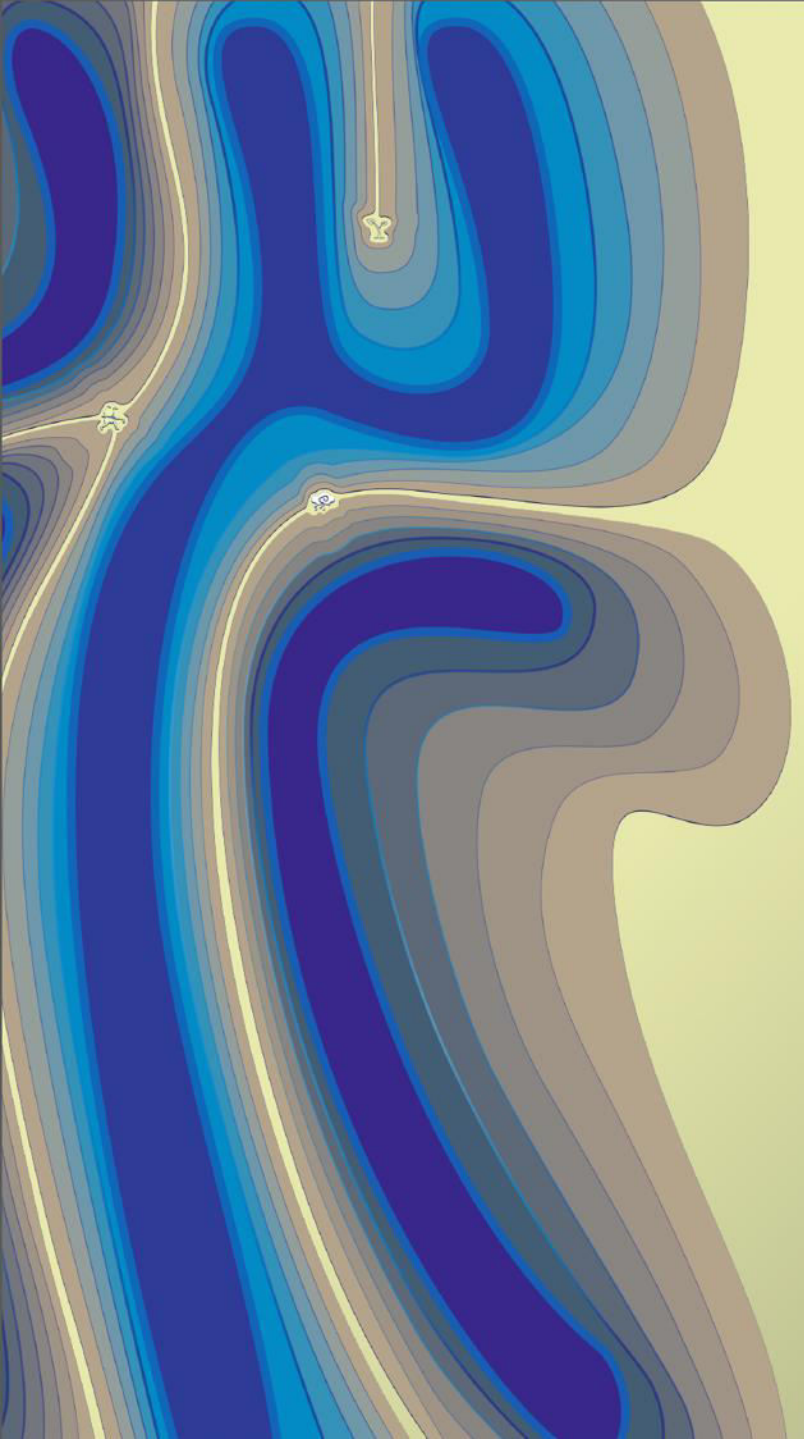


XVIII World Water Congress
International Water Resources Association (IWRA)

Sustainable Development and Water Security: Increasing Global Water Scarcity and review of Potential Solutions

Tyler G Maxwell III

AECOM

XVIII WORLD WATER CONGRESS Water for All Harmony between Humans and Nature

第18届 世界水资源大会 水与万物：人与自然和谐共生

XVIII World Water Congress
International Water Resources Association (IWRA)

Content

- Introduction
- Data Analysis of Historical Water Conflict Throughout the World
- Review of Potential Solutions

Introduction

Earth is rapidly urbanizing. Together with climate change, it exacerbates water scarcity where current water supplies not being able to meet the growing demand. Research performed by UN Dept. of Environmental and Social Affairs suggest that population in urban cities is projected to reach 6.7B by 2050.

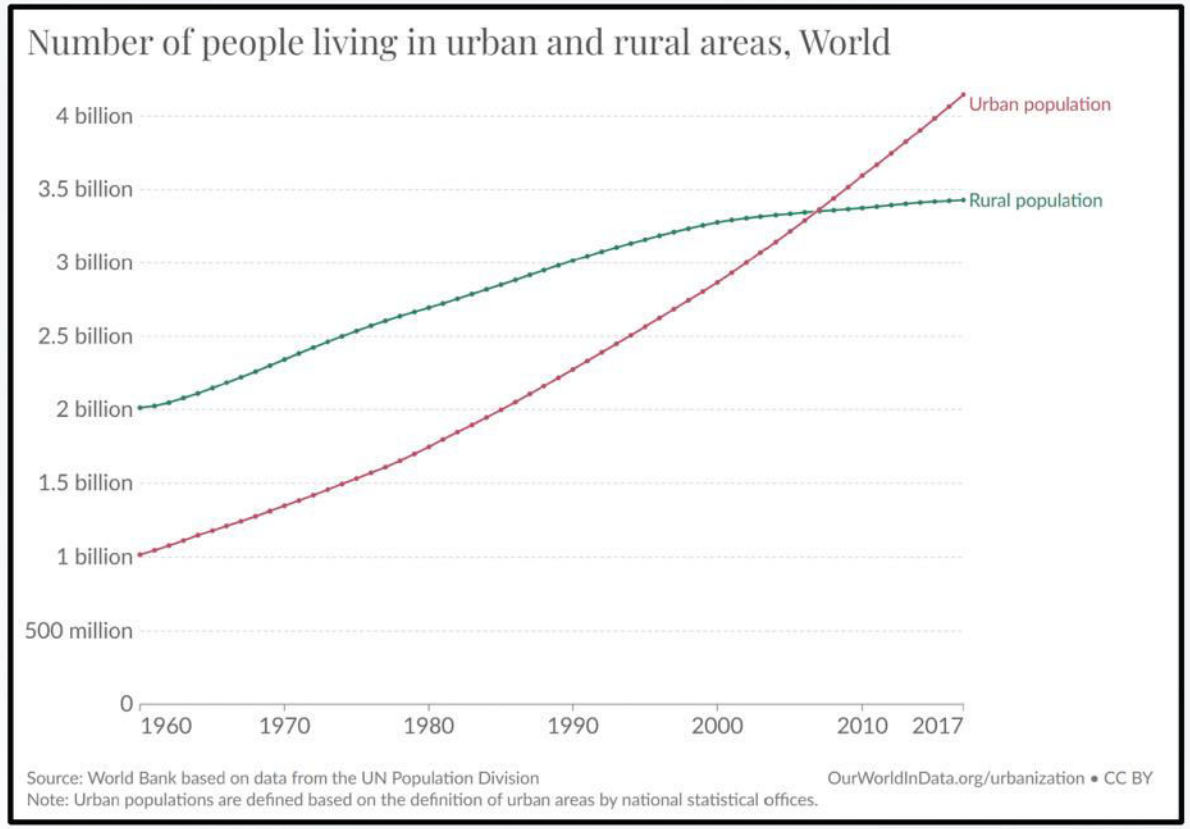


Fig 1. Historical Statistics of Urban and Rural population on Earth Throughout History. As of 2021, population in urban cities reached 4.45B and 3.43B in rural towns respectively. Obtained from UN World Urbanization Prospect.

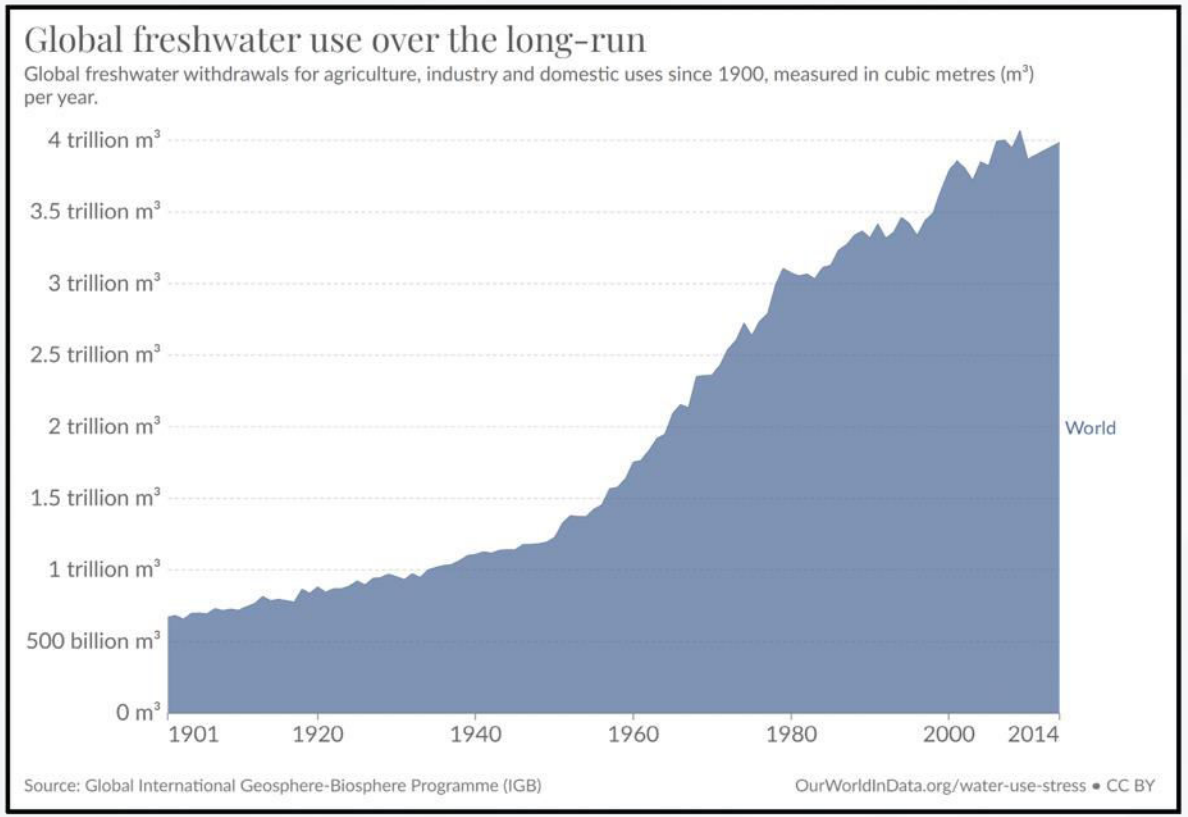


Fig 2. Historical Statistics of Global Freshwater Consumption throughout History. As of 2014, 3.99T m^3 has been consumed. Obtained from Hannah Ritchie and Max Roser (2017) - "Water Use and Stress".

The WCC is an online, open-source database that includes historical information on violence over water categorized by region and type, conflict time and date, locale, and other variables.

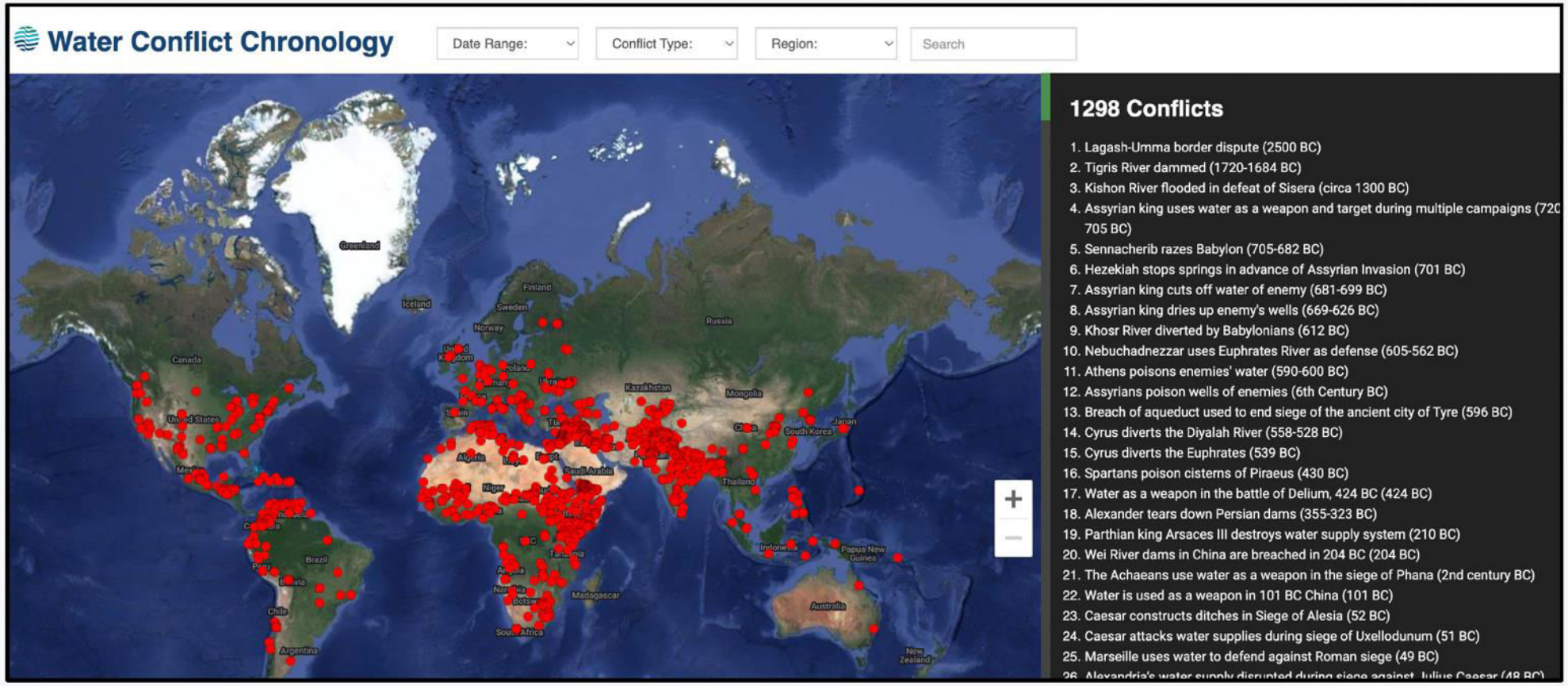


Fig 3. Screenshot of Water Conflict Chronology website developed by Pacific Institute. As of 2023, 1298 conflicts have been logged ranging from 2000 BC in southern Mesopotamia, to 2022 in Ukraine.

Data Analysis of Historical Water Conflict

XVIII World Water Congress
International Water Resources Association (IWRA)

Methodology

- Data was obtained from the WCC website where it underwent the following filters before the data analysis:
  - Events that involved physical violence/armed conflict related to water that resulted in casualties such as death, injury, cyber attack, and infrastructure damage.
    - These events were then filtered once more where casualties caused by humans were included, not environment based casualties such as earthquake, flooding, and droughts.

Data Biases

- **Available data bias:** There has been rapid technologic development in the past couple of decades that made it possible to do real-time reporting, access to internet, fast translation etc. Older data reports depended on archived news reports, books or other physical record. Therefore, a solid conclusion of data analysis is much harder to make, and should always be take into account that some earlier events might not have been recorded or easily accessible to public.
- **Quality of data bias:** This research did not independently verify each events, and the accuracy of the reports are unknown.
- **Definition bias:** The definition of water conflict changed many times over the years, therefore obtaining consistent data is almost impossible.

Results

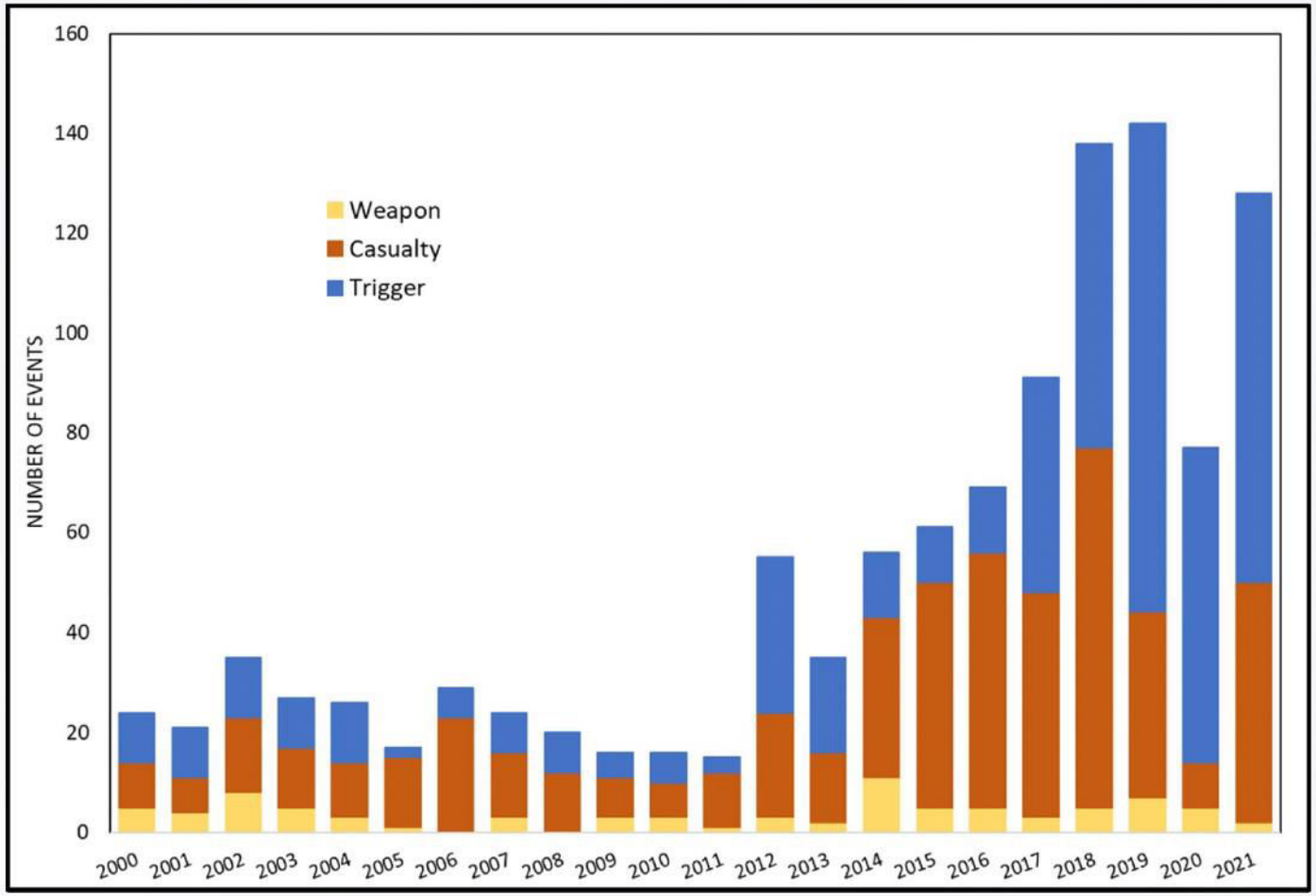


Fig 4. Number of water conflict events reported annually and categorized by Weapon, Casualty, and Trigger from 2000 to 2021. Since some events included both categories, they were considered as two events for this data visualization.

Weapon: 580 event
Casualties: 617 event
Trigger: 181 event

Events categorized under two or more are counted in each relevant category such that the total number of events in the WCC is smaller than the numbers mentioned above.

Weapon: Water Infrastructure being used as a weapon, such as poisoning the water, flooding settlements.

Casualty: Any damage to water infrastructure such as distribution channel, water/wastewater treatment plants.

Trigger: Any event that triggered disputes or violence.

Results

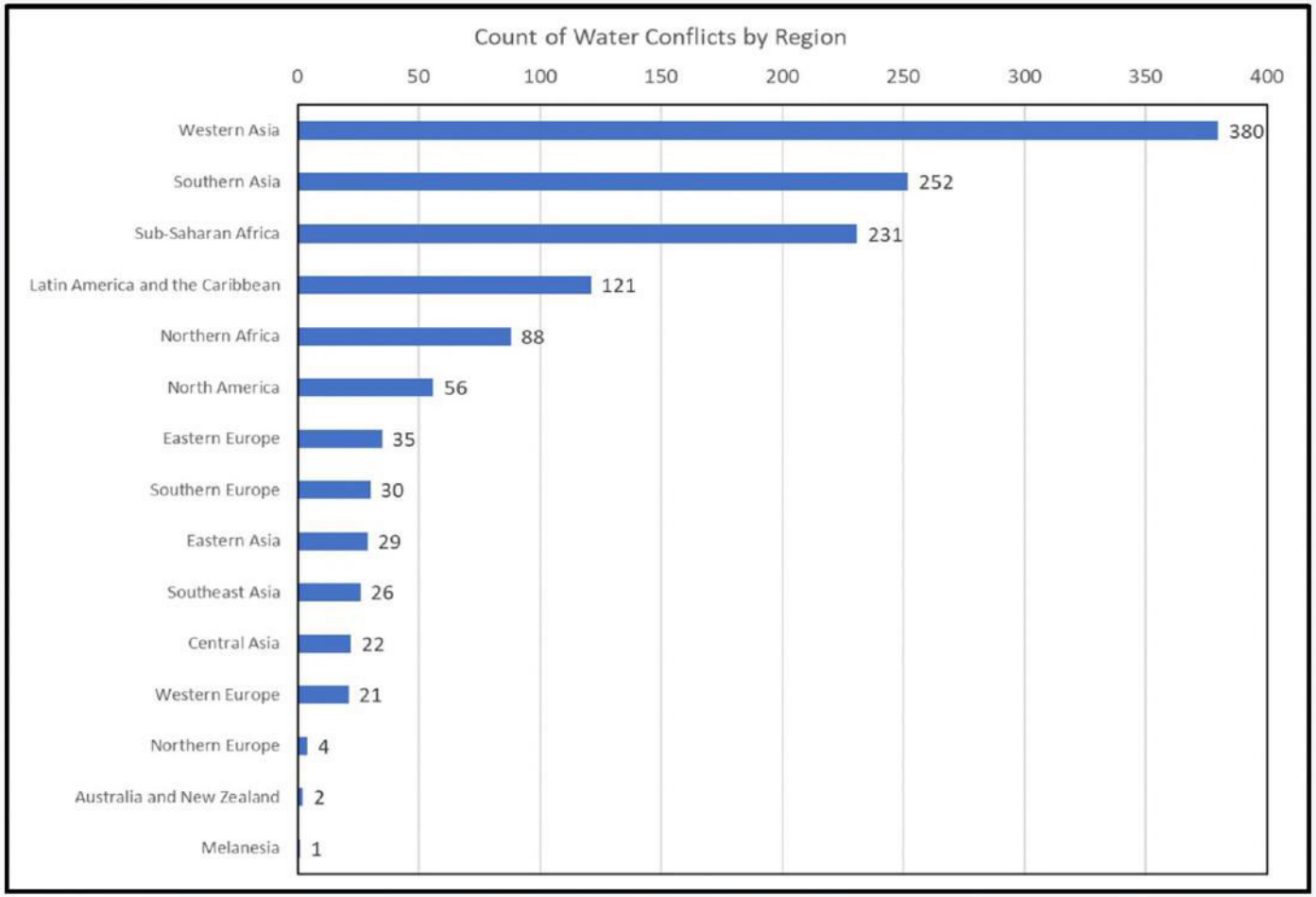


Fig 5. Number of events/conflicts categorized by region. The definition of the regions were obtained from the 2019 UN Statistical Division paper.
https://unstats.un.org/unsd/methodology/m49/#geo-regions.

Largest number of events are recorded in **Western Asia**, including the countries of the **Middle East, Gulf States, and in Sub-Saharan Africa, particularly the Sahel Region.**

Note that the spatial areas and the populations of the UN regions are vastly different: the Australia and New Zealand region encompasses just those two countries, whereas the "Sub-Saharan Africa" region includes 53 different countries.

Results

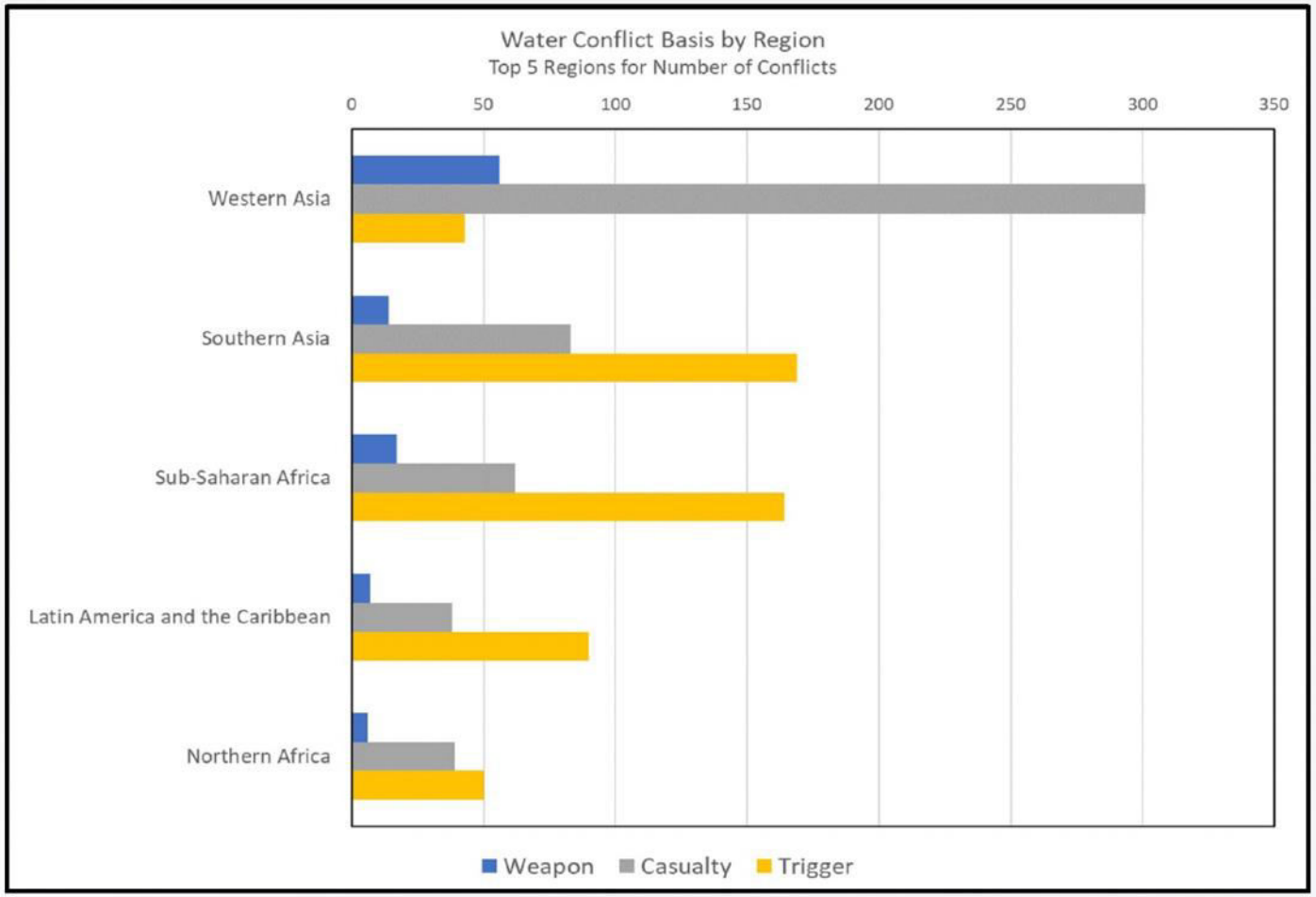


Fig 6. The top five regions based on total number of water-related conflict events for the full database. Events in two or more categories are counted in each relevant category such that the total number of events in the WCC is smaller than the total number above.

WCC has tracked 380 total events in Western Asia, with the highest number of events where water is a casualty of conflict. In the four other regions with the highest number of water-related conflict events, water as a trigger is the most common category. This outcome is largely the result of the large number of events from the wars in Yemen, Syria, and Iraq over the past decade (see, for example, the comprehensive reporting from the Yemen Data Project).

Results

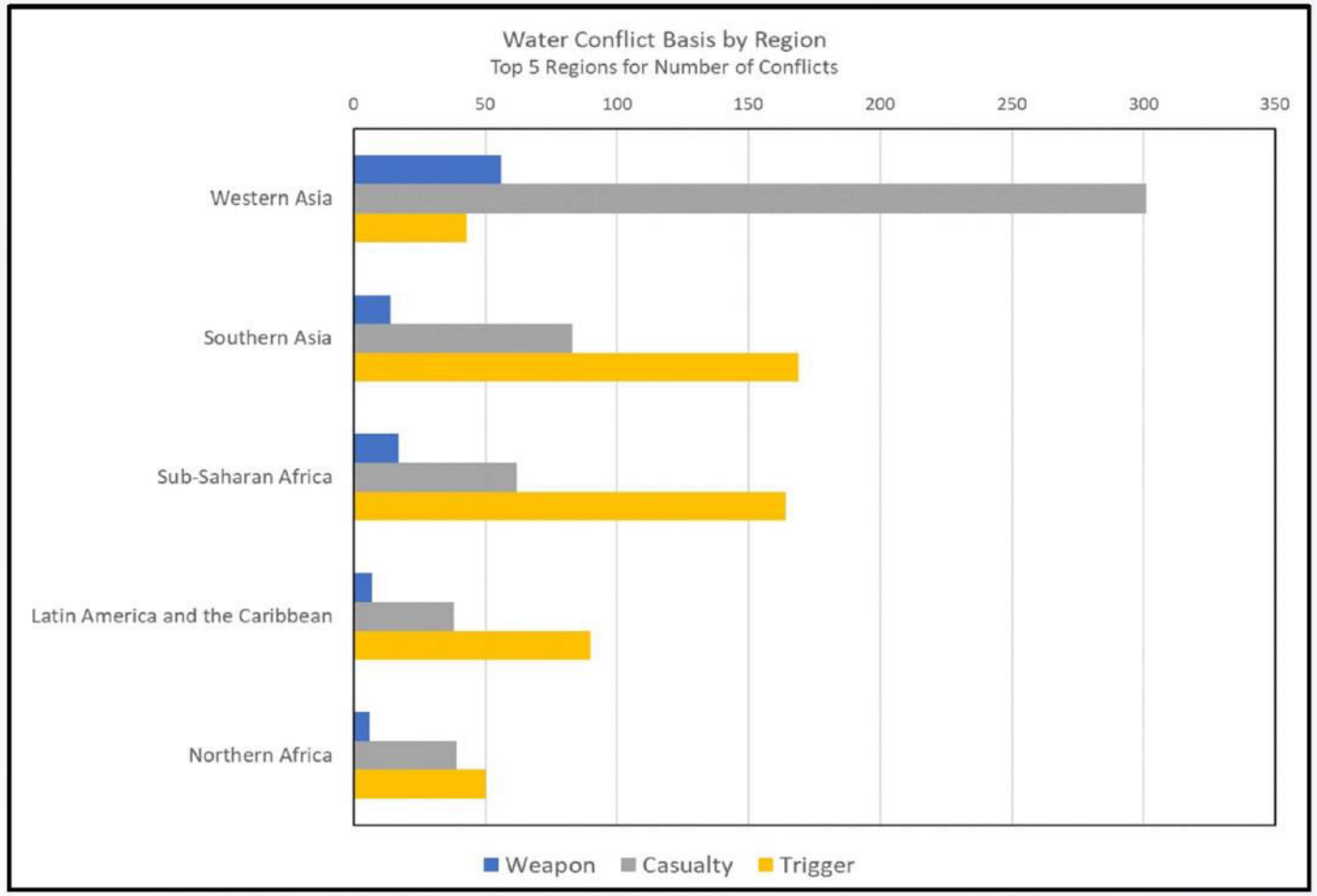


Fig 6. The top five regions based on total number of water-related conflict events for the full database. Events in two or more categories are counted in each relevant category such that the total number of events in the WCC is smaller than the total number above.

WCC has tracked 380 total events in Western Asia, with the highest number of events where water is a casualty of conflict. In the four other regions with the highest number of water-related conflict events, water as a trigger is the most common category. This outcome is largely the result of the large number of events from the wars in Yemen, Syria, and Iraq over the past decade (see, for example, the comprehensive reporting from the Yemen Data Project).

Review of Potential Solution

Feasibility analysis of potential solutions to urban water scarcity:

Increasing Water Supply:

- Groundwater Exploitation
- Seawater Desalination
- Reservoirs
- Interbasin water transfer

Decreasing Water Demand:

- Improved agricultural water technologies/infrastructures
- Population Control
- Water Tax
- Green Infrastructure

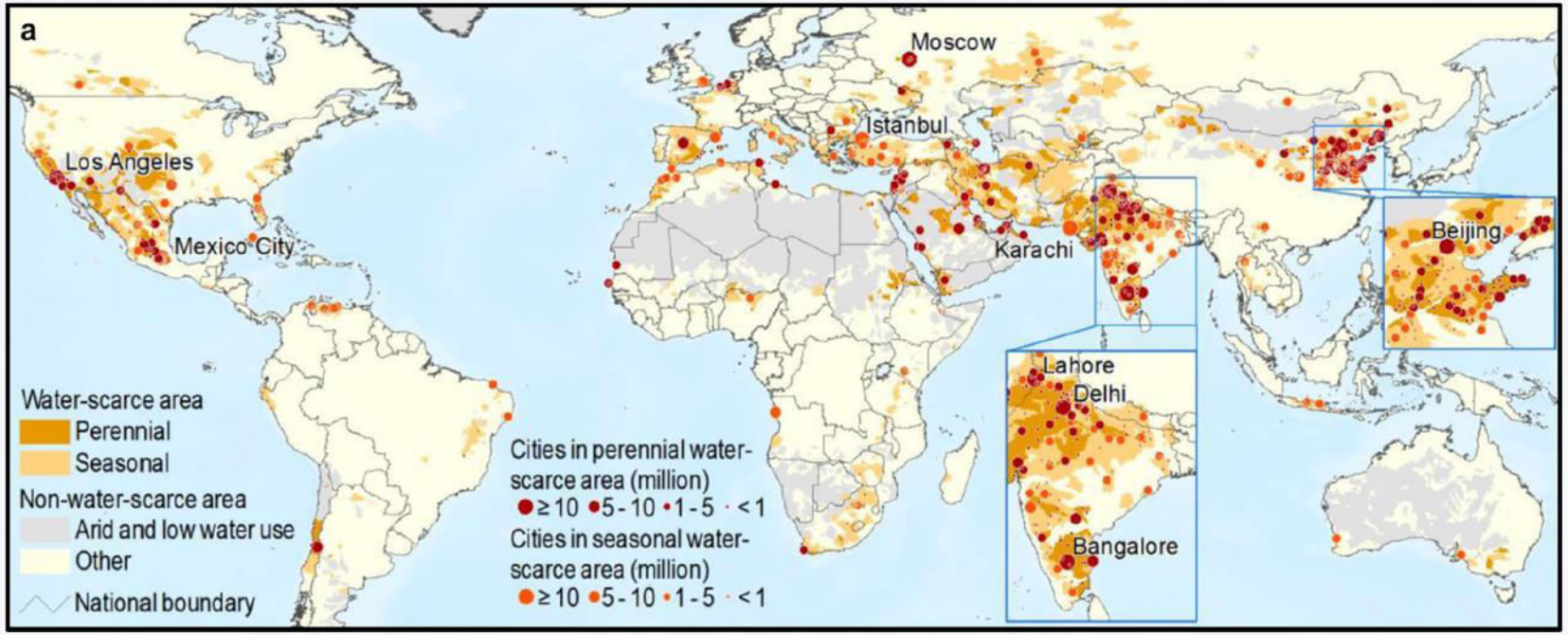


Fig 7. Current urban water scarcity. a spatial patterns of large cities in water-scarce areas (cities with population above 10 million in 2016 were labeled). Obtained from 2021 paper published in Nature by Chunyang He et al.

Results

City	Country	Feasibility of potential solutions							No solutions feasible
		SSP1&RCP2.6[a]	Desalination of sea water	Groundwater exploitation	Reservoir construction	Interbasin water transfer	Domestic virtual water trade	International water transfer/ virtual water trade	
Delhi	India	○	○	○	○	○	○	○	■
Shanghai	China	○	●	○	●	●	●	●	
Mexico City	Mexico	○	○	○	●	●	●	●	
Sao Paulo	Brazil	●	●	●	●	●	●	●	
Mumbai	India	●	●	●	●	○	○	○	
Cairo	Egypt	○	○	○	●	●	●	○	
Beijing	China	○	○	○	○	●	●	●	
New York	United States	●	●	●	●	●	●	●	
Dhaka	Bangladesh	●	●	○	○	●	●	○	
Karachi	Pakistan	○	●	●	○	○	○	○	
Istanbul	Turkey	○	●	●	●	●	●	●	
Manila	Philippines	○	●	●	●	●	●	○	
Tianjin	China	○	●	○	○	●	●	●	
Los Angeles	United States	○	●	●	○	●	●	●	
Moscow	Russia	○	○	●	○	●	●	●	
Lahore	Pakistan	○	○	○	○	○	○	○	■
Bangalore	India	○	○	●	○	○	○	○	
Jakarta	Indonesia	●	●	●	●	●	●	○	
Lima	Peru	○	●	●	●	●	●	●	
Number of megacities[b]		5 (26.3%)	12 (63.2%)	11 (57.9%)	10 (52.6%)	14 (73.7%)	14 (73.7%)	10 (52.6%)	2 (10.5%)
Number of large cities[b]		68 (23.3%)	146 (50.0%)	192 (65.8%)	151 (51.7%)	200 (68.5%)	208 (71.2%)	190 (65.1%)	16 (5.5%)

Fig 8. Early Simulation Results of implementing some water scarcity solutions in some megacities. Note: results subject to change as it's still in the early stages in its development. The black dots denote that the solution is applicable and probably can solve the issue, the white dots denote that the solution is inapplicable or cannot solve the issue, the black square denote that all the listed solutions are inapplicable or cannot solve the issue.

* - Cities with a population >10 million in 2016, which face water scarcity in 2050 under at least one scenario, were listed (sort by population from largest to smallest).

a. - Including improvement of water-use efficiency, limitation of population growth, and mitigation of climate change.

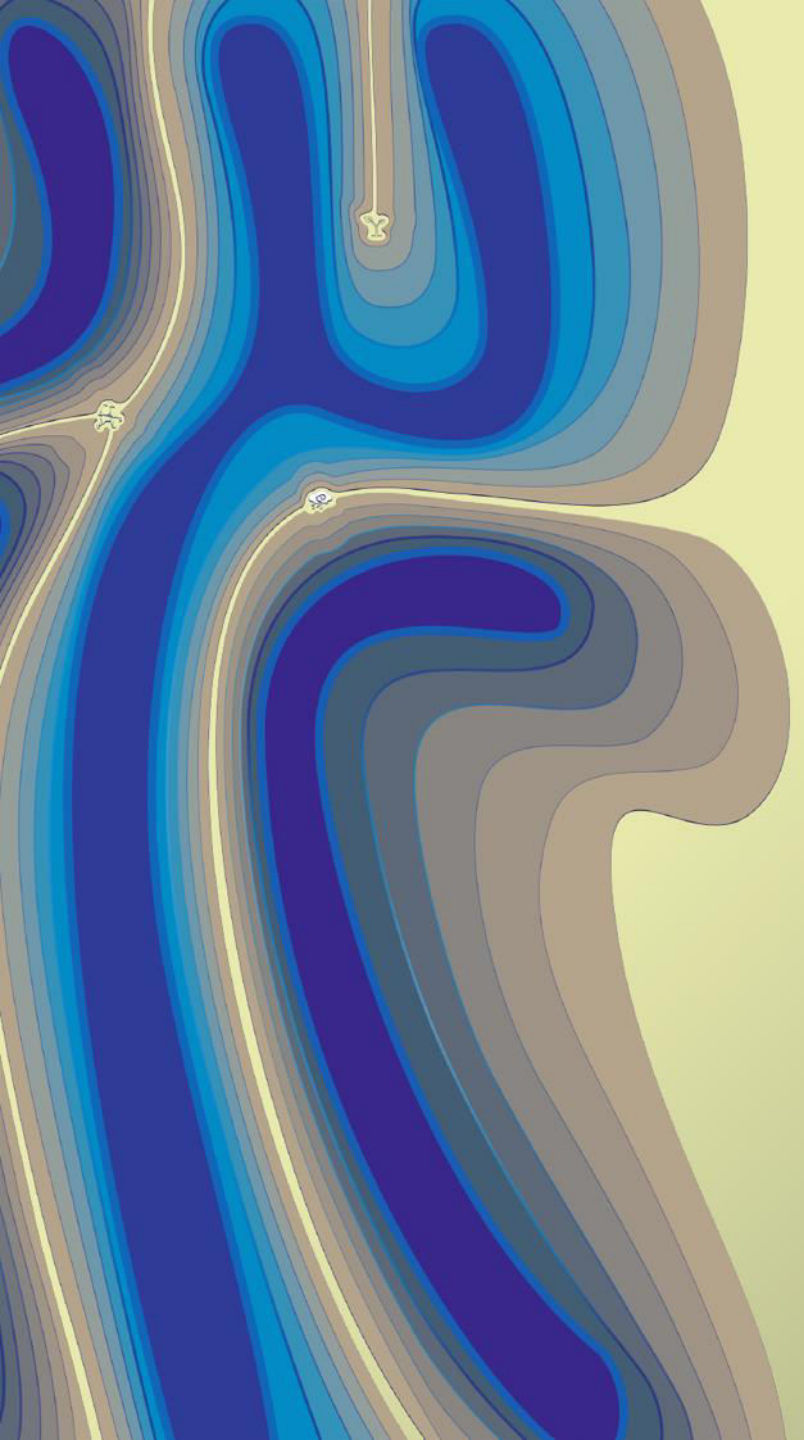
b. - Total number of water-scarce megacities/large cities, which could adopt the corresponding solution to solve water scarcity issue, was listed outside parentheses while the percentage of these cities to all water-scarce megacities/large cities was provided within parentheses.

Almost all data were obtained from the 2021 paper published in Nature by Chunyang He et al. Results were reproducible, and future research will be based on He's initial simulation studies.

Review of Potential Solution

Conclusion and Discussion

- The WCC database is designed to serve as the basis for ongoing research on the risks of water-related violence, and improvements and extensions will need to be done.
- Data from the Chronology indicates that the frequency of water-related conflicts has grown in the past two decades, especially as a result of violence in the Middle East, growing disputes during severe droughts over access to water in regions like India and Iran, and worsening confrontations between nomadic pastoralists and farmers in sub-Saharan Africa.
- Early projections suggest that global urban water scarcity will continue to intensify from 2023 to 2050.
- By 2050, near half of the global urban population was projected to live in water-scarce regions.
- Solutions to these problem does exist, but without proper laws and regulations, the effort will be useless.



XVIII
World Water Congress
International Water Resources Association (IWRA)

Thank you!

Tyler G Maxwell III

AECOM

Delivering a better world

XVIII
WORLD WATER
CONGRESS
Water for All
Harmony between
Humans and Nature

第18届
世界水资源大会
水与万物：
人与自然和谐共生