Water Resources & Adaptation to Climate Change

IWRA Climate Change Task Force

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PowerPoint Orientation

- Our H2O resources are being increasingly exploited by many factors including population growth & increased agricultural production; we are using more H2O than the amount being replenished

- Climate change poses compounding factors in the depletion of H2O resources, and degradation of H2O quality – What are these factors?

- What are the adaptation approaches that can be implemented to counteract H2O resources depletion and H2O quality degradation?

Fundamentals of Climate Change & H2O Resources

- Higher average T & changes in precipitation, T extremes, and prolonged drought are already affecting the availability of H2O resources through changes in rainfall distribution, soil moisture, glacier and ice/snow melt, and river and groundwater flows (UN Water 2022). Higher T also trigger increases in diseases, e.g., malaria.
- CC influences when, where & how much rain falls. Higher global Ts cause water to evaporate in larger amounts, resulting in more atmospheric water vapor leading to more frequent & intense storms & flooding
- More frequent storms and floods may cause overflows from sewage systems & treatment plants into freshwater sources for drinking water. This may lead to an increase in the prevalence of water-borne parasites, such as *Cryptosporidium* and *Giardia*. These parasites can cause gastrointestinal distress and in severe cases, death (EPA 2022).

See my GWSI slides

Lake Powell, Arizona, Southwest USA
2022 Severe Drought Conditions

Fundamentals of Climate Change & H2O Resources

- Excess runoff from extreme storms will collect excess nitrogen & phosphorus from fertilizers & deposit these nutrients into water bodies (eutrophication), causing algal blooms of green, blue-green, red, or brown algae (National Geo 2022).
  -Toxins from the blooms kill fish & other aquatic animals
  -Toxins can also survive purification processes of drinking water, causing human sickness
- Large glacier melt-off at accelerated rates results in less surface water for drinking & agriculture in lower elevations, & more runoff & less aquifer recharge. The increased runoff raises sea levels, inundating coastal cities & requiring costly repairs/changes to infrastructure.

Eutrophication Causes Algal Blooms

Climate Change, Drought & H2O Resources

- On a global scale, CC is already causing an increase in the occurrence of drought, as well as more intense and prolonged drought conditions (U S EPA 2022).
  -**Drought**:
  -Obviously decreases the H2O supply as replenishment lags
  -Reduces short term H2O sources such as reservoirs & lakes
  -Reduces longer term storage such as mountain snowpack
  -Reduces groundwater supplies in aquifers as pumping increases
  -Increases drinking H2O treatment costs by concentrating contaminants in source waters, which lowers water quality -
  Intensifies dry conditions & results in more wildfires
- Drought, coupled with sea level rise, will increase saltwater intrusion in surface waters & groundwater. Saltwater intrusion into groundwater will increase in coastal freshwater aquifers when water levels in wells drop due to increased pumping

Salt Pollution is a Global Problem in Agricultural Settings

Salt pollution, or salinity pollution, or salinization, is a condition of increased salts, resulting from an interconnected suite of anthropogenic pressures such as irrigation, leaching of fertilizer, stormwater runoff, and urban wastewater discharge.

The most profound effect of salt pollution occurs in agricultural settings
where soil evaporation and plant exhalation of water vapor (i.e., transpiration) are both high, and rainfall is low.

Under these conditions, dissolved salt concentrations increase and are either absorbed by plants
or evaporated into the atmosphere.

The increased salts restrict water transfer to plant roots, resulting in stunted growth, lower quality plants, and lower yield.

Enough food is lost because of saline water each year to feed 170 million people— or a country the size of Bangladesh— every day for a year.*

*Damania et al. 2019.

Salt Pollution in Irrigated Land

Climate Change, Salt Pollution, Waterlogging & H2O Resources

Salt Content Increases as Groundwater Levels Drop; this drop; supplies are being taxed per population growth & increased irrigation

The climate change-induced lowering of groundwater levels along with increased groundwater use for drinking and irrigation dries out more area in the near-surface unsaturated zone, which leads to higher salt concentrations*

These resulting higher salt concentrations persist, or worsen, during more intense climate change-induced periods of drought.

This is because, under normal conditions, periodic rain events gradually leach excess salts and plants' root zones can then tolerate the salt concentrations**

Waterlogging is the excessive distribution of surface water during irrigation.

Oftentimes too much water is released into areas with shallow groundwater, resulting in standing water in the oversaturated area and offsite runoff of this water.

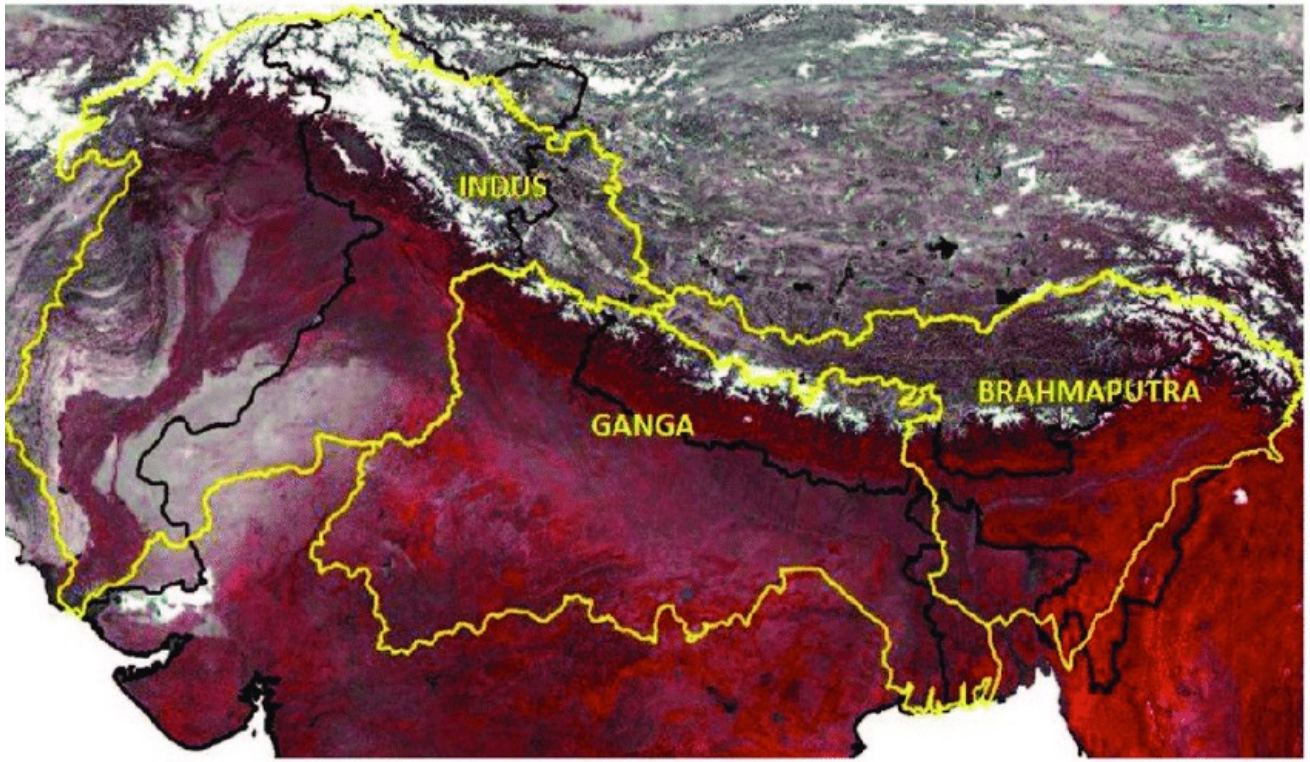
During waterlogging, the soil pores in the root zone of a crop become saturated. This saturation impedes air circulation and restricts oxygen availability and increases carbon dioxide, all contributing to diminished crop productivity.

This saturation from waterlogging also keeps excessive salts bound up in the root zone, further undermining crop yield.

Salt Pollution Adversely Affects Groundwater Resources in the Enormous Indo-Gangetic Basin

- The Indo-Gangetic Basin, fed primarily by the massive Indus, Ganges & Brahmaputra Rivers, encompasses more than 250 million hectares across Bangladesh, India, Pakistan & southern Nepal, hosting more than 750 million people & constituting over 100 million hectares of agricultural land that accounts for 25 percent of global groundwater abstraction. Therefore, the Indo-Gangetic Basin has arguably one of the most important water systems on the planet*
- 60% of the groundwater in the basin's upper aquifers is contaminated by high concentrations of either naturally-occurring **arsenic or salt** primarily from irrigation*

Indo-Gangetic Basin



Temperature Pollution, Climate Change, & Ecosystem Degradation

- ***Temperature pollution, or thermal pollution,*** is the degradation of H2O quality by any process that changes ambient H2O temperature
- It could result in lower T from the release of cold water from large impoundments or industrial facilities, or higher T from solar radiation
- Example: In Seattle/Washington, too many trees have been cut along streams & rivers, allowing solar radiation to increase H2O T
  -Warm streams harm salmon by reducing oxygen and allowing diseases and bacteria to spread
- This adversely affects not only salmon but other species dependent on them, such as Orcas whales (and humans)
- Global warming/climate change exacerbates the increasing T problem

Distressed Columbia River Salmon
Washington, Pacific Northwest, USA

H2O Resources & How They are Managed Impact Most Aspects of Society & the Economy

- Human health , food production, domestic water supply and sanitation, energy, industry, and the functioning of ecosystems.

- The poor are likely to be most adversely impacted.

Realities of H2O Resources Management Challenges

- Data sharing between nations needs improvement
- Data sharing/interdisciplinary scientific collaboration (Molden et al 2022) throughout either regions within a country – or between neighboring nations - can help cooperatively manage surface H2O shortages in the dry season; flooding/storage problems in rainy season; and potentially ease groundwater overpumping
- Formalized collaboration between water-sharing nations including China, India, Bangladesh, NepaL and Bhutan would be mutually beneficial (Getirana et al. 2022)

Realities of H2O Resources Management Challenges

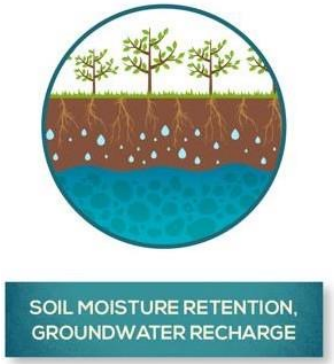
- Mekong River Commission of Cambodia, Laos, Thailand & Vietnam shares data via a transboundary agreement & serves as a model
- For citizens/scientists native to India or native to Bangladesh, access to crucial hydrological data is not publicly available & researchers must seek out officials individually to authorize data reviews (Getirana et al. 2022)
- This impedes sharing of fundamentally useful data, e.g., upstream river flow levels from the upstream Ganges R. in India to downstream Bangladesh; or groundwater levels, precipitation, H2O quality, & H2O consumption info

What Do We Mean by Nature-Based Solutions (NBS) for Water?

Nature-based solutions (NBS) use, or mimic, natural processes to cost effectively contribute to the improved management of H2O.

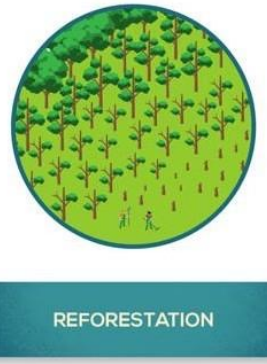
The defining feature is not whether an ecosystem being used is “natural” but whether natural processes are being proactively managed to achieve a water-related objective.

A NBS uses ecosystem services to contribute to a water management outcome. A NBS can involve conserving or rehabilitating natural ecosystems and/or the enhancement or creation of natural processes in modified or artificial ecosystems. (UN Water 2018)



SOIL MOISTURE RETENTION, GROUNDWATER RECHARGE

NATURAL AND CONSTRUCTED WETLANDS



REFORESTATION

RIPARIAN BUFFER STRIPS

URBAN GREEN SPACES AND GREEN BUILDINGS

DRY TOILET

Adaptation via Nature-Based Solutions

It has been estimated that global crop production could be increased by nearly 20% as a result of on-farm soil and water management practices in rain-fed agriculture alone (e.g., improved water harvesting through modifying tillage regimes or mulching)

Adaptation to Climate Change Requires Better H2O Management

Adaptation approaches will require additional funds

- Upgrade infrastructure to:

-prepare flood-prone areas in floodplains by expanding floodplains or preserving wetlands or constructing levees/artificial embankments

-prepare coastal cities for inundation from sea level rise

-prepare wastewater treatment systems and sewage systems for inevitable overloads from flooding/monsoons

-counteract ***temperature pollution*** in streams and rivers by planting more trees to shade/cool waterways

Adaptation to Climate Change Requires Better H2O Management

- The Indo-Gangetic Basin, one of the world's most important water systems, has 60% of the groundwater in the basin's upper aquifers contaminated by high concentrations of either naturally-occurring arsenic or salt primarily from irrigation*
- It is understood that many people in this basin do not have a choice on choosing the cleanest drinking water, nor do they have the money to install a household filtration system to improve their water quality.
- However, climate change and increasing pumping for irrigation and drinking water will continue to decrease H2O quality and some type of government-subsidized H2O treatment for at least some irrigation H2O or in-home filtration system for drinking H2O may be unavoidable.

Low-cost But Meaningful Adaptation

- Increasing technical support from governmental bodies or academia or non-profits to develop adaptation strategies

- Forging multi-national transboundary data-sharing agreements such as Mekong River Commission

5 Strategies for Climate Change Adaptation (World Resources Institute 2020)

1)Protect Coastal Wetlands: Salt marshes, mangroves & seagrasses are marine coastal ecosystems that naturally filter water; act as a buffer against sea level rise and storm surges & floodwaters, & store tons of carbon in their roots and soil.

2) Promote Sustainable Agroforestry: This is integration of diverse trees or shrubs with crops and livestock. Pastures with trees sequester 5 – 10 times more carbon than treeless areas of the same size. Farmland can be more productive by growing a diverse blend of crops & raising livestock simultaneously using significantly less land & less H_2O for irrigation.

3) Decentralize Energy Distribution: Global warming adversely affects grid reliability. Large, centralized power plants/infrastructure are more vulnerable to climate change-induced weather events that can interrupt the grid power transmissions. Decentralized systems powered by renewable energy with shorter transmission lines and smaller distribution areas are more climate-resilient and can recover from disasters more quickly.

5 Strategies for Climate Change Adaptation (World Resources Institute 2020)

4) Secure Indigenous Peoples' Land Rights:

-Indigenous communities manage almost 50% the earth's land surface, & up to 2.5 billion people depend on this land for their livelihoods.

-These communities have practiced adaptation principles for generations.

-These communities actually legally own less than 20% of this land.

-Where indigenous people do have legal rights to their land, deforestation is at least two times lower than similar areas without such ownership, as has unfortunately been observed in Bolivia, Brazil and Columbia.

-Securing indigenous peoples' rights will ensure they can retain land that is rightfully theirs, protect natural resources, and sustain their livelihoods in the face of climate change.

5) Improve Mass Transit:

-Road transport accounts for 72% of global transportation-related emissions.
-Significant disruptions to transportation infrastructure can be caused by climate change-induced extreme storms & heat.
-Disruptions will disproportionately affect low-income population, or urban dwellers with few mobility options.
-Low-carbon mass transit will help relieve problems posed by these disruptions.