# Development of a Global National Water Management Index

A proposal for a set of water-related indicators for monitoring SDGs on a global scale

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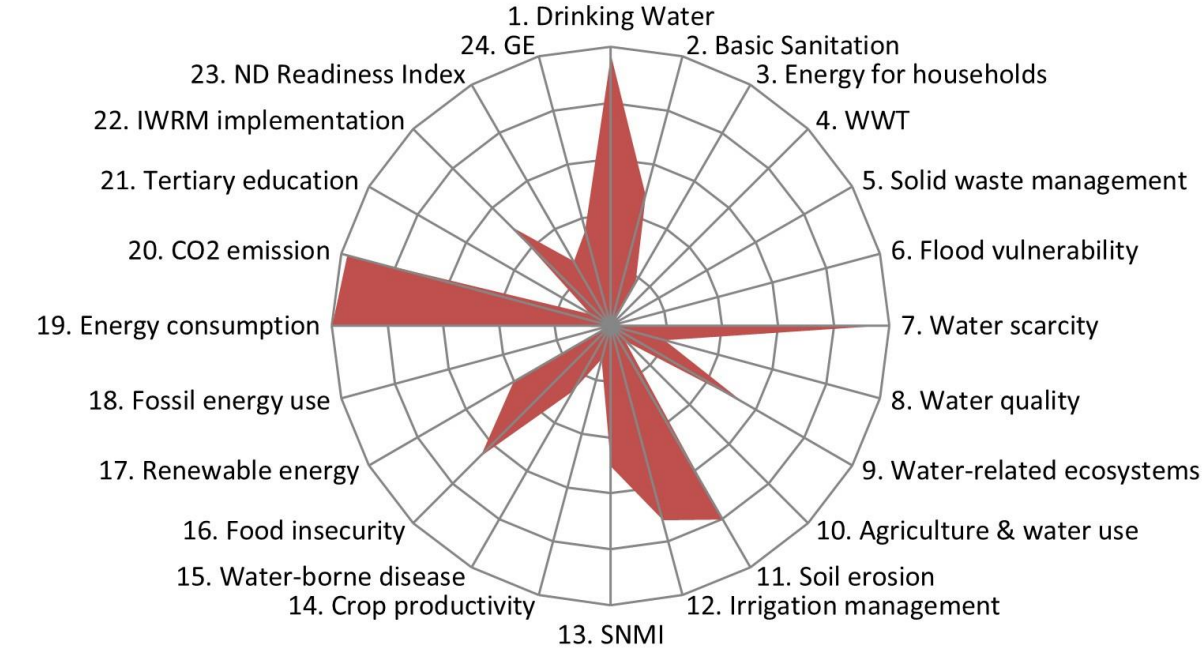



*Figure: country performance on NBF (Bangladesh)*

# Project Overview

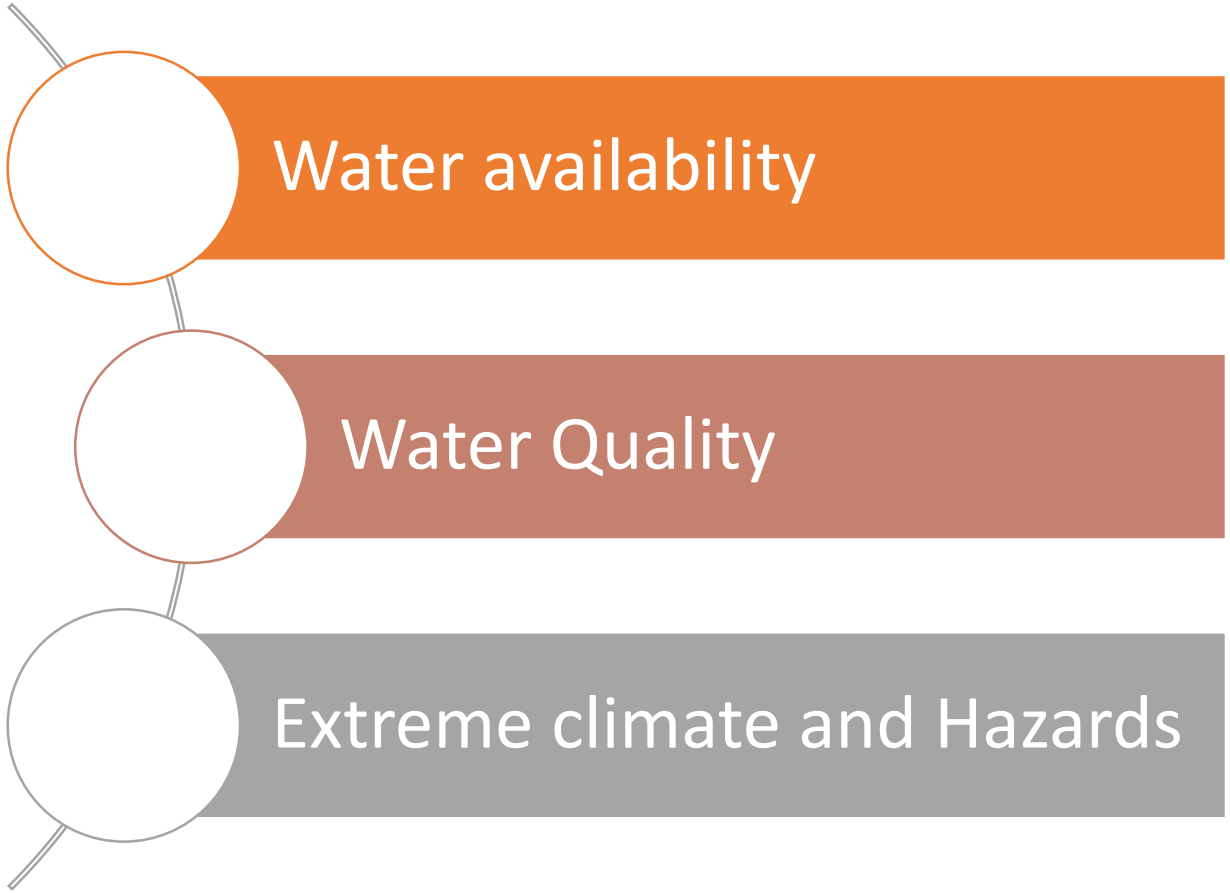
| Previous Study | This Study |
| --- | --- |
| 2019 version of National Blueprint Framework | New version of National Blueprint Framework |
| ✓ a water management framework to show the progress and challenges in water-related SDGs at national level | ✓ a comprehensive framework based on a critical assessment of SDG 6 at the level of the EU28<br>✓ taking into consideration<br>1. the water-energy-food (WEF) nexus<br>2. the lack of water-related data in developing countries |
| ✓ applicable for EU28 | ✓ applicable for all countries, |

# Contents

# Introduction: water challenges

Trends:

- Population growth
- Economic development
- Urbanization
- Industrialization
- Changing consumption patterns



# Introduction: SDGs and WEF nexus


**Figure 1** *The water-centric 17 Sustainable Development Goals for each sector (United Nations, 2015c; Makarigakis & Jimenez-Cisneros, 2019).*

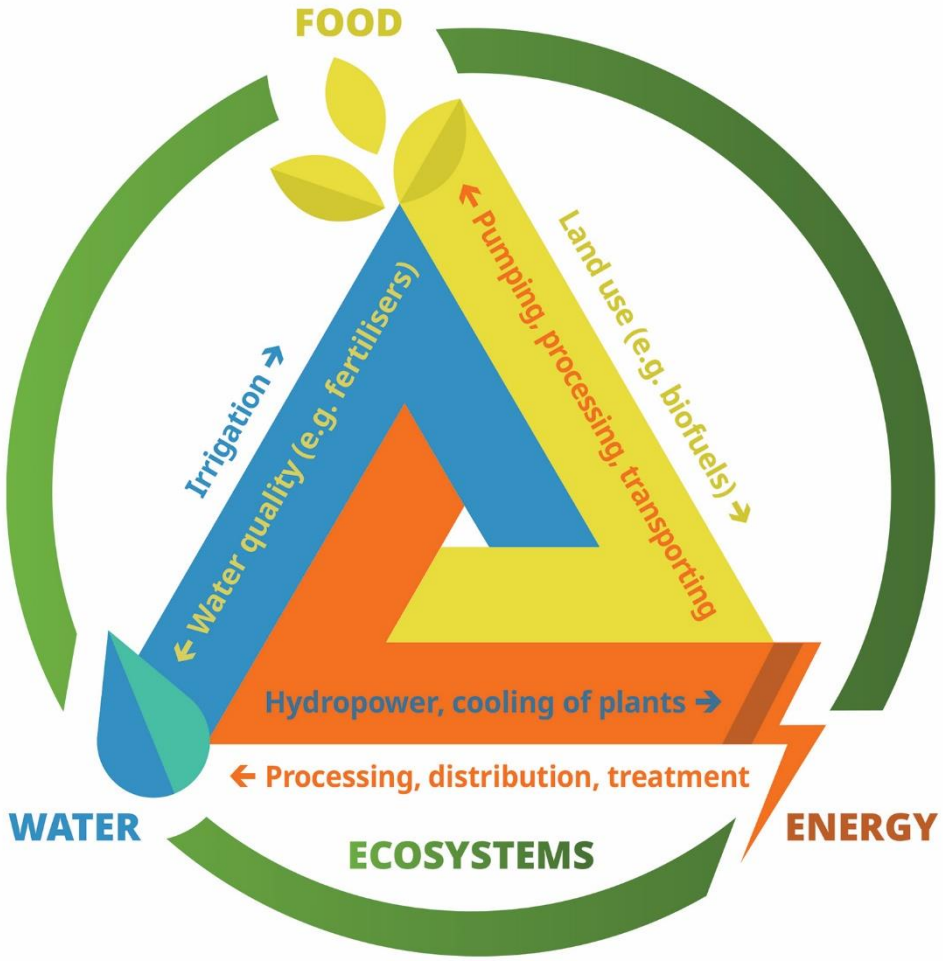



**Figure 2** *The WEF Nexus approach (Global Water Partnership, 2019)*

# Introduction: National Blueprint Framework (NBF)

| Category | Indicator |
|---|---|
| I. Water stress | 1. Water stress (aquastat) |
| | 2. Flood vulnerability |
| | 3. Transboundary cooperation |
| | 4. Tertiary education |
| II. Water quality | 5. Surface water quality |
| | 6. Groundwater quality |
| | 7. Ecological water quality |
| III. Access to basic services | 8. Drinking water quality |
| | 9. Connected to drinking water supply (%) |
| | 10. Connected to improved sanitation (%) |
| | 11. Water affordability |
| IV. Infrastructure | 12. Infrastructure investment (% GDP) |
| | 13. Water leakage (%) |
| V. Waste water treatment | 14. Secondary WWT (%) |
| | 15. Tertiary WWT (%) |
| | 16. Nutrient recovery (%) |
| | 17. Waste Water to Energy (%) |
| VI. Solid waste treatment | 18. Solid waste collected (%) |
| | 19. Solid waste recycled (%) |
| | 20. Solid Waste to Energy (%) |
| VII. Climate adaptation | 21. CO2 emission per capita per year |
| | 22. Renewable energy (% of total) |
| | 23. Notre Dame Readiness Index |
| | 24. IWRM (%) |

*Table 1. 2019 version NBF (Essex et al., 2020)*

*Towards a new NBF:*

a comprehensive NBF that can be applied in all countries, based on a critical assessment of SDG 6 at the level of the EU28.

taking into consideration:

(a) the water-energy-food (WEF) nexus
(b) data availability in developing regions
(c) the enormous water challenges in the developing countries

# Research Question

What updates can be proposed to optimize the indicator framework to be applicable in developing countries, with complementary water-related indicators that can be used or linked to SDG6?

**Phase 1 Understanding the linkages among water-energy-food nexus**

- RQ1. What linkages exist among WEF sectors that can be taken into account for improving the IWRM on a national level?

**Phase 2 Indicator framework development**

- RQ2. Can a more suitable set of indicators be developed that takes into account the WEF nexus and the limited data availability in developing countries for an improved NBF to measure the progress on SDGs implementation?

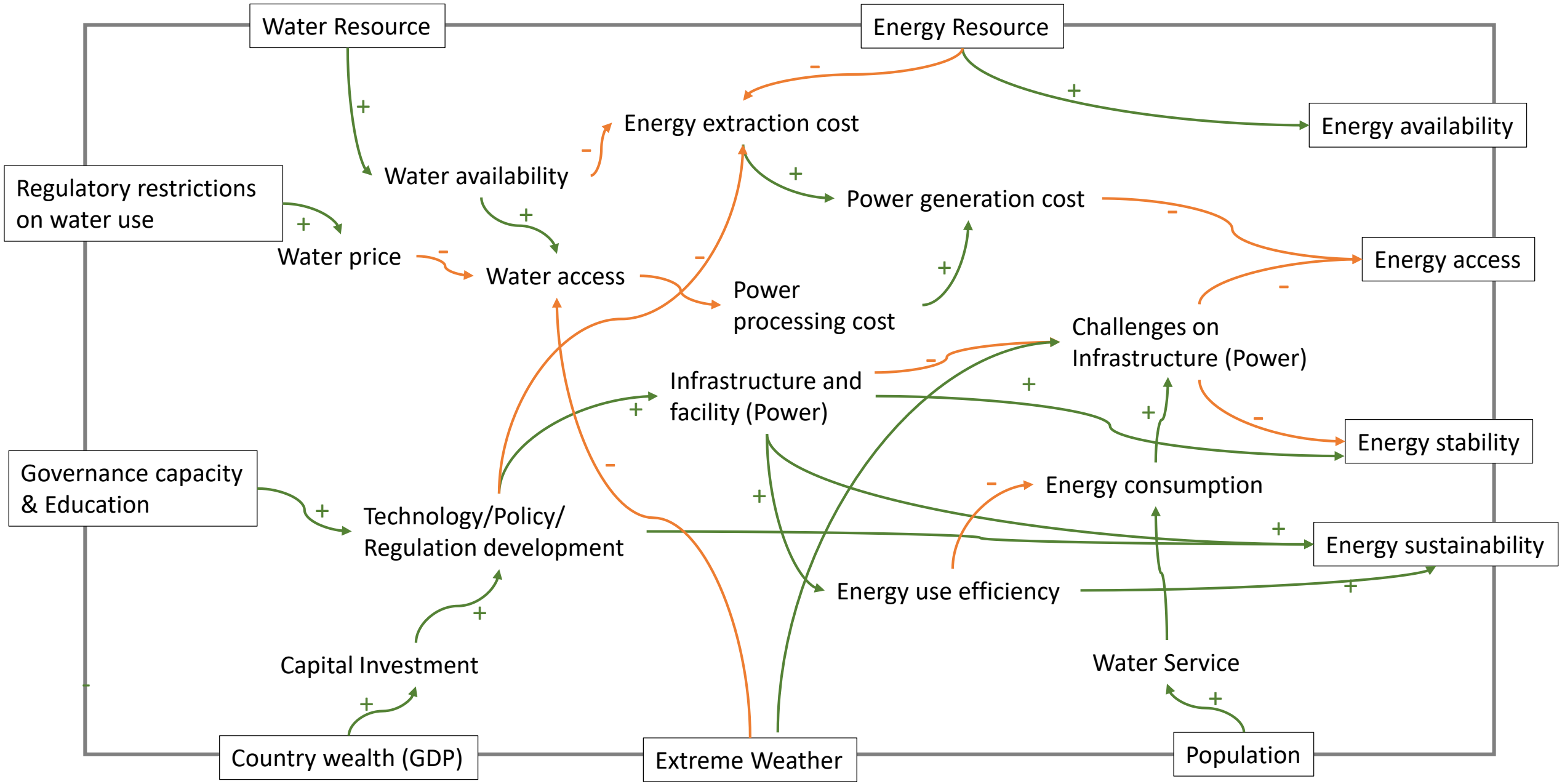
**Phase 3 Apply the new NBF to all countries**

- RQ3. To what extent does the proposed index represent regional variety on a global scale?

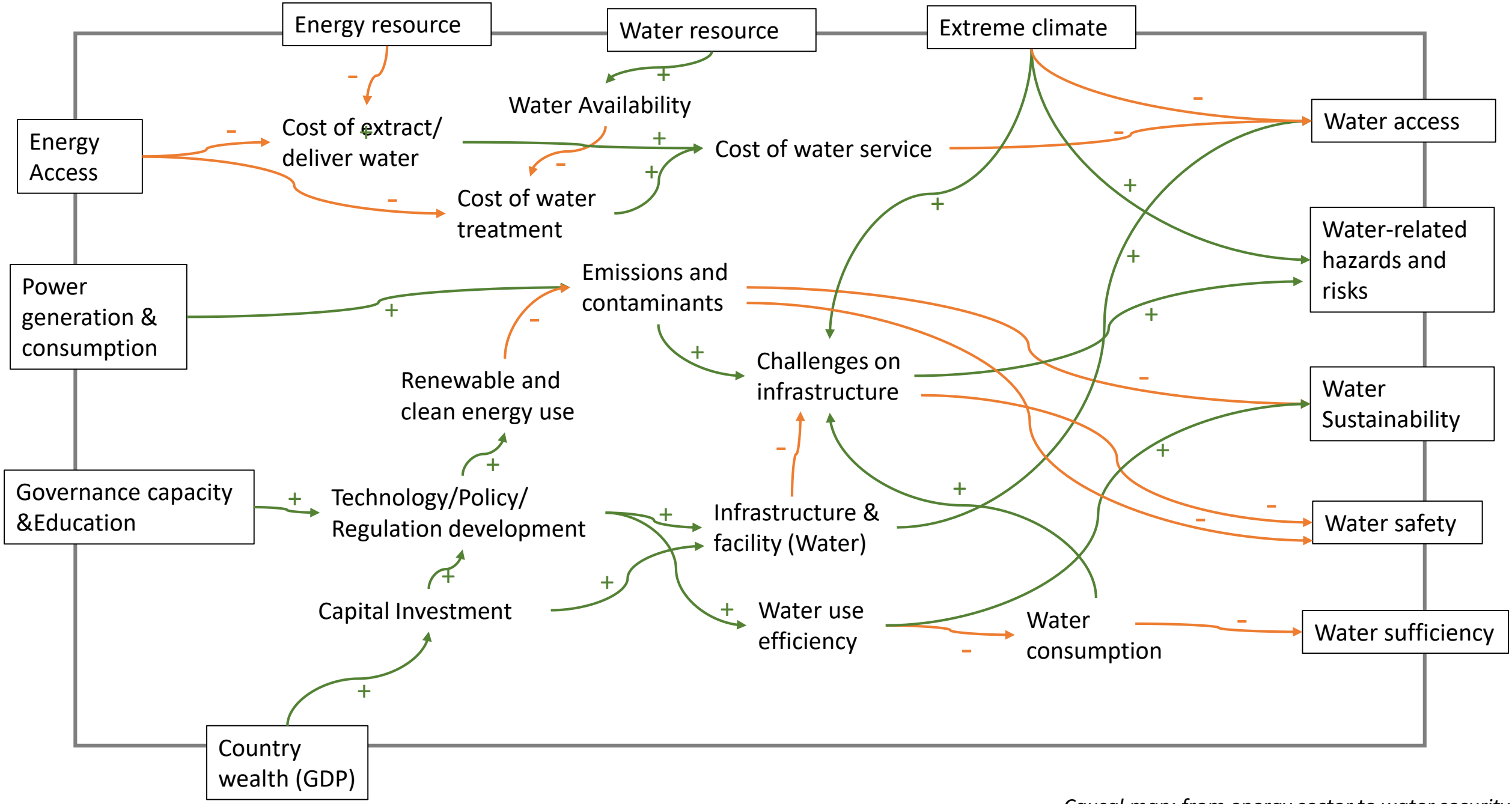
# Phase 1 Water-energy-food nexus

*Table 2 Various dimensions of security referents (Source: Staupe-Delgado, 2019; FAO, 2013)*

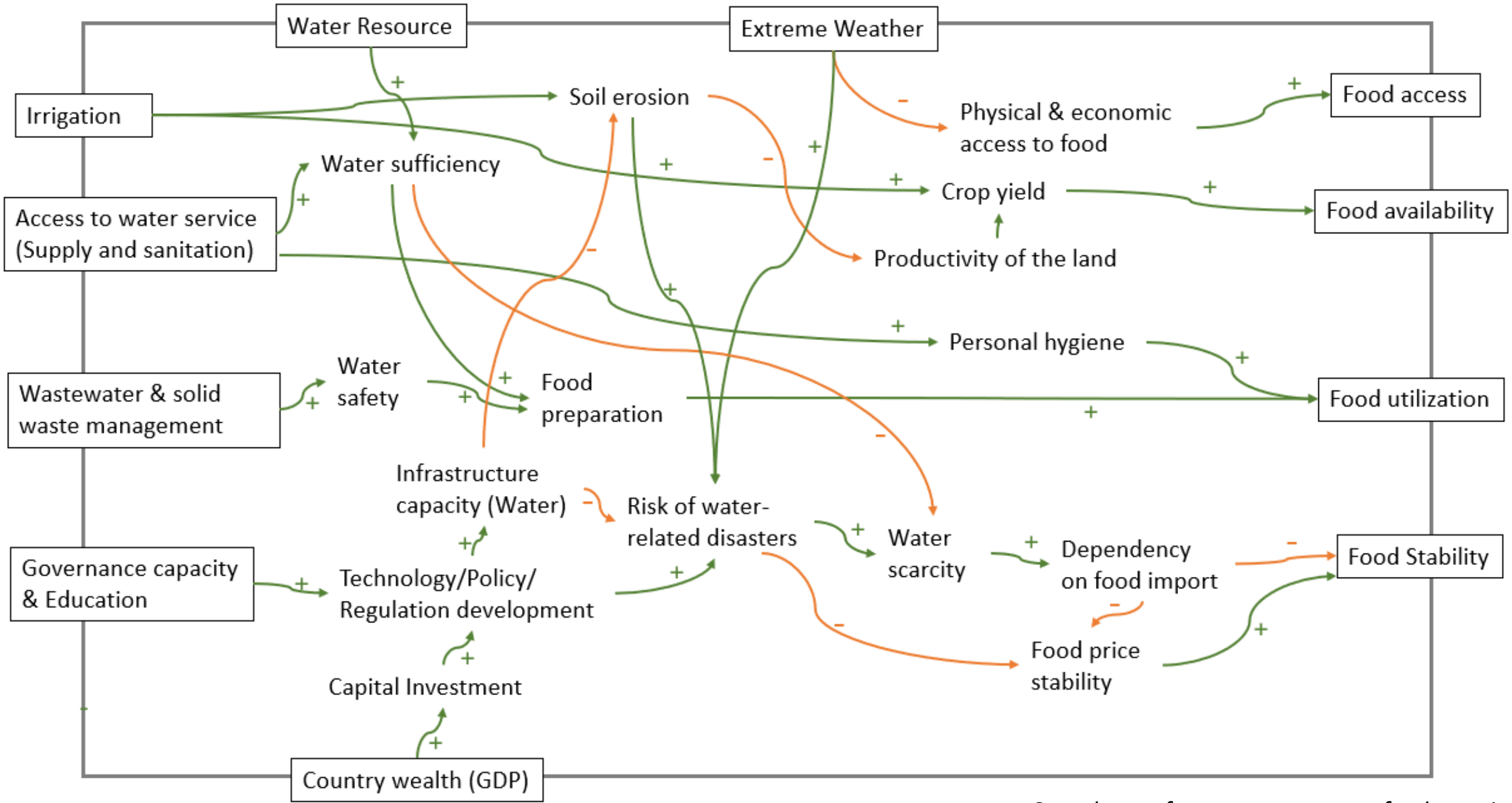
| **Water Security** | **Energy Security** | **Food Security** |
|---|---|---|
| Sufficiency<br>Safety<br>Hazards<br>Access<br>Sustainability | Availability<br>Access<br>Stability<br>Safety and security<br>Sustainability | Availability<br>Access<br>Utilization<br>Stability |



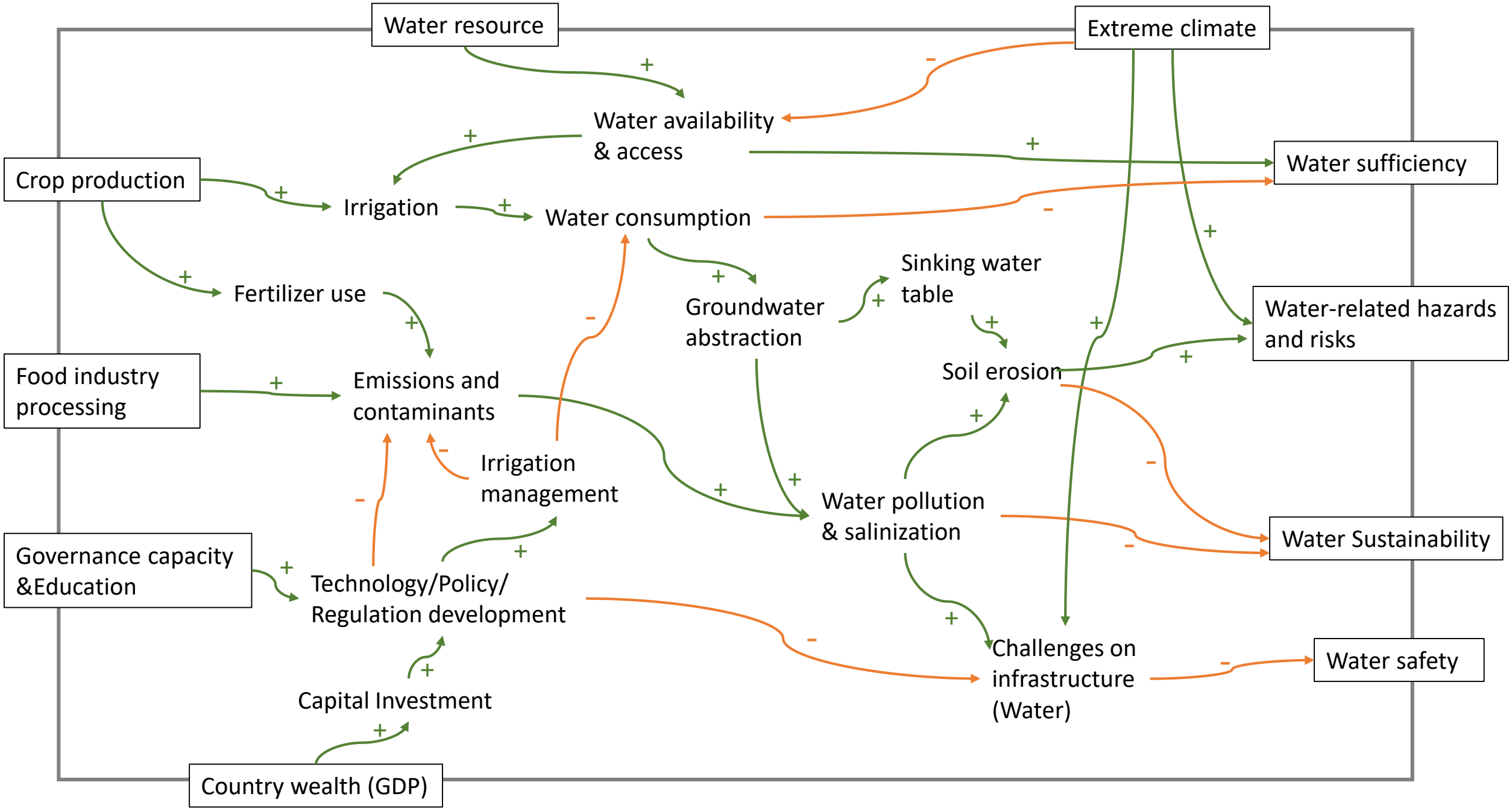

*Causal map: from water sectors to energy security*




*Causal map: from energy sector to water security*




*Causal map: from water sector to food security*




*Causal map: from food sector to water security*

# Phase 2 Indicator framework development

**a. Category improvements: cover more diverse focused areas**

| | Category | Aim |
|---|---|---|
| Water | 1. Household Water Security | assess to what extent household water, sanitation, and hygiene needs are reached on a national scale |
| Water | 2. Urban Water Security | assess the key water-related factors relevant to better urban water services. |
| Water | 3. Environment and Water Resources | assess the environmental status of water resources and ecosystems |
| Food | 4. Water, Land and Food | assess to what extent agriculture and irrigation may influence the water sector. |
| | 5. Human Health | track human health-related problems caused by unsafe sanitation, unsafe drinking water and food insecurity |
| Energy | 6. Water and energy | focus on the energy-related aspects that associated to water security or affected by the water sector. |
| | 7. Governance and Resilience | focuses on issues on governance and water management which tend to be associate with long-term water related issues. |

# Phase 2 Indicator framework development

**b. Indicator improvements:**

## Principle on indicator selection

- "SMART" (Koop & van Leeuwen, 2015a):
- Specific (simple, sensible, significant)
- Measurable (meaningful, motivating).
- Achievable (agreed, attainable).
- Relevant (reasonable, realistic and resourced, results-based).
- Time bound (time-based, time limited, time/cost limited, timely, time-sensitive).

## Principle on indicator development

- Water-related indicators: mainly based on the old version of NBF;
- Food- and energy- related indicators: newly developed based on the analysis of WEF nexus
- Governance-related indicators: mainly based on the old version of NBF;

# Phase 2 Indicator framework development

## b. Indicator improvements:

| Category | Indicator |
|---|---|
| **Household Water Security** | 1. Basic drinking water supply |
| | 2. Basic sanitation connection |
| | 3. Energy for household clean water |
| **Urban Water Security** | 4. Wastewater treatment |
| | 5. Solid waste management |
| | 6. Flood vulnerability |
| **Environment and Water Resources** | 7. Water scarcity |
| | 8. Water quality risk |
| | 9. Water-related ecosystems' change |
| **Management and Governance** | 21. Tertiary Education Attainment |
| | 22. IWRM implementation |
| | 23. Notre Dame Readiness Index |
| | 24. Government Effectiveness |

*Indicators proposed (part 1)*

# Phase 2 Indicator framework development

## b. Indicator improvements:

*Indicator proposed (category: water, land and food)*

| Indicator | Rationale |
|---|---|
| 10. Agriculture and water use | The indicator provides a measure of water scarcity potentially caused by agriculture. |
| 11. Soil erosion | Groundwater abstraction is in necessity for irrigation but has resulted in various environmental problems including soil erosion. At the same time, soil erosion is a major threat to food security and ecosystem viability (Wuepper et al., 2020). |
| 12. Irrigation management | "This indicator provides a measure of the dependence of a country's or region's agriculture on irrigation. It shows the vulnerability of agriculture to water stress and climatic shocks (such as droughts), which has implications for national food security depending on production and trade patterns" (Food Security Information and Knowledge Sharing System, 2017). |
| 13. Sustainable nitrogen management index | Fertilizers are rich in nitrogen and the use of them can lead to widespread damage through nitrogen pollution (Bodirsky et al., 2014). |
| 14. Crop productivity | The indicator shows if a country can produce food, which has implications for many natural factors, such as climate (hydrological patterns, water-related disaster, etc.) and water resources. |

# Phase 2 Indicator framework development

## b. Indicator improvements:

*Indicator proposed (category: human health)*

| Indicator | Rationale |
|---|---|
| 15. Water-borne disease risks | This outcome indicator is a reasonable way to tracks diseases and deaths caused by unsafe sanitation and drinking water. |
| 16. Prevalence of food insecurity | Hunger, malnutrition, and reduced health and quality of life are all potential public health consequences of food insecurity (Furness et al., 2004).<br>This indicator provides a way to track the prevalence of moderate or severe food insecurity. |

*Indicator proposed (category: water and energy)*

| Indicators | Rationale |
|---|---|
| 17. Renewable energy | In general, renewable energy (e.g., wind and solar power) leads to fewer water pollutants compared to fossil fuel energy, and the use of which is a way to mitigate climate change (Owusu & Asumadu-Sarkodie, 2016). |
| 18. Electricity production from oil, gas and coal sources (%) | The lifecycle of fossil fuels is relevant to multiple water-related risks, e.g., pollutants that threat water quality, large water consumption threating water sufficiency. This indicator provides a way to assess water stress potentially caused by fossil fuels. |
| 19. Energy consumption | This indicator provides a way to assess the stress on energy sufficiency. |
| 20. CO2 emission | CO2 is the main composition of greenhouse gas (GHG) that in a long term have the global warming effect. High GHG emissions will negatively impact the climate and resources (van Vuuren et al., 2011). |

# Phase 2 Indicator framework development

## b. Indicator improvements:

Scoring method:

1) Indicator score:

$$\text{Indicator} = 10^* \frac{(X - B)}{(A - B)} \text{ or } 10\text{-}10^* \frac{(X - B)}{(A - B)}$$

A: the target value; B: the lowest value

Sum up:

- Set target value → calculate the distance
- Re-scale to score 0-10
- Higher score → better performance

2) National Blueprint Index:

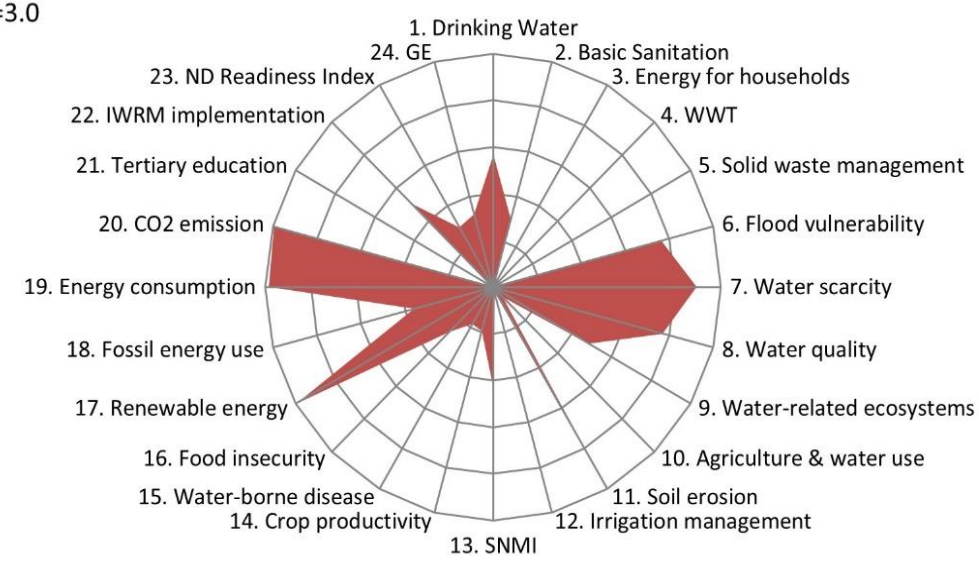
$$\textbf{National Blueprint Index} = \sqrt[n]{(a_1 + 1) \times (a_2 + 1) \ldots (a_n + 1)} - 1$$

*Geometric mean has been selected because it emphasizes the need to improve the lowest scoring indicators.*

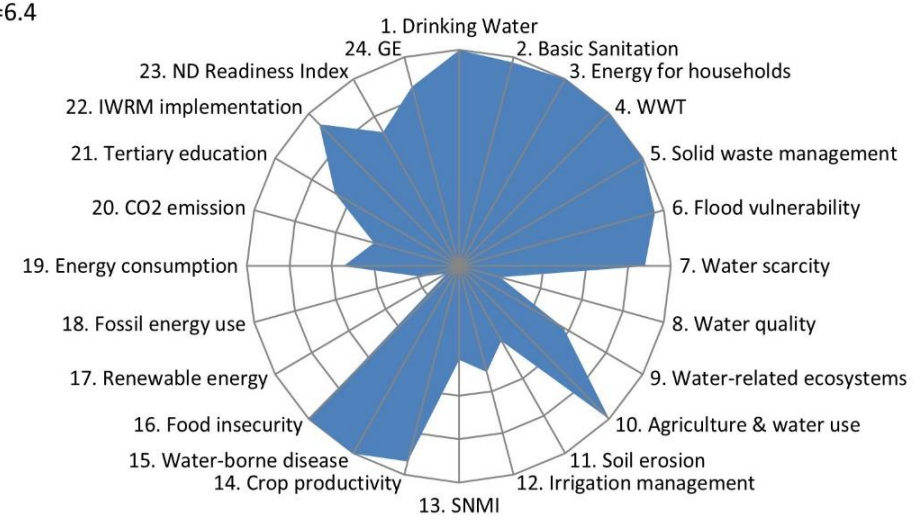
# Phase 3 Indicator results

## a. Country performance:

**Tanzania**
NBI=3.0

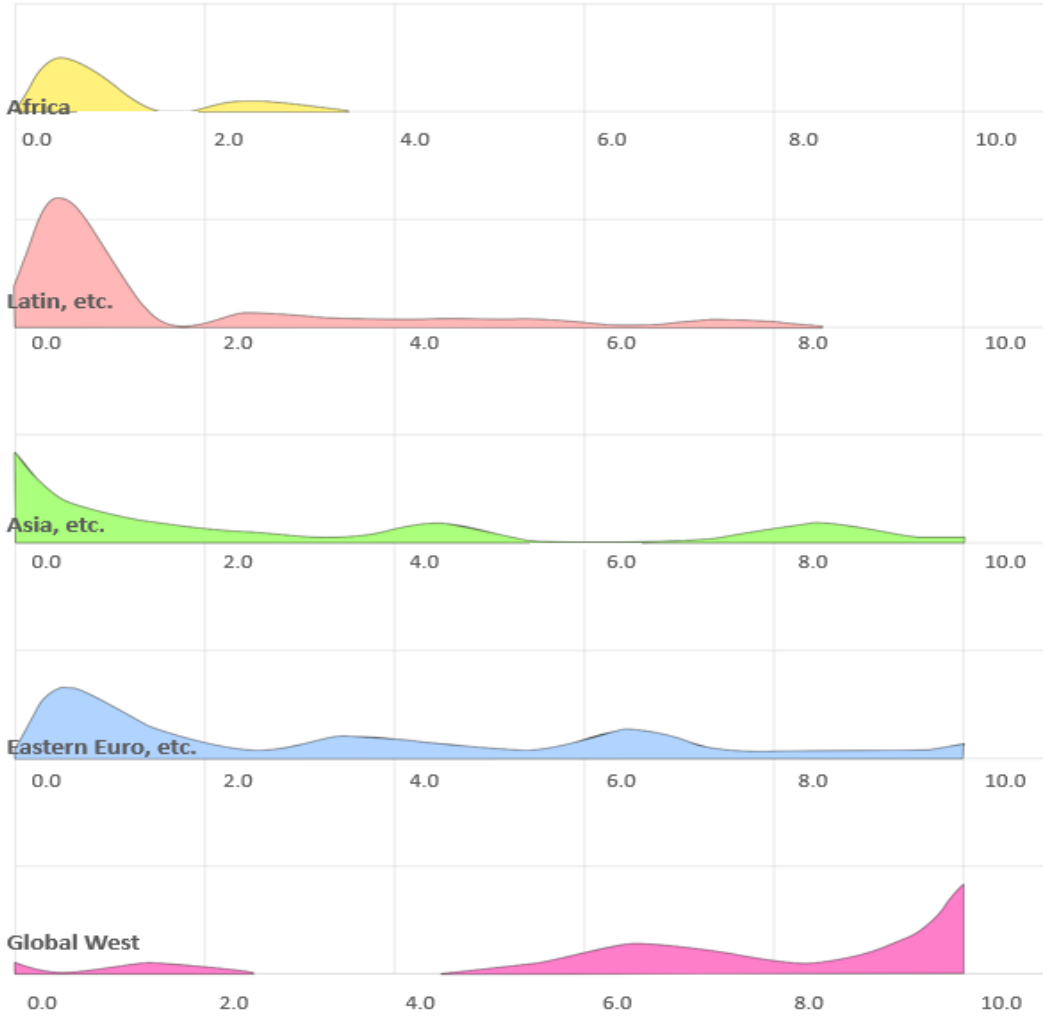



**Netherlands**
NBI=6.4

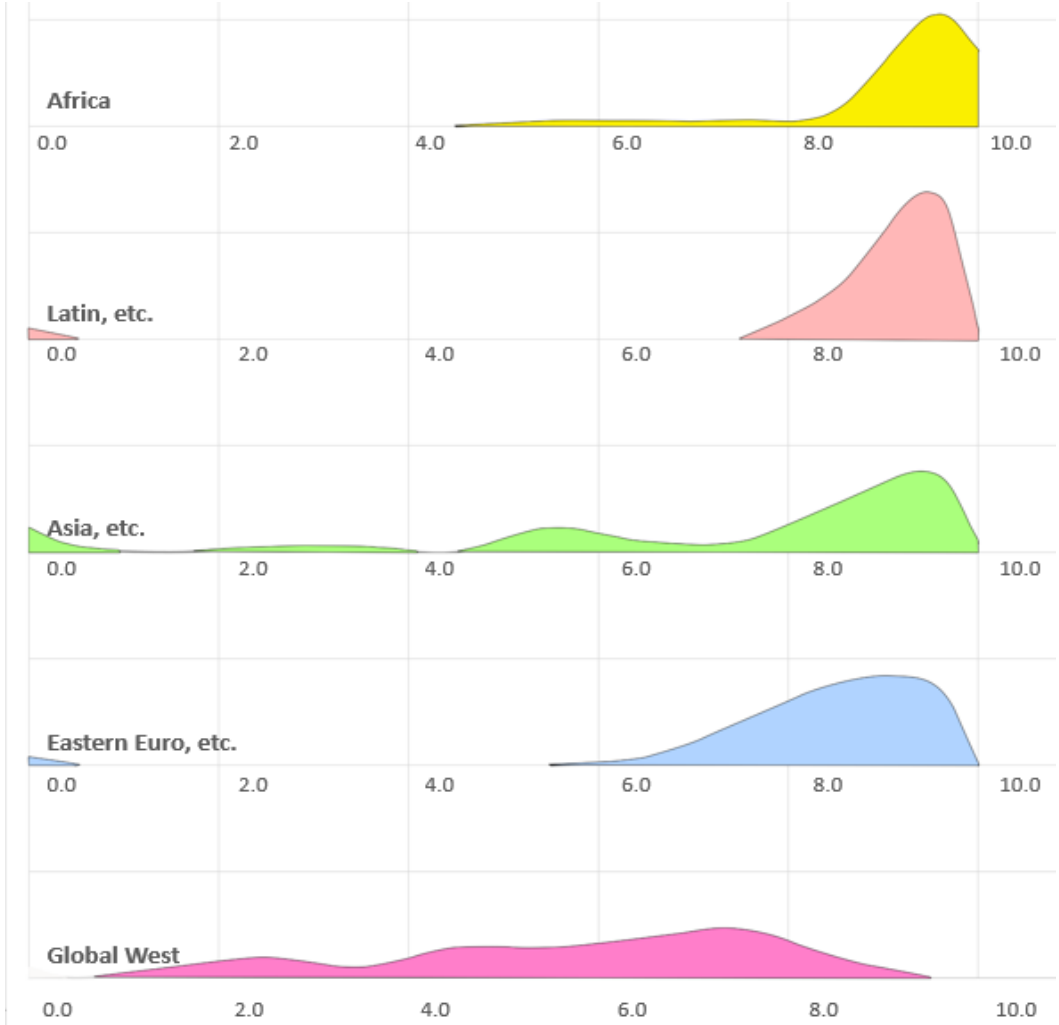


# Phase 3 Indicator results

## b. Indicator performance:




*Regional performance on Wastewater treatment (Category 2. Indicator 4)*

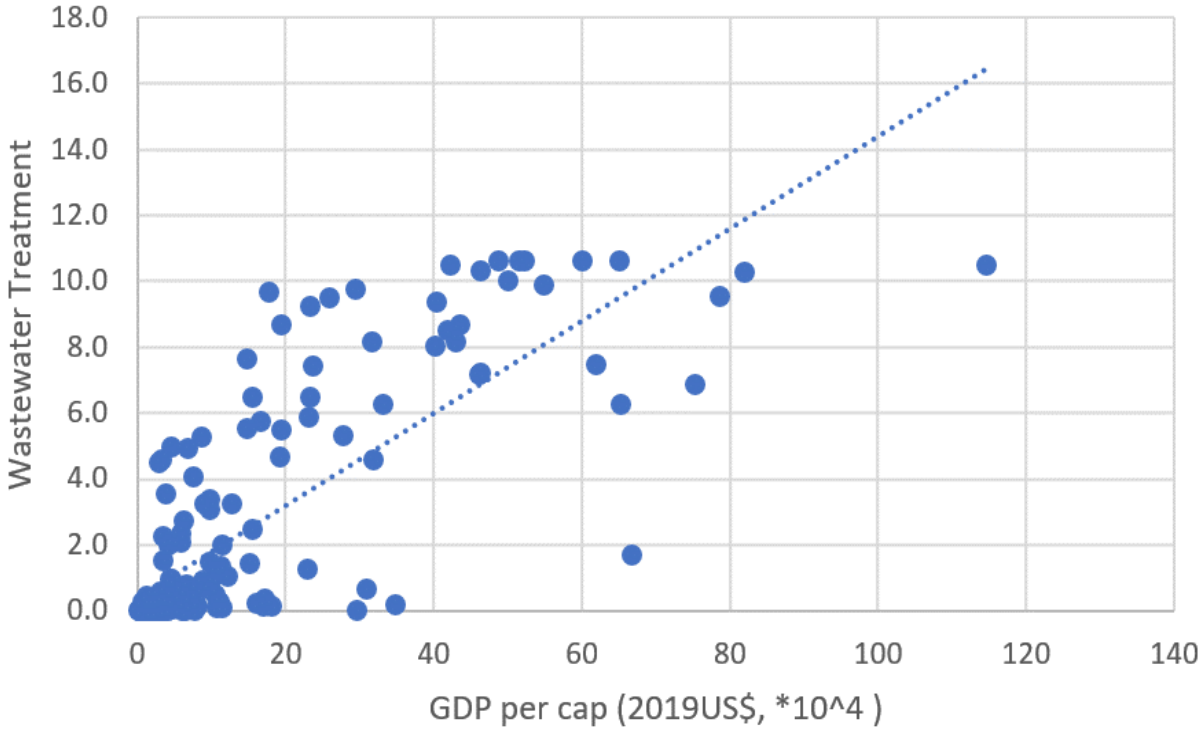



*Regional performance on CO2 emission (Category 6. Indicator 20)*

# Phase 3 Indicator results

## c. Result assessment:

Compare the country performances to the external factors

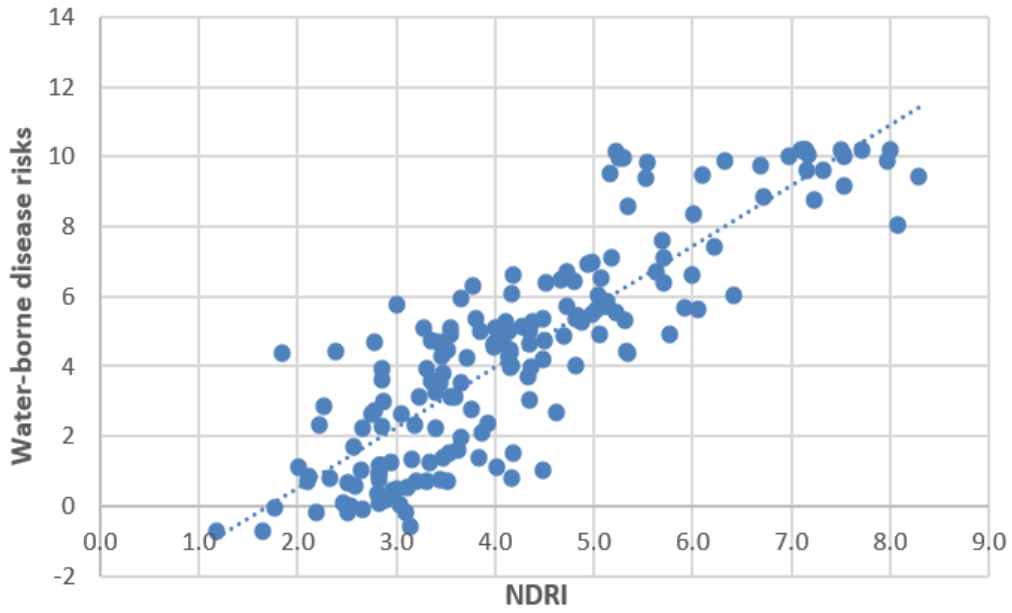


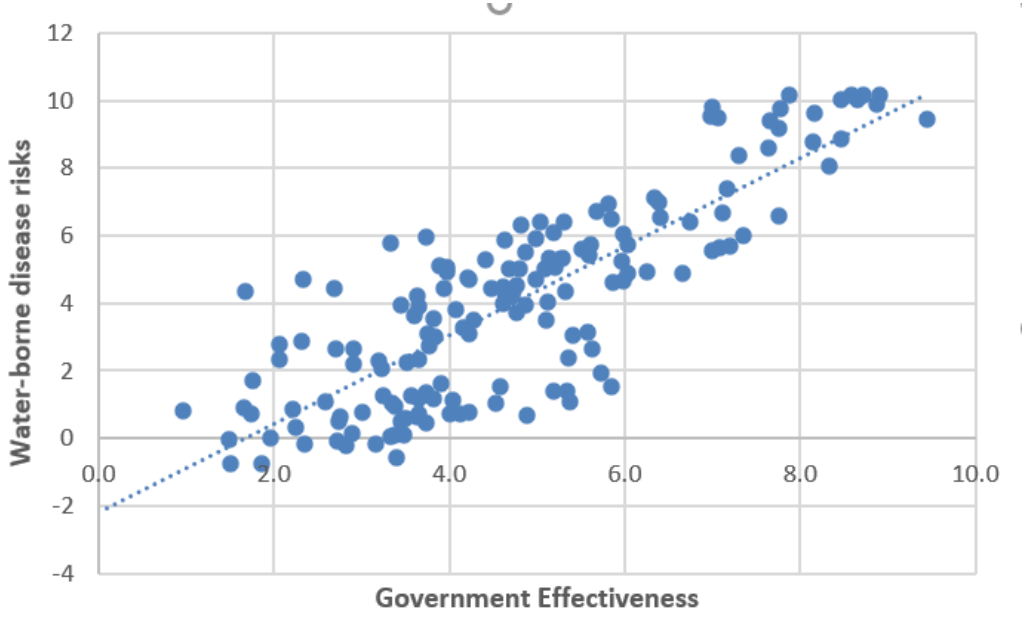

*Relationship between Wastewater Treatment score and country wealth, as measured by GDP per capita (Pearson correlation coefficient r=0.74)*

# Phase 3 Indicator results

## c. Result assessment:

Compare the country performances for different indicators




*The relationship between water-borne disease risks* scores and *governance-related indicator* scores *(r=0.86, left; r=0.82, right)*

# Phase 3 Indicator results

## c. Result assessment:

Other findings: countries that get scores exceeding those of their peer nations

Example:

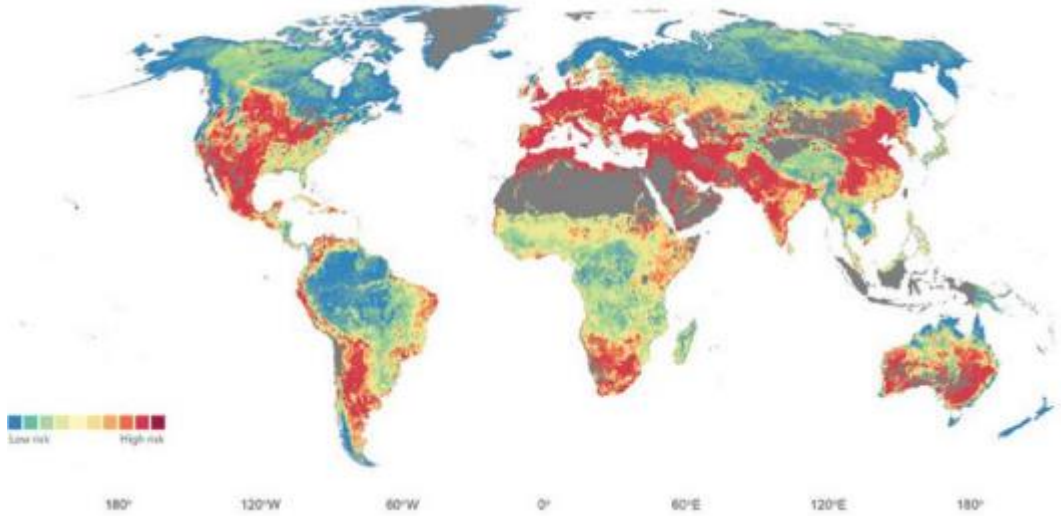
| LATIN AMERICA & CARIBBEAN | |
|---|---|
| Colombia | 10.0 |
| Grenada | 7.9 |
| Saint Lucia | 7.8 |
| Antigua and Barbuda | 7.5 |
| Mexico | 7.4 |
| Saint Vincent and the Grenadines | 7.3 |
| Barbados | 6.7 |
| Brazil | 6.6 |
| Chile | 6.6 |
| Costa Rica | 6.5 |
| Dominica | 6.2 |
| El Salvador | 5.6 |
| Ecuador | 5.4 |
| Uruguay | 4.9 |
| Argentina | 4.5 |
| Guyana | 4.4 |
| Panama | 4.2 |
| Honduras | 4.0 |
| Paraguay | 3.5 |
| Jamaica | 3.2 |
| Bolivia | 3.1 |
| Peru | 3.0 |
| Cuba | 2.6 |
| Belize | 1.7 |
| Guatemala | 1.7 |
| Nicaragua | 1.1 |
| Trinidad and Tobago | 1.0 |
| Dominican Rep | 0.6 |
| Haiti | 0.1 |
| Bahamas | 0.0 |
| Suriname | 0.0 |
| Venezuela | 0.0 |

# Discussion

## Limitations

- Temporal completeness

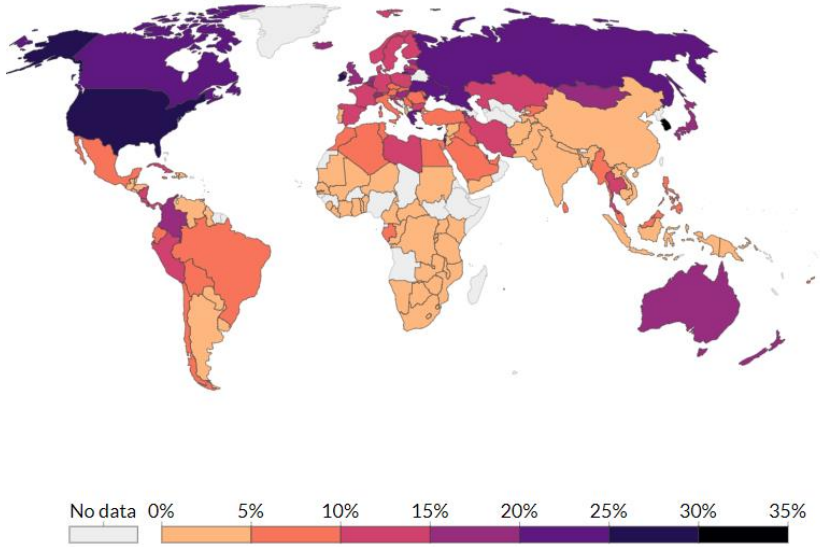
e.g., Global Risk of Poor Water Quality (Data source of indicator 8)




*Source: (Damania et al, 2019)*

- Recency:

e.g., Tertiary Education Attainment (Data source of indicator 21)




*Source: (Our World in Data, 2010)*

# Discussion

## Further study ： Data processing

- Data standardization:

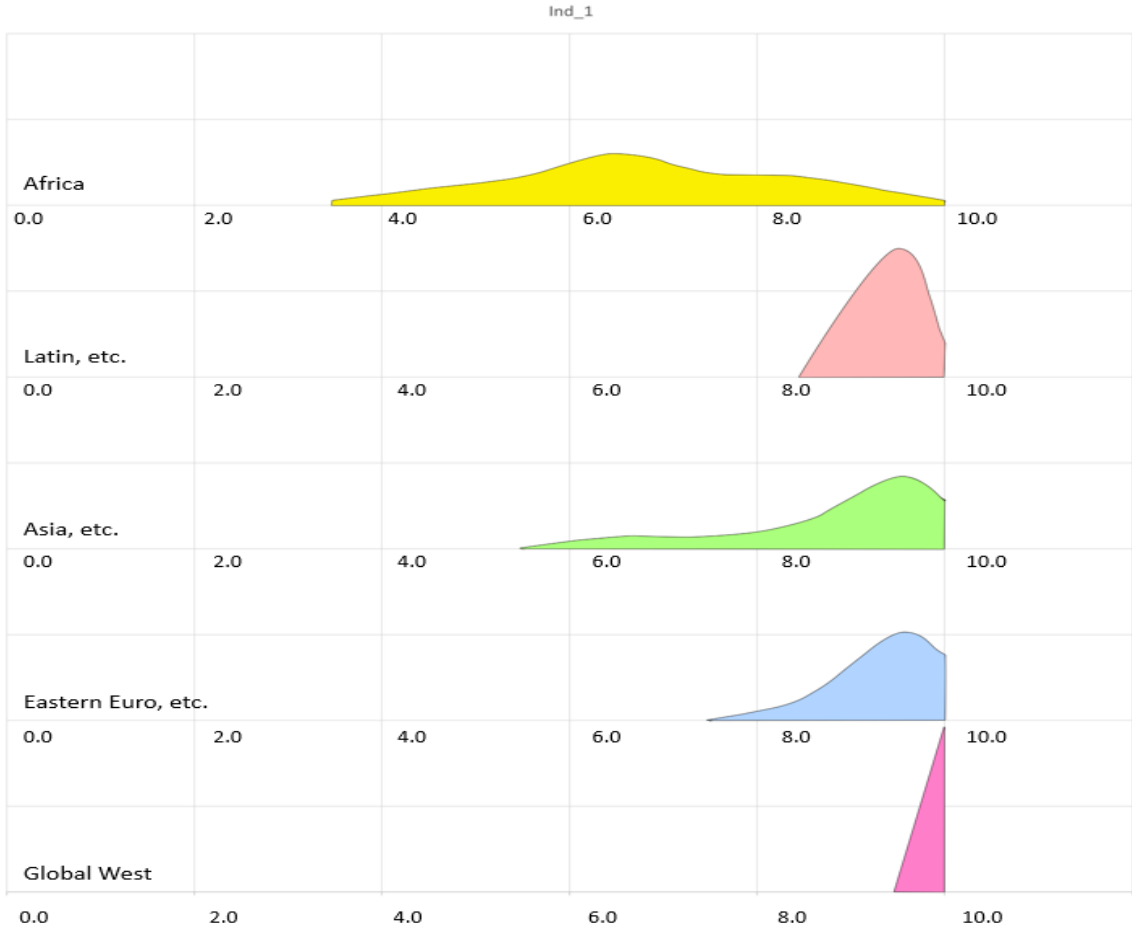
e.g., Indicator 20. *CO2 emission*

Other issues worthy to be discussed:

GDP,
GDP growth,
Greenhouse Gas: composition ratio,
Etc.

- Data transformation: avoid results' skewness

e.g., Indicator 1. *basic drinking water supply*



# Conclusion

1) Concepts and theories of water-, energy- and food security can contribute to a better understanding of the sustainability of water, energy and food systems. A means-ends system analysis provides an effective way of understanding the dynamic and complex linkages of the WEF nexus.
2) The shifted focus to WEF nexus (with a firm basis in IWRM) leads to a wider range of focused areas and necessitated the re-categorizing of the framework.
3) By reformulating the indicators in a SMART manner, the newly developed NBF is easily applicable to a sufficient number (at least 145) of countries and the NBF results are effective in representing the regional characteristics and the vulnerability of individual countries.
4) The priority on the spatial completeness of the dataset still results in many restrictions in data selection.

# Conclusion (continued)

5) The correlations between some NBF indicators and external factors are aligned with the inter-linkages and inter-dependencies that exist in the WEF nexus.

6) It is worth looking at countries that receive scores exceeding those of their peer nations, because they are potentially good examples to share their experiences and to provide guidance to other countries to improve their sustainability, i.e., to successfully implement the UN SDGs.

7) For further research towards a more effective and accurate indicator framework, it is suggested to do further research in data processing (data standardization and transformation).

*Thank you !*