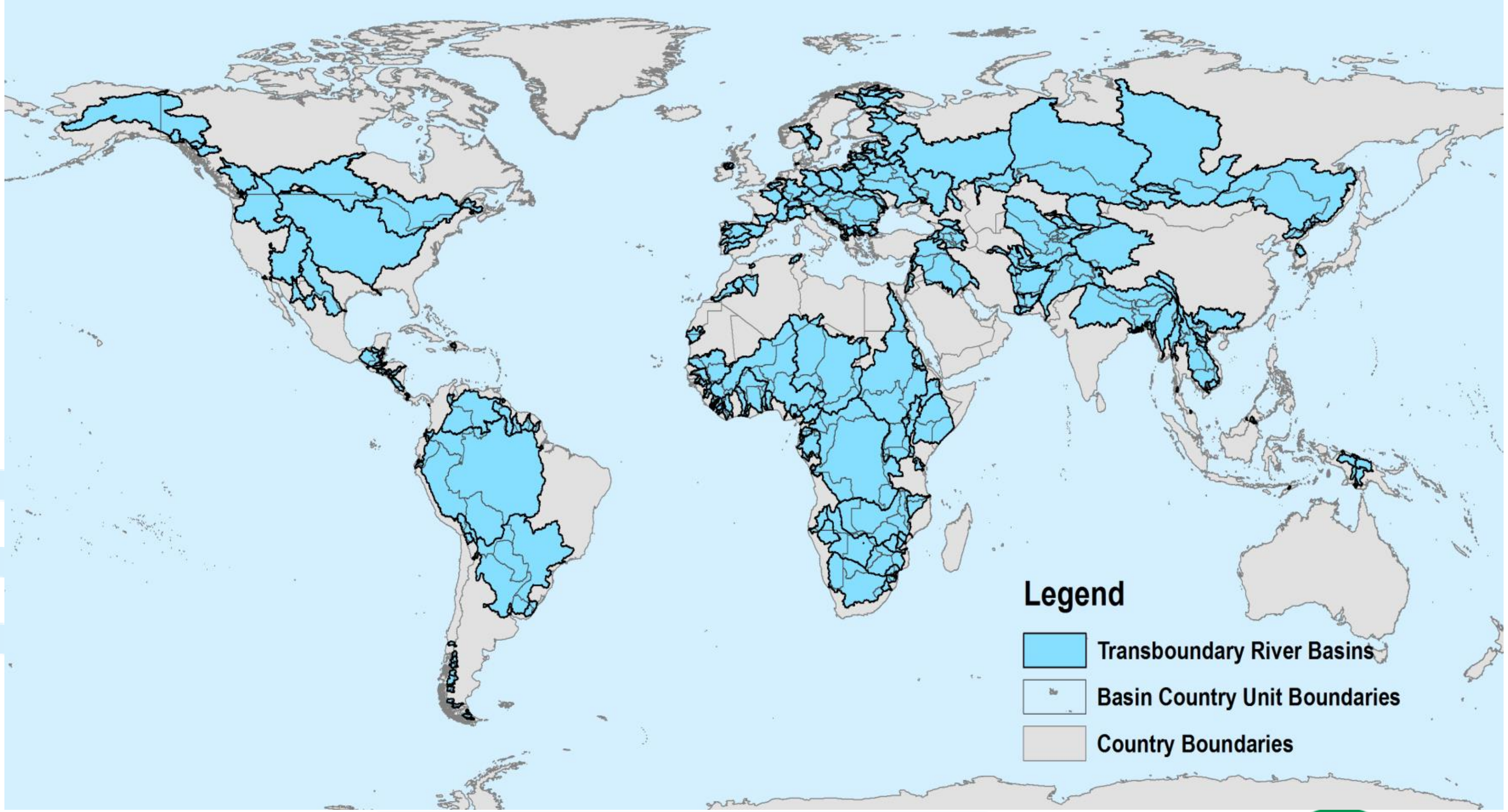
- Sedimentation control in the reservoir by sediment flushing, sluicing or dredging must be supported by erosion control in the watershed in order to prolong reservoir life (useful life) as long as possible.
- Investment in erosion control is to be encouraged and continuous de-siltation is necessary to prolong the life time of dams and reservoirs.

Issues related to Dams and Reservoirs of Shared Rivers

TASK TEAM ON TRANSBOUNDARY WATERS (TT)

Transboundary river basins contain 40% of world’s population

& 60% of world’s food production.



twap-rivers.org

Issues related to Dams and Reservoirs of Shared Rivers

- **Agreement and regulations of building dams over shared rivers should be in place before building dams to avoid negative impact on downstream communities.**
- **Example: Originating in Germany, the Danube flows southeast for 2,850 km passing through or bordering Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova and Ukraine before draining into the Black Sea. The Danube is of great economic importance to the 10 countries all of which variously use the river for freight transport, the generation of hydroelectricity, irrigation, industrial and residential water supplies. Convention on Cooperation for the Protection and Sustainable Use of the Danube River (Danube River Protection Convention) came into effect in 1998.**

Societal Issues related to Dams and Reservoirs

Societal Issues related to Dams and Reservoirs

- Societal impact on local communities during and after the building of the dam. By moving them to new areas with possible change in land use and the landscape, their economy and traditions are afected. We must ensure that they are better off after the Dam and Reservoirs building.

Environmental Issues related to Dams and Reservoirs

Environmental Issues related to Dams and Reservoirs

- Change in local climate “new microclimate” due to cloud formation over the reservoir areas as a result of evaporation. Case of High Aswan Dam, Egypt.
- Ecological impact on wildlife including fish and fish migration due to change in river flows, water depth & water temperature.
- Balance must be struck between environmental impacts of development, and environmental conservation served by the development.

Evaporation Losses from Reservoirs

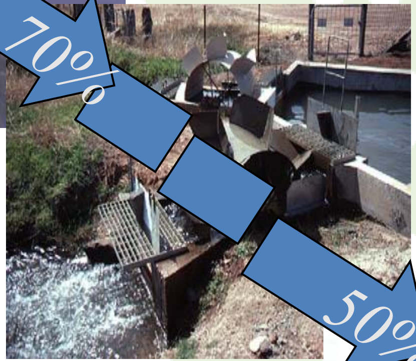
Evaporation Losses from Reservoirs

- The evaporation losses from the reservoirs could be very significant . However, it is hardly accurately quantified and reduced.

Efficiencies from Storage to the field

Dam

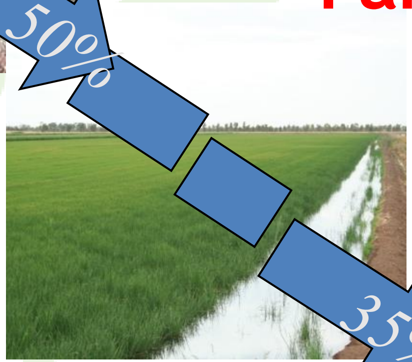
Channel



Dam to Farm

- Operating Spills
- Poor Measurement
- Leaks
- Seepage
- Evaporation

Farm



Supply to Crop

- Poor Service
- Slow Delivery
- Varying Flows
- Poor Control

Plant

Use by Plant

- Imprecise Timing
- No measurement of Crop Needs

Reservoirs and lakes can offer floating solar space, reducing Evaporation losses and saving lands

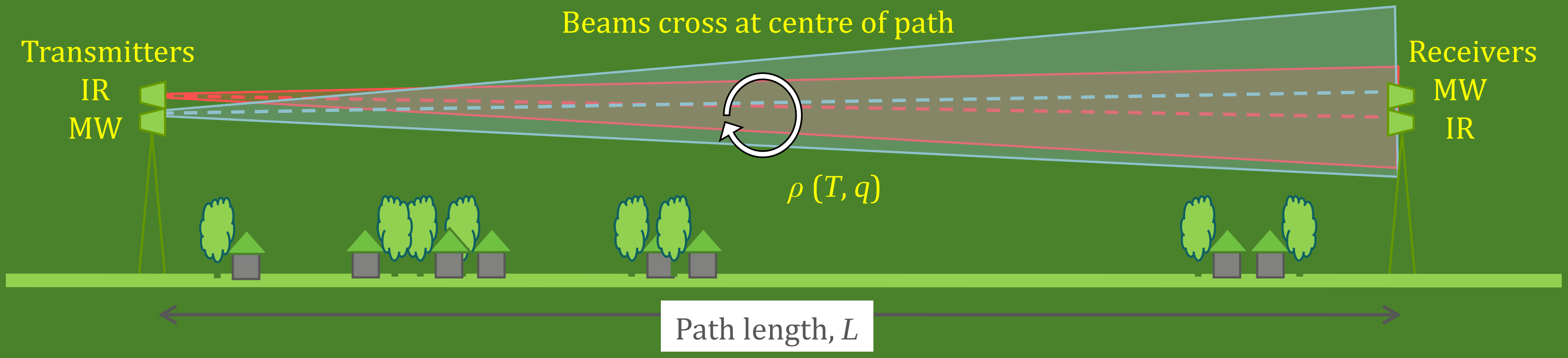
Farm lakes and irrigation reservoirs could host renewable electricity generation, according to Berkshire farmer and energy entrepreneur Mark Bennett who has just built the UK’s first floating solar farm on a new 60m-litre irrigation reservoir at his Sheeplands Farm near Wargrave, UK.

UK Centre for Ecology & Hydrology

ICID•CIID

Scintillometry at multiple wavelengths

Combine optical/infra-red with micro/radio-wave scintillometer – sensitive to both temperature and humidity fluctuations.



Up to 10 km Path Length

Refractive index changes because of air density differences – heat and moisture.

Management Issues

Management Issues

- Good Maintenance and Operation system is essential for Dam’s safety.
- The need for regulations to control water harvesting into unauthorised reservoirs as this negatively affects the flow to rivers and dams.
- Multipurpose dams and reservoirs for water and energy security is preferred over single use dams and reservoirs.
- Intensive 4 months rain (Monsoon) in some Asian countries requires a suitable design, operation and maintenance system and holistic integrated water supply/demand management to ensure steady water supply over the whole year.
- There is a need to raise awareness of the benefits gained from dams and reservoirs in terms of: water and food security, society welfare and income, leisure & tourism and local /regional economy while safe guarding the environment and the ecological services.

Benefits of Dams and Reservoirs

- We need dams, their reservoirs store water in times of surplus and dispensing it in times of scarcity. Dams prevent or mitigate devastating floods and catastrophic droughts.
- They adjust natural runoff with its seasonal variations and climatic irregularities to meet the pattern of demand for irrigated agriculture, power generation, domestic and industrial supply and navigation.
- They provide recreation, attract tourism, promote aquaculture and fisheries, and can enhance environmental conditions.
- The impact of dams and reservoirs on environment is inevitable and undeniable; if land is flooded, people are resettled, the continuity of aquatic life along a river is interrupted, and its runoff modified and often reduced by diversions.

Do We need more Dams and Reservoirs? Yes

- In the future we will need to increase water supply by increasing rainwater and runoff harvesting and store the water in reservoirs. Reasons are:
- In order to meet the current challenges of population increase while water is limited, we will need to double food production by 2050. This needs extra water supply.
- The future climate change predicts more frequent extreme events of flood and drought. Irrigation and food production requires a steady water supply throughout the year.
- Energy use is likely to increase by 30-40% by 2050. We need multipurpose Dams/reservoirs to produce renewable clean energy "Hydropower" to meet the energy demand and mitigate the green house gas generated by fossil fuel.

Do We need more Dams and Reservoirs? Yes

- **Since the groundwater reservoirs presently tapped to provide about half of irrigation, drinking and industrial water supply are already heavily overdrawn in many parts of the world, the only large-scale solution apart from saving water is to increase the share of surface water from storage reservoirs.**
- **Given the foreseeable depletion of fossil fuels, which presently are used to satisfy three quarters of primary energy requirements worldwide, plus the problem of the greenhouse effect and global warming, there is an urgent need to gradually replace them with clean energy such as Hydropower which does not not release CO_2.**
- **Dams and Reservoirs provide water for irrigation, domestic and industrial water supply, energy production and flood control. Other benefits include navigation, fisheries, natural / wild life habitat, tourism and job creation.**


thank you!