Water and limits of humanity in the anthropocene

Anthropocene is a proposed geological epoch when humans started making significant impact on Earth's geology and ecosystems

Earthrise, taken on December 24, 1968, by Apollo 8 astronaut William Andres.

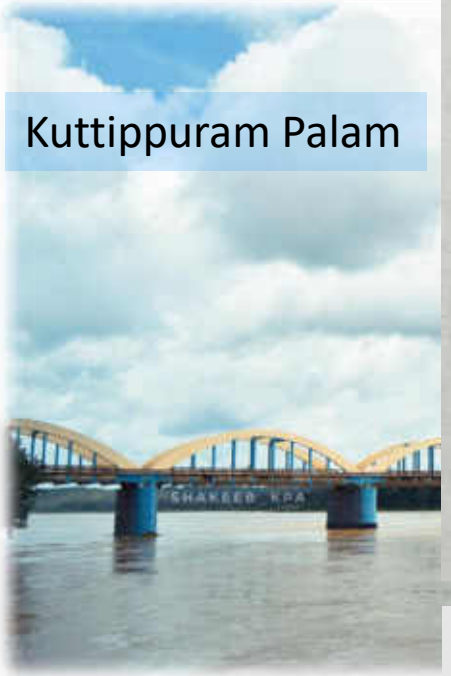
Nature photographer Galen Rowell declared it "the most influential environmental photograph ever taken".

Water is the most important inheritance of our planet

“Pale blue dot” Voyager 1 Feb. 14, 1990

From Wikipedia

Warnings from Kerala



കളിയും ചിരിയും കരച്ചിലുമായ്-
ക്കഴിയും നരനൊരു യന്ത്രമായാൽ,
അംബ, പേരാറേ, നീ മാറിപ്പോമോ
ആകുലയാമൊരഴുക്കു ചാലായ്?

If the man, who with his usual playfulness laughter and tears become machine like, will you too mother 'Perar', change into a canal of grief carrying sewage?

E
1906-1974

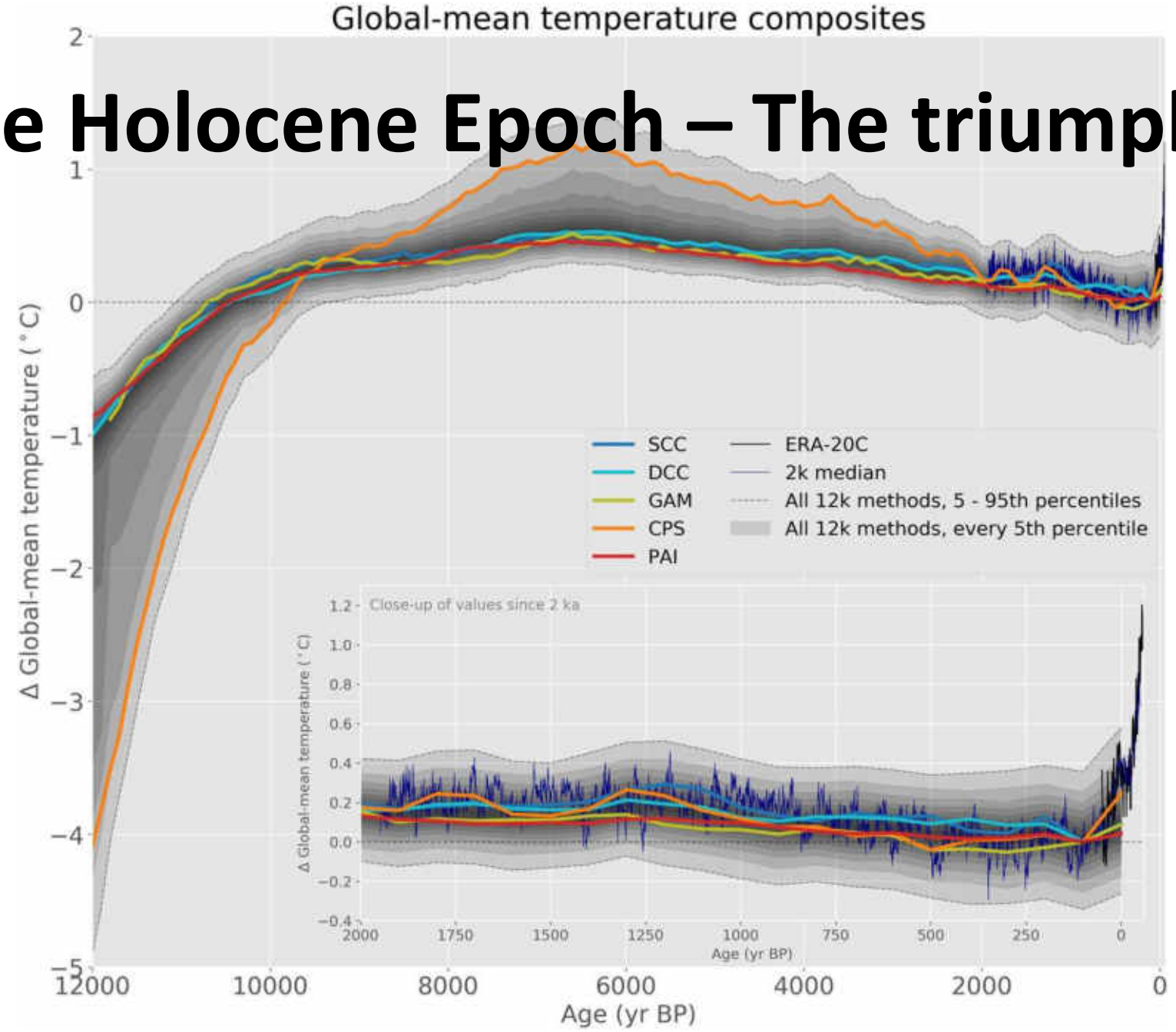
Rachel Carson, 1940

Images: Wikipedia, Edassery Smaraka Trust, K.P.A. Shakeeb

Mathrubhumi Weekly Feb. 21, 1954

Video by Engin Akyurt from Pixabay

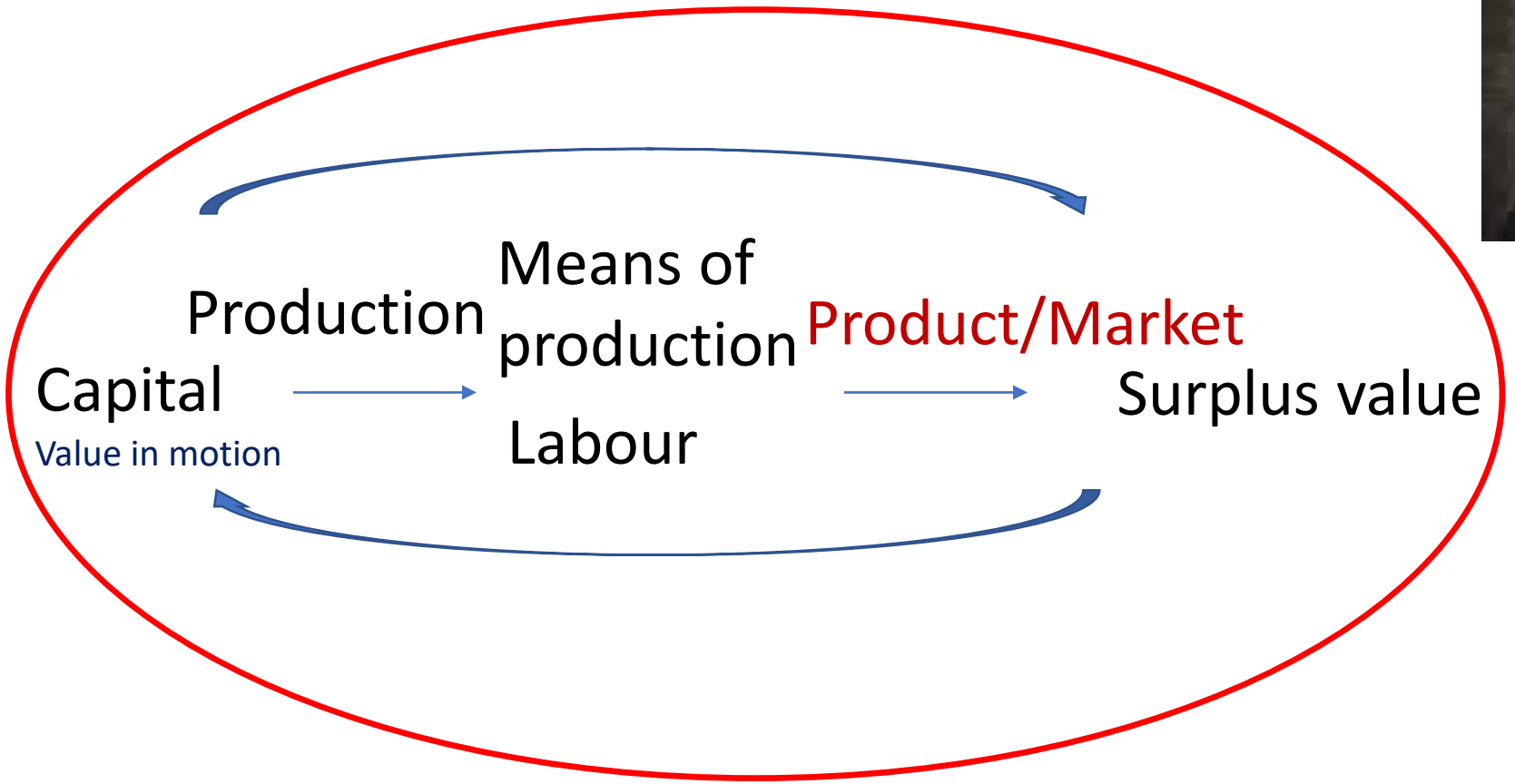
The Holocene Epoch – The triumph of man



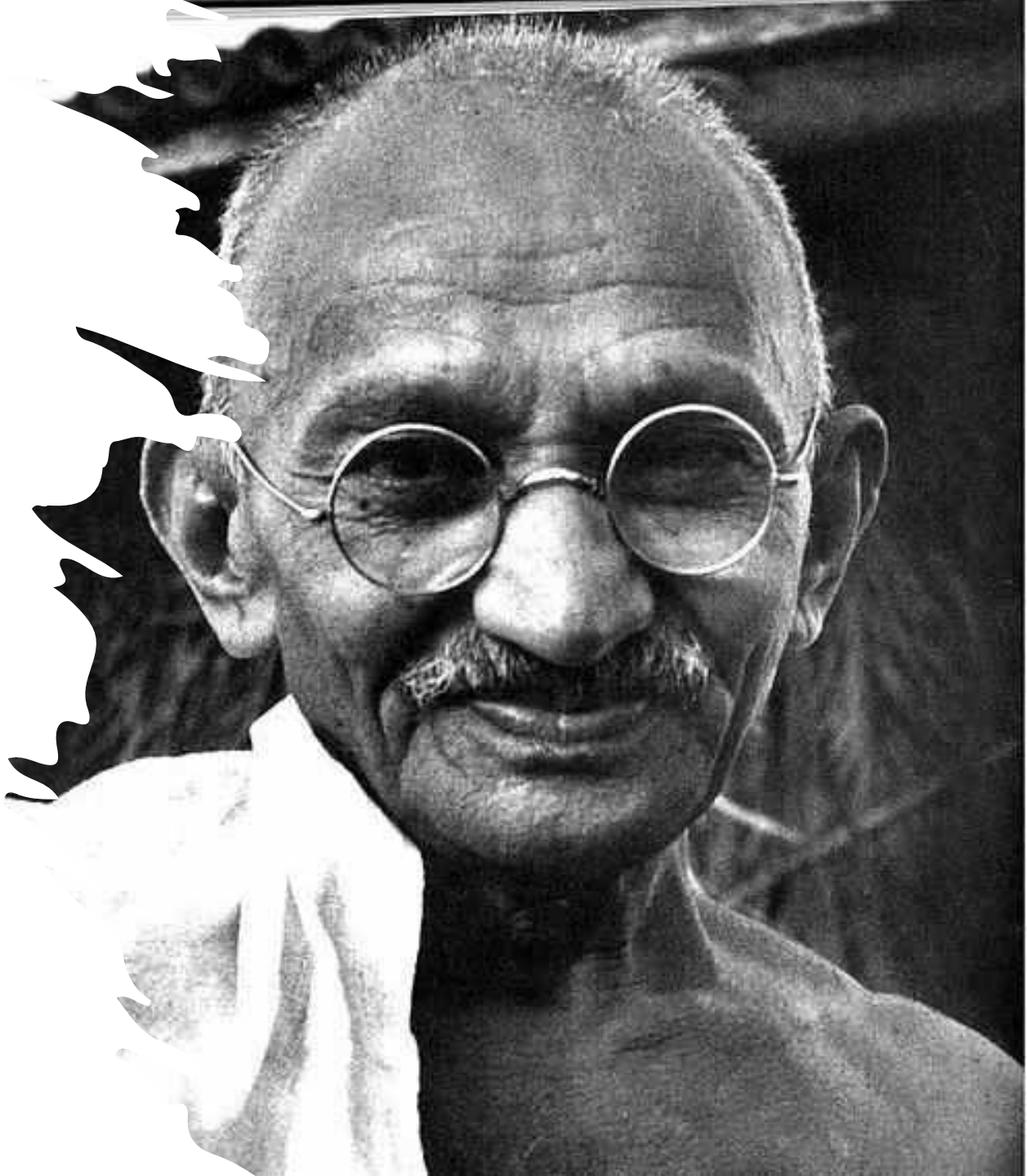
Global mean surface temperature from the Temperature 12k database using different reconstruction methods. The black line is instrumental data for 1900–2010 from the ERA-20C reanalysis product. The inset displays an enlarged view of the past 2000 years.

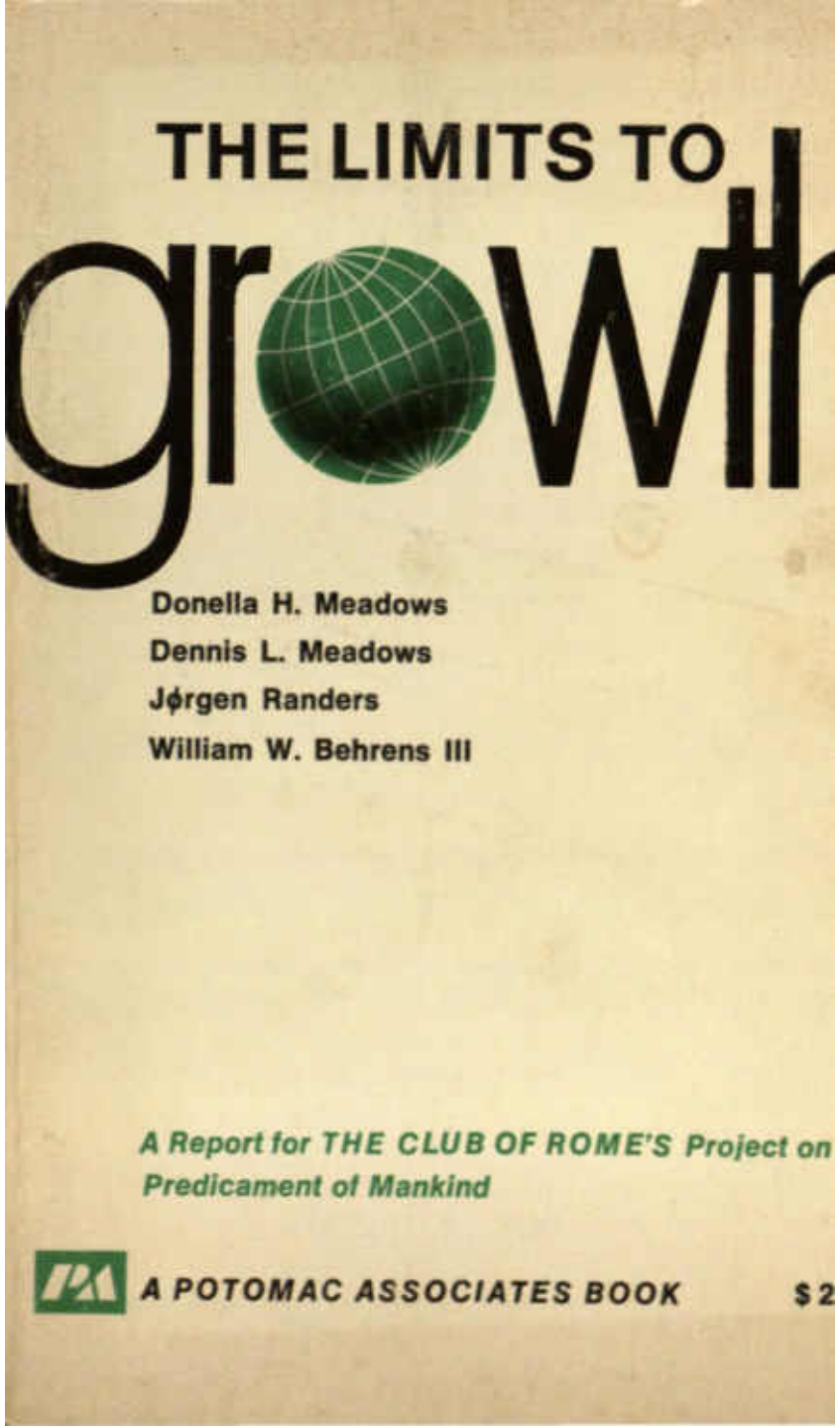
Darrell Kaufman et al. *Scientific Data* **volume 7**,
Article number: 201 (2020)

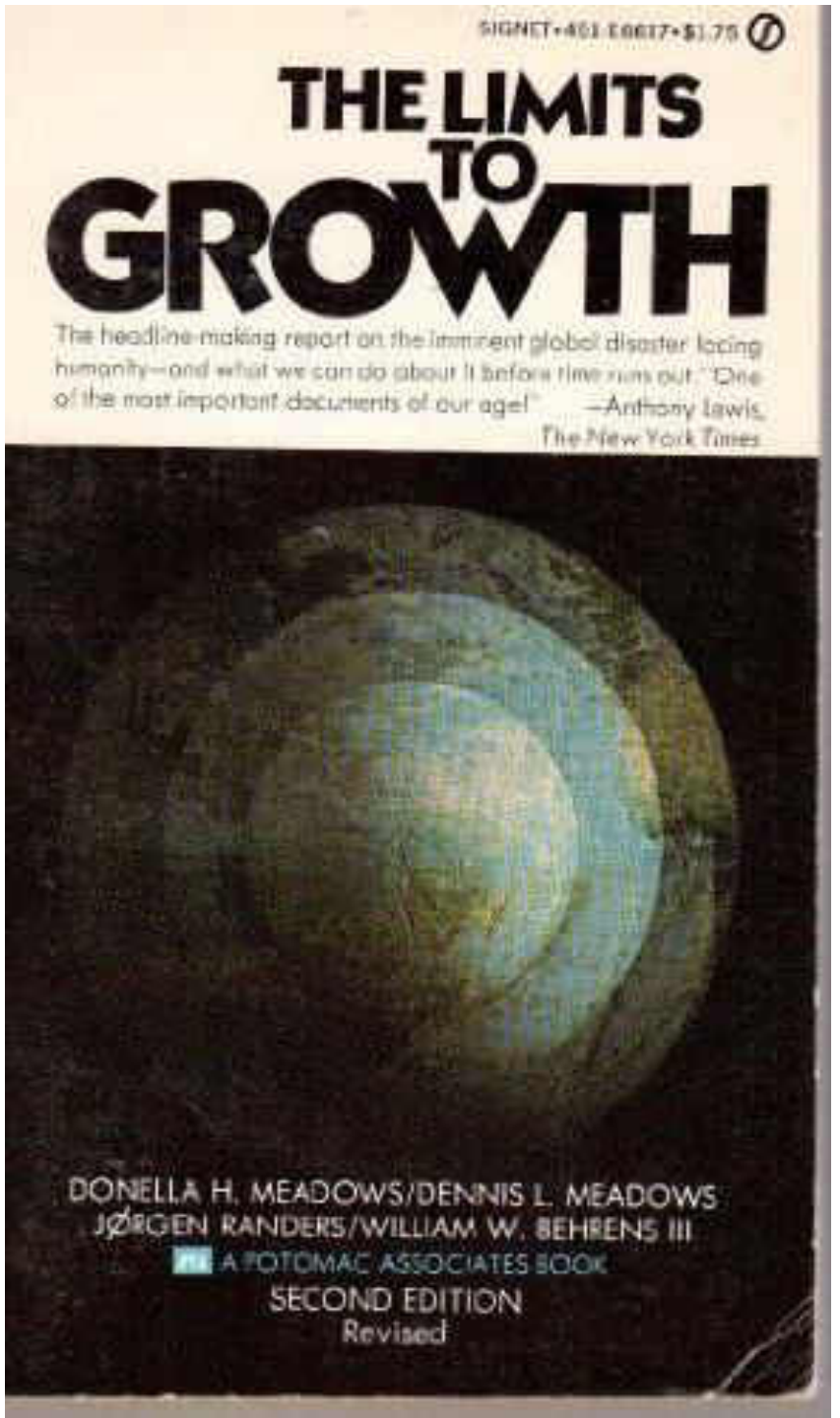
Capitalism and its inherent issues

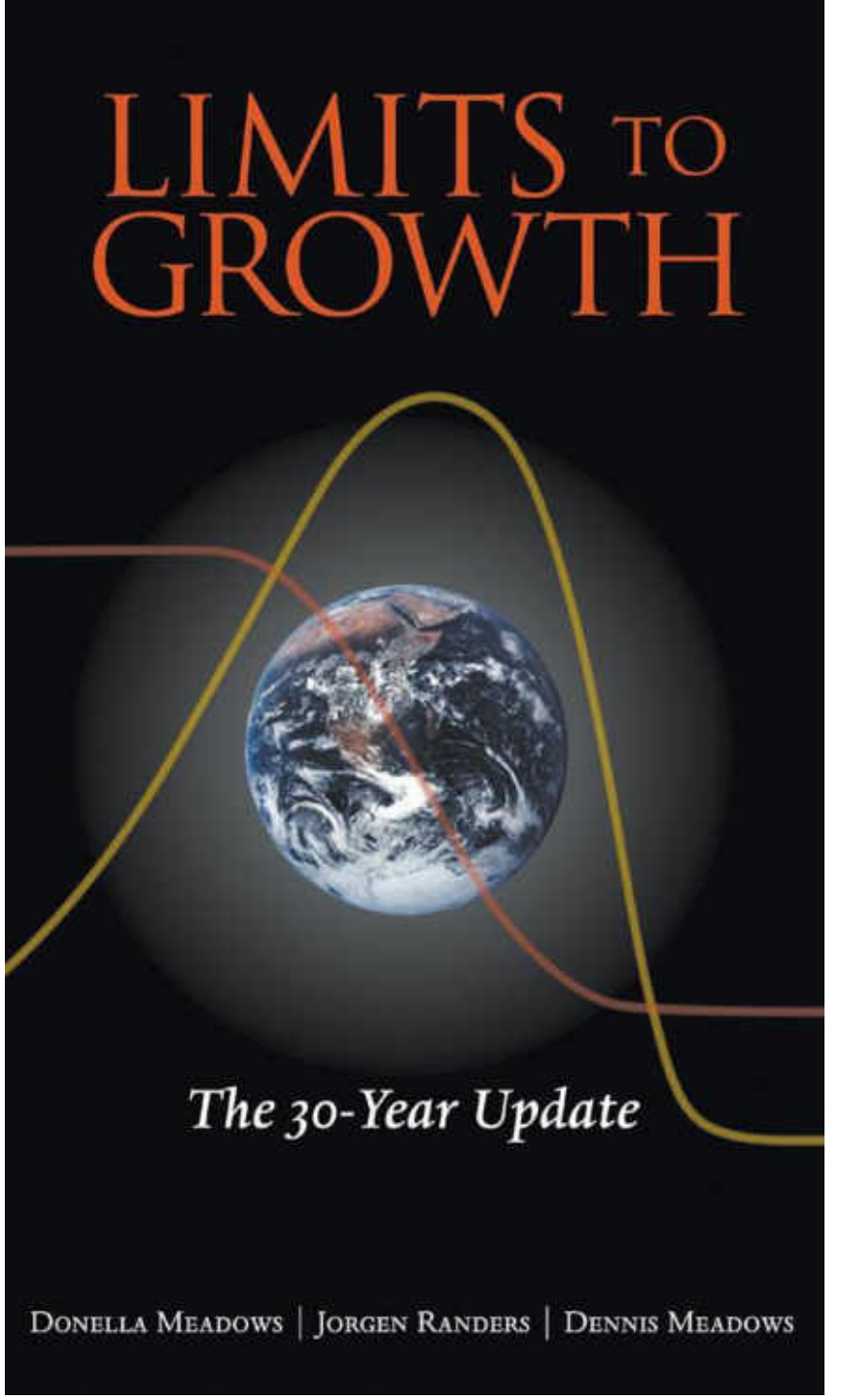


The world has enough for everyone's need, but not enough for everyone's greed.

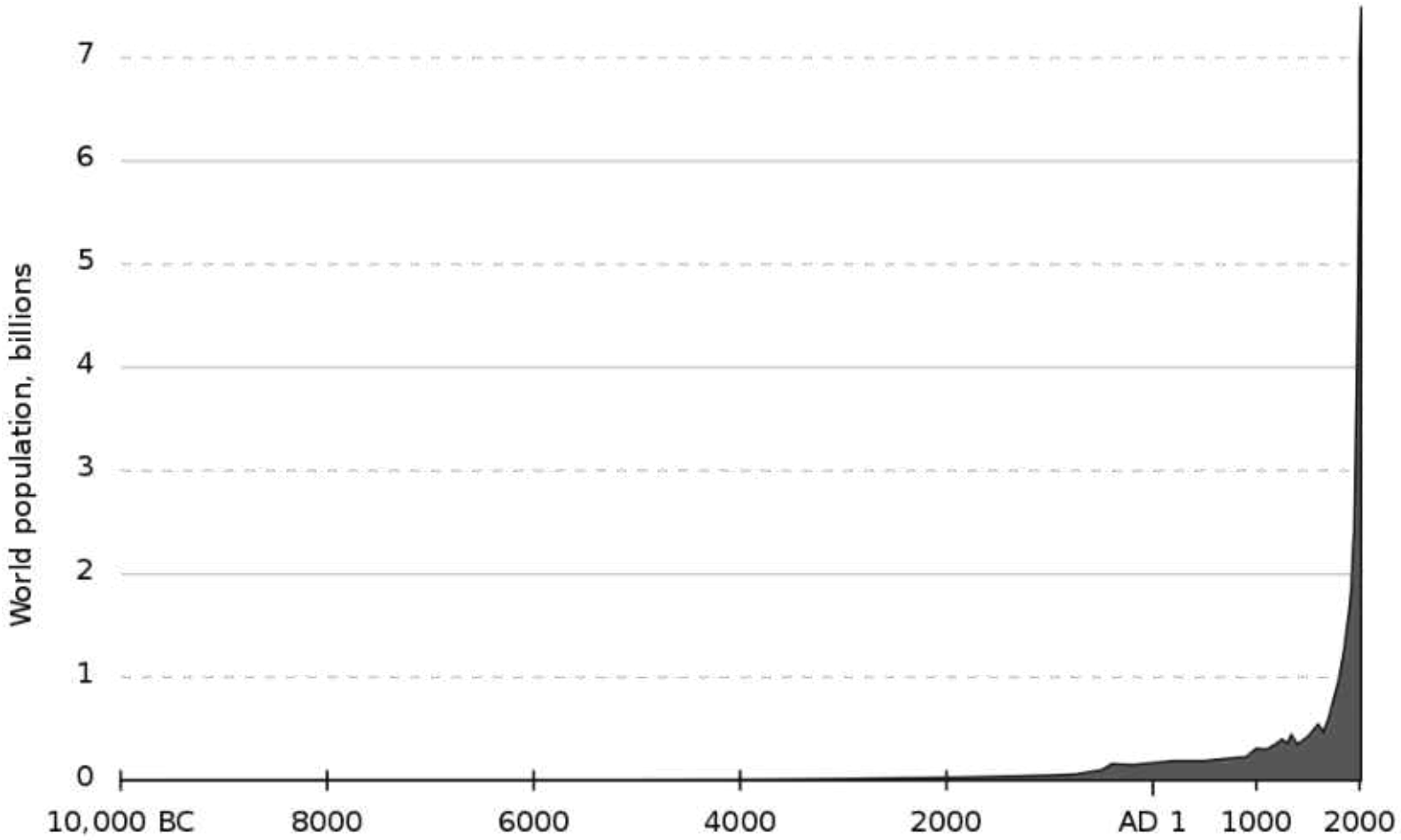



THE LIMITS TO
growth
Donella H. Meadows
Dennis L. Meadows
Jørgen Randers
William W. Behrens III
A Report for THE CLUB OF ROME'S Project on Predicament of Mankind
A POTOMAC ASSOCIATES BOOK
$2


SIGNET • 451 E6617 • $1.75
THE LIMITS TO GROWTH
The headline-making report on the imminent global disaster facing humanity—and what we can do about it before time runs out. "One of the most important documents of our age!" —Anthony Lewis, The New York Times
DONELLA H. MEADOWS/DENNIS L. MEADOWS
JØRGEN RANDERS/WILLIAM W. BEHRENS III
A POTOMAC ASSOCIATES BOOK
SECOND EDITION
Revised


LIMITS TO GROWTH
The 30-Year Update
Donella Meadows | Jorgen Randers | Dennis Meadows

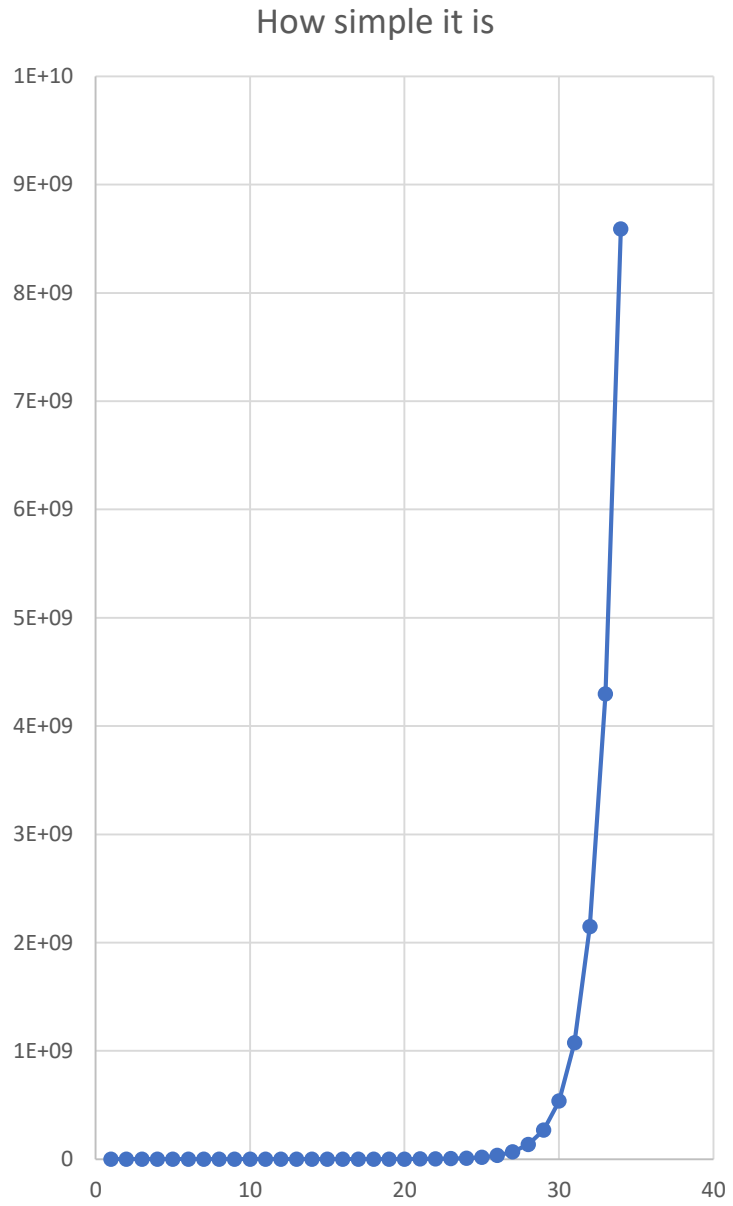
World population

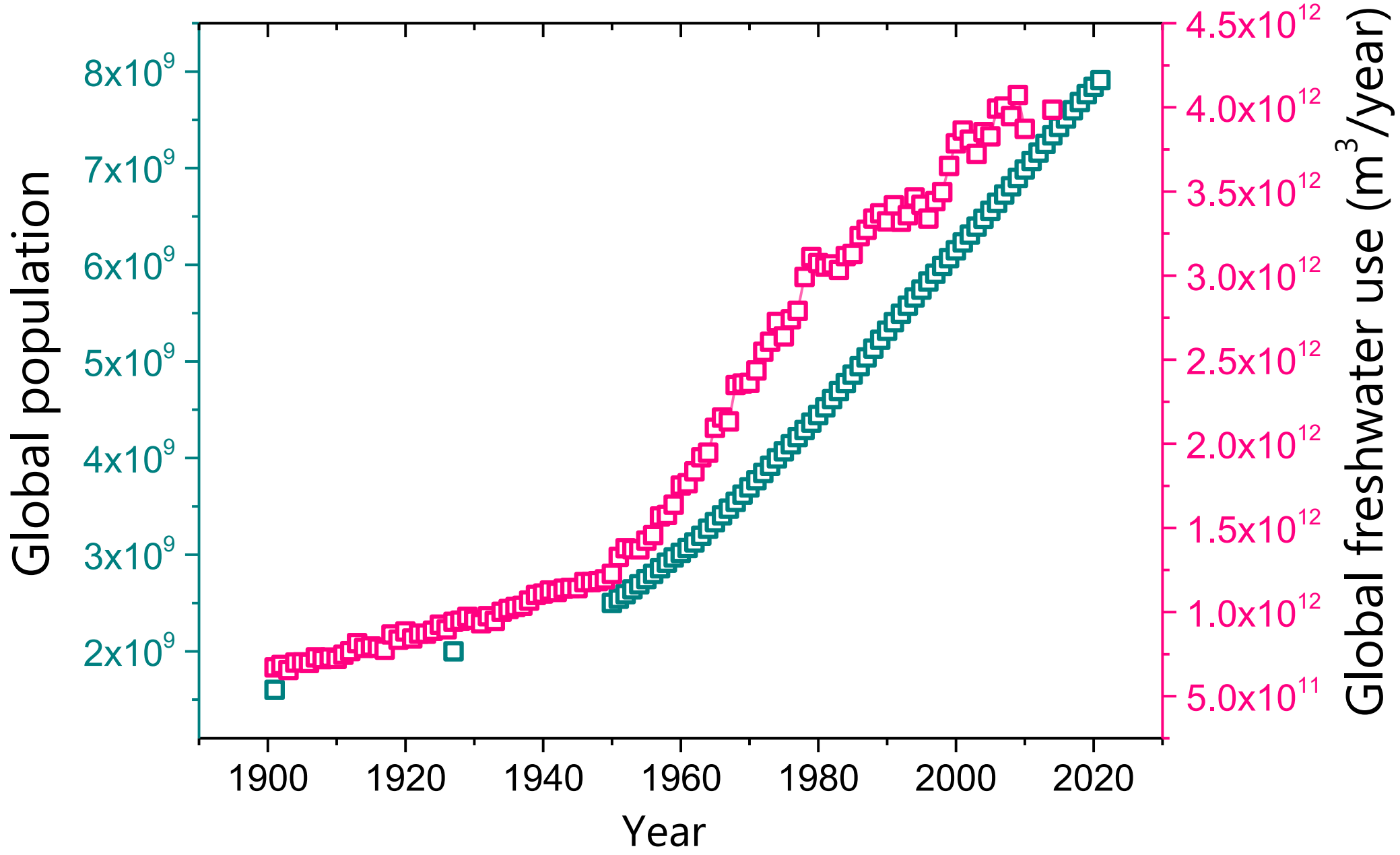


Wikipedia

- 34 generations to make
- our population

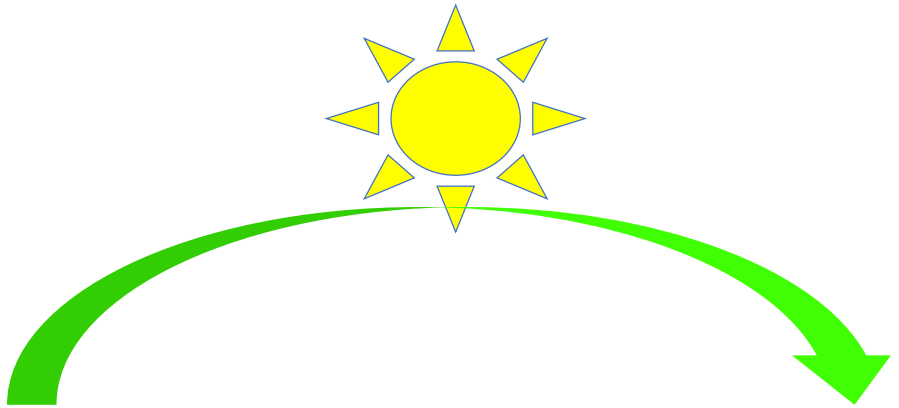
- 34 x 25 = 850 years




Global population
8x10^9
7x10^9
6x10^9
5x10^9
4x10^9
3x10^9
2x10^9
4.5x10^12
4.0x10^12
3.5x10^12
3.0x10^12
2.5x10^12
2.0x10^12
1.5x10^12
1.0x10^12
5.0x10^11
Global freshwater use (m^3/year)
1900
1920
1940
1960
1980
2000
2020
Year

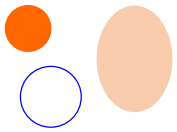
Growth in a confined space will cause restrictions

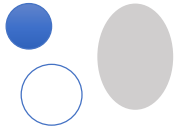
We opened the cycle



Water + Carbon dioxide

Sugar + Oxygen





105 billion tons of H_2O

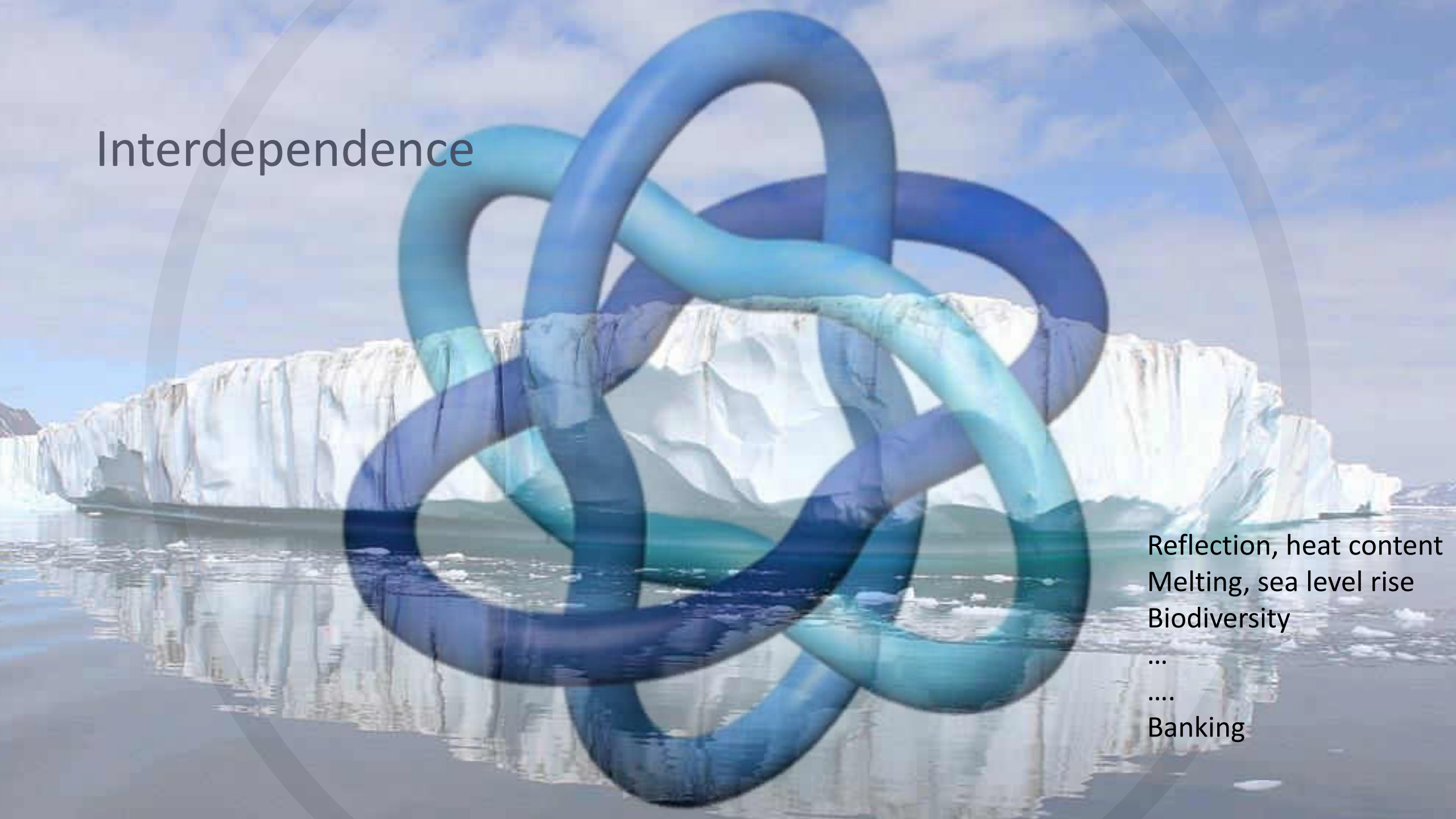
258 billion tons of CO_2

29 billion tons of CO_2

31 billion ton of H_2O needed for our people

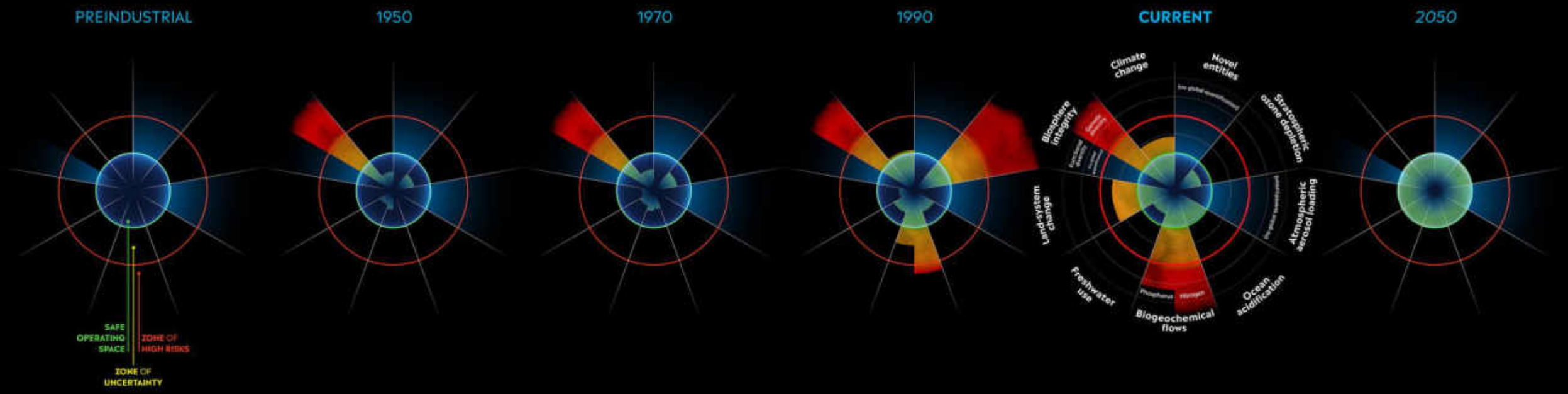
4.5. trillion m^3

Interdependence

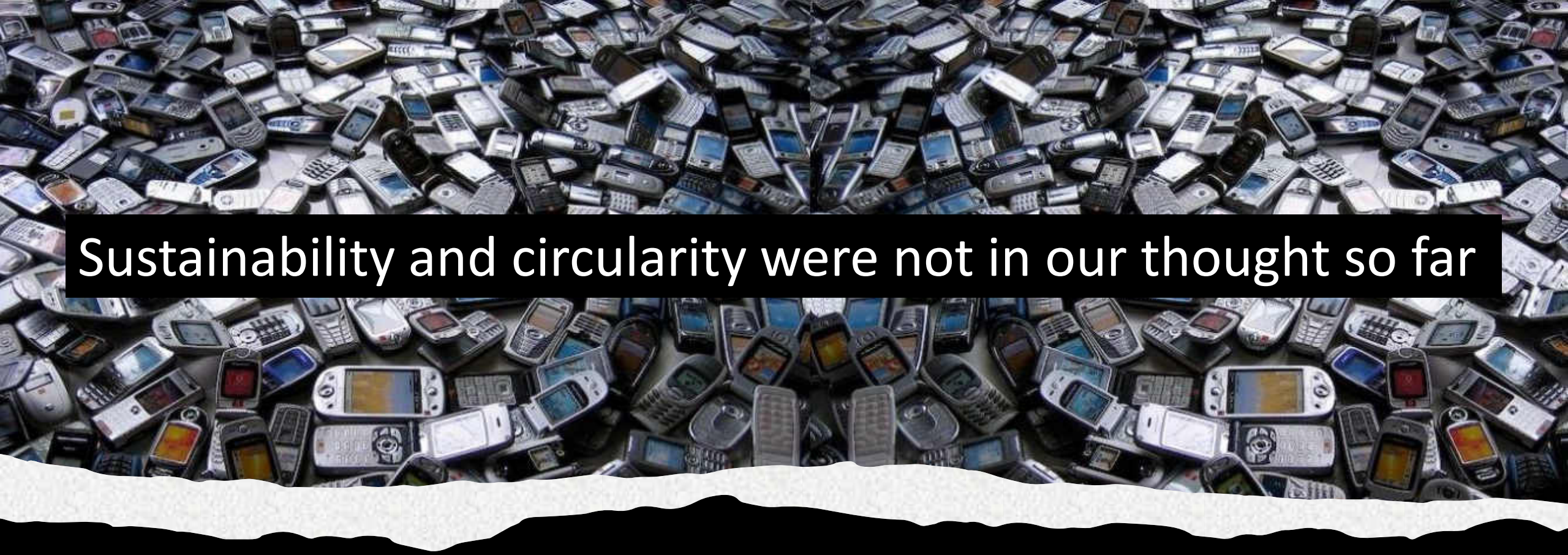


Reflection, heat content
Melting, sea level rise
Biodiversity
…
….
Banking

Planetary boundaries



https://globaia.org/planetary-boundaries

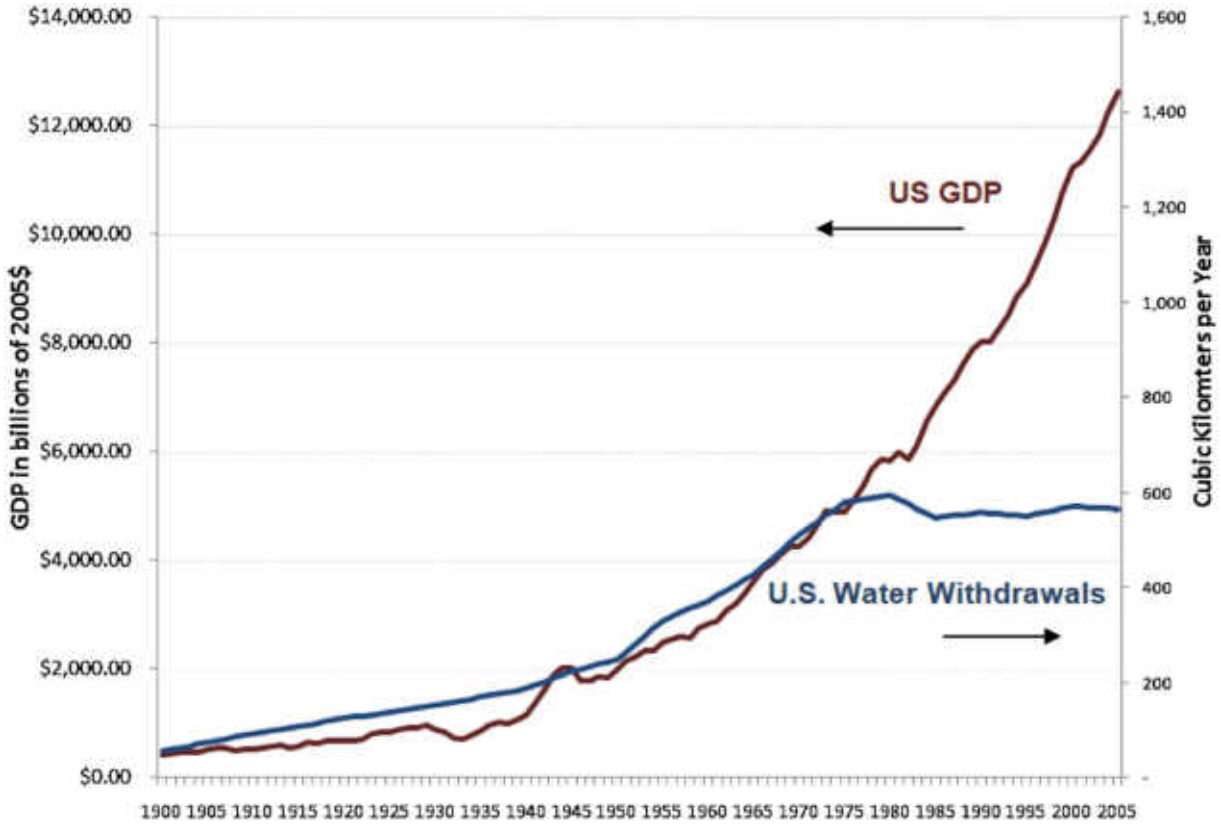


Sustainability and circularity were not in our thought so far

Rediscovering functions with elements that built biology


Biological complexity is built with just a few elements
https://blog.gale.com/celebrating-the-periodic-table/

Water and GDP



US gross domestic product (GDP) in 2005 dollars from 1900 to 2005 (left axis) plotted with total water withdrawals for all purposes in cubic kilometers per year (right axis). Data on GDP come from the US Bureau of Economic Analysis; data on water use comes from the US Geological Survey.

Peter H. Gleick and Meena Palaniappan, Peak water limits to freshwater withdrawal and use, PNAS, 2010, 107, 11155–11162

Warning is also for Kerala

3.6 million cars in 1457 km roads (NH)

180000 tons of plastic waste per year in 38863 km^2 land (about 4.65 tons per km^2)

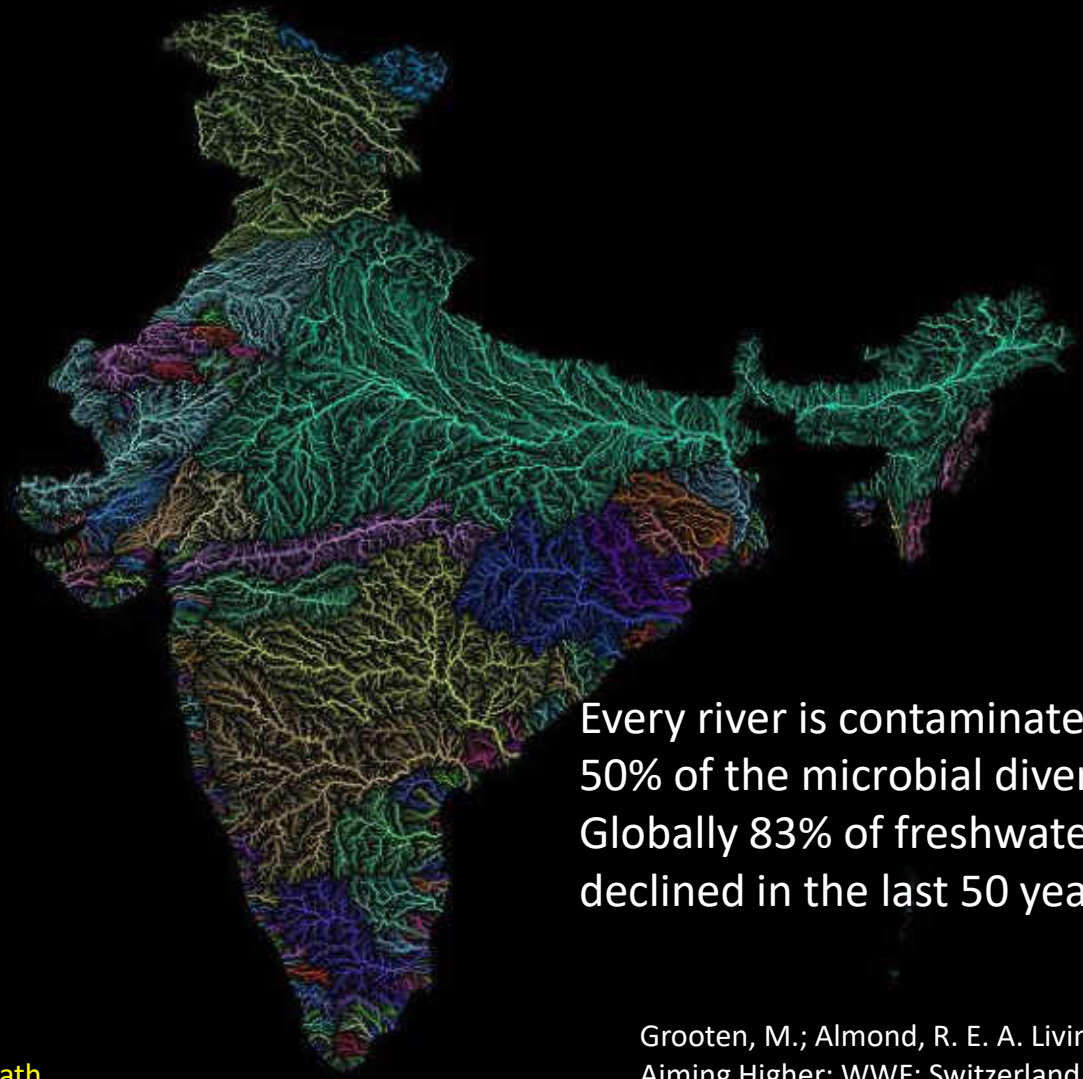
Per capita water availability 1545 cubic meter

Limits at every stage – food, energy, housing….

Construction consumes 15% of freshwater need in our country

The land of rivers

and the greater impact



Every river is contaminated
50% of the microbial diversity is lost for ever
Globally 83% of freshwater species have declined in the last 50 years.

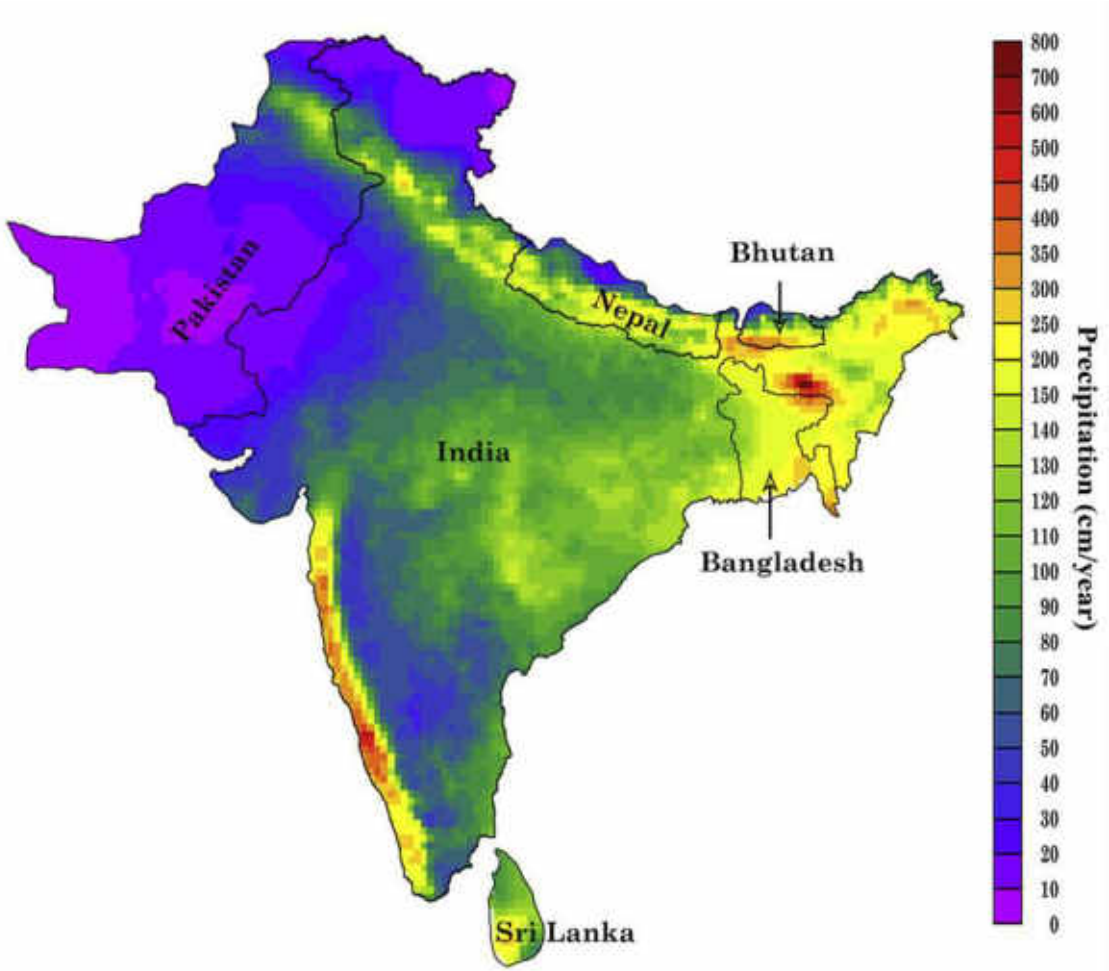
From S. Vishwanath

Grooten, M.; Almond, R. E. A. Living Planet Report - 2018: Aiming Higher; WWF: Switzerland, 2018.

No river is free of pollution

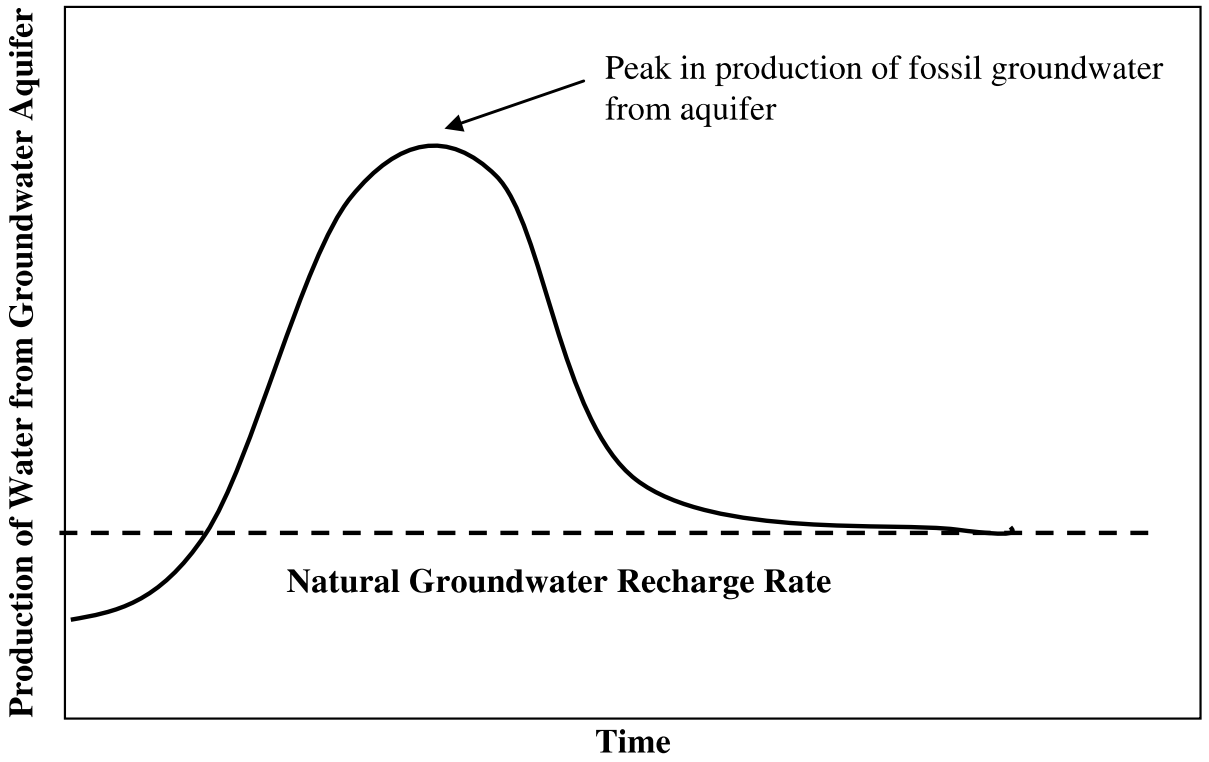
https://www.livemint.com/news/india/delhi-cpcb-raises-concerns-on-pollution-in-yamuna-river-11607261448670.html
Dec. 6, 2020

Precipitation 1961-2007



Groundwater systems of the IndianSub-Continent, Abhijit Mukherjee, Dipankar Saha, Charles F. Harvey, Richard G. Taylor, Kazi Matin Ahmed, Soumendra N. Bhanja, Journal of Hydrology: Regional Studies, 4 (2015) 1–14

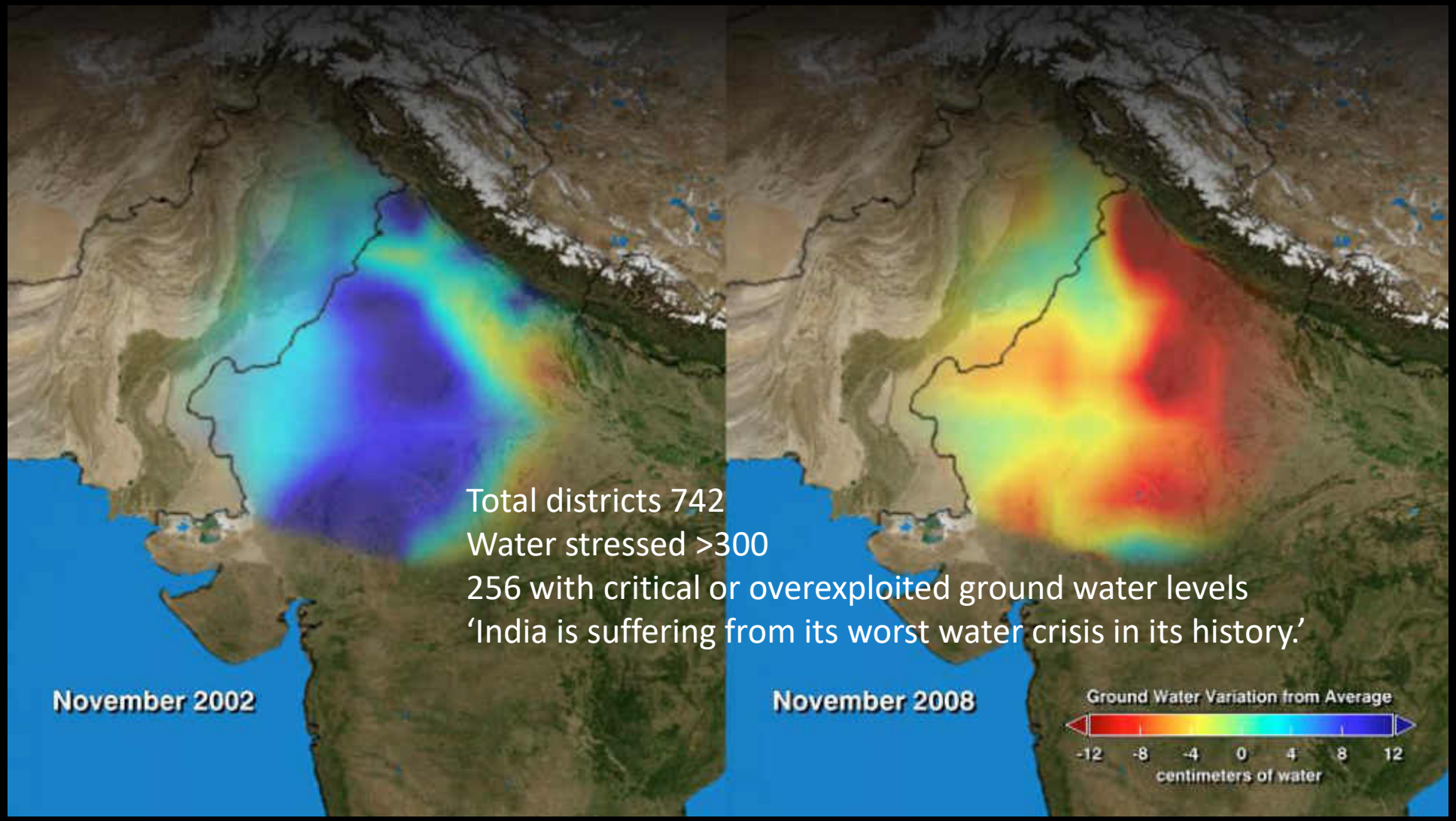
Groundwater



This theoretical curve shows the progression of unsustainable water extraction from a groundwater aquifer, hypothesizing a peak-type production curve for water after the production rates surpass the natural groundwater recharge rate and production costs rise. Long-term sustainable withdrawals cannot exceed natural recharge rates.

Peter H. Gleick and Meena Palaniappan, Peak water limits to freshwater withdrawal and use, PNAS, 2010, 107, 11155–11162

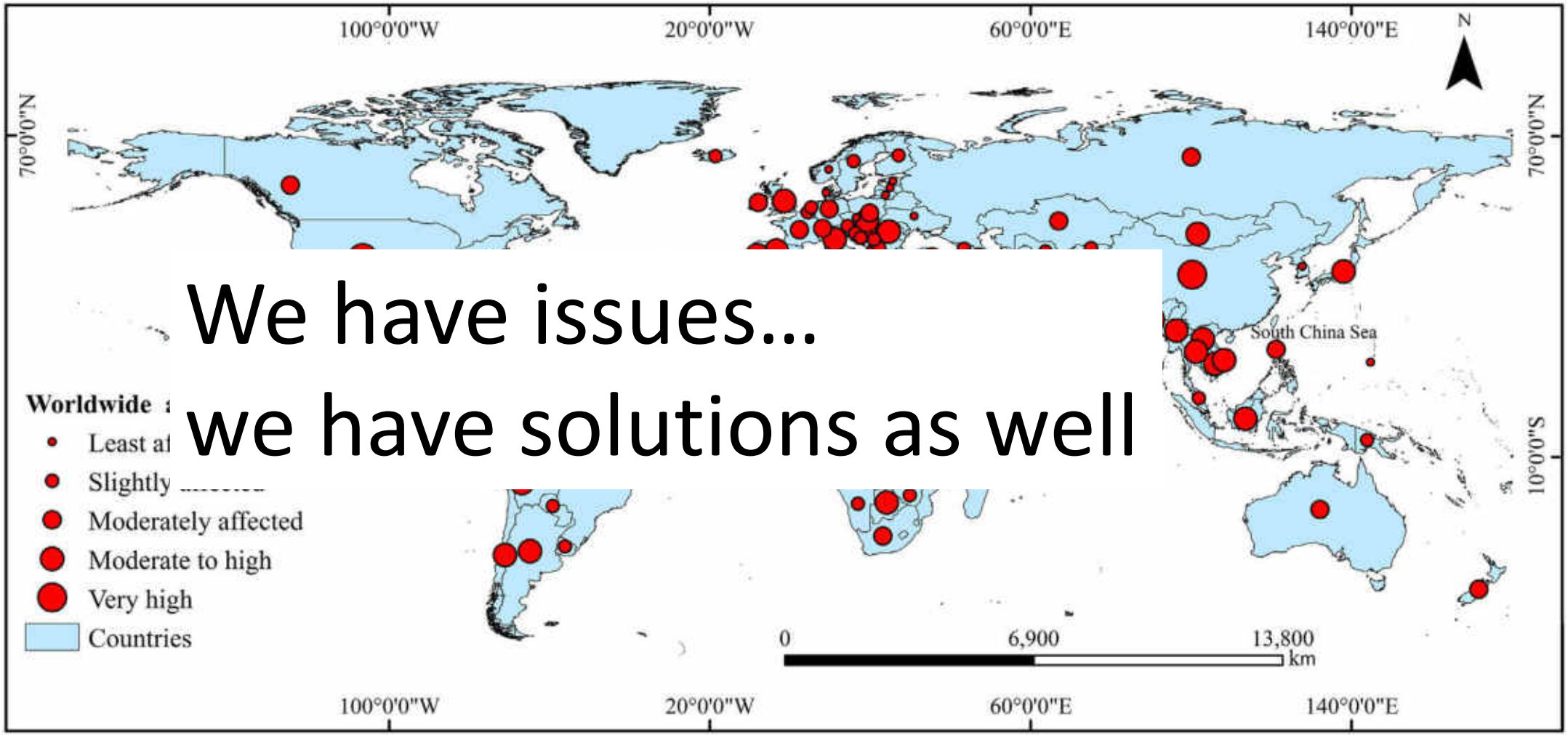
Data from North India



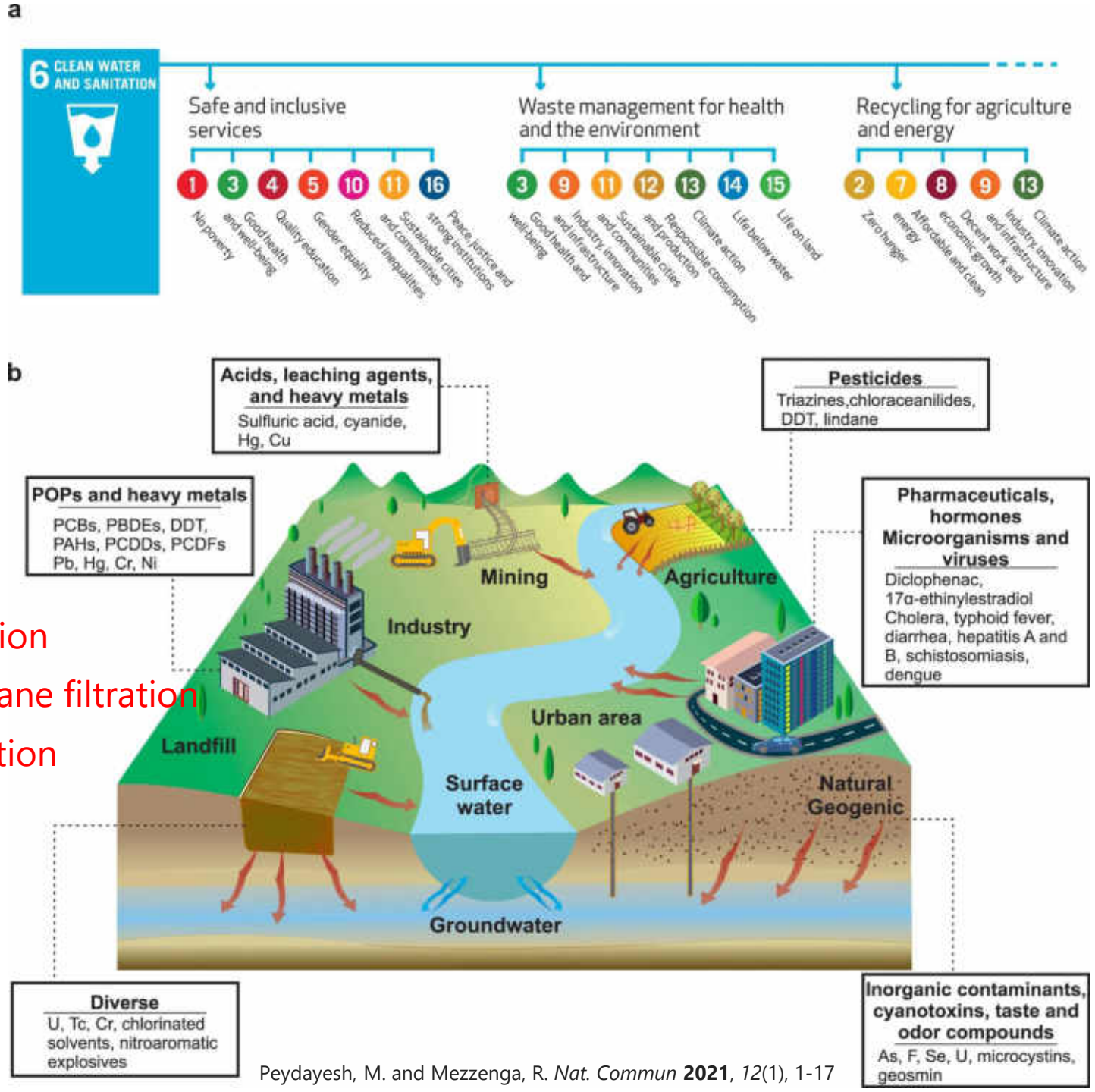
Total districts 742
Water stressed >300
256 with critical or overexploited ground water levels
‘India is suffering from its worst water crisis in its history.’

Data from NASA

Arsenic poisoning across the world



E. Shaji, M. Santosh, K. V. Sarath, Pranav Prakash, V. Deepch and B. V. Divya, Geoscience Frontiers, 12 (2021) 101079.



Distillation

Membrane filtration

Adsorption

Peydayesh, M. and Mezzenga, R. *Nat. Commun* **2021**, *12*(1), 1-17

We developed environmentally friendly water positive nanoscale materials for affordable, sustainable and rapid removal of arse
from drinking water.

There are over 1700 community installations across the country, serving 1.3 million people with arsenic and iron-free water eve

Biopolymer-reinforced synthetic granular nanocomposites for affordable point-of-use water purification

Mohan Udhaya Sankar[1], Sahaja Aigal[1], Shihabudheen M. Maliyekkal[1], Amrita Chaudhary, Anshup, Avula Anil Kumar, Kamalesh Chaudhari, and Thalappil Pradeep[2]

Unit of Nanoscience and Thematic Unit of Ex

Madras, Chennai 600 036, India

Edited by Eric Hoek, University of California,

(received for review November 21, 2012)

Creation of affordable materials for cons water is one of the most promising ways drinking water for all. Combining the composites to scavenge toxic species other contaminants along with the abo affordable, all-inclusive drinking water without electricity. The critical proble synthesis of stable materials that can uously in the presence of complex s drinking water that deposit and caus surfaces. Here we show that such con be synthesized in a simple and effective out the use of electrical power. The na sand-like properties, such as higher shea forms. These materials have been used water purifier to deliver clean drinking ily. The ability to prepare nanostructu ambient temperature has wide releva water purification.

vailable; and (*c*) continued retention matrix is difficult.

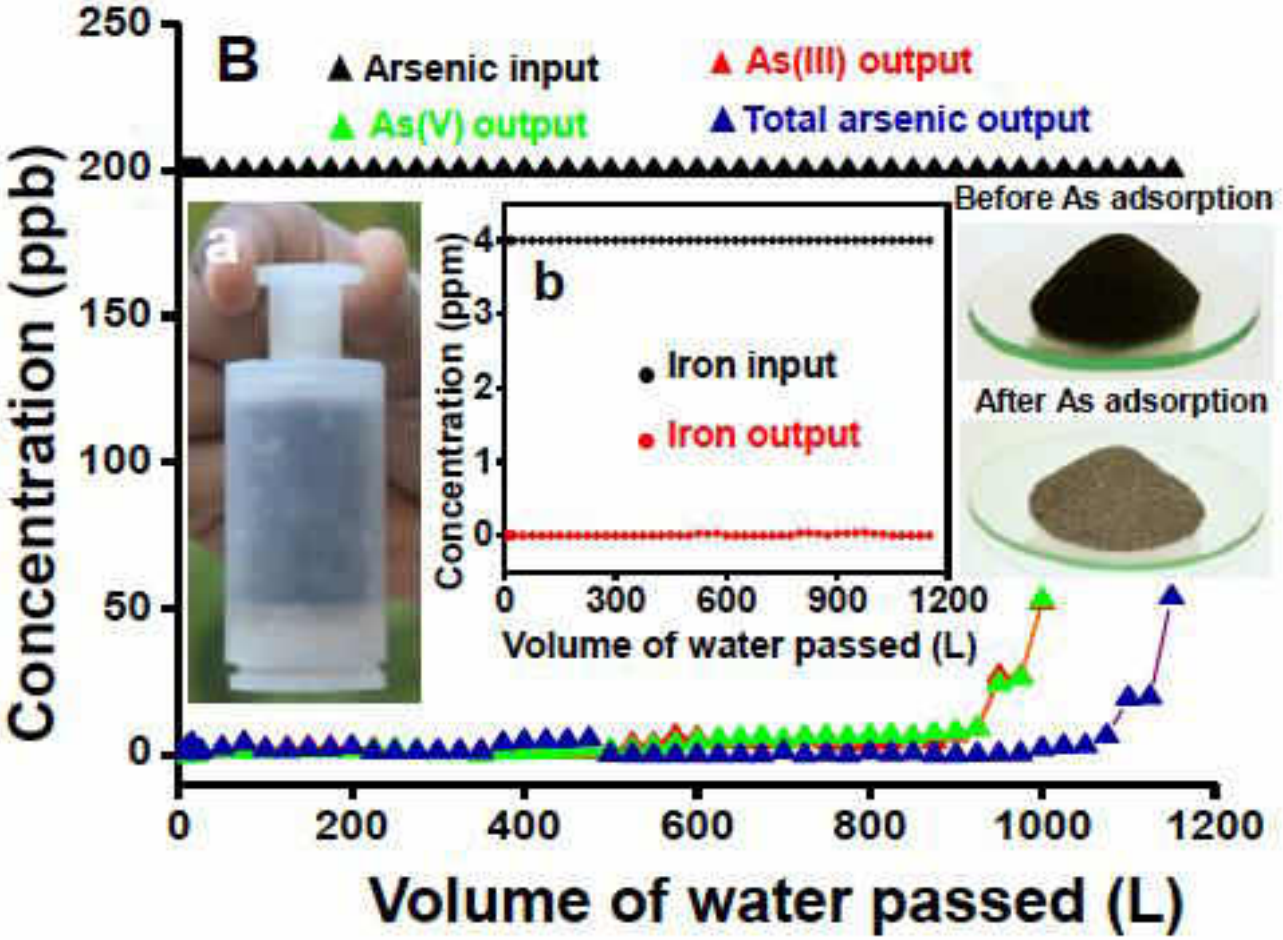
ate a unique family of nanocrystalline n granular composite materials pre- ature through an aqueous route. The mposition is attributed to abundant -O- on chitosan, which help in the crys- oxide and also ensure strong covalent surface to the matrix. X-ray photo-) confirms that the composition is rich ps. Using hyperspectral imaging, the aching in the water was confirmed. to reactivate the silver nanoparticle ıal antimicrobial activity in drinking osites have been developed that can ıts in water. We demonstrate an af- device based on such composites de- ınd undergoing field trials in India, as spread eradication of the waterborne

hybrid | green | appropriate technology | frugal science | developing world

Results and Discussion

M. Udhaya Sankar, et. al. *Proc. Natl. Acad. Sci.,* 110 (2013) 8459-8464.

Range of materials, their affordability and safety



Safety of spent media, TCLP

A. Anil Kumar, et. al. *Adv. Mater.*, 29 (2016) 1604260.

Clean water for everyone

ACS Sustainable Chemistry & Engineering Editorial, December 2016

Implementation - From 25 KLD to 1 MLD

Large water supply schemes

Capacity: above 1 MLD

5 schemes in use across India

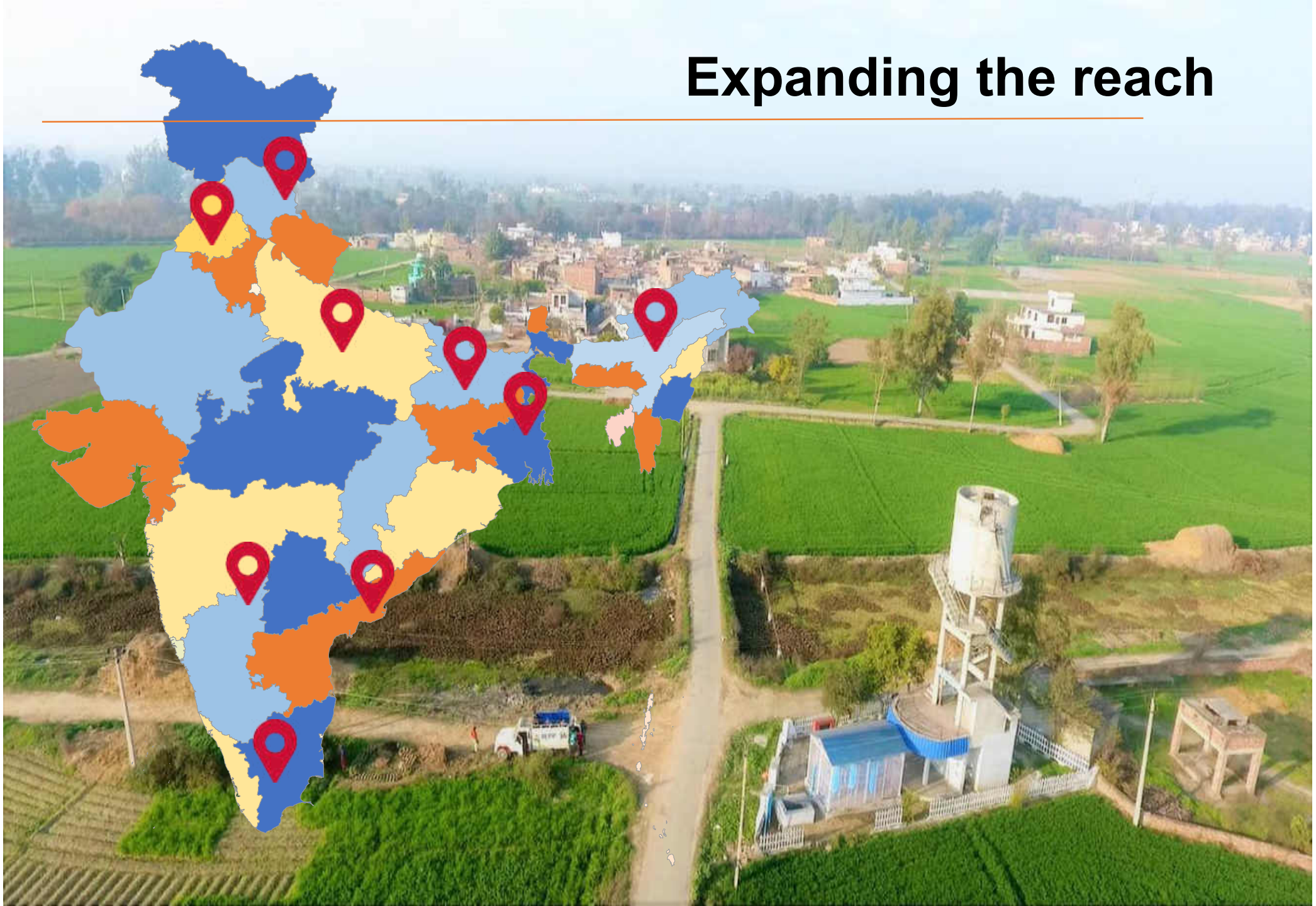
Retrofitted Water Purification Plant

Capacity: 0.1-1 MLD

Over 180 units in use across India

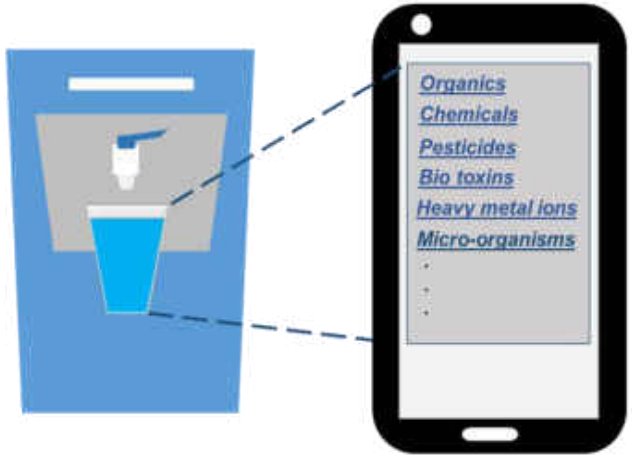
Across the country

Expanding the reach

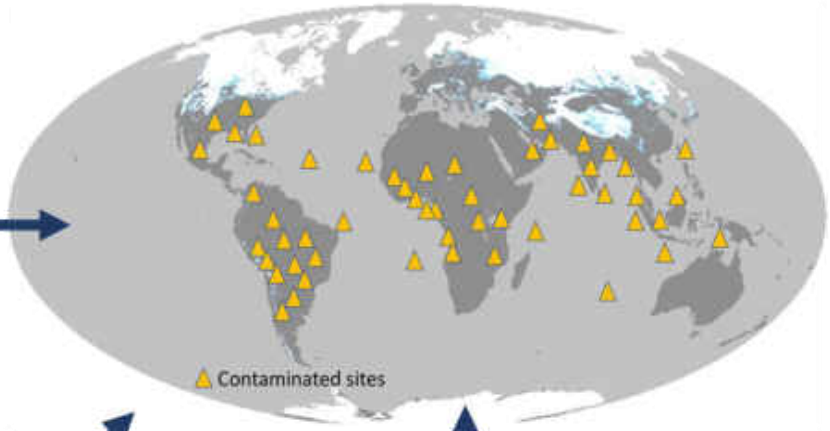


Smart water purifiers and big data

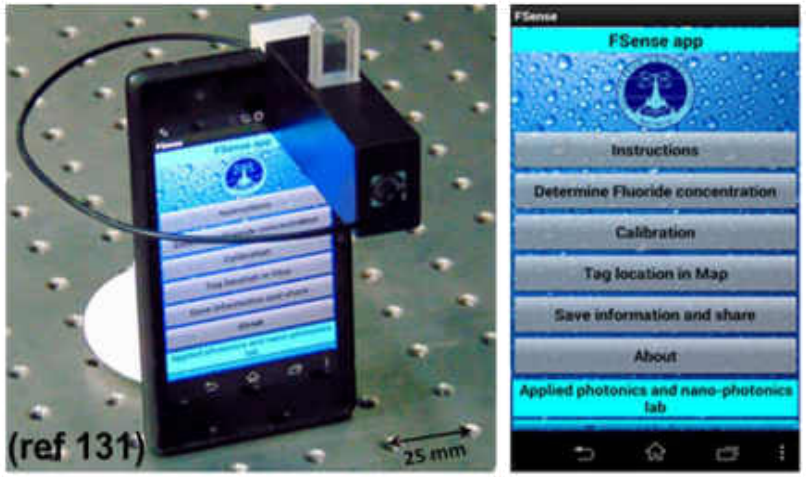
Smart Water Purifiers linked to IoT



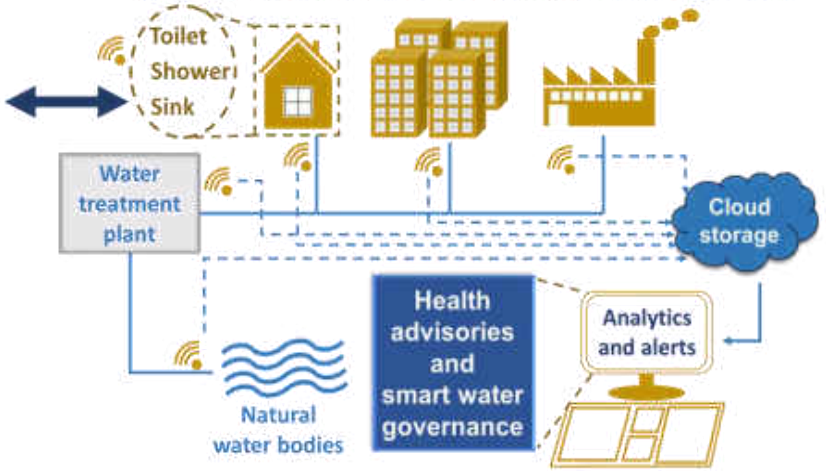
Global Map of Water Health



Cost-effective sensor accessory for point-of-use applications



IoT- enabled sensing for households and distribution networks



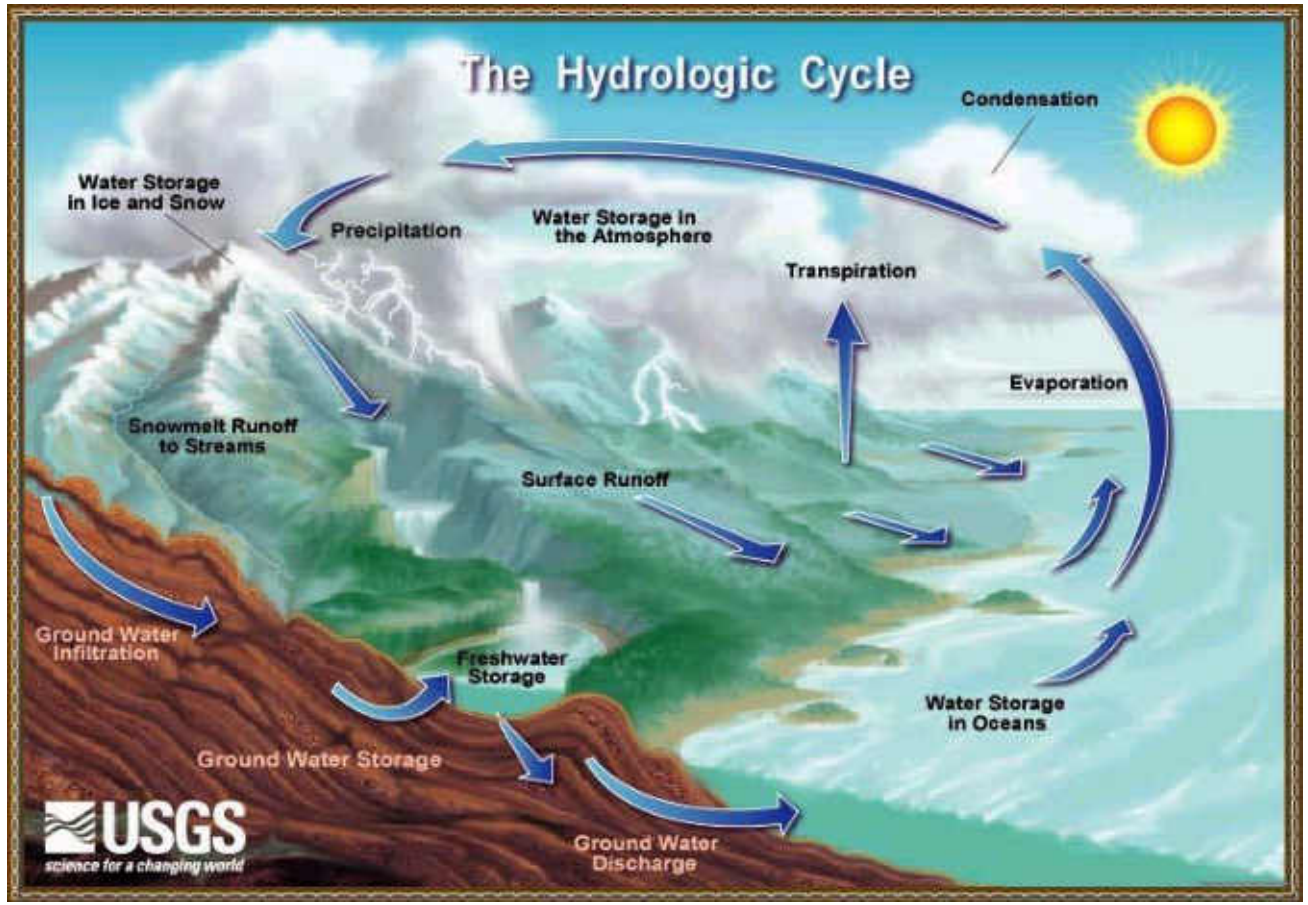
Ankit Nagar and Thalappil Pradeep. *ACS Nano* (perspective), 2020.

When will there be water for all? What to do for that?

There is enough, if we do not open the cycle.

Every other entity is also a cycle – carbon, nitrogen, sulphur, phosphorus,…

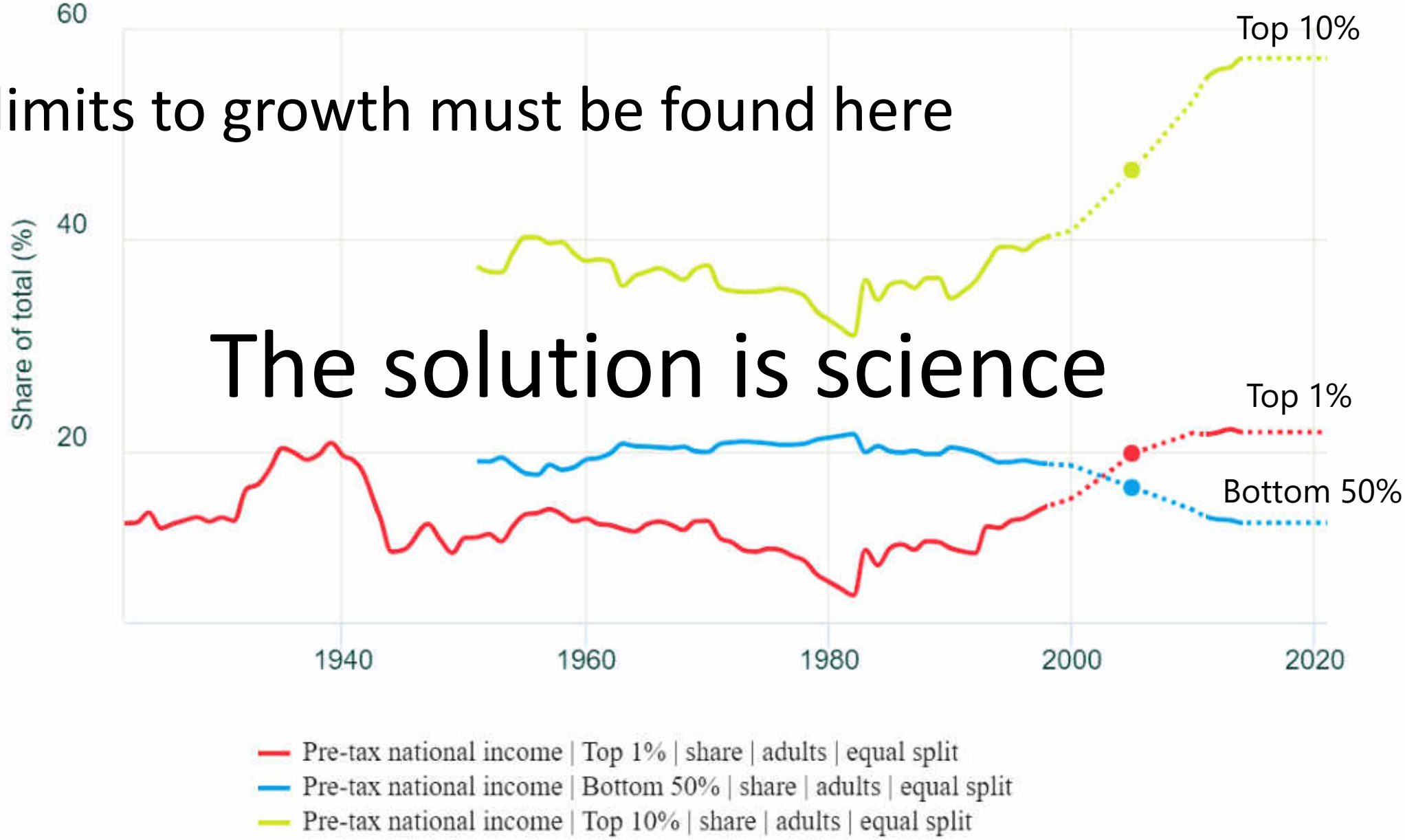
1. Water must belong to the state
2. Water must be recycled, 100%
3. Rain must be stored
4. Water must get into planning, thinking and action



Income inequality, India, 1922-2021

Our limits to growth must be found here

The solution is science

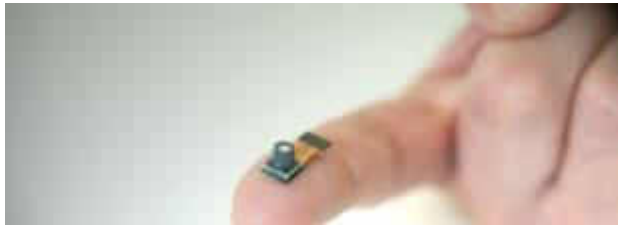


Source: https://wid.world/country/india/

Sensors and new opportunities

Analog/Grating
Equipment
$ 5~6 Billion (2017)
a few **100k units (2017)**

Ultra compact Low Cost
Spectral Sensor Module
~ Billions units (? 2027)

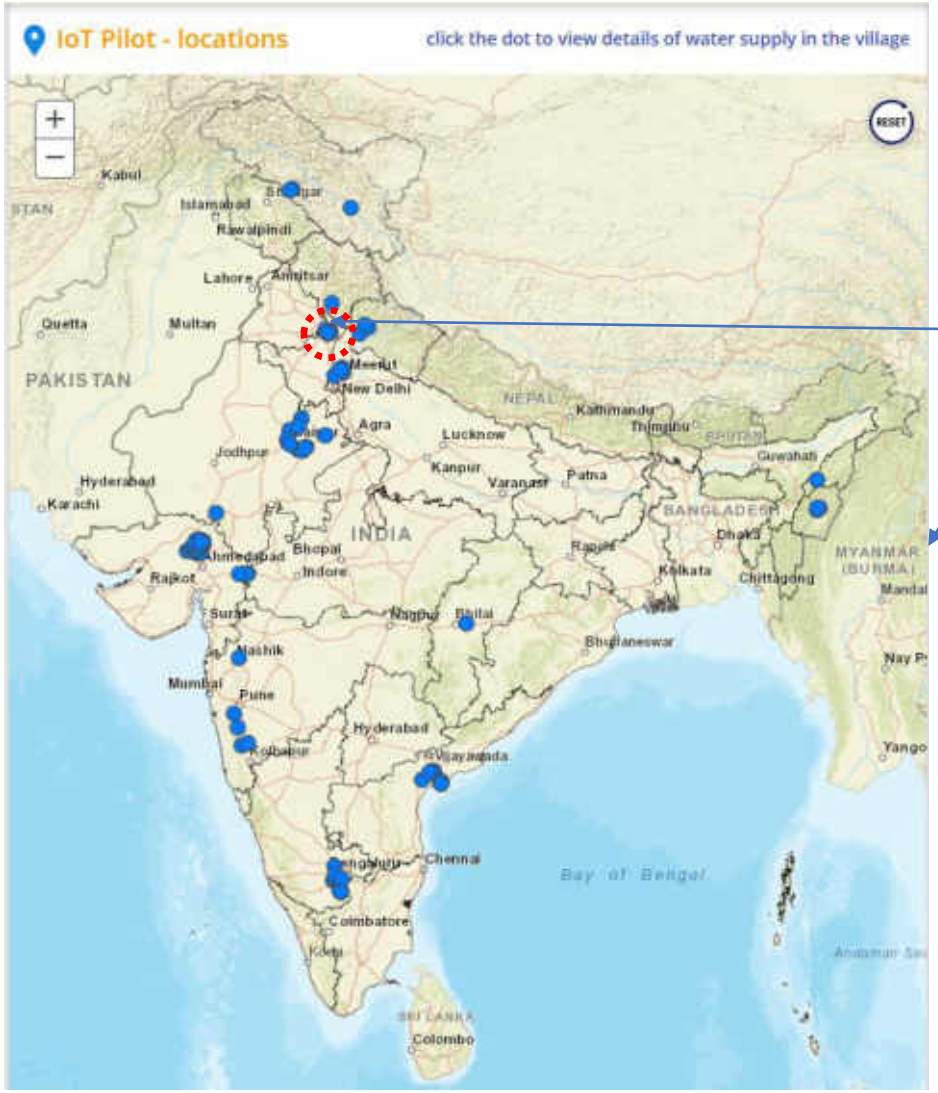


Water quality measurement – In the pipeline

nanoλ

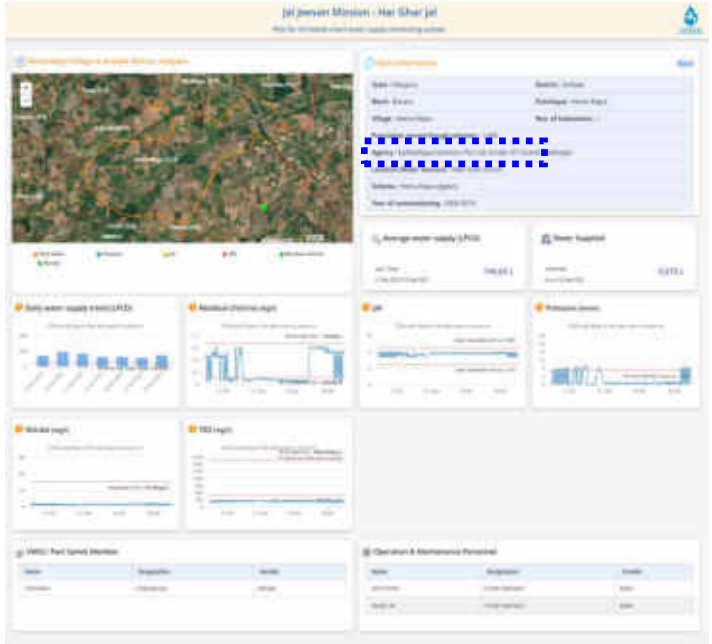
Analytical devices

India’s water is being monitored



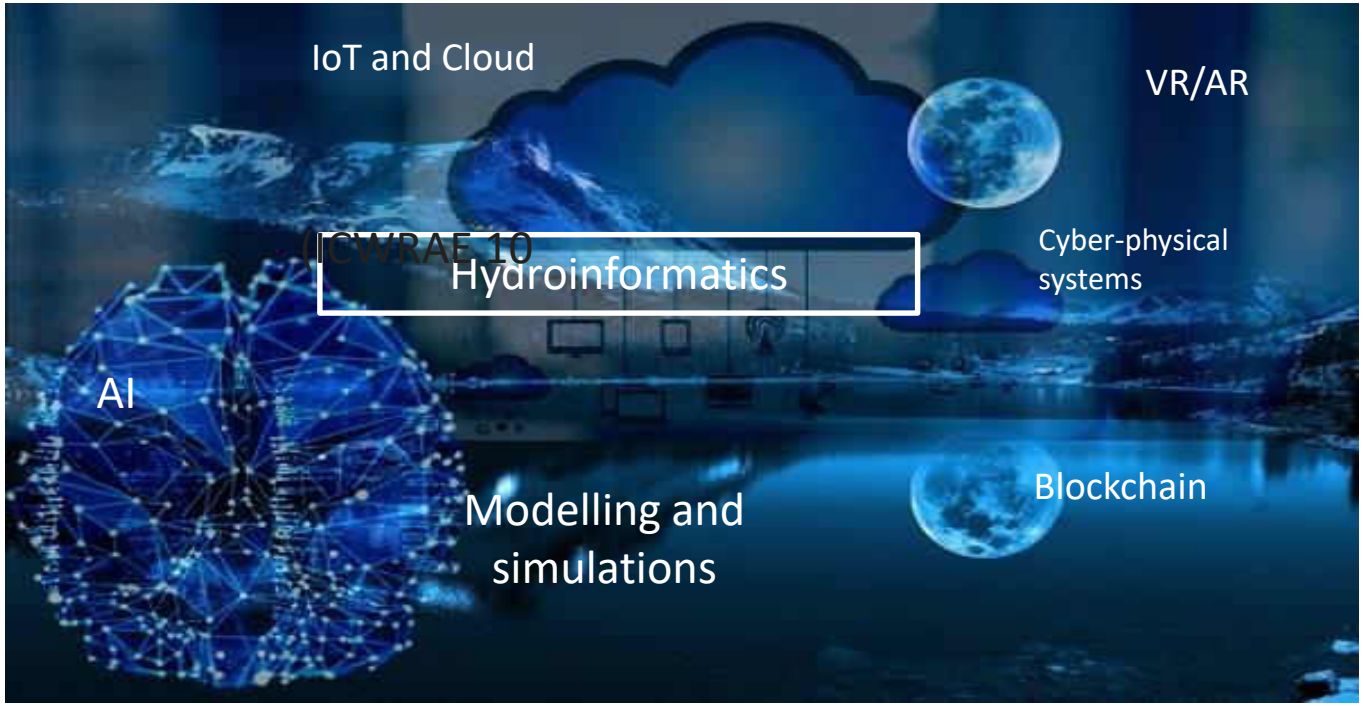
IITM/IISc

Installations made by four companies



Hydroinformatics

Application of computing technologies for efficient, sustainable and equitable water management.

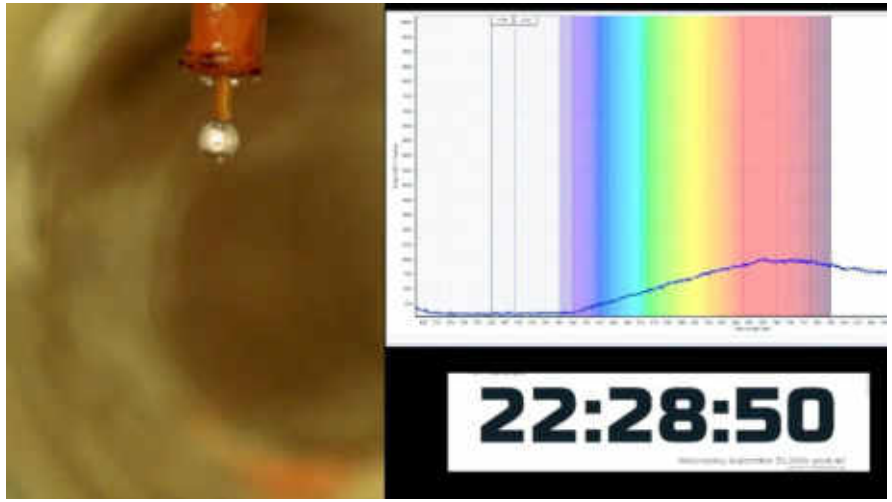


Water continues to fascinate science

Elastic ice

Xu, P. *et al.*, *Science*, **2021**, *373*, 187–192

Metallic water



Mason, P. E. *et al., Nature*, **2021**, *595*, 673–676

The AMRIT Team, 2013

Water team at IIT: A. Sreekumaran Nair, Anshup, M. Udhaya Sankar, Amrita Chaudhary, Renjis T. Tom, T. S. Sreeprasad, Udayabhaskararao Thumu, M. S. Bootharaju, K. R. Krishnadas, Kalamesh Chaudhari, Soujit Sengupta, Depanjan Sarkar, Avijit Baidya, Swathy Jakka Ravindran, Abhijit Nag, S. Vidhya, Biswajit Mondal, Krishnan Swaminathan, Azhardin Gnayee, Sudhakar Chennu, A. Suganya, Rabiul Islam, Sritama Mukherjee, Tanvi Gupte, Jenifer Shantha Kumar, A. Anil Kumar, Ankit Nagar, Ramesh Kumar Soni, Tanmayaa Nayak, Sonali Seth, Shihabudheen M. Maliyekkal, G. Velmurugan, Wakeel Ahmed Dar, Ganapati Natarajan, N. Pugazhenthiran, A. Leelavathi, Sahaja Aigal, S.Gayathri, Bibhuti Bhusan Rath, Ananthu Mahendranath, Harsh Dave, Erik Mobegi, Egor Moses, Hemanta R. Naik, Sourav Kanti Jana,...

Avula Anil Kumar, Chennu Sudhakar, Sritama Mukherjee, Anshup, and Mohan Udhaya Sankar

Funding: Department of Science and Technology, Government of India

Start-ups and partners:

PhD Theses: Bindhu Varughese, M. R. Resmi, M. Venkataramanan, N. Sandhyarani, R. Selvan, A. Sreekumaran Nair, M. J. Rosemary, Renjis T. Tom, C. Subramaniam, Jobin Cyriac, V. R. Rajeev Kumar, D. M. David Jeba Singh, Akshaya Kumar Samal, E. S. Shibu, M. A. Habeeb Muhammed, P. R. Sajanlal, T. S. Sreeprasad, J. Purushothaman, T. Udayabhaskararao, M. S. Bootharaju, Soumabha Bag, Robin John, Kamalesh Chaudhari, Ammu Mathew, Indranath Chakraborty, Radha Gobinda Bhuin, Ananya Baksi, Amitava Srimony, Anirban Som, Rabin Rajan Methikkalam, K. R. Krishnadas, Soujit Sengupta, Depanjan Sarkar, Atanu Ghosh, Rahul Narayanan, Avijit Baidya, Shridevi Bhat, Papri Chakraborty, Swathy Jakka Ravindran, C. K. Manju, Abhijit Nag, S. Vidhya, Jyoti Sarita Mohanty, Debasmita Ghosh, Jyotirmoy Ghosh, Md. Bodiuzzaman, Biswajit Mondal, Tripti Ahuja, Esma Khatun, Krishnan Swaminathan, K. S. Sugi, Amrita Chakraborty, Sudhakar Chennu, Sritama Mukherjee, Madhuri Jash, Sandeep Bose, Md. Rabiul Islam, Pallab Basuri, Mohd Azhardin Ganayee, Tanvi Gupte

>25 Post-doctoral fellows, >130 masters students and visitors

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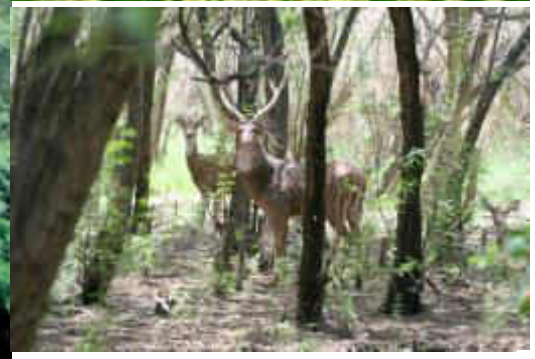

Bhaskar Ramamurthi/V. Kamakoti

Let me thank the country for making our science possible