

# Challenges and Initiatives in Meeting SD Goal #6: Clean Water for All by 2030

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Hydrogeologists (IAH)**



# Talk outline

## Sustainable Development Goal 6

- What is SDG 6 and the associated UN Global Indicators and Targets?
- Challenges, and need for clean water and sanitation
- Where we lag behind
- Groundwater – a particular challenge
- Example Niger, Africa
- Suggestions for a way forward

# What is Sustainable Development Goal 6?



- One of 17 SDGs











**SUSTAINABLE DEVELOPMENT GOALS**  
17 GOALS TO TRANSFORM OUR WORLD



Quality and  
of  
gets

# SDG 6 Targets - Most by 2030

<b>TARGET 6-1</b>  SAFE AND AFFORDABLE DRINKING WATER	<b>TARGET 6-2</b>  END OPEN DEFECTION AND PROVIDE ACCESS TO SANITATION AND HYGIENE	<b>TARGET 6-3</b>  IMPROVE WATER QUALITY, WASTEWATER TREATMENT AND SAFE REUSE	<b>TARGET 6-4</b>  INCREASE WATER-USE EFFICIENCY AND ENSURE FRESHWATER SUPPLIES
<b>TARGET 6-5</b>  IMPLEMENT INTEGRATED WATER RESOURCES MANAGEMENT	<b>TARGET 6-6</b>  PROTECT AND RESTORE WATER-RELATED ECOSYSTEMS	<b>TARGET 6-A</b>  EXPAND WATER AND SANITATION SUPPORT TO DEVELOPING COUNTRIES	<b>TARGET 6-B</b>  SUPPORT LOCAL ENGAGEMENT IN WATER AND SANITATION MANAGEMENT



Abundant, clean, available groundwater promotes international stability



# Clean Water – The Challenge

- U.N World Water Development Report 2020 estimates 4 **billion** people face water scarcity at least one month each year
- 1.6 **billion** economic water shortage – no infrastructure to obtain sufficient water
- 52% of the world's population will live in water-stressed regions by 2050
- 3,400,000 will die each year from lack of clean drinking water (~9,300 people each day)
- Mostly children (2,200,000/yr)
- Does not reflect deaths associated with lack of handwashing and resultant deaths with global pandemics such as Covid-19
- Estimates are that approximately 6,000 children die each day from diarrheal fluid loss or lack of clean drinking water
- About one child every 14 seconds.
- The United Nations and the World Health Organization have attributed water-related causes to about 80% of all diseases in the developing world.



# Statistics – Estimates vary but these are approximate values

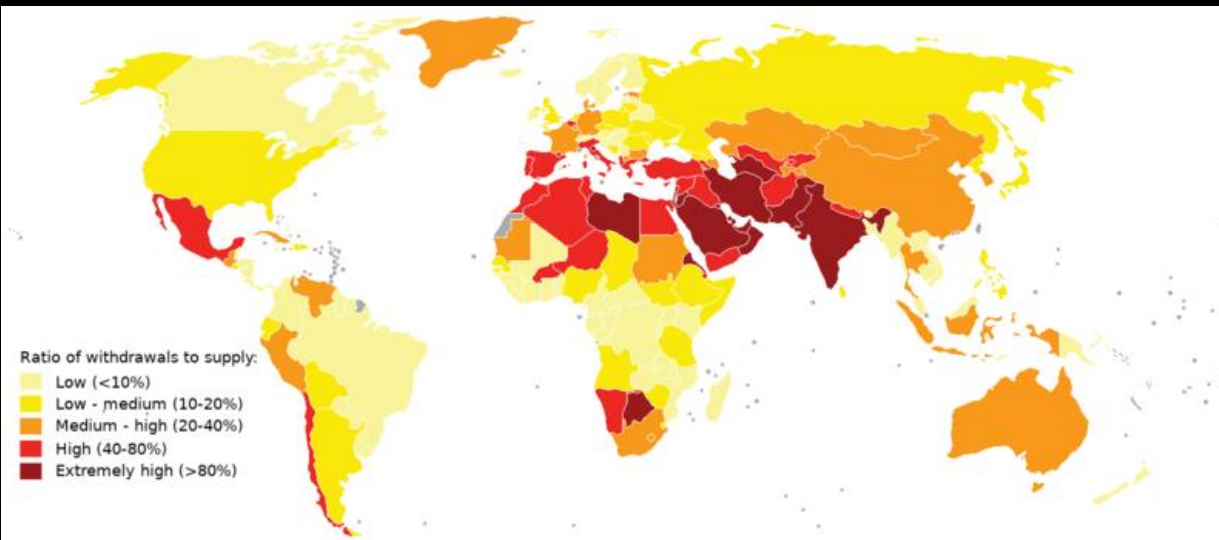
- **2 billion** people in the world do not have a safe supply of clean water close to home.
  - **3.6 billion** people in the world – more than half of the world's population – do not have access to a decent toilet.
    - **2.3 billion** people do not have access to basic hygiene facilities
- Source - WHO/UNICEF (2021) Progress on household drinking water, sanitation and hygiene 2000-2020. Joint Monitoring Program.
- Every minute a newborn dies from an infection caused by lack of safe water and an unclean environment. (WHO, 2015)

Around the world, **up to 443 million** school days are lost every year because of water-related illnesses. (Human Development Report, 2006)

- Every \$1 invested in water and toilets returns an average of \$4 in increased productivity. (WHO, 2012)
- Promoting good hygiene is one of the most cost-effective health interventions. (Disease Control Priorities, third edition (volume 2), 2016)
- If everyone, everywhere had clean water, the number of diarrheal deaths would be cut by a third. (Tropical Medicine and International Health, 2014)

# Global Challenges – Overcoming Scarcity

- **When a territory withdraws 25% or more of its renewable freshwater resources it is said to be 'water-stressed'.**
- **72% of all water withdrawals are used by agriculture, 16% by municipalities for households and services, and 12% by industries.**





# Beyond a shadow of a drought

About **4 billion** people experience severe water scarcity during at least one month of the year

Mekonnen and Hoekstra, 2016

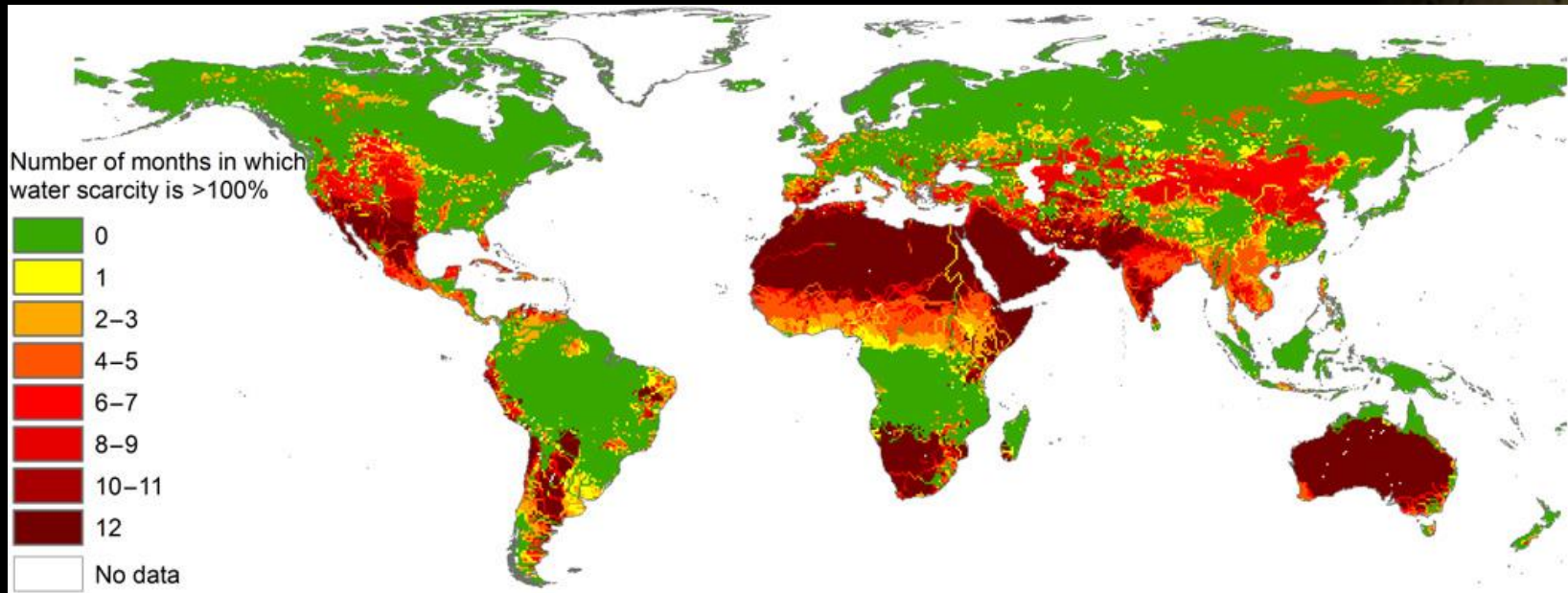


**700 million people worldwide could be displaced by intense water scarcity by 2030.**

Global Water Institute, 2013



# Global Challenges – Overcoming Scarcity



**Half the global population are already living in potential water scarce areas at least one month per year and this could increase to some 4.8–5.7 billion in 2050. About 73% of the affected people live in Asia (69% by 2050). [Burek et al., 2016](#))**

# Drought and Famine

- **Example – Sub Sahelian Africa**
- **1968 -1975 Drought - 200,000 died**
- **millions of herd animals were dead**
- **many thousands of children were brain damaged from inadequate nutrition**
- **Economy of region (8 countries) devastated**
- **Large shifts in population**
- **Major Societal upheaval**



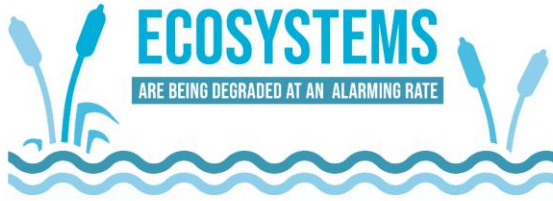
6 CLEAN WATER AND SANITATION



## ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL

### THE WORLD'S WATER-RELATED ECOSYSTEMS

ARE BEING DEGRADED AT AN ALARMING RATE



OVER THE PAST 300 YEARS,

**OVER 85%**

OF THE PLANET'S WETLANDS

HAVE BEEN **LOST**



# Regulatory and Governance Challenges

Concern with lack of enforcement of water-related laws and regulations

Corruption - Every 10% of investment in the water sector that is lost to corruption equates to over \$75 billion in losses per year, according to a 2016 study.





592+ Transboundary aquifers (IGRAC)

Few Transboundary groundwater agreements compared to surface water



# Global Challenges – ending gender bias



***“No country can every truly flourish if it stifles the potential of its women and deprives itself of the contribution of half its citizens.” — Michelle Obama***

# What about water quality?







# **Water Quality and Sanitation**

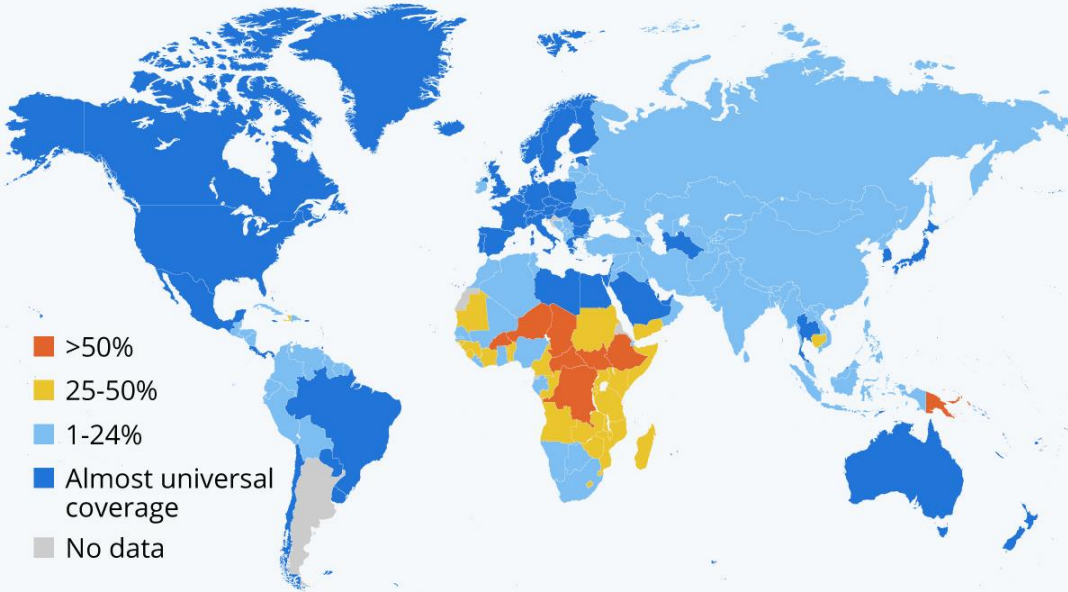
**UN estimates 2.3 billion people worldwide do not have access to toilets or sanitary pit latrines**

# Unsafe Water Kills More People Than Disasters and Conflicts

Number of deaths in 2020, by selected sources



Share of people without access to basic drinking water service in 2020\*



\* defined as water from protected wells or springs in less than 30 minutes distance  
Sources: WHO/UNICEF, U.N., PRIO/UCDP, III

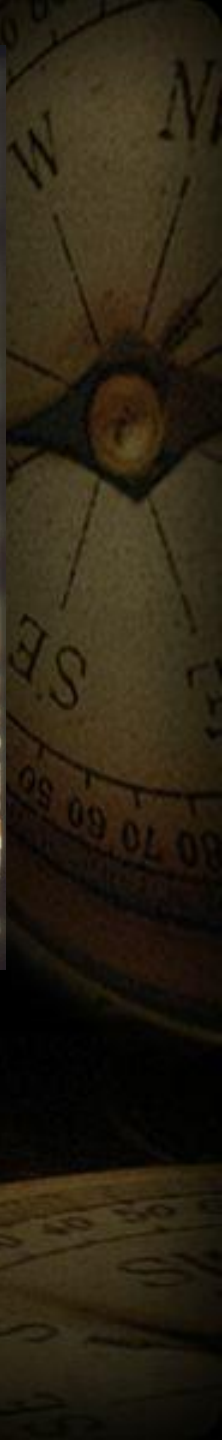


# Global Challenges – inadequate sanitation

- People forced to inhabit, provide sanitation and obtain water from very limited areas.
- Shallow groundwater widely used as the source of water.
- Inadequate protection of groundwater from onsite sanitation and waste disposal
- Three billion people do not have access to handwashing facilities with soap.
- Still, ~673 million people practice open defecation.



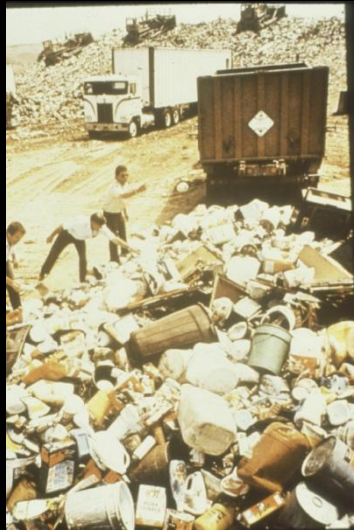
# Landfills, Cesspools



# Toxic Waste Challenges



## Industrial and Agricultural Pollution – historical and “emerging” contaminants



***What people don't understand is like when water gets polluted, it's an entire aquifer. There's a whole fascinating world that exists underneath our feet that we don't see, the same world that's what Eric Decker is***

# How to Dispose of DDT

## GUIDELINES

### Homeowners

To get rid of DDT (dichloro diphenyl trichloroethane) products such as aerosol bombs, liquid sprays, powders, and dusts—bury them on your own property. If each homeowner does so, these products will be safely dispersed and will reduce dangerous concentrations of DDT and other toxic materials at public disposal sites. By law, ingredients are listed on the label.

1. Select a place away from trees and other desirable shrubs or plants and at least 50 feet from any well or surface water such as a lake, stream, pond, or drain.
2. Dig a hole deep enough to cover the DDT products and containers with three feet of dirt.
3. Aerosol (pressurized) cans should not be punctured, but put in the hole intact.
4. Glass and metal containers should be opened and put in the hole tilted down to allow drainage. The glass should not be broken.
5. Bags and boxes should be buried intact.
6. The hole should not be left open. It should be filled with three feet of dirt immediately.

The only exception to the above recommendations is if the water table on your property is less than five feet below the ground. (If you do not know your underground water level, call your local health department.) If the water table on your property is less than five feet below the ground, your health department will advise you on what to do.

**NOTE:** DDT and other toxic products should NOT be flushed down the toilet, poured down a drain, put in the garbage or trash can, or taken to a public dump or landfill.

### Agricultural, Commercial and Municipal Users

The disposal of DDT in larger quantities should be done in one of the following ways:

#### A. Bury on Own Property

1. Select a site at least six feet above the highest groundwater table in an area that is not likely to be used for crops or building purposes. The site should be at least 300 feet from any well or surface body of water including lakes, streams, ponds and drainage ditches.
2. Dig a hole deep enough to cover the insecticide and containers with three feet of soil.
3. Open containers of liquids before placing them in the hole so as to permit drainage of the insecticide from the containers.
4. Place bags or cartons containing wettable powders or dusts in the hole intact.
5. Fill in the hole with soil immediately.

#### B. Disposal Through Michigan Department of Natural Resources

Notify your field office, Michigan Department of Natural Resources, of products to be disposed of, particularly those in 30 and 55 gallon drum lots. The Michigan Department of Natural Resources will take them to central collection facilities. Here, storage facilities will be posted and locked and materials will be held for proper disposal.

**IN CASE OF ACCIDENTAL POISONING OR SUSPECTED POISONING—A LOCAL POISON CONTROL CENTER OR PHYSICIAN SHOULD BE CONTACTED IMMEDIATELY. (over)**

concentrations of DDT and other toxic materials at public disposal sites. By law, ingredients are listed on the label.

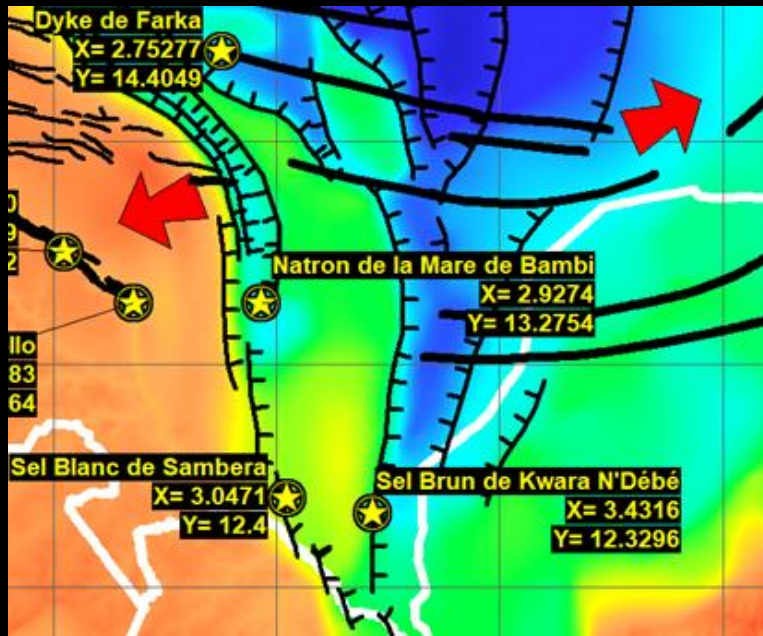
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# Potential for Arsenic Contamination because it isn't measured in groundwater - Niger

## Groundwater quality along basement fractures in the dallols



Sambera  
clear salt

Kwara  
N'Debe  
brown salt

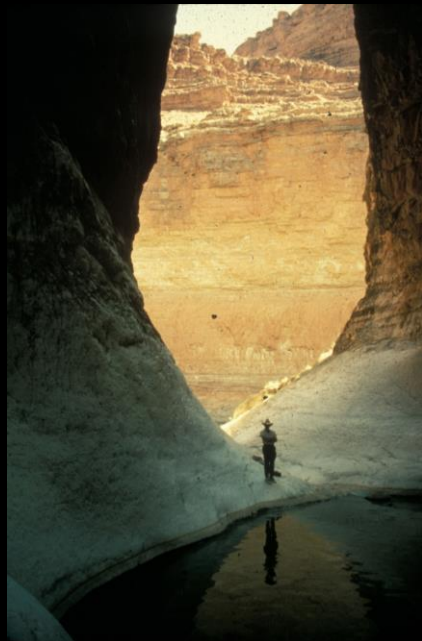
Natron of  
the mare  
de Bambi

Preparing sample capsules for XRF analysis

Sambera's white salt, like Kwara N'Débé's, is collected by populations at the top of N-S-oriented basement faults, consistent with rift opening, **with high contents of rubidium, nickel and chrome.** These metals reflect their hydrothermal origin from the basement

The Natron de la Mare de Bambi also has **high contents of rubidium and arsenic.** These metals reflect their hydrothermal origin from the basement

# Natural Background Groundwater Contamination – including Spring and Ecosystem Health



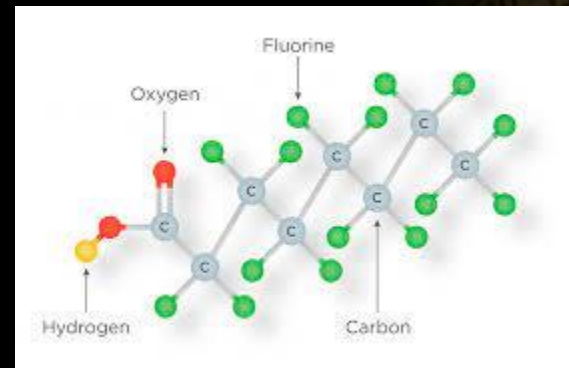


# Arsenic (As)

- 87 % of time not analyzed
- 53.8 % above MCL when detected
- 78 Springs above MCL of 0.01 mg/L



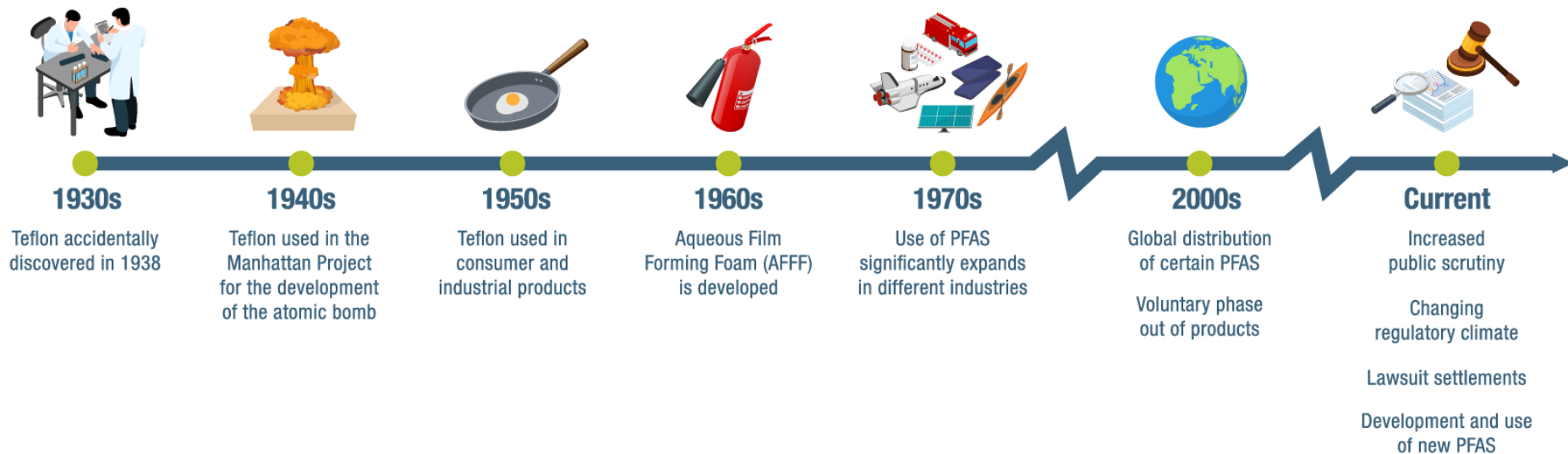
# New Pollutants – example PFAS



- “forever chemicals”

## PFAS Development ...

## ...and Evolution



# Muir Glacier, SE Alaska

August, 1941 (photo by William Field)

August, 2004 (photo by Bruce Molnia)

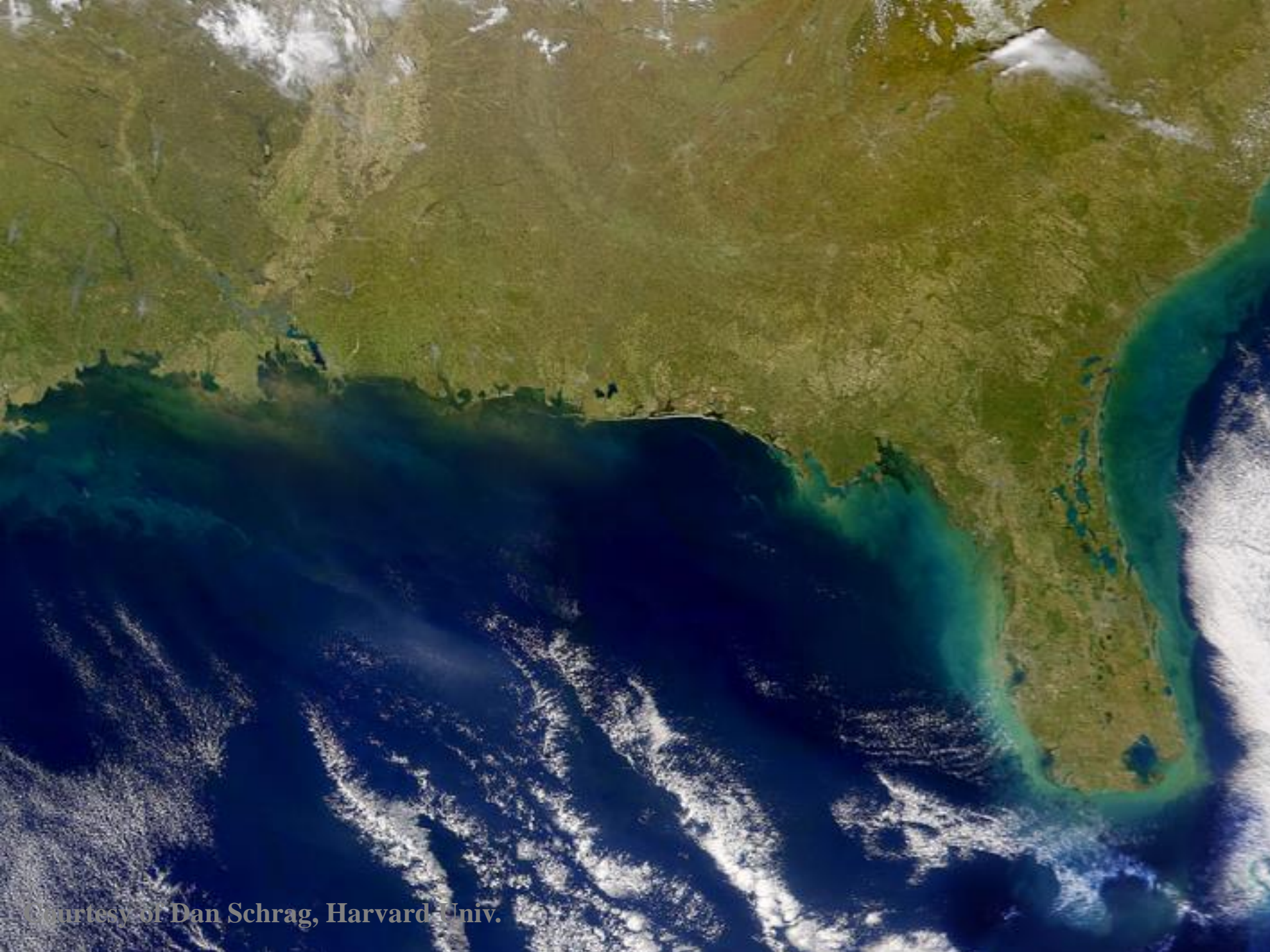


# Glaciar Lanín Norte





Courtesy of Dan Schrag, Harvard Univ.



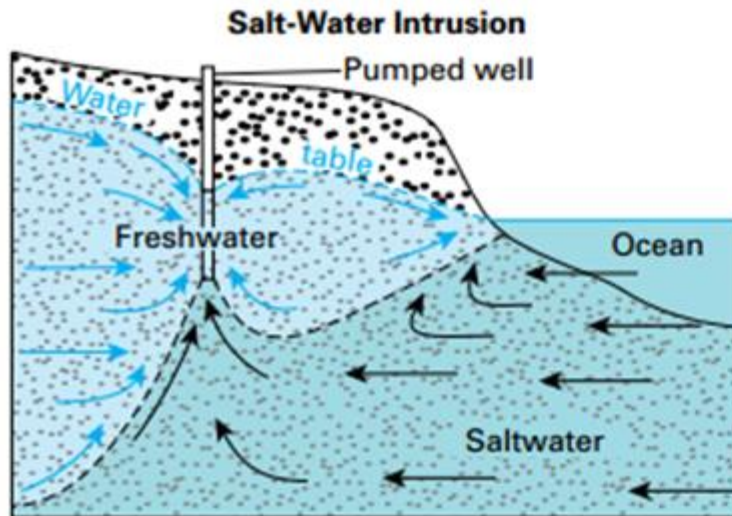
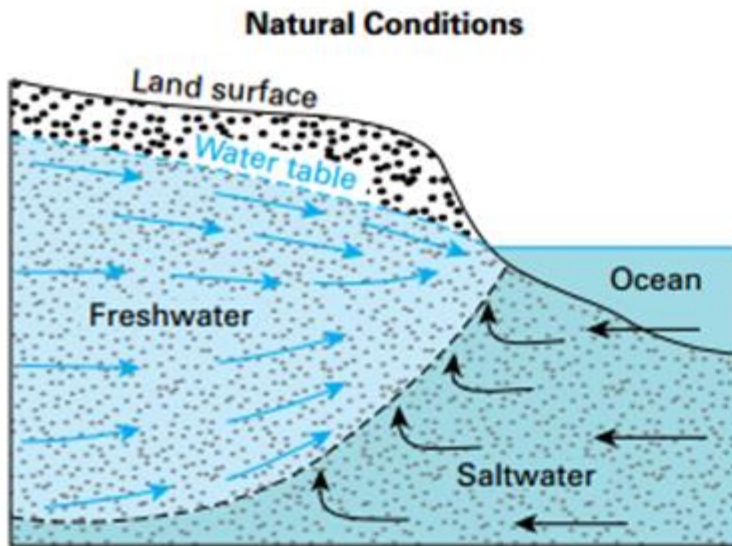
Courtesy of Dan Schrag, Harvard Univ.







# Global Challenges - Coastal Saline Water Intrusion



# Importance of Groundwater

- Provides drinking water to at least 50% of the global population
- Over 97% of the fresh, liquid water on earth is groundwater
- Key element in global resilience to climate change, Underpinning of energy production, Supports food security and economic development
- In times of Covid-19, groundwater promotes hand washing in isolated rural communities.



Worldwide, approximately 2.5 billion people depend solely on groundwater resources to satisfy their basic daily water needs





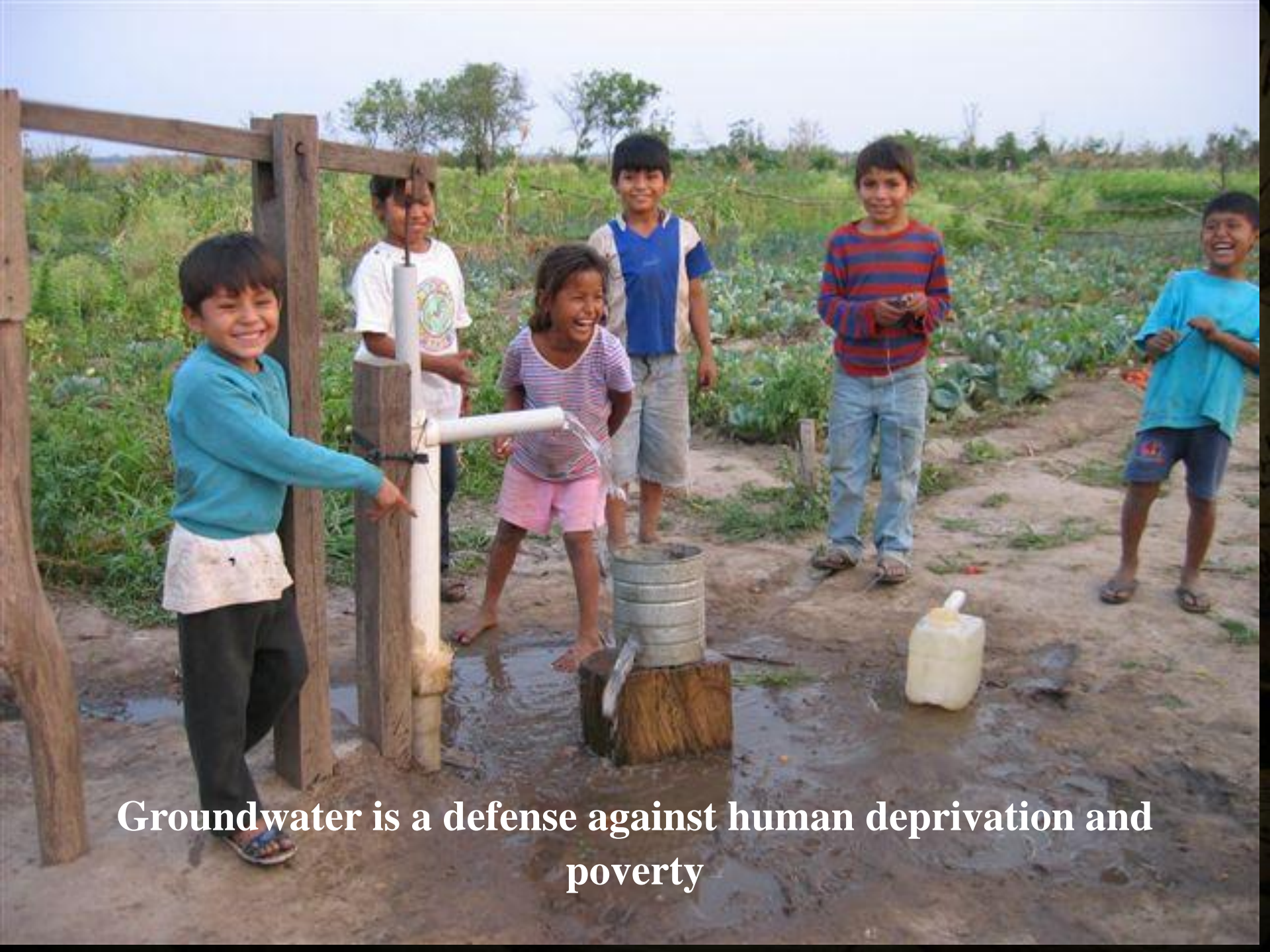
**Groundwater supports  
food security and  
economic development,  
and is essential to the  
health of all living things.**





# Groundwater is a shield against ecosystem loss

*For many of us, water simply flows from a faucet, and we think little about it beyond this point of contact. We have lost a sense of respect for the wild river, for the complex workings of a wetland, for the intricate web of life that water supports. Sandra Postel*



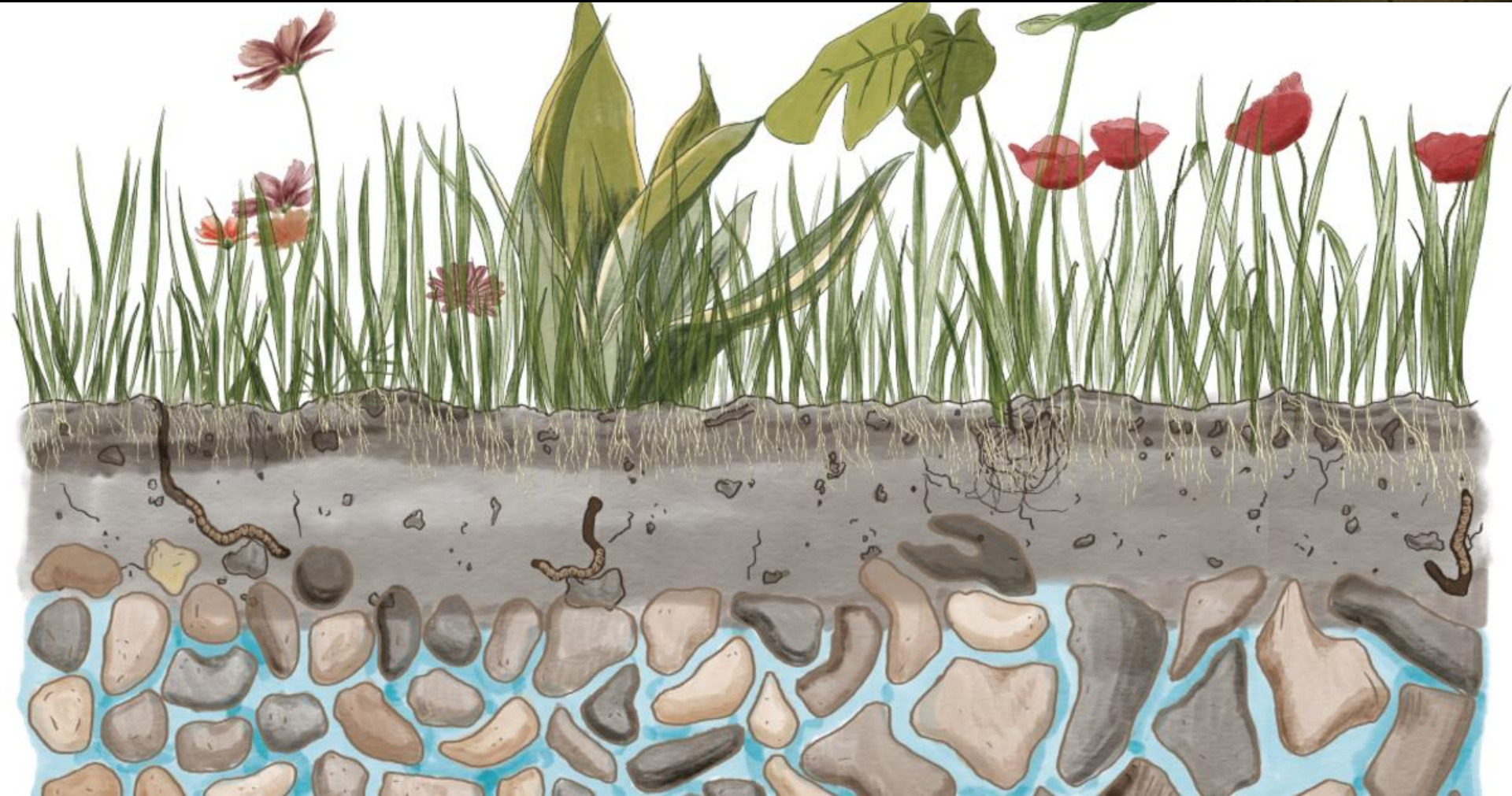
**Groundwater is a defense against human deprivation and poverty**



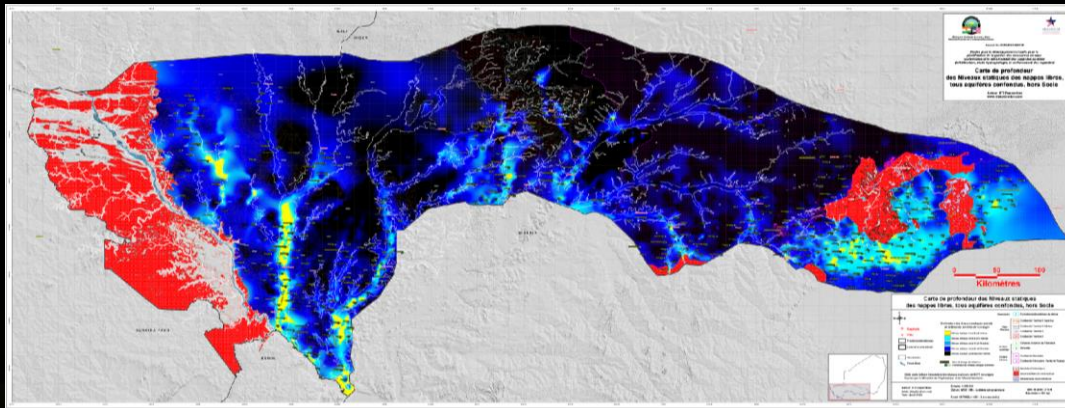
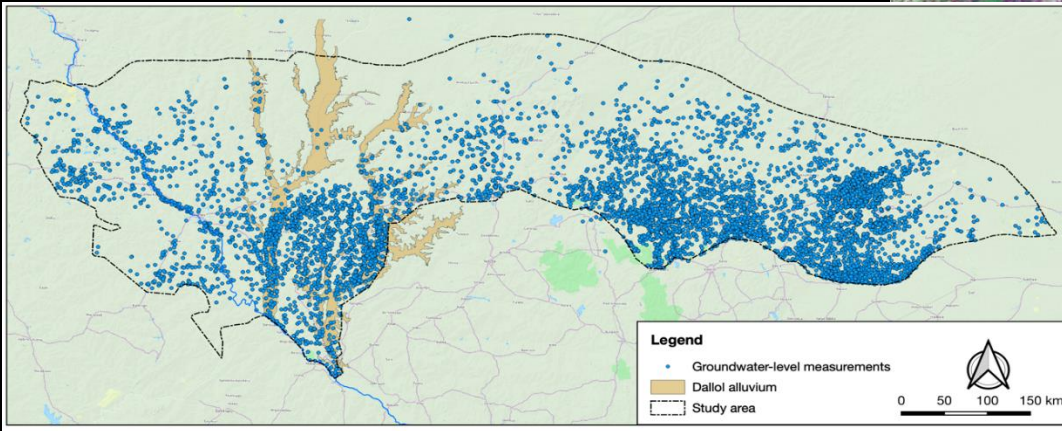
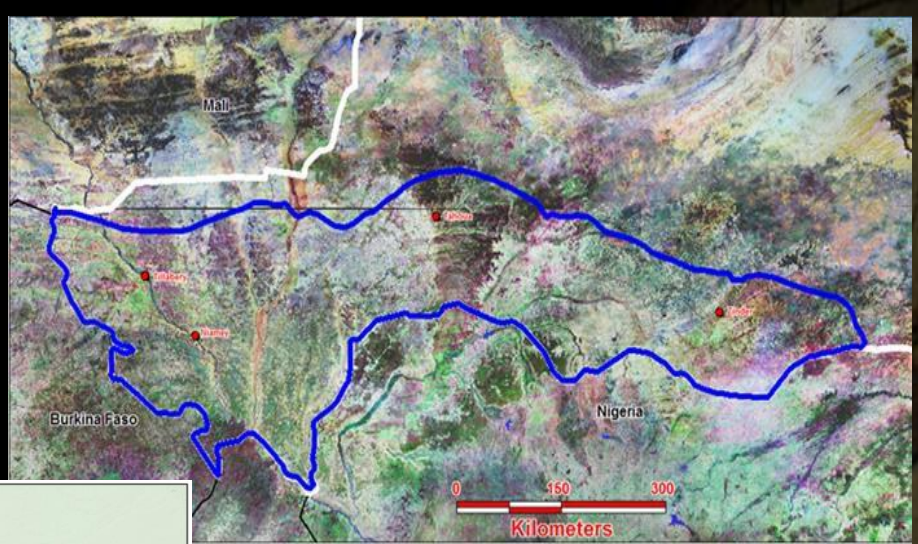
# So Why is Groundwater Invisible?



# U.N. World Water Day 2022: Groundwater, Making the Invisible, Visible



If there is magic on this planet, it is contained in water. Loren Eiseley



# Niger - Landlocked

- About 80% in the Sahara Desert
- Surrounded by 7 different countries
- “Frying Pan of the World”
- 56% of population does not have access to clean drinking water



# Niger - health and water scarcity

- Consistently one of the lowest on the World Health Organization Index
- Life expectancy at birth: total population: 55.9 years, male: 54.7 years female: 57.3 years (2017 est.)
- 210 out of 223 nations
- 2005 “famine” – drought 2018 , locusts, poverty



# Niger – population and poverty

- Highest fertility rate in the world –about seven children per woman
- Population doubled in about 25 years (compared to 61 years globally)
- Roughly 48 % of population is 14 or younger
- According to UNESCO 42.9% of Nigerien children between five and fourteen are working instead of going to school



# Niger



- **Main agriculture subsistence farming but only 11% of land is arable**
- **Over 80% of population identifies as Islamic**
- **Principal educated language is French**
- **Threats do exist in form of kidnapping, slavery (although officially outlawed), Boko Haram**
- **ISIS and Al Qaeda**

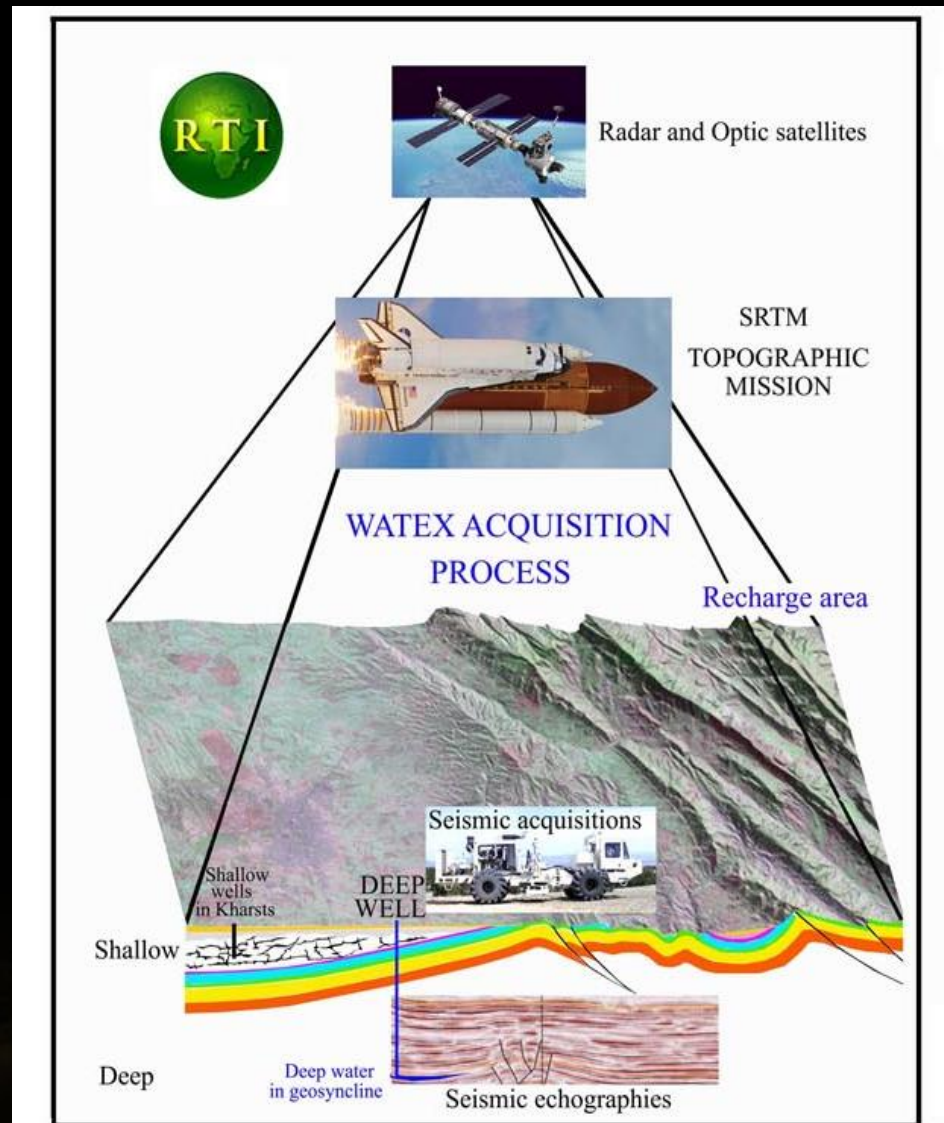


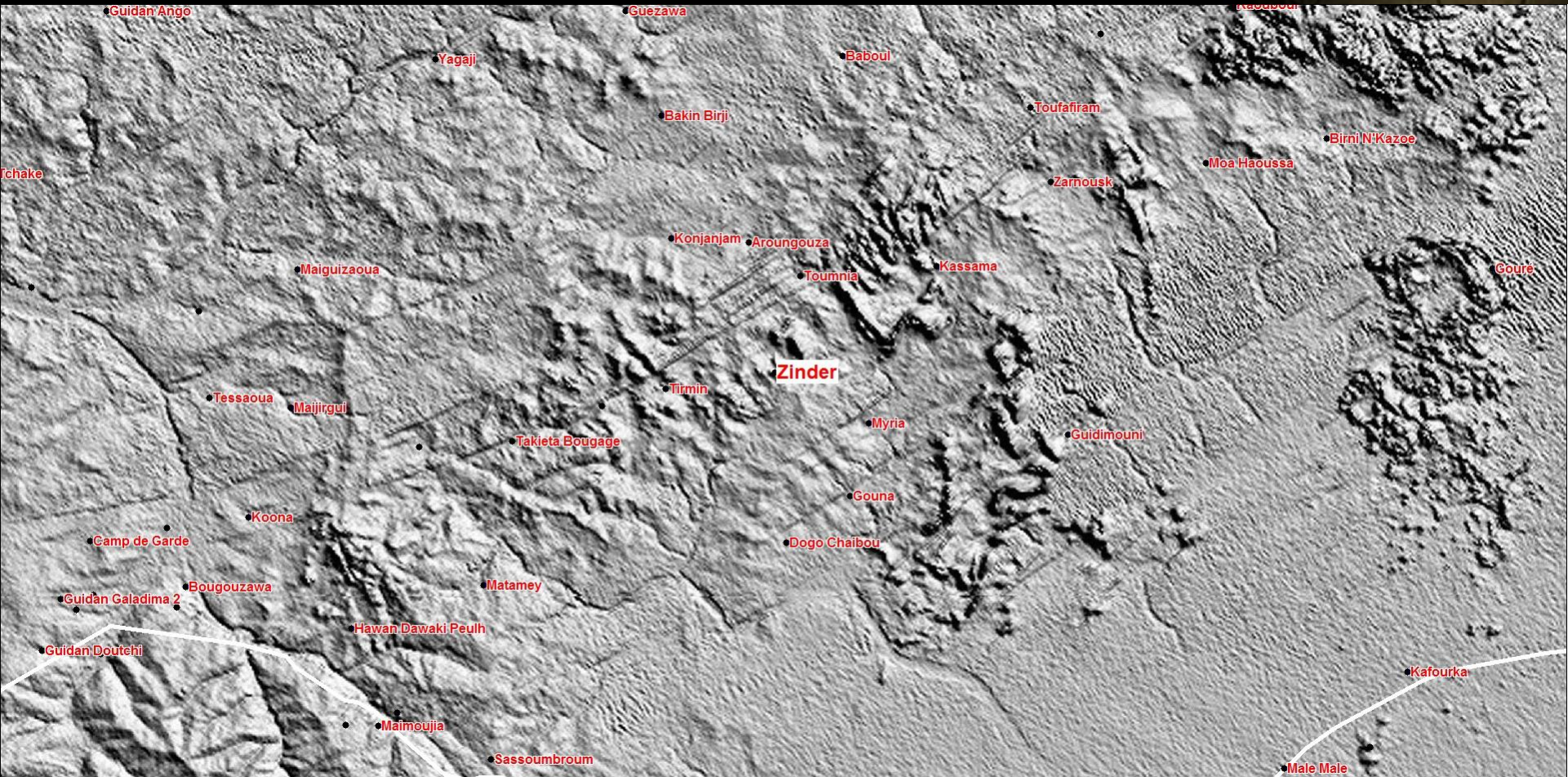
# End of the dry season



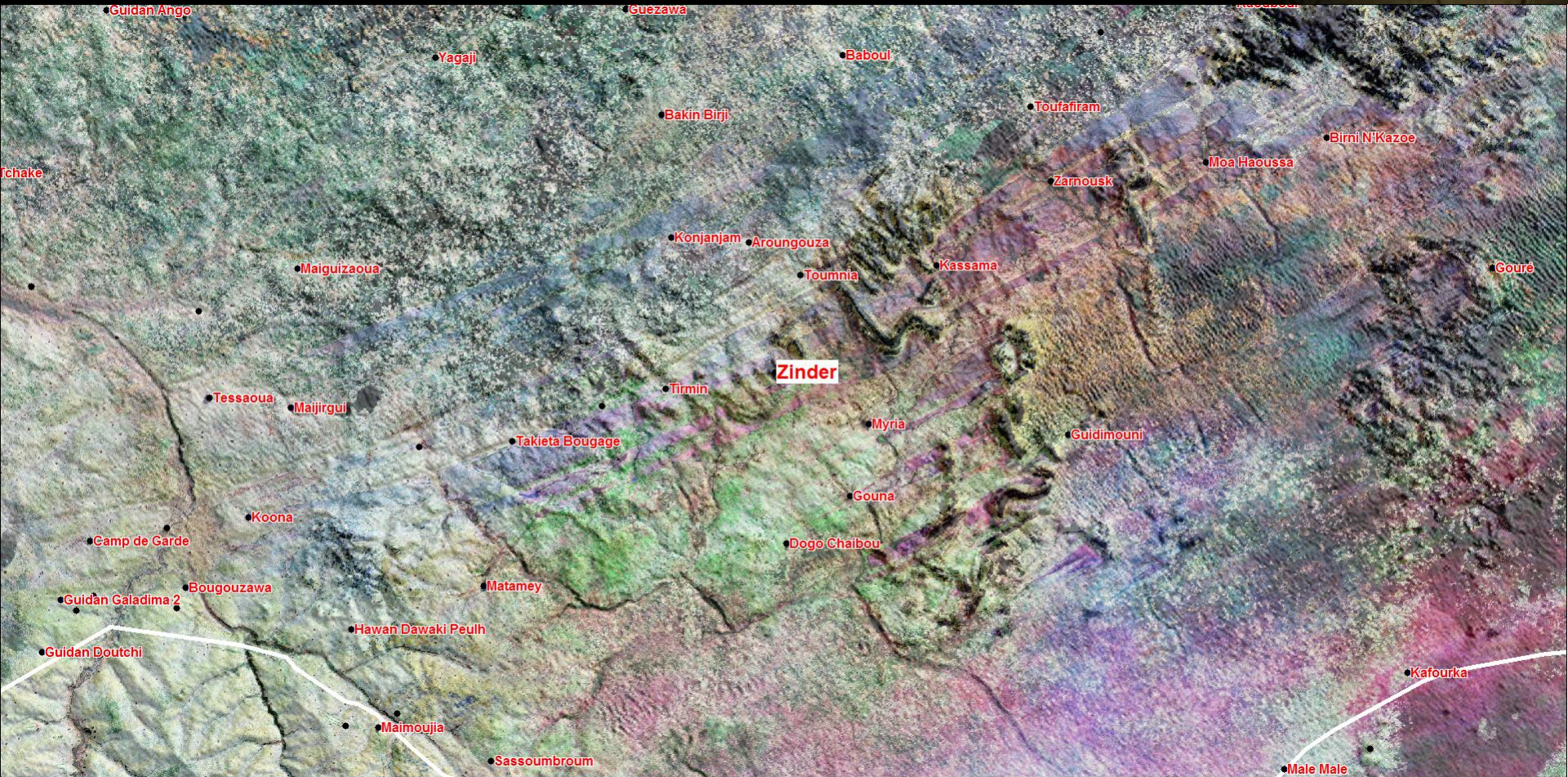


# WATEX method: a new method of remote sensing to better understand the Hydrogeology of Niger

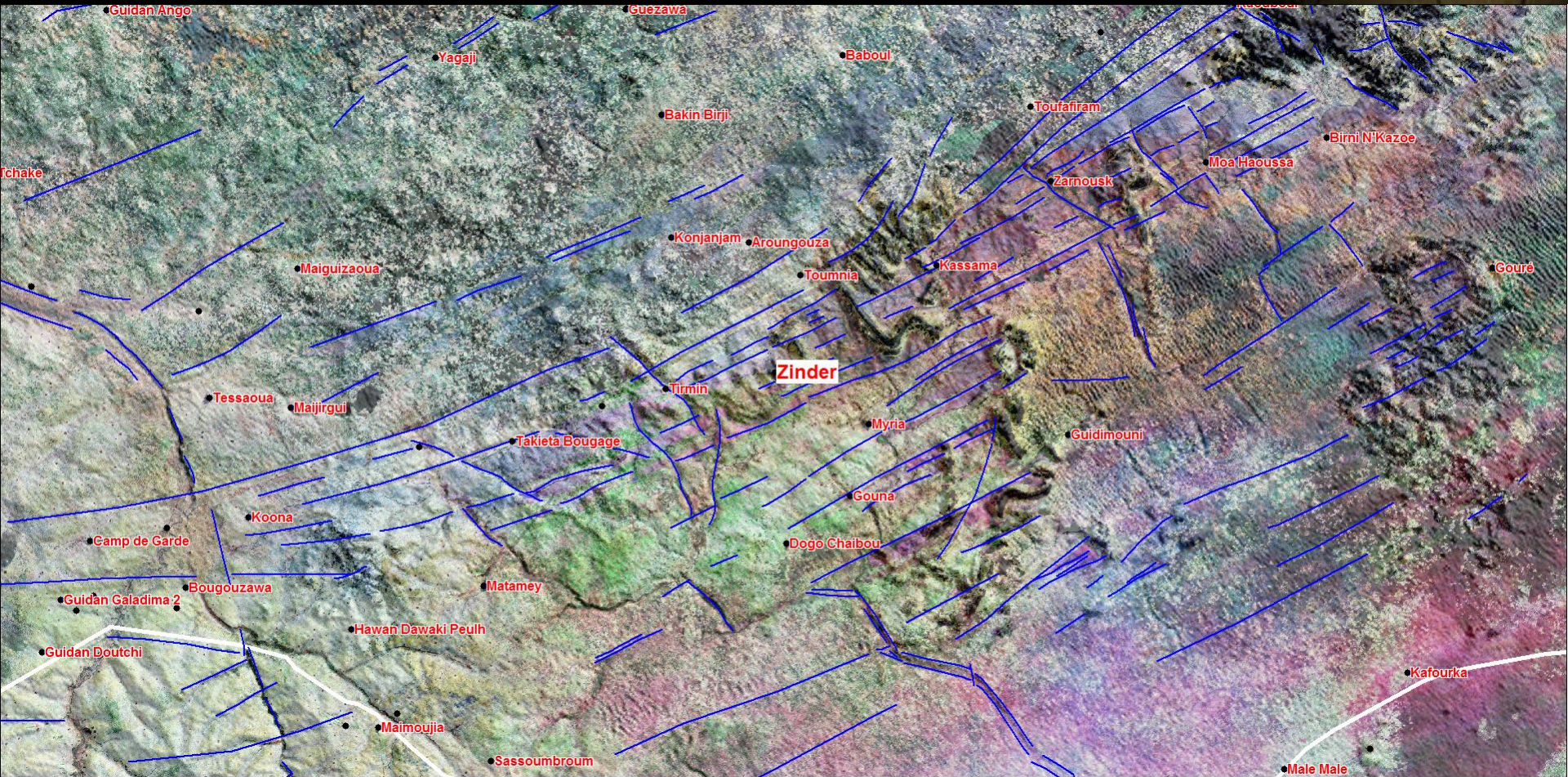




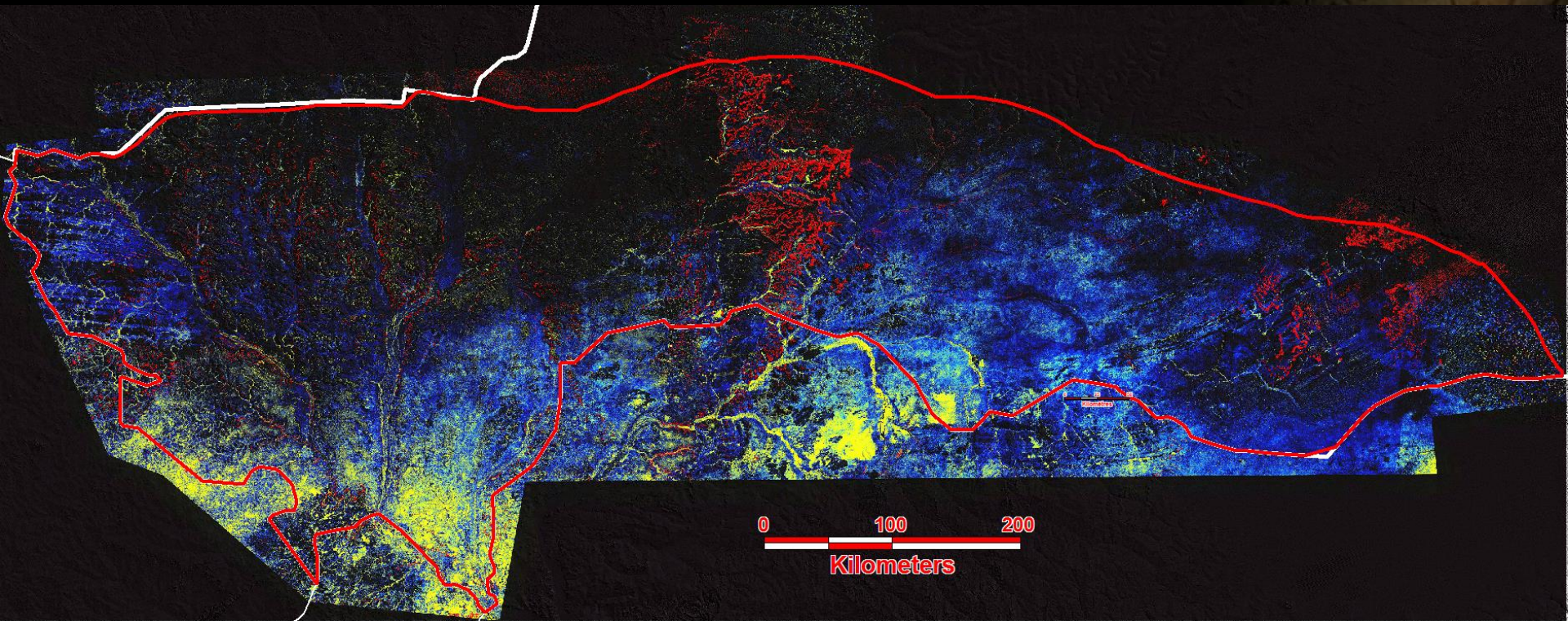
# Landsat 8 imagery



# Transfer faults (or hydrothermal dikes) oriented NE-SW on the Zinder uplift from Landsat 8 imagery







# Presentation of all the study area WATEX imagery which represents the culmination of the whole of a sequence of treatments



This ultrasound image represents the aquifer potential up to a depth of 60 m for dry areas on the surface





## Zonations du potentiel aquifère entre 0 et 60 m

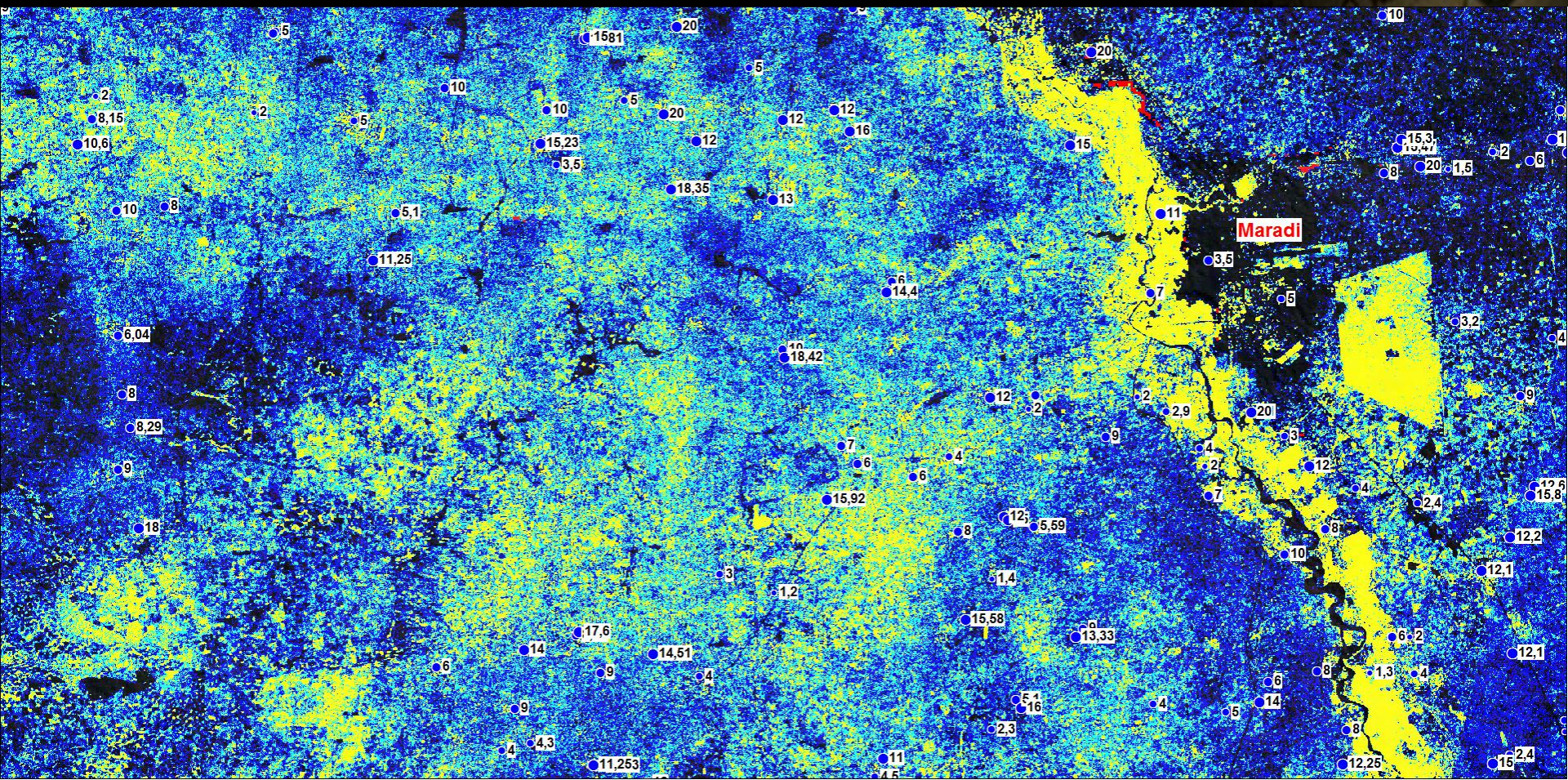
-  Zones à très haut potentiel
-  Zones à potentiel médian
-  Zones à potentiel bas
-  Zones sans potentiel entre 0 et 60 m



# An area of top/medium potential (zoomed in)

## Zonations du potentiel aquifère entre 0 et 60 m

-  Zones à très haut potentiel
-  Zones à potentiel médian
-  Zones à potentiel bas
-  Zones sans potentiel entre 0 et 60 m

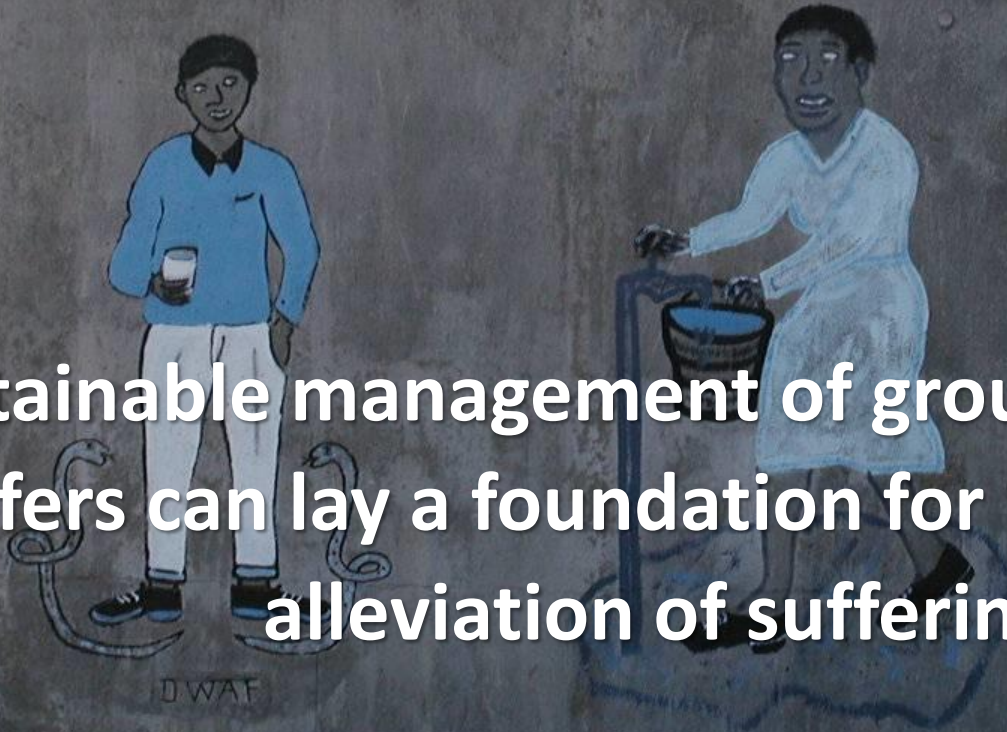


# Suggested Ways Forward



- Effective Hydrophilanthropy
- Move toward Sustainability
- Better Monitoring, Data Collection, and Data sharing
- Capacity Building
- Connecting Research and Innovation with Practitioners
- Advocacy

WATER WASHES AWAY POVERTY



**Sustainable management of groundwater and aquifers can lay a foundation for peace and the alleviation of suffering.**



# Hydrophilanthropy

**Philanthropy = a desire to help mankind, especially as shown by gifts to charitable or humanitarian institutions; benevolence (Webster's New World Dictionary, 2<sup>nd</sup> Edition)**

**Definition – Humanitarian actions which increase and sustain clean water in areas of need**

# Suggested Ways to Move Forward



**Student Association for International Water Issues, University of Nevada, Reno install well – Kenya, 2004**

Journal of Contemporary  
**Water Research & Education**

Issue 145  
August 2010

**Hydrophilanthropy and Education**

A Publication of the  
Universities Council on Water Resources

The cover of the journal features a collage of images related to water and community development. The central image shows a person operating a water pump. Other images include a well installation, a group of people, and a person carrying a water container. The title "Hydrophilanthropy and Education" is circled in red. The logo of the Universities Council on Water Resources is at the bottom left.

Using Appropriate, Transferable Technology

# Changing the Paradigm

**Shift in Goals from Number of Beneficiaries to Sustainability** –  
historical breakdowns

- **21 African nation survey reported that 36% of installed well pumps were non-functional** (*Rural Water Supply Network Work Plan, January 2009-December 2011*)
- **Menaca region of Mali, 80% of water points are “dysfunctional”** *The Institute for Environment and Development (IIED 2009)*
- **58% are in need of repair in northern Ghana**



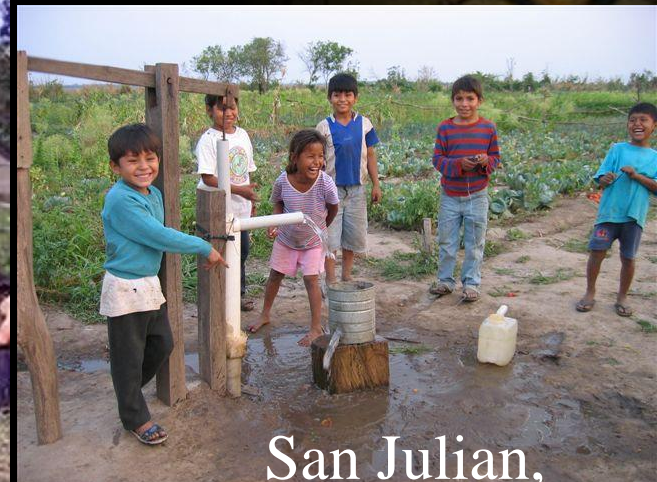
# Rainwater Harvesting System – Liquidambo, Guatemala – January 2010; Higher Education System of Nevada



# Manual Well Drilling – Turkana, Kenya – 2007; University of Nevada students, Teaching the Local Men and Women How to Drill



# Low Tech is sometimes the best tech



San Julian,  
Bolivia











## Other Challenges – Subsidence

Examples  
South Africa  
and Arizona



**One Possible Future Solution -  
The Feasibility of Using Large, Retired and  
Mothballed Ocean Vessels as Mobile  
Desalinization and Power Plants**

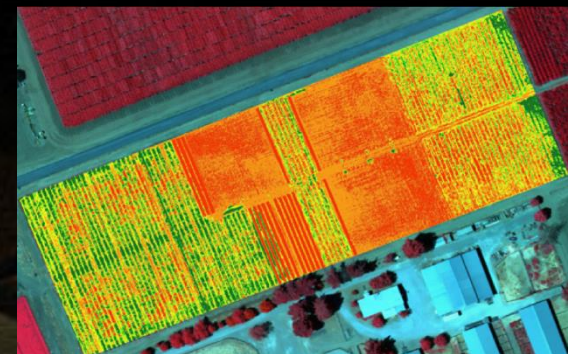
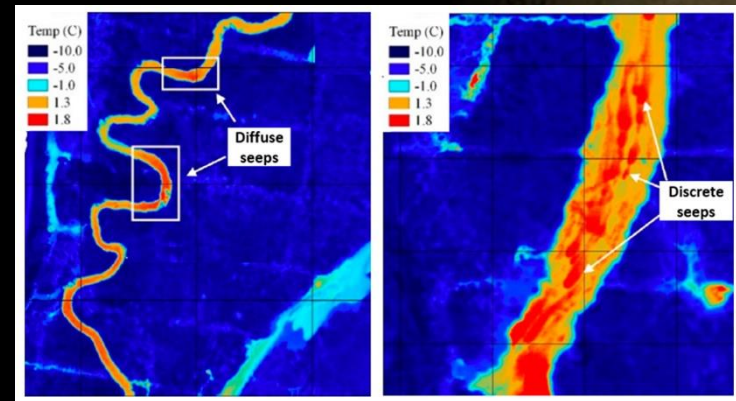




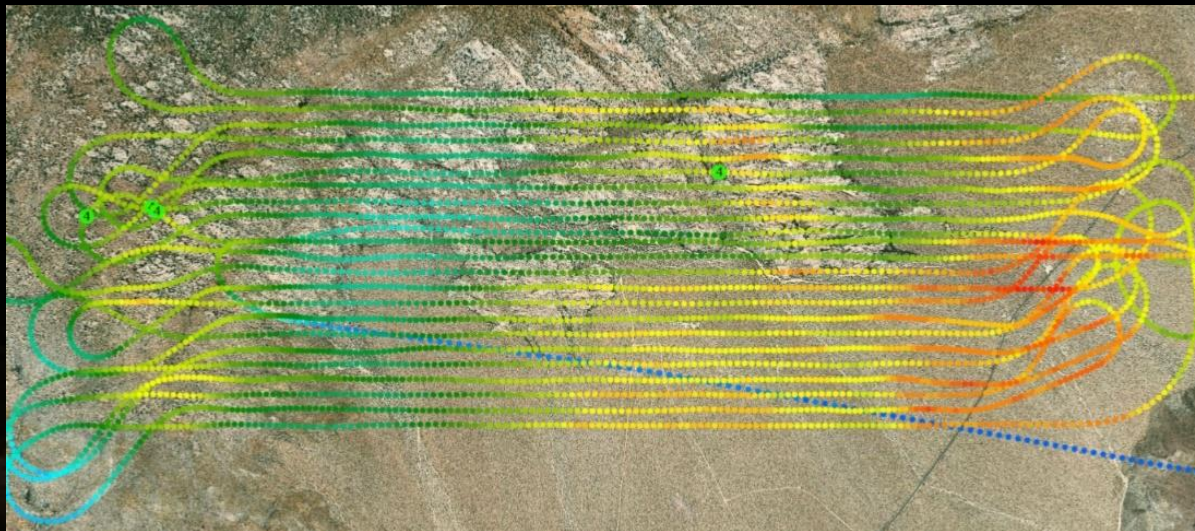
**DESAL Watercraft Carrier Concept –  
John Zulaikha, 2005**

- **Wind, wave, tide, and solar energies with battery and reverse osmosis desalination**
- **Daily routine governed by the tide, wave, wind, and sun direction.**
- **Massive - able to withstand storms and/or relocate.**

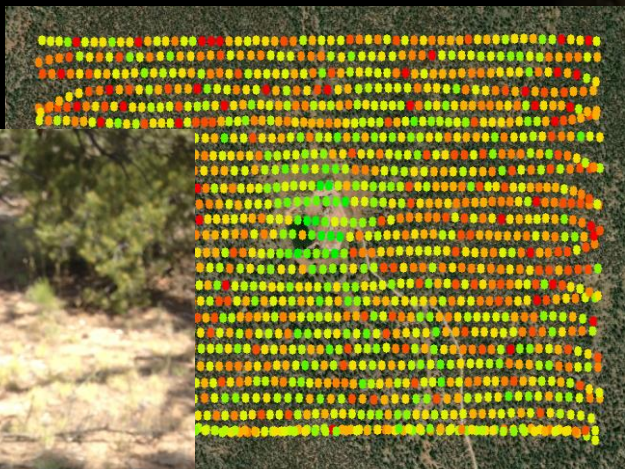
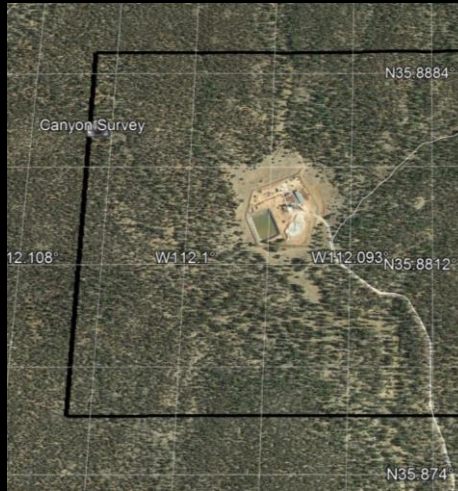
# New Solutions – Remote Imagery



# New Geophysical tools

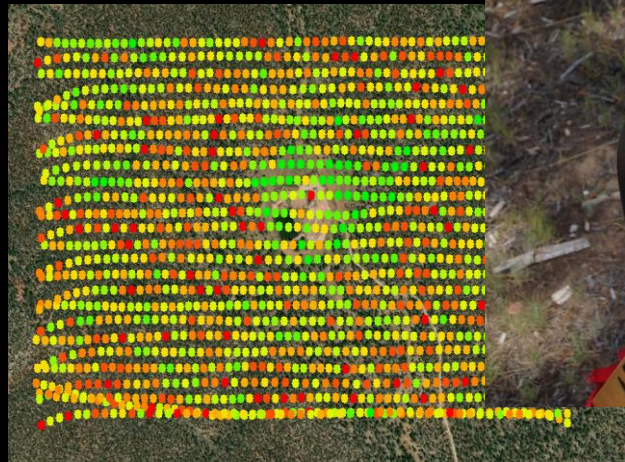


# Example – Remote sensing for potential contamination Northern Arizona, USA

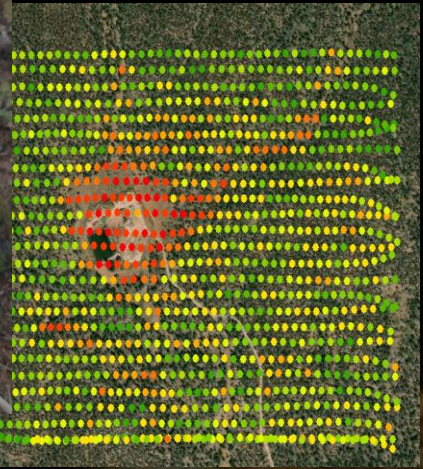


eU
0.859618 - 1.915219
1.915220 - 2.403757
2.403758 - 2.772346
2.772347 - 3.123641
3.123642 - 3.472655
3.472656 - 3.842707
3.842708 - 4.279645
4.279646 - 4.853749
4.853750 - 5.742885
5.742886 - 8.310310

Uranium



Thorium

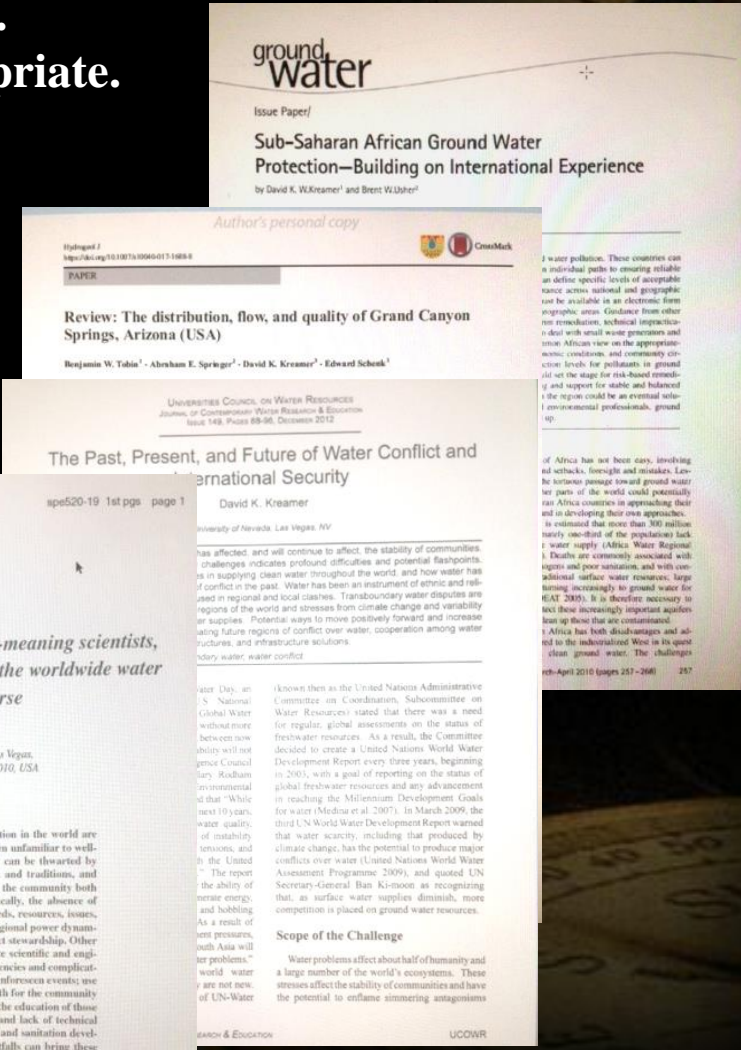
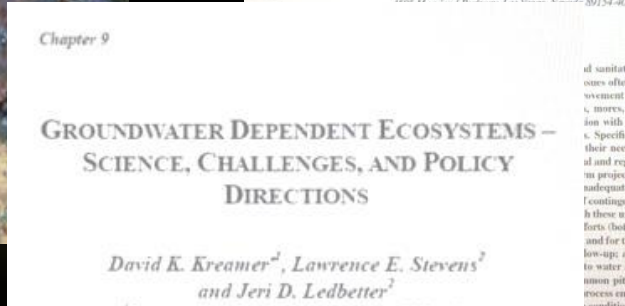
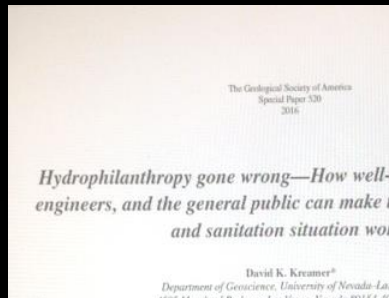
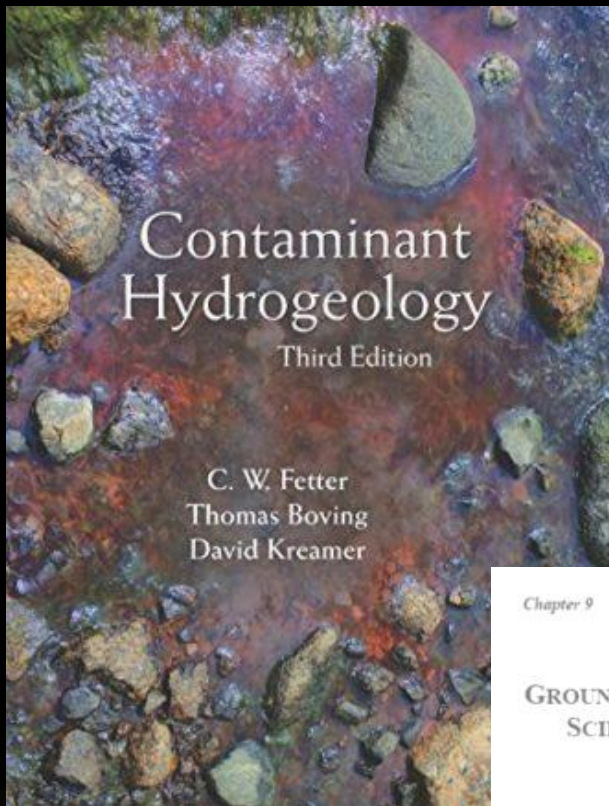


Potassium

survey	K
0.530283 - 0.772887	
0.772888 - 0.886839	
0.886840 - 0.987862	
0.987863 - 1.096082	
1.096083 - 1.216694	
1.216695 - 1.361441	
1.361442 - 1.540505	
1.540506 - 1.800366	
1.800367 - 2.115568	
2.115569 - 2.520513	

# So, aside from the technical solutions we work toward everyday, what additional things can we (or do we already) do to make the world better?

**Publish. Make high quality data available. Make use of innovative technologies where appropriate.**





# **Selected Suggestions for Improvement (bottom up)**

- **Education – Community, Primary, University**
- **Holistic Sanitary Community Improvement**
- **Increase Analytical, Technical and Economic Capability**
- **Wellhead Protection**
- **Improving Enforcement**



# What else can we do?

## Education and Capacity Building





# Water Quality training in Iraq



# So what can we (or do we already) do?

Be an advocate for the wise use and protection of groundwater and all water resources

Example – Become a signatory of the Sao Paulo – Brussels Groundwater Declaration



Make the invisible, visible!



# **Water Professionals Acting Together**



**“What our society has today is a  
perfection of means and a  
confusion in goals” Albert Einstein**

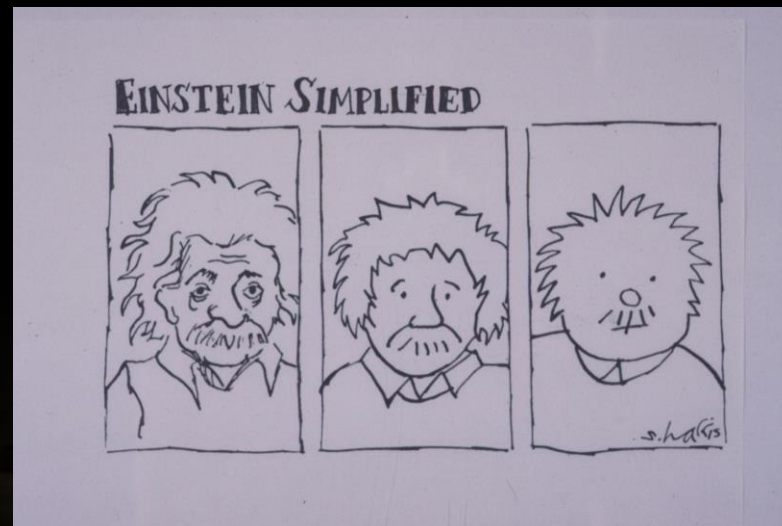
**Shift in Goals from Number of Beneficiaries to Sustainability**

**Better Data Collection and Sharing**

**More Emphasis on Groundwater**

**Better Steps to Connect Innovations with Practitioners**

**Capacity Building**



# Water in many languages and cultures

*“Water, like religion and ideology, has the power to move millions of people. Since the very birth of human civilization, people have moved to settle close to it. People move when there is too little of it. People move when there is too much of it. People journey down it. People write, sing and dance about it. People fight over it. And all people, everywhere and every day, need it.”* –Mikhail Gorbachev

*Water is the driving force of all nature.*  
Leonardo da Vinci

*If a tree falls in the forest, will you make a sound? —*  
*(Homer Simpson, The Simpsons)*