International WaterCentre

Nature based solutions, ecosystem services and water security

Ben Stewart-Koster

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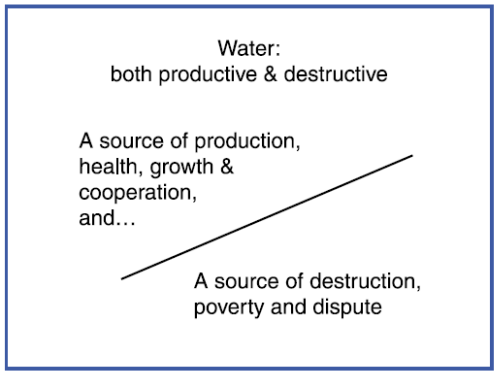
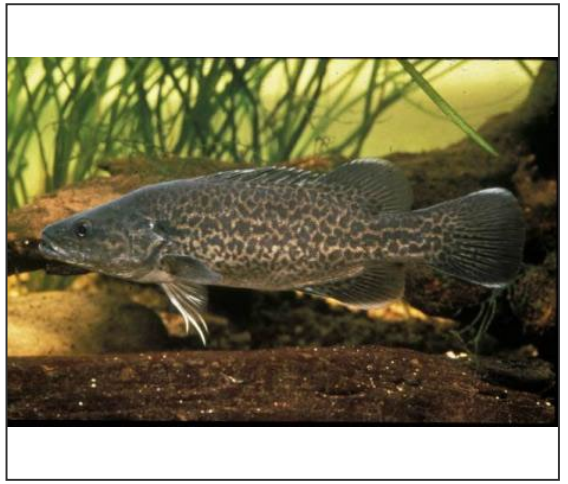
Outline for today

- Water supply, water scarcity, water security
- Aquatic ecosystem health and ecosystem services
- Monitoring aquatic ecosystem health
- Case study – AWDO 2020
  - Regional water security assessment
  - Integration of ecosystem health and water security
- Discussion and questions

Water supply

- Water plays many roles in society
  - Positive
    - Drinking
    - Irrigation (urban and agricultural)
    - Ecosystem services
  - Negative
    - Flooding
    - Erosion
    - Drought

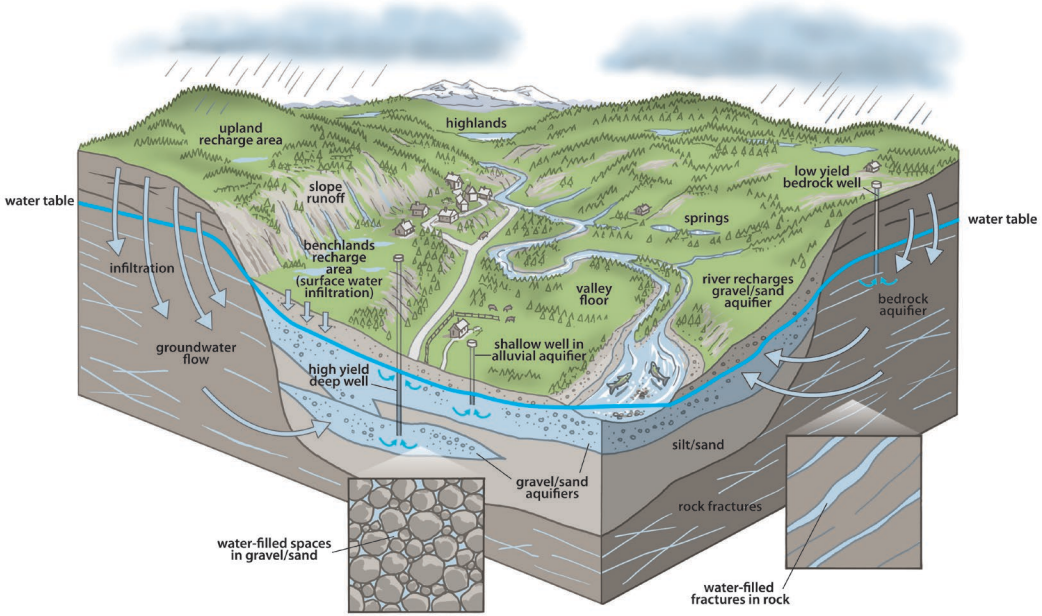




Blue and green water

Blue water: liquid water stored on the surface and in groundwater aquifers

Green water: Infiltrated rainwater in the soil available to vegetation (including agricultural crops)

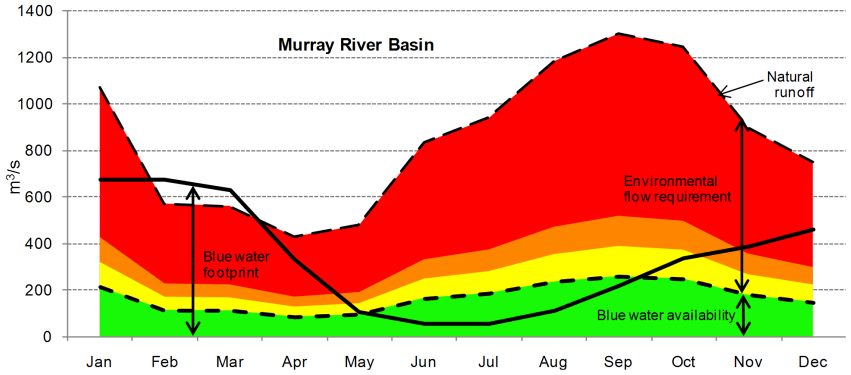


Blue water scarcity

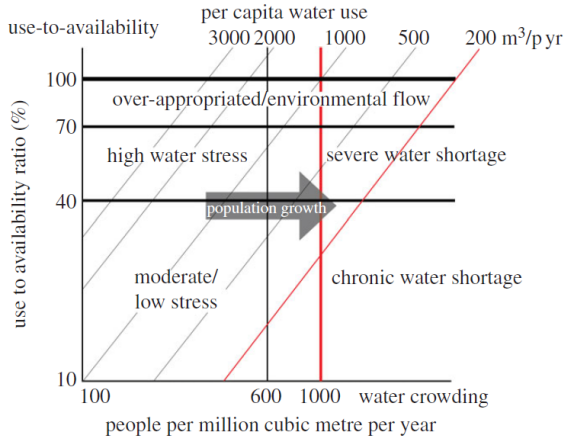
"The blue water scarcity in a river basin is defined as the ratio of the total blue water footprint to the blue water availability in a river basin during a specific time period" (Hoekstra et al. 2012, *PLoS one*)

May be caused by:

- Water crowding (i.e too many people dependent on the resource)
- High use to availability ratio (i.e. inefficient water use)



Hoekstra et al. 2012, *PLoS one*



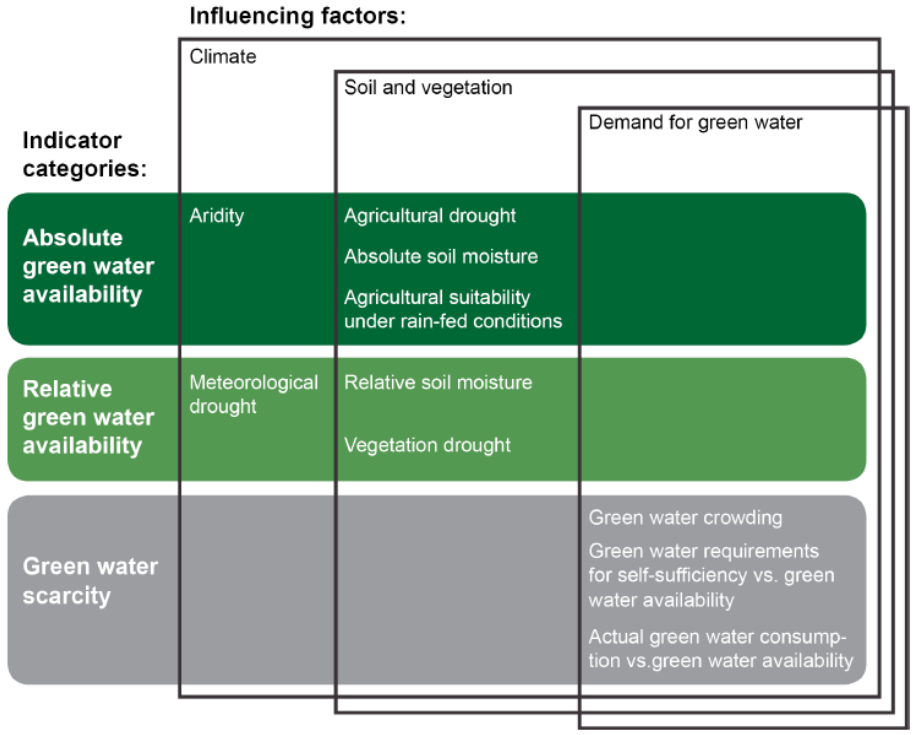
Falkenmark 2013, *Phil. Trans. A*

Green water scarcity

The competition over limited green water reserves in the face of competing demands

Influenced by:

- climate
- soil management
- agricultural production
- land use change
- population growth and consumption patterns



Schyns et al. 2015, *Hydol. Earth Syst. Sci*

From water supply and scarcity to water security

- Many different definitions of water security exist but a widely accepted and useful definition is from Grey and Sadoff (2007):
  - The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies
- Recent discussions have sought to integrate more social diversity and inclusion into approaches to water security (see Zeitoun et al, 2016, *GEC)*
  - Traditional approaches to water security often focused on infrastructure
  - Water security is multi-faceted and may be available to some members of society but excluded from others

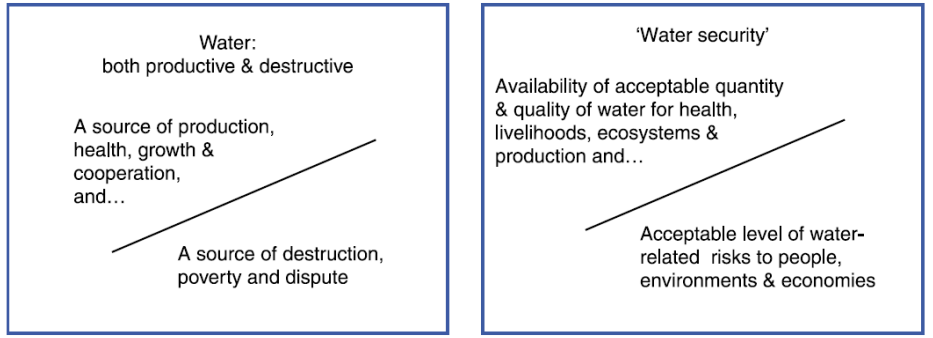


Fig. 1. Defining 'water security': water as a source of production and destruction.

It's not always about infrastructure

Despite world class infrastructure, Brisbane has come very close to water related disasters

- January 2011
  - Wivenhoe Dam, the principal water supply reservoir for the city, came very close to overtopping and potentially collapsing
  - Dam releases flooded the city but prevented a greater disaster had the dam wall failed
- January 2013 and February 2022
  - Floods of very poor quality water downstream of the dam, but upstream of the water treatment plant forced the shut down of the treatment reservoir

National Queensland

This was published 7 years ago

Brisbane suburbs risk running out of drinking water

Authorities warned at least seven suburbs – Tarragindi, Camp Hill, Carina North, Mount Gravatt, Tingalpa, Rocklea and Oxley – could run dry after muddy flood water forced the closure of the city's main treatment plant at Mount Crosby.

Catchment and instream condition

The condition of a catchment plays a major role in water security, ecosystem health and ecosystem services

- “The valley rules the stream” – Hynes, 1975

Ecosystem services that increase water security

A headwater stream in Puerto Rico

Freshwaters Illustrated
https://vimeo.com/162427775

Ecosystem services that increase water security

- Abundant shrimp clean the water
  - Filtering and sweeping

Freshwaters Illustrated
https://vimeo.com/162427775

Ecosystem services that increase water security

A headwater stream in Puerto Rico

The shrimp “clean up the water, filter feeding out a lot of organic material and turning it into shrimp which turns it into fish food…and they’re working 24 hours a day 7 days a week at no cost…”

“For this system to work in the mountains and for water quality to be available to the public outside the forest, outside the mountains, have to have connectivity, for shrimp to migrate upstream and downstream.”

Freshwaters Illustrated
https://vimeo.com/162427775

A healthy stream

Few stressors

- Intact catchment and riparian vegetation
- Unaltered flow regime
- Connectivity allowing fish movement

Ecological outcomes

- Nutritious algal growth
- Good water quality
- Diverse micro-habitats
- High species richness

A healthy stream

Ecosystem services

- Clean water
  - drinking,
  - irrigation
  - recreation
- Supporting abundant fisheries
- Flood mitigation

An unhealthy stream

Many stressors

- Increased nutrient inputs from fertiliser
- Catchment and riparian vegetation removed
- Altered hydrology from upstream dam
- Reduced connectivity limiting fish movement

Ecological outcome

- Algal bloom in stagnant water
- Poor water quality
- Deeply incised channel with limited fish habitat
- Reduced species richness

An unhealthy stream

Loss of ecosystem services

- Water treatment costs for drinking are elevated
- Potential fish kills and reduced health of surviving fish
- Downstream regions more vulnerable to flooding
- Loss of recreation
  - Tourism and local use impacted

Case study: aquatic ecosystem health and water security

Water security case study

Asian Water Development Outlook 2020

- An assessment of water security of 49 countries in the Asia-Pacific region
  - Collaboration of multiple institutions around the region
- National Water Security Index
  - A healthy catchment, reliable supply, a level of equitable access and managed risks to disasters contribute to water security

Source: AWDO 2020. https://www.adb.org/publications/asian-water-development-outlook-2020

AWDO 2020

National Water Security Index comprises 5 Key Dimensions

- KD1: Rural household water security
- KD2: Economic water security
- KD3: Urban water security
- KD4: Environmental water security
- KD5: Water related disaster security

Source: AWDO 2020. https://www.adb.org/publications/asian-water-development-outlook-2020

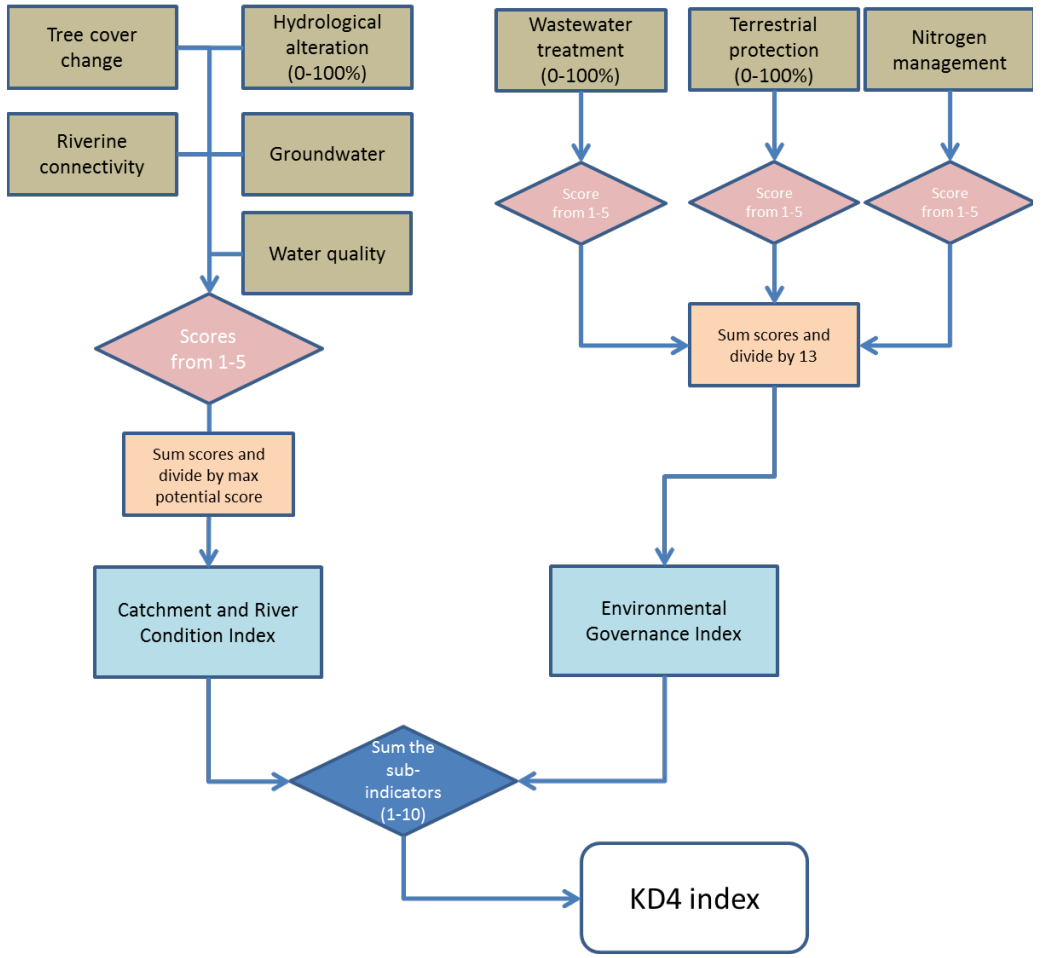
AWDO 2020

KD4 – Environmental water security

"…assesses the health of rivers, wetlands and groundwater systems and measures the progress on restoring aquatic ecosystems to health on a national and regional scale."

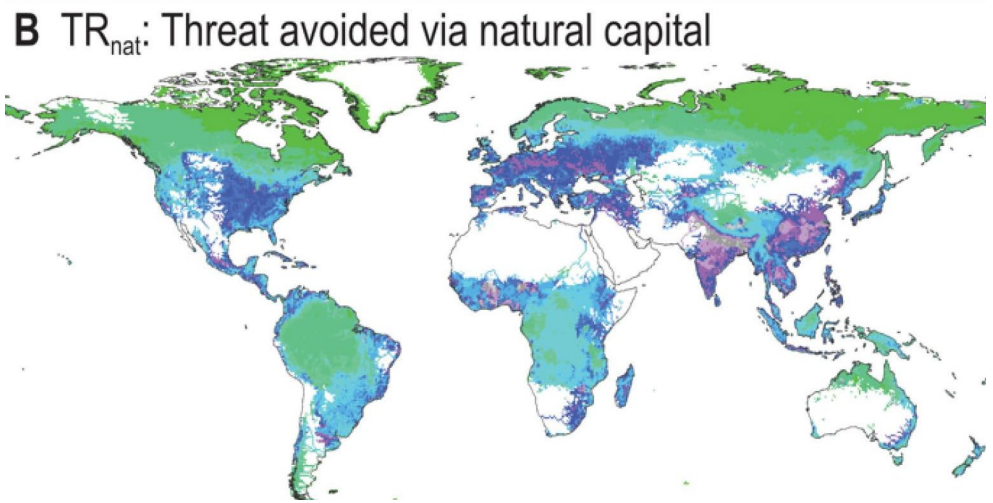
1. Catchment and Aquatic System Condition Index
   - Assess pressures on rivers and wetlands due to the condition of the catchment and instream environment

2. Environmental Governance Index
   - Assessed environmental performance that are outcomes of good governance



Why monitor ecosystem health?

- Strong connection between ecosystem health and water security
    - Current global extent of natural capital estimated to contribute $1.3 trillion annually, towards water security
- To ensure that important environmental ‘assets’ and ‘values’ are protected.
- To ensure that our investments in protection or restoration are effective
- SDG indicators evaluate ecosystem services that depend on healthy ecosystems



Vörösmarty et al. 2021. https://doi.org/10.1016/j.gloenvcha.2021.102344

Assessing ecosystem health across countries

- Several challenges exist for KD4 to assess “the health of rivers and measures progress on restoring rivers and ecosystems to health”
  - Different expectations of what constitutes an acceptably “healthy” river
  - What would a healthy river look like?
    - Is it safe to drink the water?
    - Will it have more fish?
    - Will it be safe to eat the fish?
- Without clearly defined objectives, it is difficult to select appropriate indicators and target values, and impossible to know if objectives have been met.

Assessing ecosystem health across countries

- Lack of consistent river health indicator data available within and between countries.
- Usually requires significant effort to define and monitor
  - Need to select indicators that respond to ecosystem changes that impact a river and indicate the change in the “health” of the river

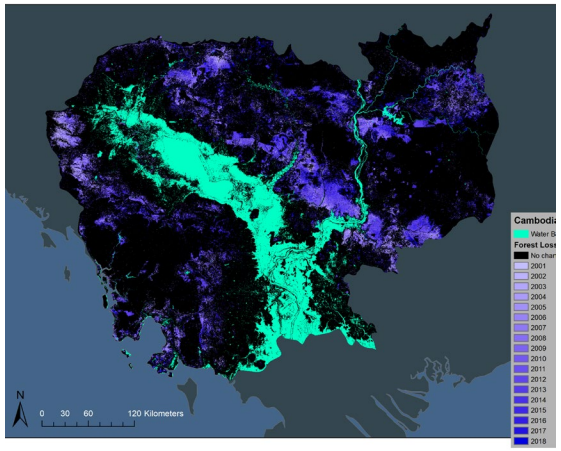
Assessing ecosystem health across countries

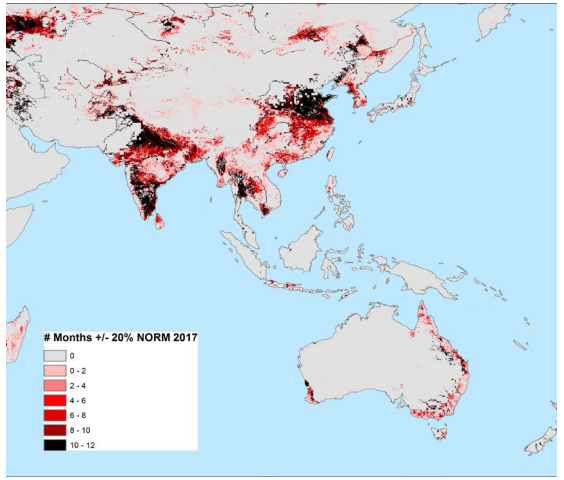
- To overcome these challenges we analysed large scale spatial data sets to uncover trends of environmental change

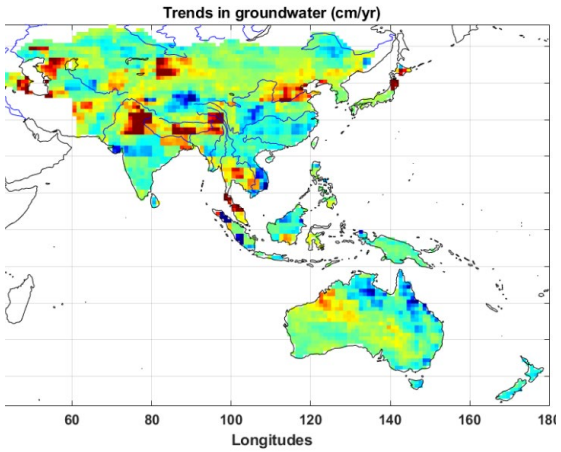
Assessing aquatic ecosystem health across countries

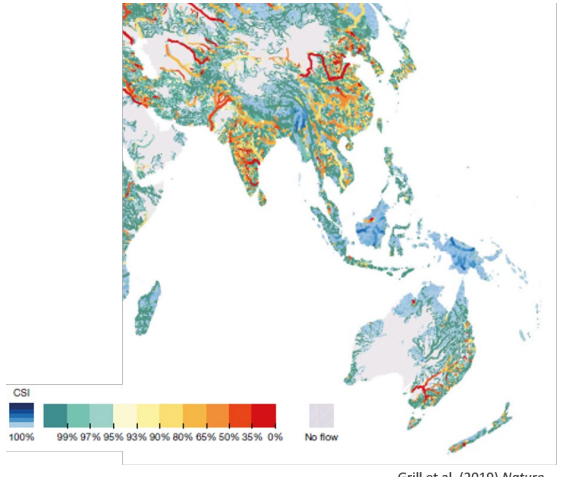
Catchment and Aquatic System Condition Index (CASCI)

1. Riparian land cover change
   - Known influence on aquatic ecosystem condition
2. Hydrological alteration
   - Known influence on aquatic ecosystem condition
3. Groundwater depletion
   - Direct measurement of sustainability of groundwater extraction
4. Water quality
   - Estimate of pressures that impact ecosystem condition
5. Riverine connectivity
   - Known impact on instream biotic communities and









Catchment and Aquatic System Condition Index

Riparian land cover change

- Quantify the extent and trend of land cover change within 100m of river channels and wetlands in each country
- Annual satellite data from 2001 - 2018

POLICY DIRECTION

Journal of Applied Ecology

Riparian buffers in tropical agriculture: Scientific support, effectiveness and directions for policy

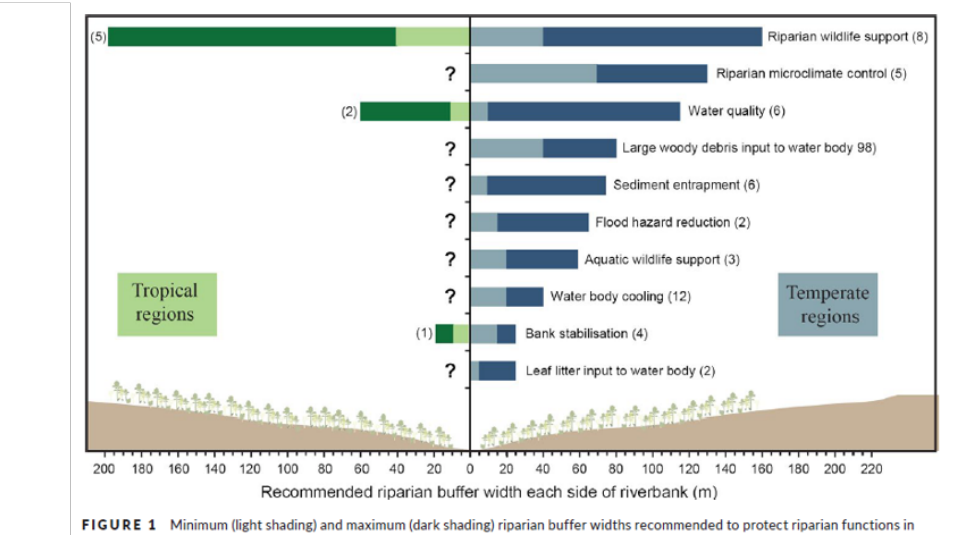
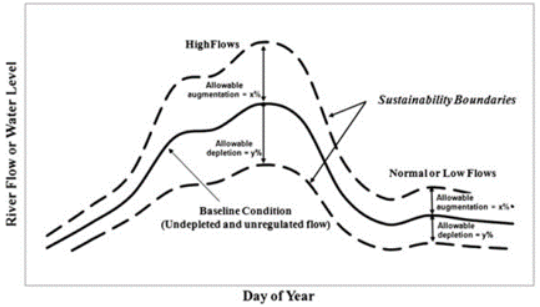


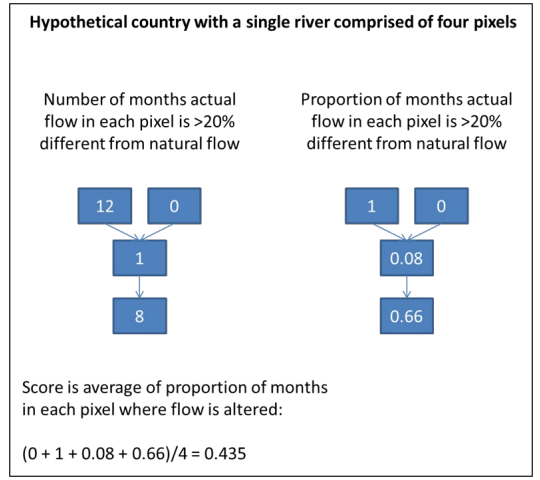
FIGURE 1 Minimum (light shading) and maximum (dark shading) riparian buffer widths recommended to protect riparian functions in

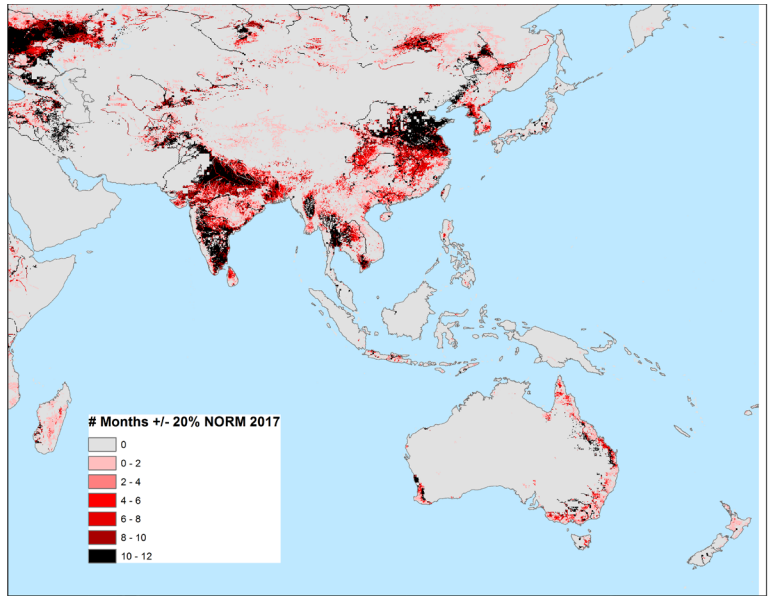
Catchment and Aquatic System Condition Index

Hydrologic alteration

- Quantify the extent of river flow alteration that impacts ecosystem health
- Monthly hydrologic model data from 2002 – 2016
  - The monthly river flow is considered “hydrologically altered” if flows are more than 20% different from pristine conditions (Richter et al. 2012)



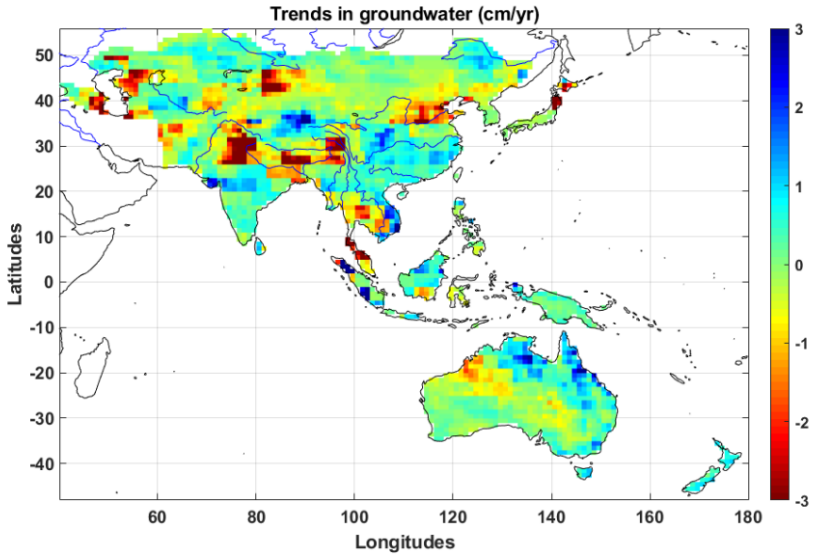


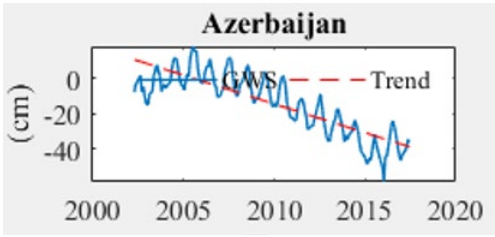


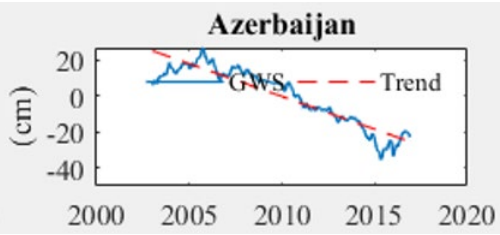
Catchment and Aquatic System Condition Index

Groundwater depletion

- Quantify the extent and trend of groundwater levels within each country
- Monthly satellite data from 2002 – 2016
  - Detrend seasonal signal of groundwater recharge from wet season rainfall
  - Quantify the trend of groundwater levels



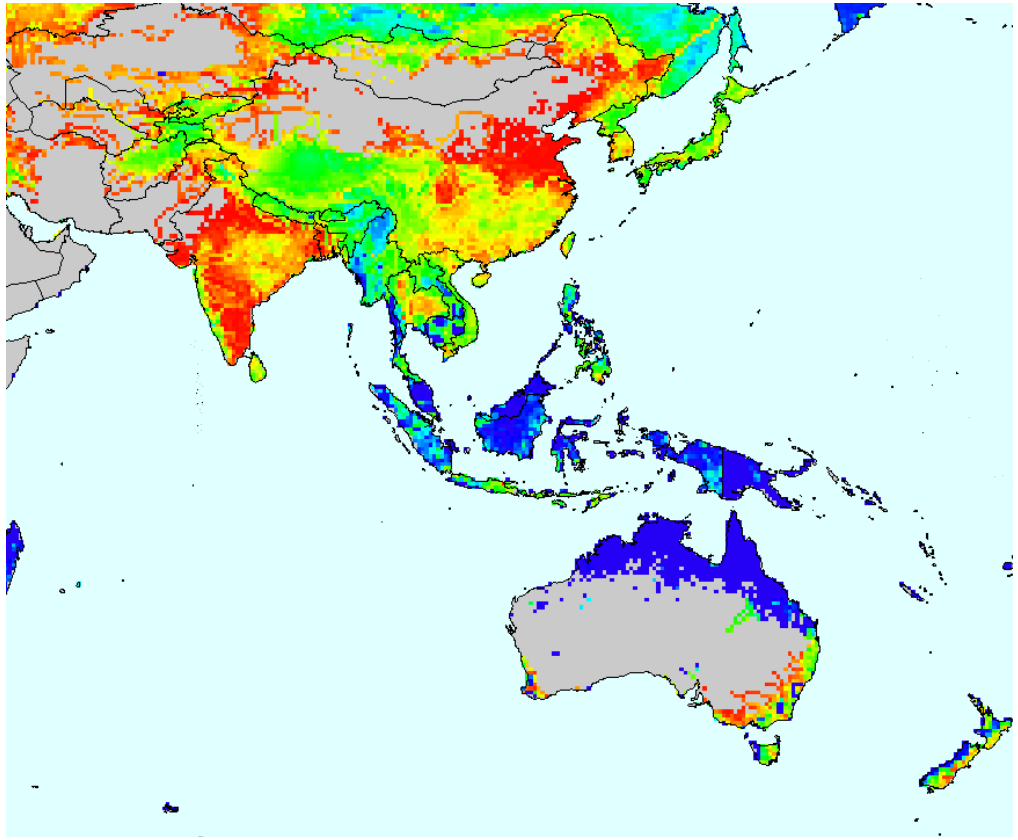




Catchment and Aquatic System Condition Index

Water quality

- Quantify the pressures on water quality from pollution loads in aquatic systems
- As there are no globally standardised datasets of observed water quality data (such as pH, dissolved oxygen etc.), it is difficult to develop a water quality indicator reflecting the state of water quality
  - Used existing published data on pollution loads from Vörösmarty et al. (2010), reflecting conditions circa 2000
  - Updated these values by weighting them by the Sustainable Nitrogen Management Index

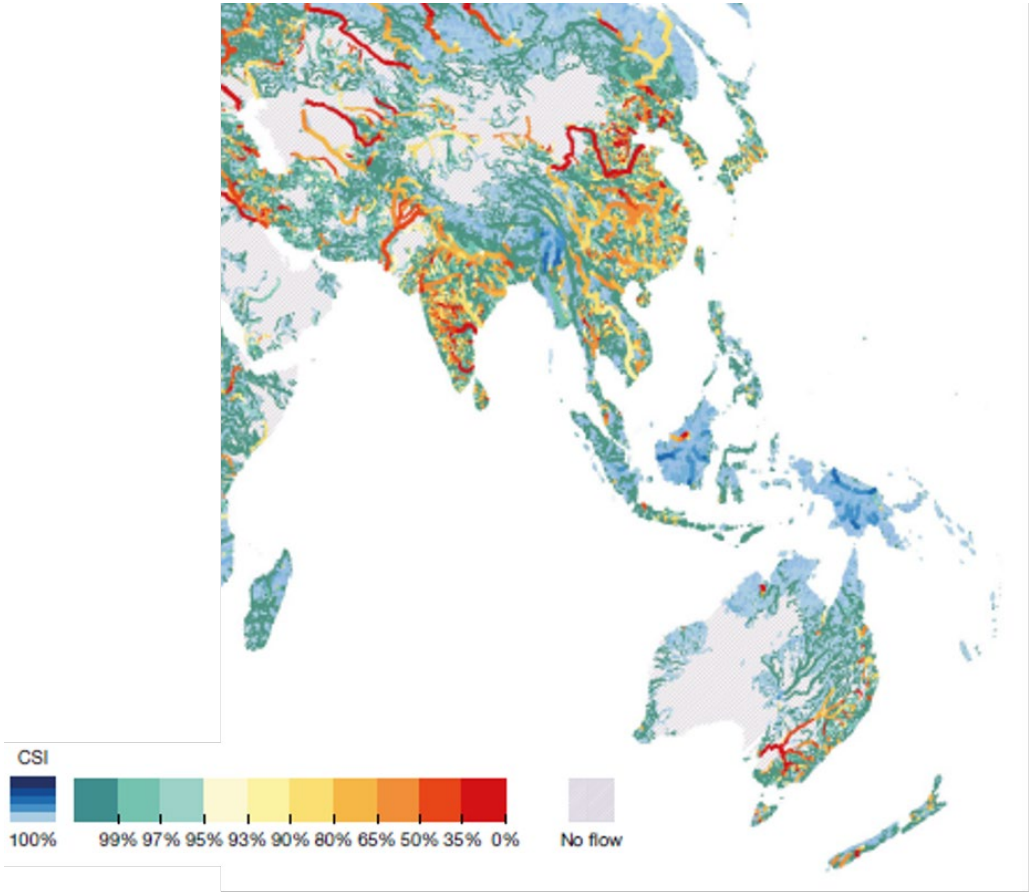


Catchment and Aquatic System Condition Index

Riverine connectivity – Connectivity Status Index

- Global assessment of connectivity of rivers with disruptions being due to the presence of dams, weirs and other barriers to fish migration, sediment and nutrient flows (Grill et al. 2019)

- Using a discharge weighted average of the CSI meant countries like Australia did not score well, simply because they had a large surface area that is undeveloped



Grill et al. (2019) *Nature*.

Environmental Governance Index

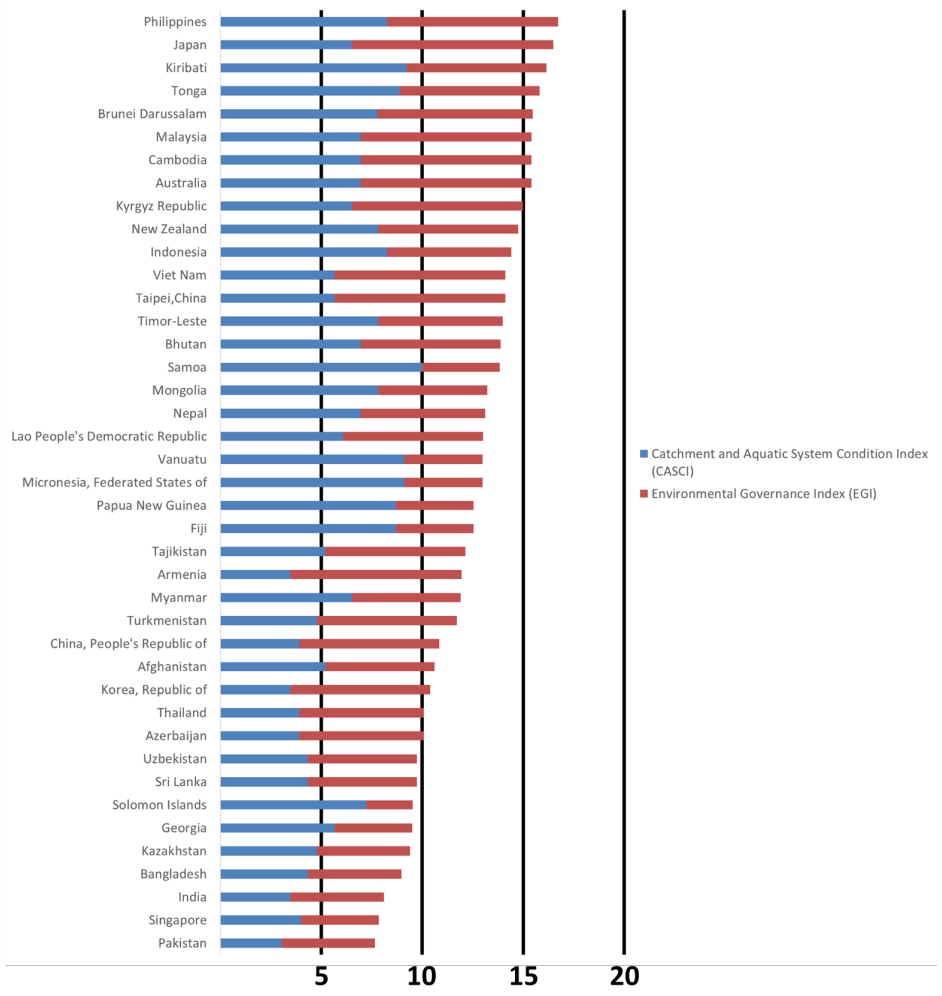
Country level sub-indicators from Yale Environmental Performance Index that highlight the outcomes of good environmental governance

1. Percentage of wastewater treatment
   - Achieving higher levels of wastewater treatment will help countries reduce pressure on aquatic ecosystems from poor water quality
2. Terrestrial protected areas
   - Percentage of land area of each biome that is protected in the country
3. Sustainable nitrogen management index
   - Nitrogen use efficiency to quantify how much nitrogen enters the environment

AWDO 2020

KD4 – Environmental water security

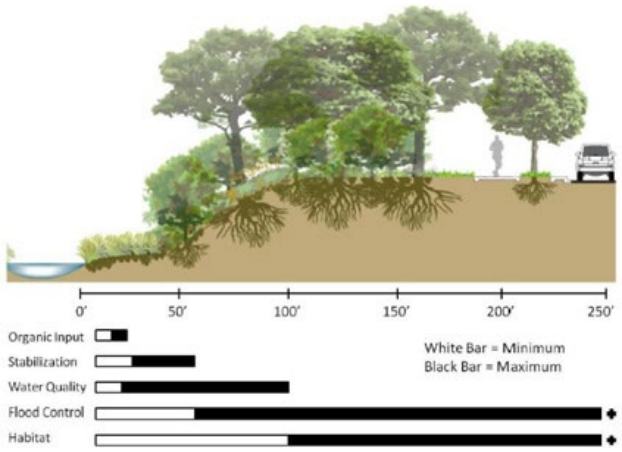
- Countries with a high score for the CASCI tended to have a high EGI
  - Some exceptions, eg. Fiji and Federated States of Micronesia
- Both advanced and developing economies scored well for the overall index

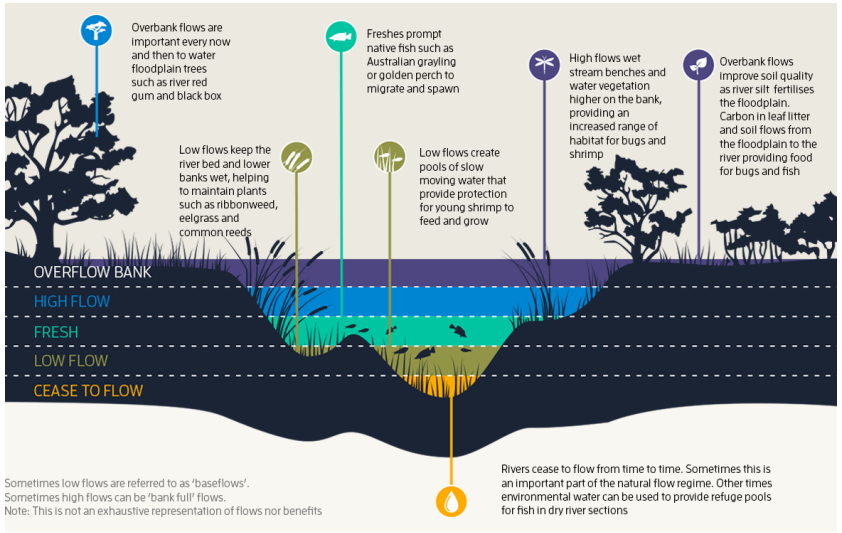


Improving aquatic ecosystem health and water security

Nature based solutions

- Protection and restoration of riparian vegetation
- Sustainable use of groundwater
- Effective environmental flow releases
- High quality infrastructure to allow sediment flows (e.g. multi-offtake dams)





Discussion: AWDO 2020

- AWDO itself is a regional assessment to guide interactions between ADB and member countries
  - Country level assessment provides member countries with quantitative basis to address existing and emerging issues of water security
- Integrates aquatic ecosystem health and its contribution to water security
- Local-scale assessments of the ecosystem health indicators provide guidance on regions where nature based solutions may be possible

Summary

- Healthy aquatic ecosystems provide a range of ecosystem services including contributing to water security
- Changes to the landscape that reduce ecosystem health can reduce ecosystem services and impact downstream users of water
- Monitoring aquatic ecosystem health helps identify processes that are impacting ecosystem services such as the provision of clean water and fisheries production
- Nature based solutions, such as the revegetation of the riparian zone can help restore aquatic ecosystem health and ecosystem services that may have been lost

International WaterCentre

Griffith UNIVERSITY
Queensland, Australia

Group discussion

- Discuss the ecosystem services that healthy aquatic ecosystems currently provide in your own country or area of work
  - Are there any that have been lost in recent years?
  - Are there any that are under threat from changes to the landscape or other developments?
- Discuss efforts to monitor aquatic ecosystem health in the region you live and work
  - If you are not aware of any, can you discuss potential opportunities to implement it, such as any particularly important catchments used for water supply or fisheries