Participatory approach for enhancing robust water resource management and adaptation to water security

Institute for Global Environmental Strategies

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Self Introduction

– 2018~ Working as Senior Policy Researcher in the Institute for Global Environmental Strategies, Hayama, Japan
– 2014-18: JSPS Postdoctoral Fellow, University of Tokyo and United Nations University, Japan
– 2012: Ph.D., Geo-environmental Science, University of Tsukuba, Japan

Research interests

– Climate Change Adaptation and Water Resource Management
– Numerical Simulation for Contaminant Fate and Transport
– Sustainability Developmental Goals (SDGs)
– Global Changes and its impacts on Water Resources; Ecosystem Services
– Physical, Chemical and Isotope Hydrogeology

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Global report

1. Worked as **Chapter Scientist** for the **Fifth Assessment Report (AR5)** of the **Intergovernmental Panel on Climate Change (IPCC)**. Mainly associated with the IPCC's Working Group-II report that focuses on "Impacts, Adaptation, and Vulnerability' with chapter "Foundations for Decision making" which was released in December 2014.

(https://ipcc-wg2.gov/AR5/contributors/chapter/chapter-2)

2. Currently also working as contributing author for Chapter 10 i.e. Asia, AR6, IPCC WGII.

3. Currently working as Lead author /scoping expert for IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services)
assessment of the interlinkages among biodiversity, water, food and health in the context of climate change

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

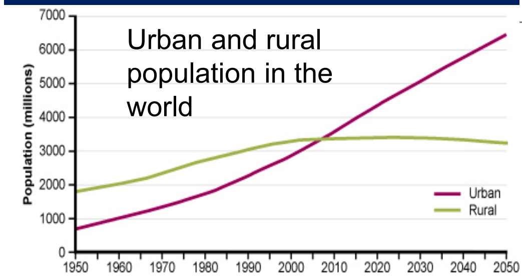
ipbes
Science and Policy for People and Nature

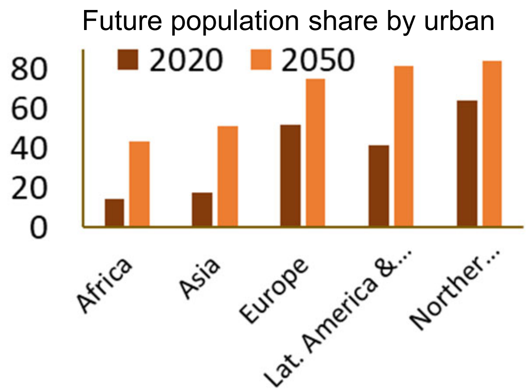
Environment and its component

Development that meets the needs of the present **without compromising** the ability of future generations to meet their own needs.

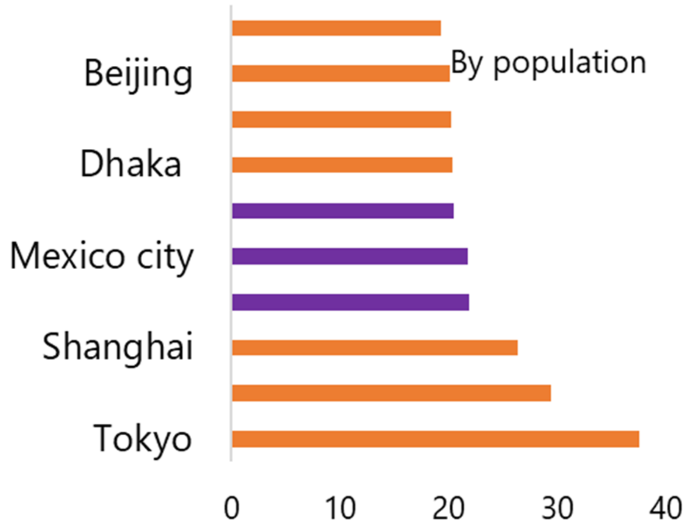
Unsustainable Paths of Development in Developing Asia

Rapid growth of urban population



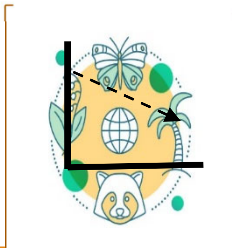


Urban-centric development paths

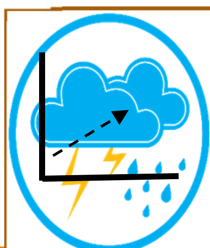


Out of top 10 largest cities, 7 of them are located in Asia

Unsustainable resource consumption paths



Ecosystem and biodiversity loss

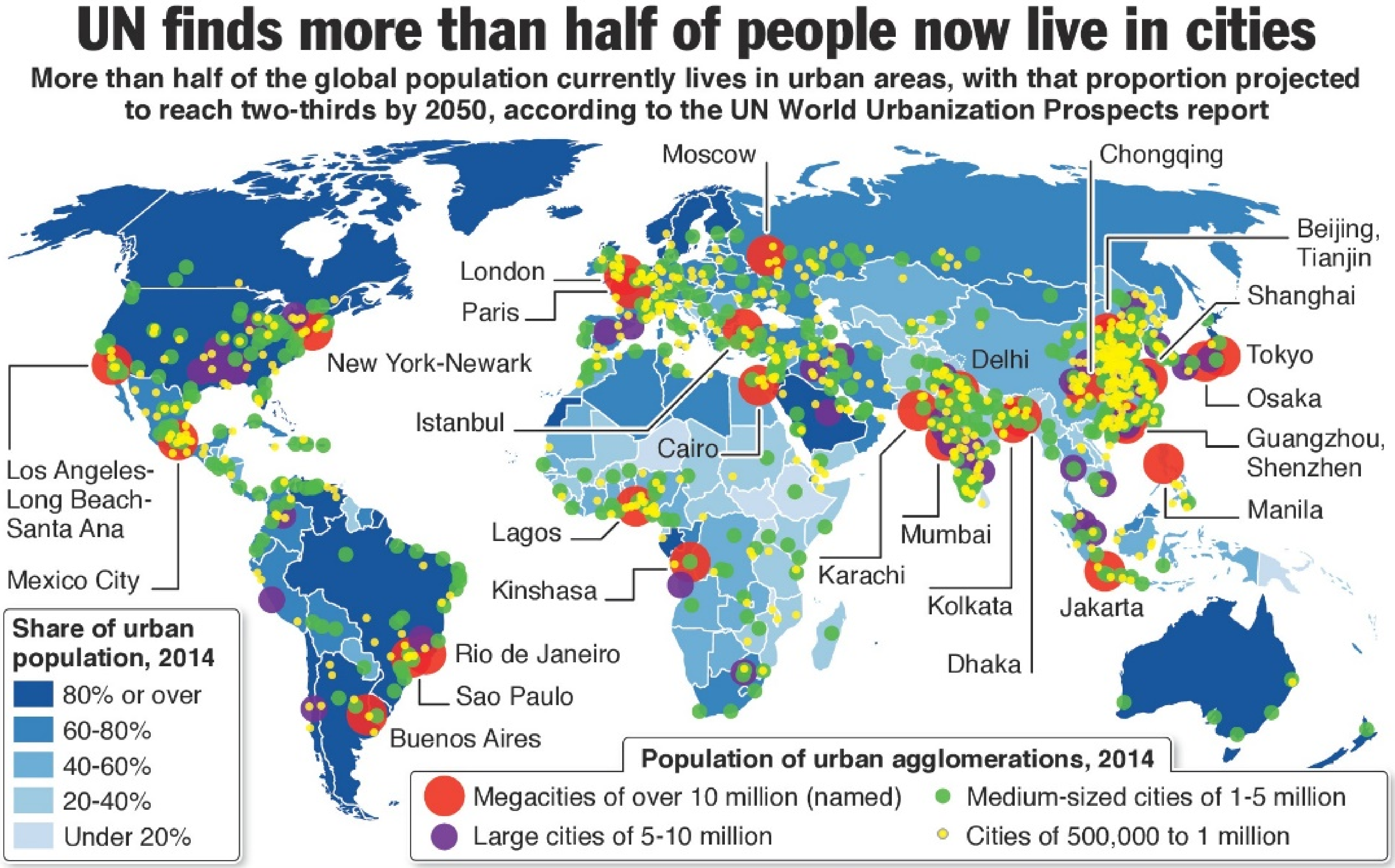


Climate change risk

Disaster risk

Pressure on natural resources

Global water resources: Facts and statistics



Which means huge pressure on natural resources particularly on "**water**"

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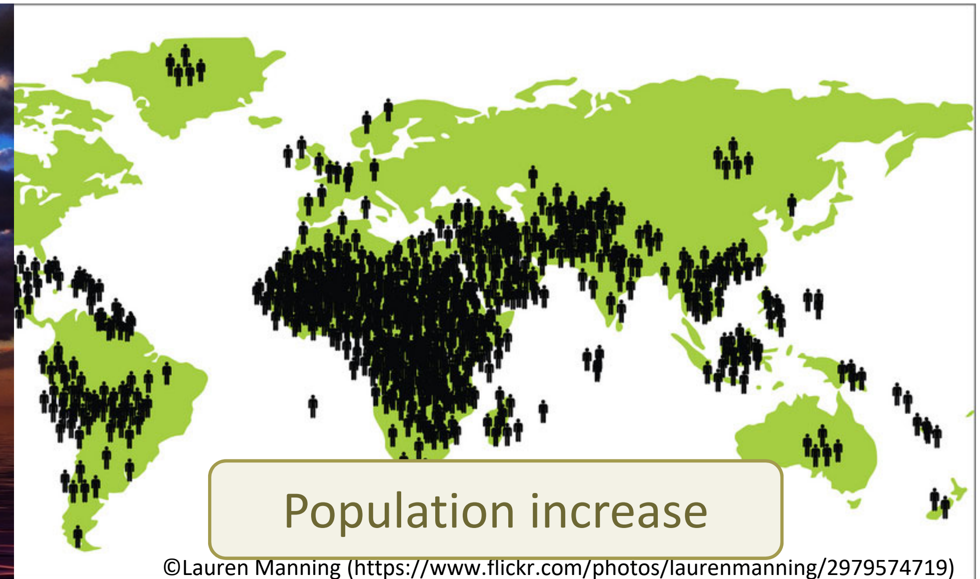
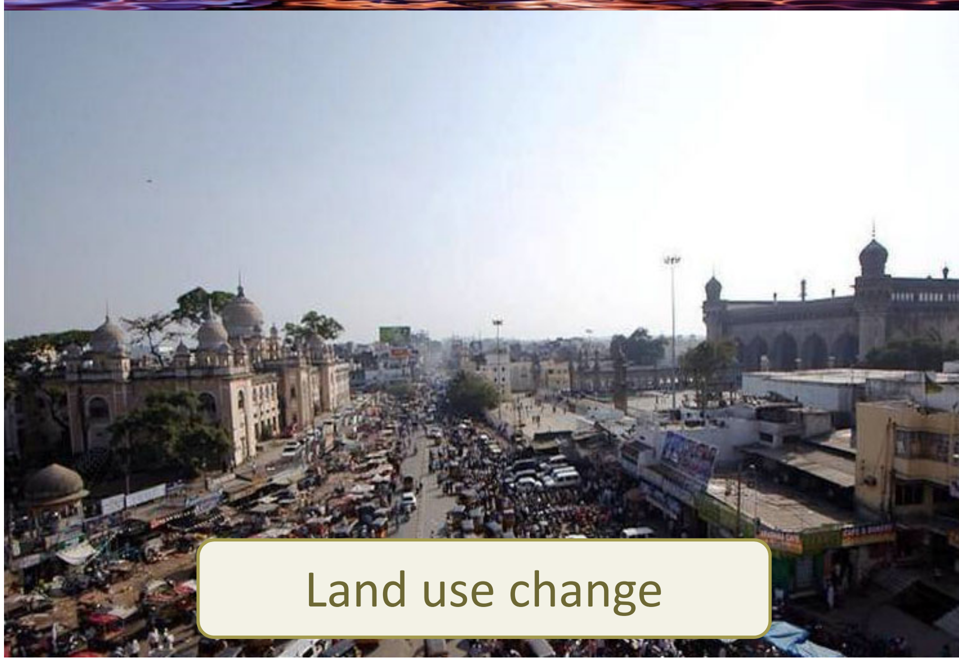
Key factors affecting water resources





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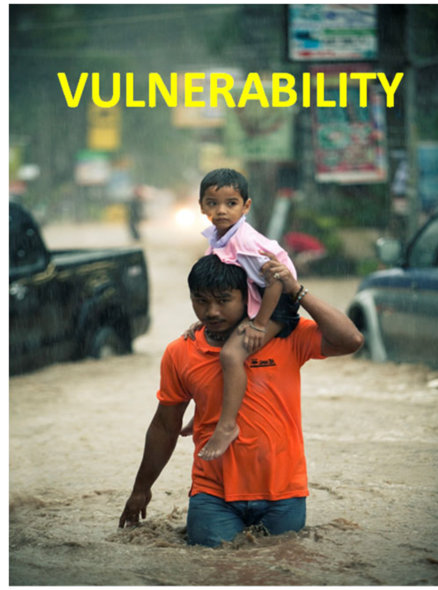
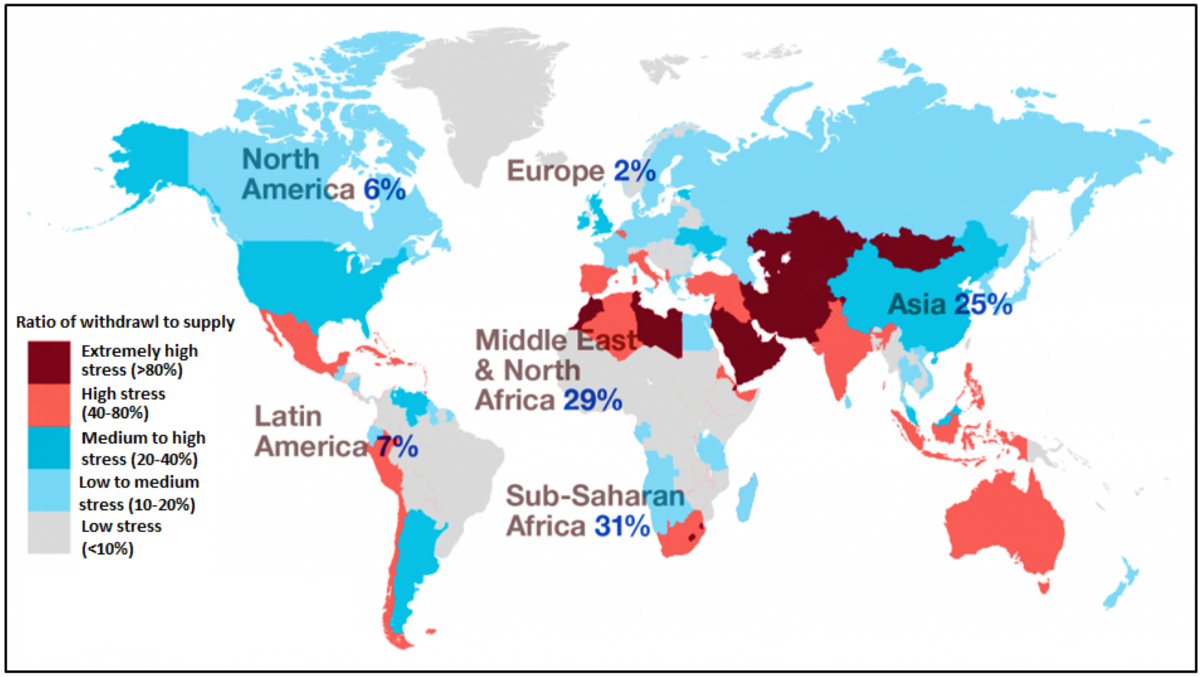
Global changes and its impact on water resource and livelihood

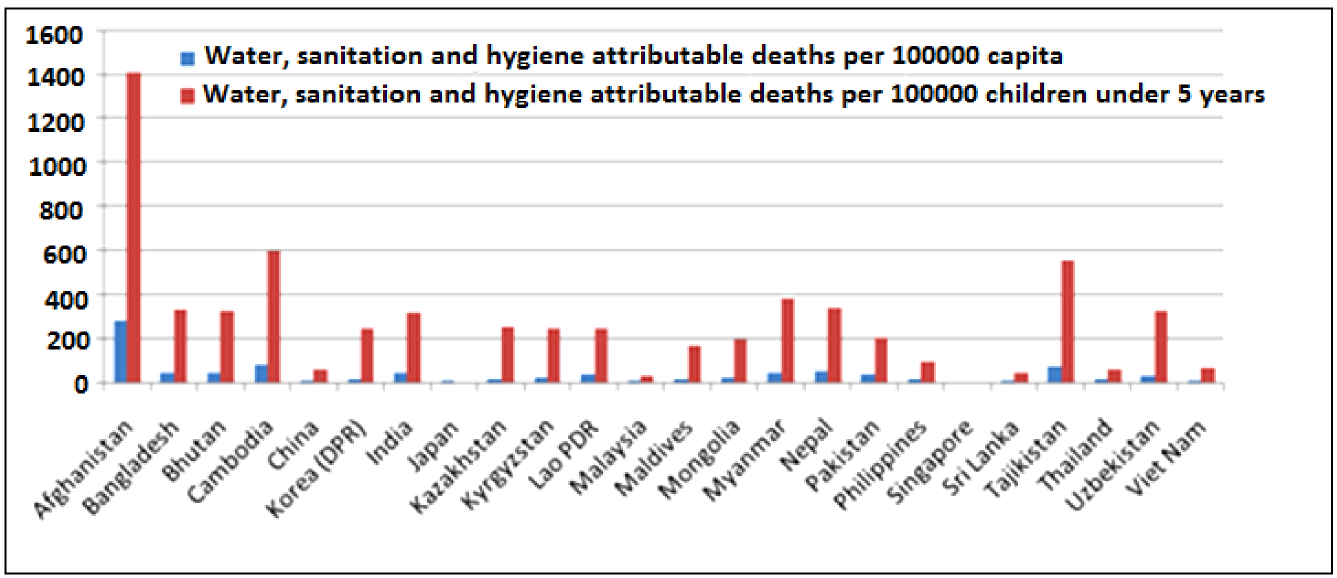


Vulnerability refers to the inability (of a system) to withstand the effects of a hostile environment.

Water sanitation and health (WASH)



Average per capita water availability is sufficient enough but spatio-temporal asymmetry is great.



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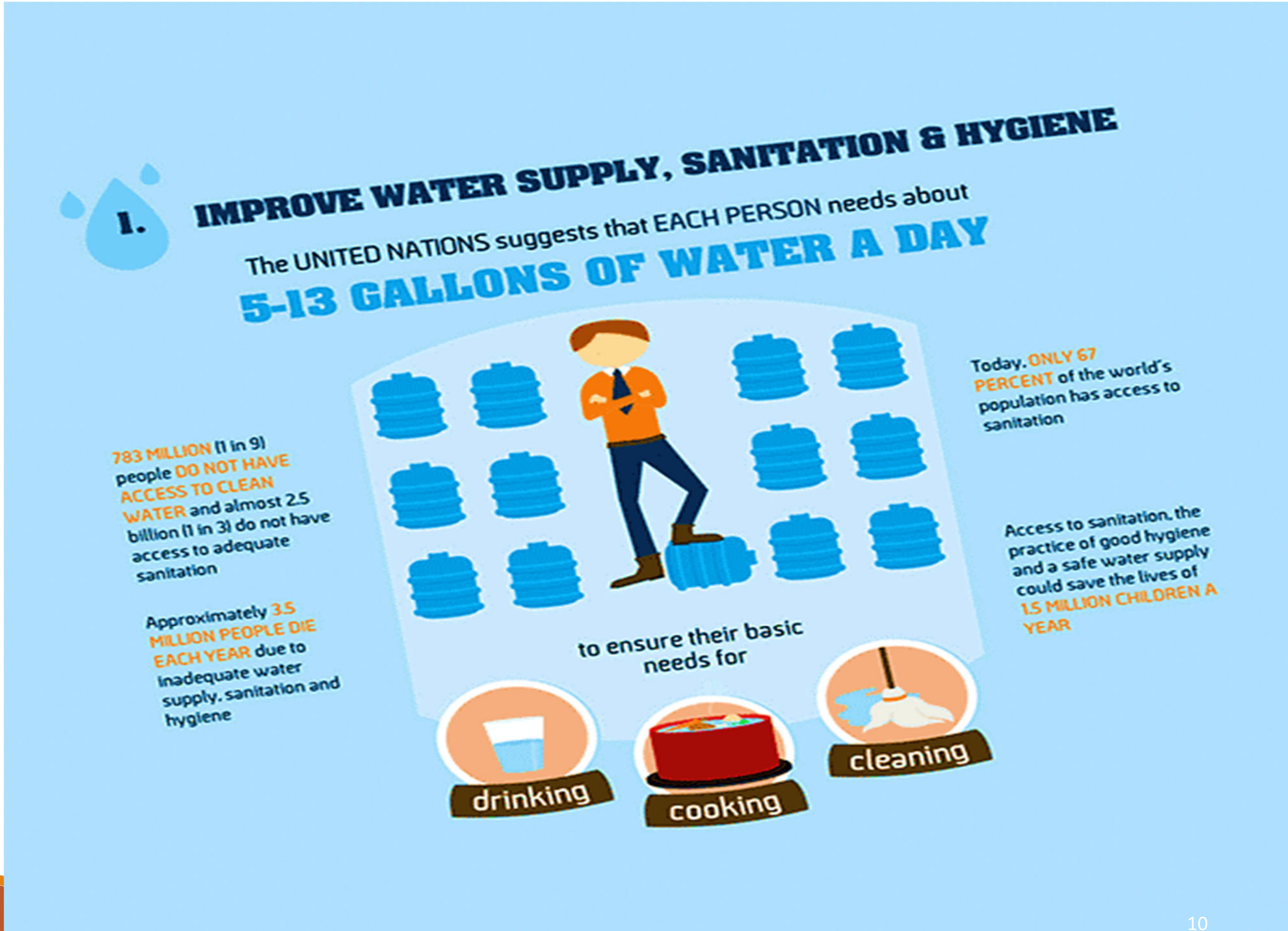
Water Pollution



Common issues related to water pollution

- Direct disposal of untreated sewerage into river are observed in different segments of the river.

- Outlets of toilets in squatter settlements are being directly discharged into the river.

- Large part of the river banks can be observed as solid waste dumping sites of individual houses and municipalities.

- Lack of sewerage system, centralized treatment system to tackle all of the domestic and industrial wastewater generated locally.

- The use of combined drainage for stormwater and sewage for conveying the pollution to a treatment facility will have to cope with rainfall events that will greatly increase flows.

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Water pollution

- ✓ Poor health condition
- ✓ Ecosystem degradation
- ✓ Aesthetic value decrease
- ✓ Economic loss






That emphasizes the role of water scientist/ hydrogeologist vital to conserve this precious resource…..

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Management perspectives

Key issues to be dealt here:
Diligent monitoring, big data availability, future prediction, IWRM, science-policy interface etc.

The DPSIR model – schematic view (Holistic approach)

Driving forces

Social and economic developments which exert or mitigate pressures on the environment

Pressures

Stresses the human activities put on the environment, stemming from socio-economic activities

State

State of the environment, i.e. the present condition in terms of quantity and quality of resources

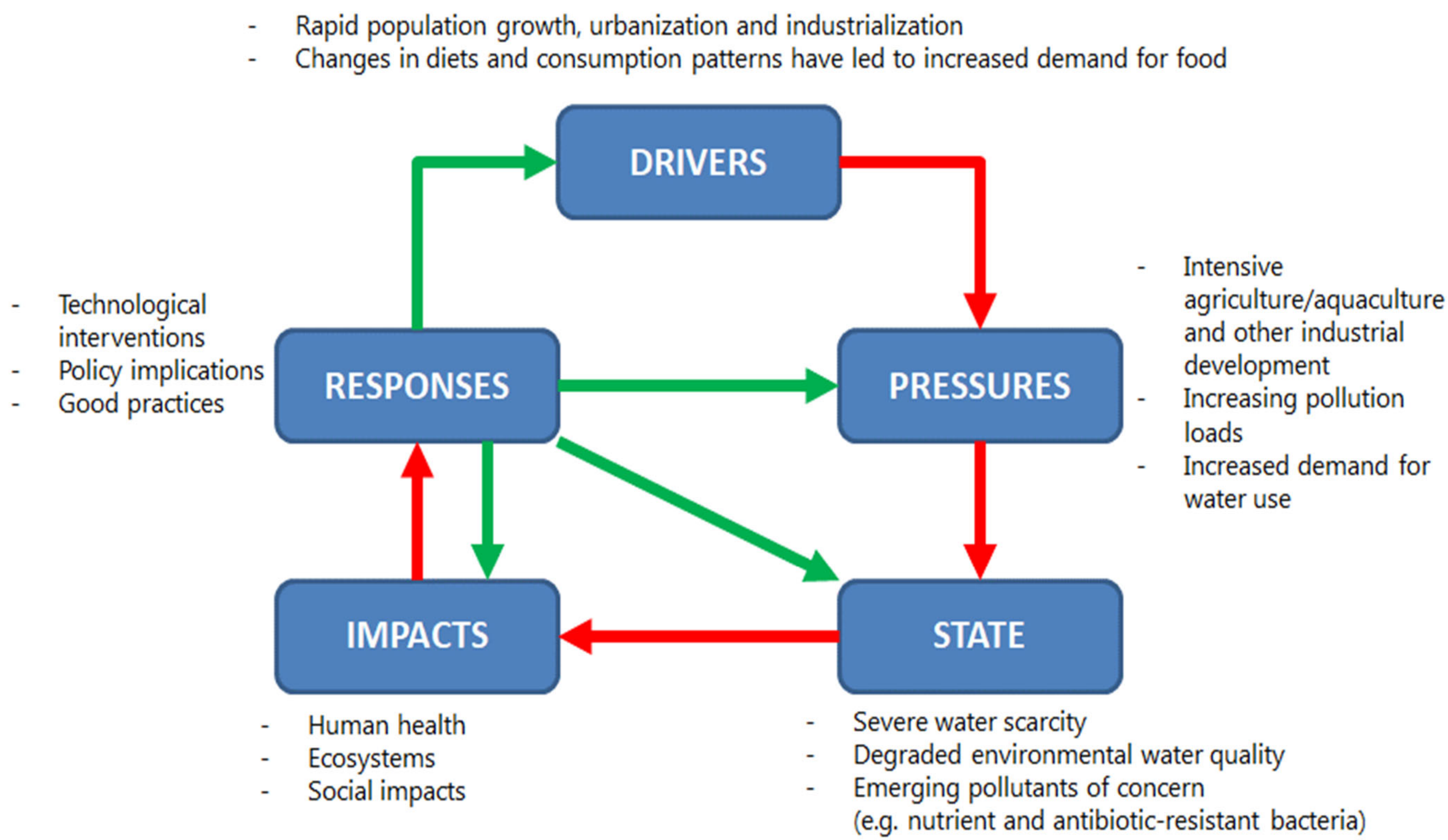
Impacts

Effects of a changed environment and the consequences for human health, the economy, etc.

Responses

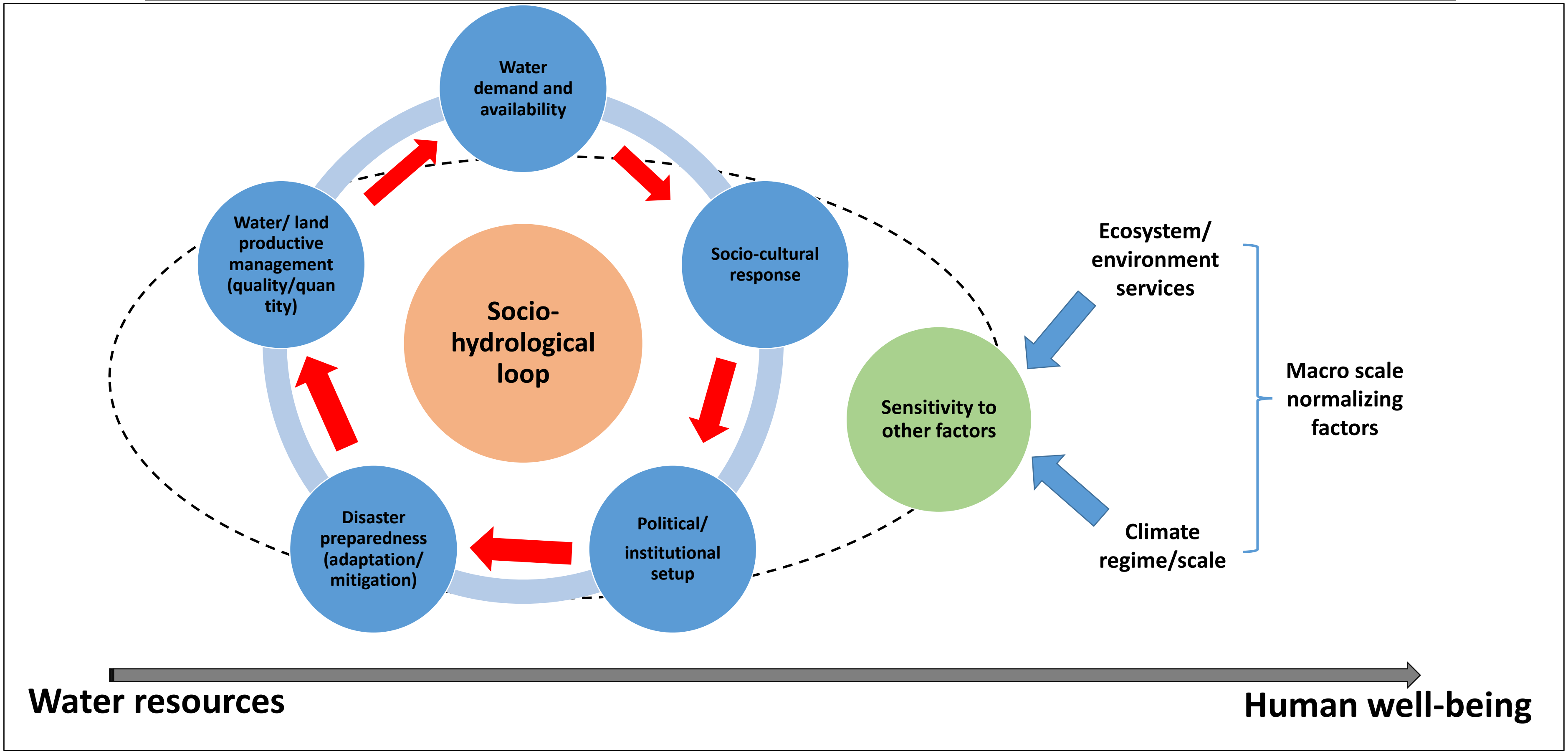
Measures and responses undertaken by society to address environmental concerns

DPSIR model (For water resource management)

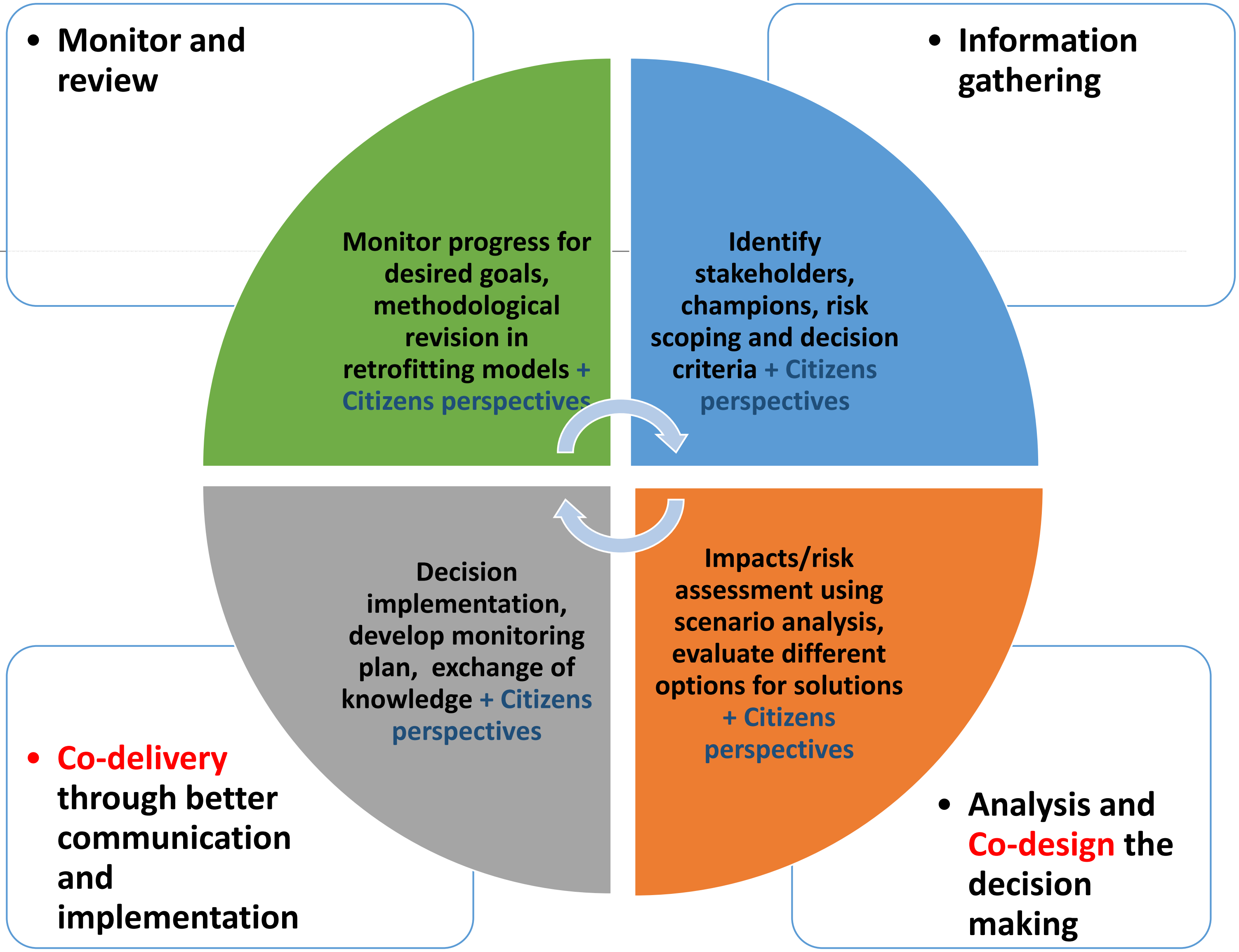


Schematic diagram for socio-hydrology

Reference- Kumar, P., et al (2020) Socio-hydrology: a key approach for adaptation to water scarcity and achieving human well-being in large riverine islands. Progress in Disaster Science, 8, 100134, doi.org/10.1016/j.pdisas.2020.100134.



Socio-hydrological approach



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Participatory Watershed Land-use Management (PWLM) model

Reference- Kumar, P., et al (2020) Participatory approach for enhancing robust water resource management: case study of Santa Rosa sub-watershed near Laguna Lake, Philippines. Water, 12, 1172, doi:10.3390/w12041172.

Application of socio-hydrology in the Philippines

- The Philippines is a **rapidly growing country, but uncoordinated rapid urban expansion, inadequate wastewater management infrastructure, poor governance, frequent extreme weather events, exacerbates the water quality deterioration.**
- **Result- Poor health condition, Ecosystem degradation, Aesthetic value decrease, Economic loss**
- **No studies actually attempted to understand the status of water resources and their management strategies for the near future**.
- Considering the gap in **integrating climate change adaptation and mitigation measures into the land-use planning process at the watershed level**, a **multi-stakeholder participatory approach to develop a robust and resilient water resource management strategy**.

- **Hence we have proposed an integrated approach called "PWLM (Participatory Watershed Landuse Management)" which we have used in this paper.**

Objectives

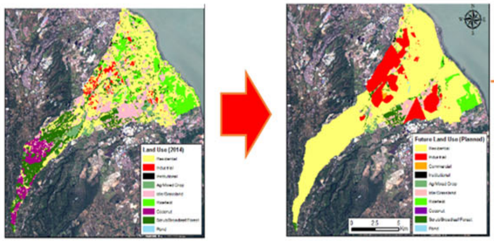
- Contribute to **evidence-based policymaking** for sustainable water environments by
  - Provide **scientific tools** to forecast the future state of urban water environments by answering **"What if situation"**
  - Support **capacity development** aiming at improving urban water environments

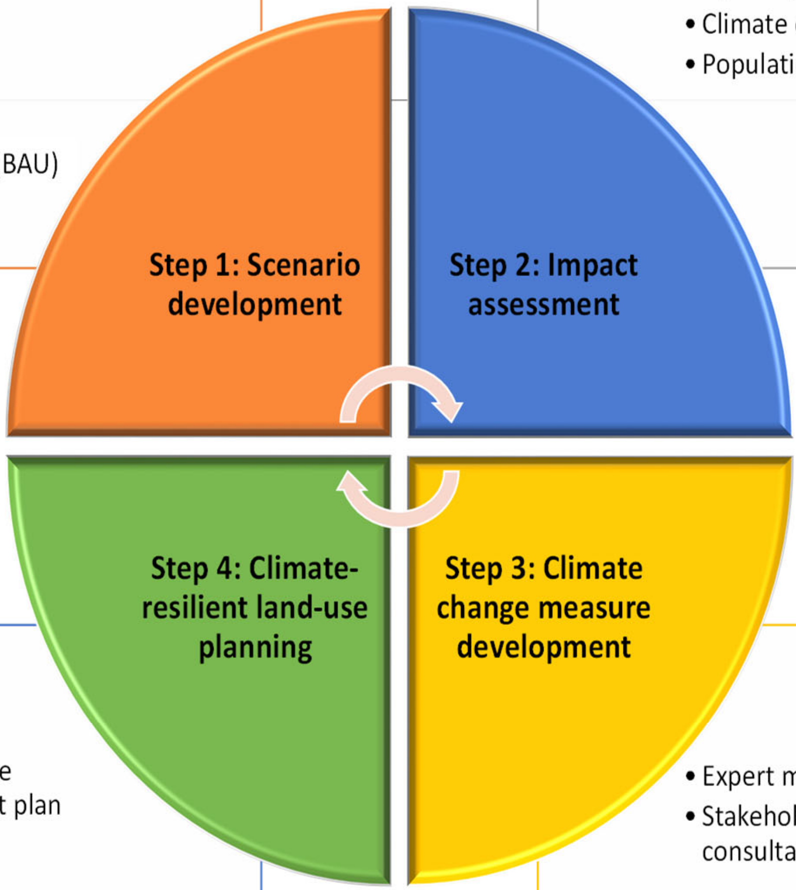
Participatory Watershed Land-use Management (PWLM) model

- Participatory land-use mapping

Land-use, 2014

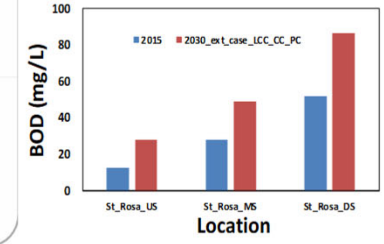
Future land-use plans, 2030 (BAU)





- Hydrological modeling
- Climate downscaling
- Population projection

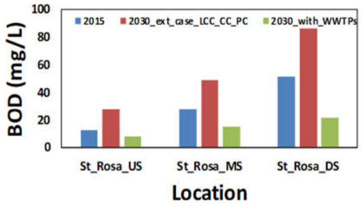
Hydrological modelling



Identifying countermeasures with local governments

- Expert meeting
- Stakeholder consultation

Identifying benefits of adaptation/ mitigation measures, mainstreaming them into local policies

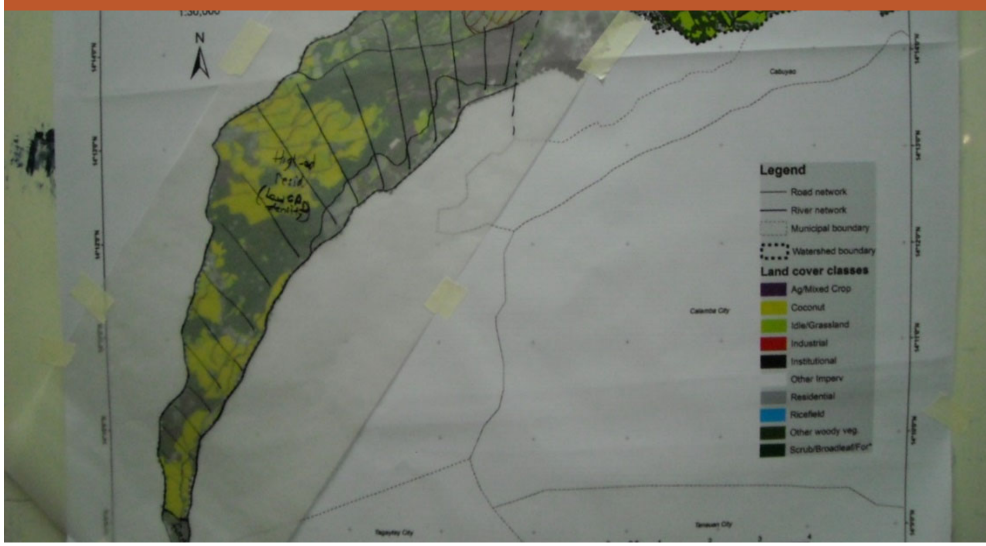


- Wastewater infrastructure development plan

1. Scenario development

Participatory GIS

Revealing future development & land-use



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2. Impact assessment

Objectives

- As mentioned above, climate change along with rapid urbanization and non-structured government policies results in severe water pollution, makes long section of the river unsuitable for any use in recent past.
- Contribute to **evidence-based policymaking** for sustainable water environments by
  - Provide **scientific tools** to forecast the future state of urban water environments by answering **"What if situation"**
  - Support **capacity development** aiming at improving urban water environments

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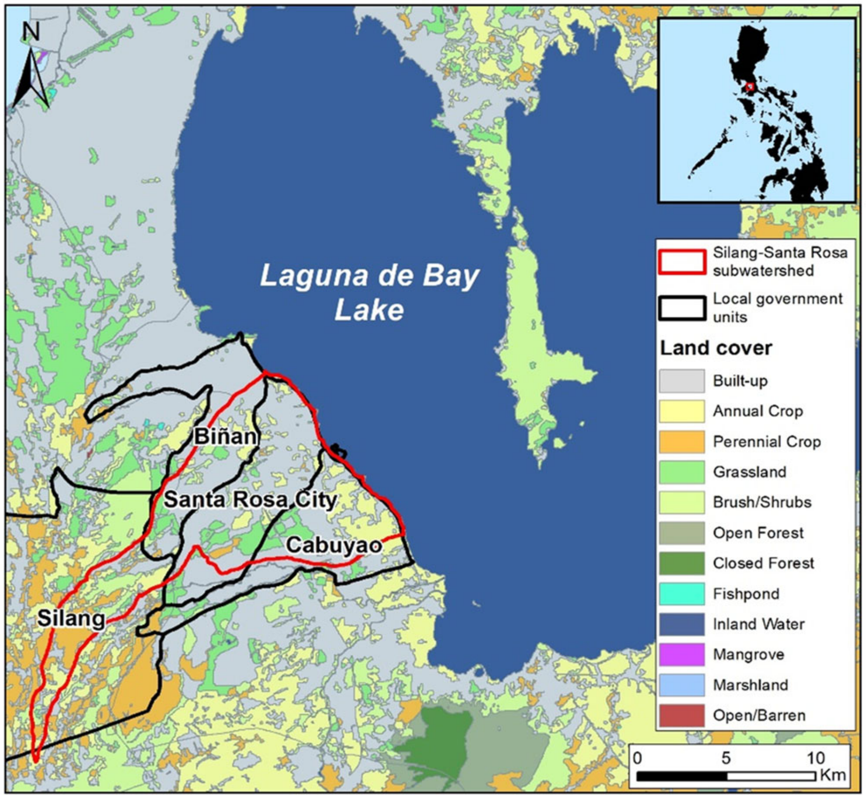
Study Area



- Santa Rosa is one of the major river and mainly passes through Binan, Santa Rosa, Silang City
- Annual rainfall: 1950 mm
- Population in St Rosa Watershed area: 641884
- Watershed Land Use – 7% coconut, 25 % built up, 8 % forest, 25% grassland, 9 % industrial, 8 % mixed crop, 17 % rice crop

LAND USE	SANTA ROSA	SILANG	CABUYAO	BIÑAN	TOTAL
Coconut	0	0.07	0	0	0.07
Commercial-Residential	0.12	0.02	0.08	0.04	0.25
Forest	0	0.07	0	0	0.08
Grass Lands	0.11	0.02	0.06	0.06	0.25
Industrial	0.04	0	0.02	0.03	0.09
Mixed Crop	0.05	0.04	0.02	0	0.08
Rice Lands	0.07	0	0.08	0.02	0.17
TOTAL	0.37	0.22	0.25	0.16	1

Source: Santa Rosa Watershed Hydrology and Hydrogeology Report (2009)

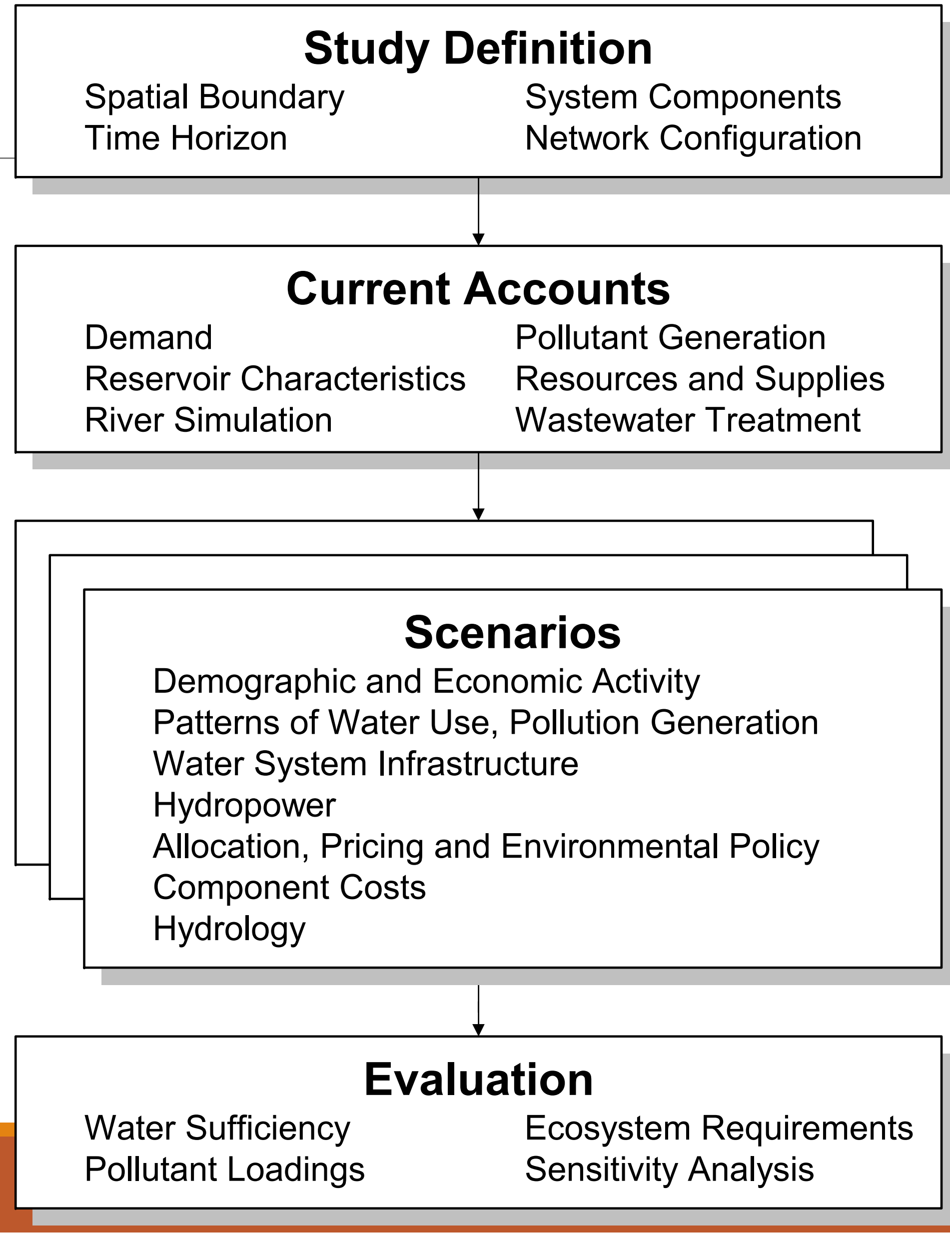
Water quality modeling

- WEAP (Water Evaluation And Planning) model is a highly flexible hydrologic-water quality model
- WEAP can model large number of pollutants
- GIS-based, graphical drag & drop interface
- Mass balance equations are the foundation of WEAP model
- Scenario management capabilities

Water Evaluation And Planning System

SEI STOCKHOLM ENVIRONMENT INSTITUTE

BRIDGING SCIENCE AND POLICY SINCE 1989

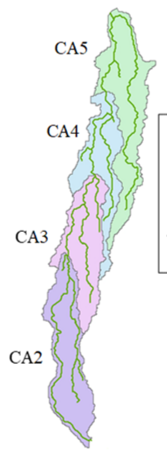


Hydrologic modeling- Rainfall-runoff method used in this study

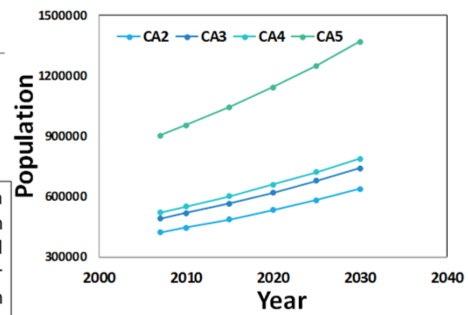
Input dataset required for model

1. Population growth- Ratio method

Population



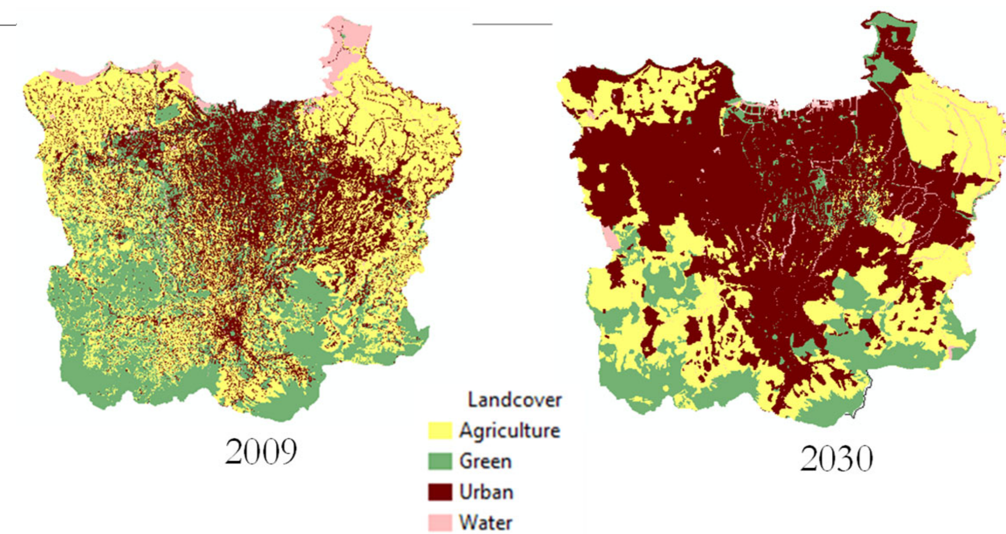
Future population is estimated from ratio method using data for Jakarta city from UNDESA



Year	CA2	CA3	CA4	CA5
2007	420597	489615	520483	903972
2010	443982	516837	549422	954233
2015	485882	565613	601273	1044287
2020	531736	618991	658017	1142840
2025	581918	677408	720116	1250693
2030	636836	741337	788076	1368725

UNDESA growth data

2. Future LULC- Land change modeler



3. Climate change- Climate downscaling

Statistical downscaling followed by regression analysis (monthly average data is used here)

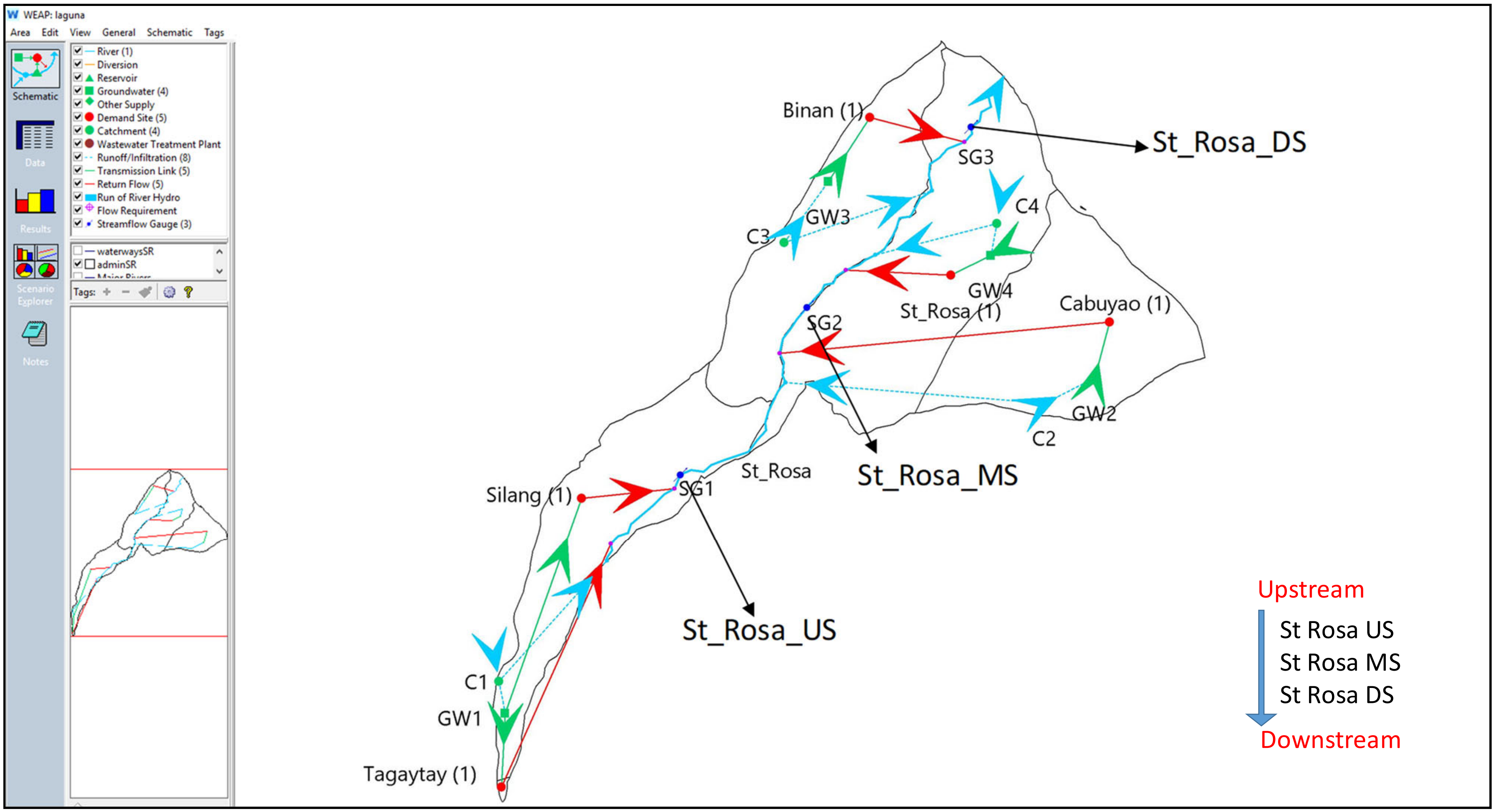
Scenarios

- RCP4.5 (medium emission)
- RCP8.5 (High emission)

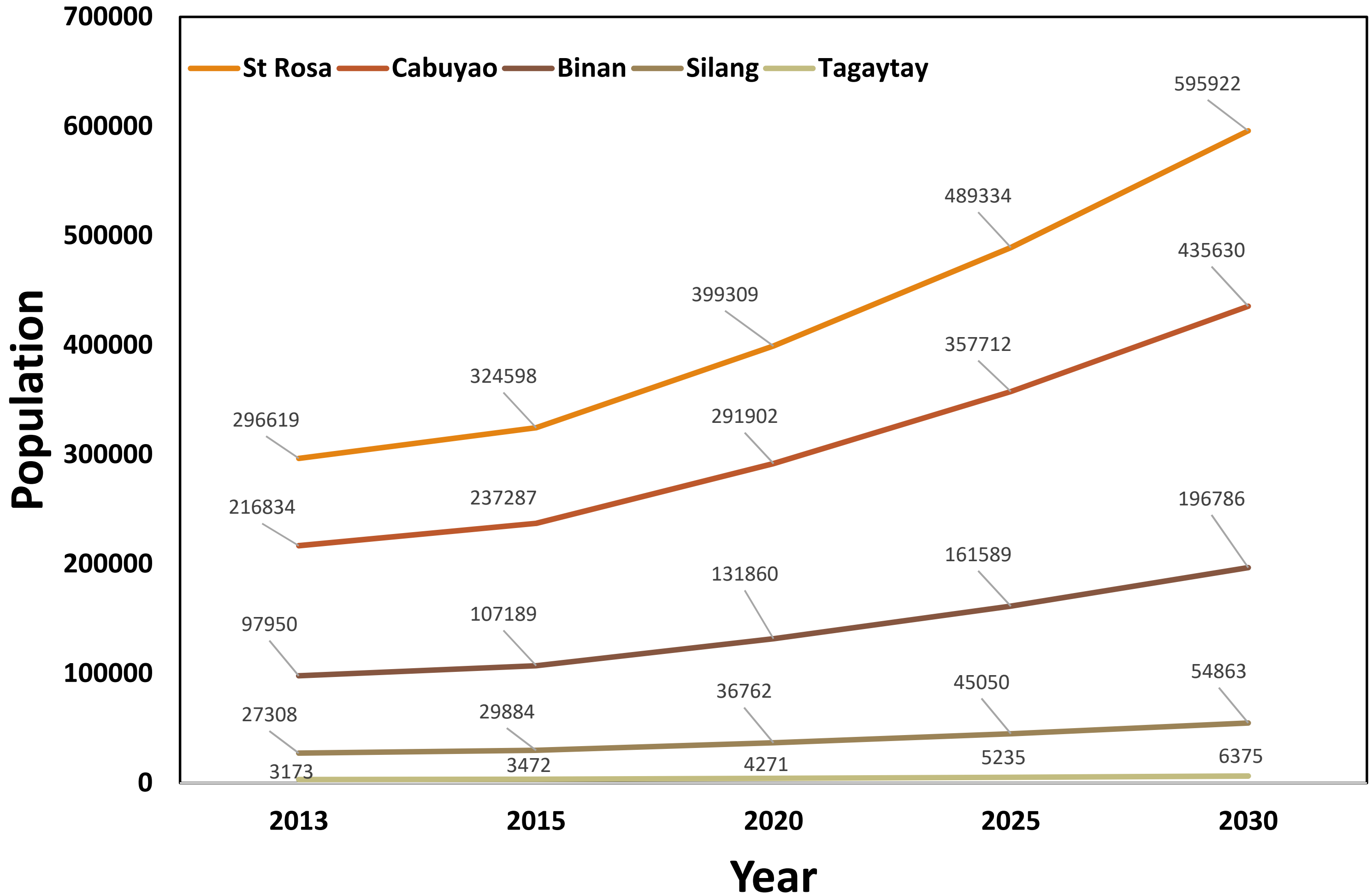
GCMs

- MRI-CGCM3.2 (Meteorological Research Institute, Japan; Resolution ~110km)
- MIROC5 (JAMSTEC/UoT/NIES, Japan; Resolution: ~ 140 km)
- HadGEM2-ES (Met Office Hadley Centre, UK; Resolution: ~150 km)

St Rosa river basin model setup under WEAP interface

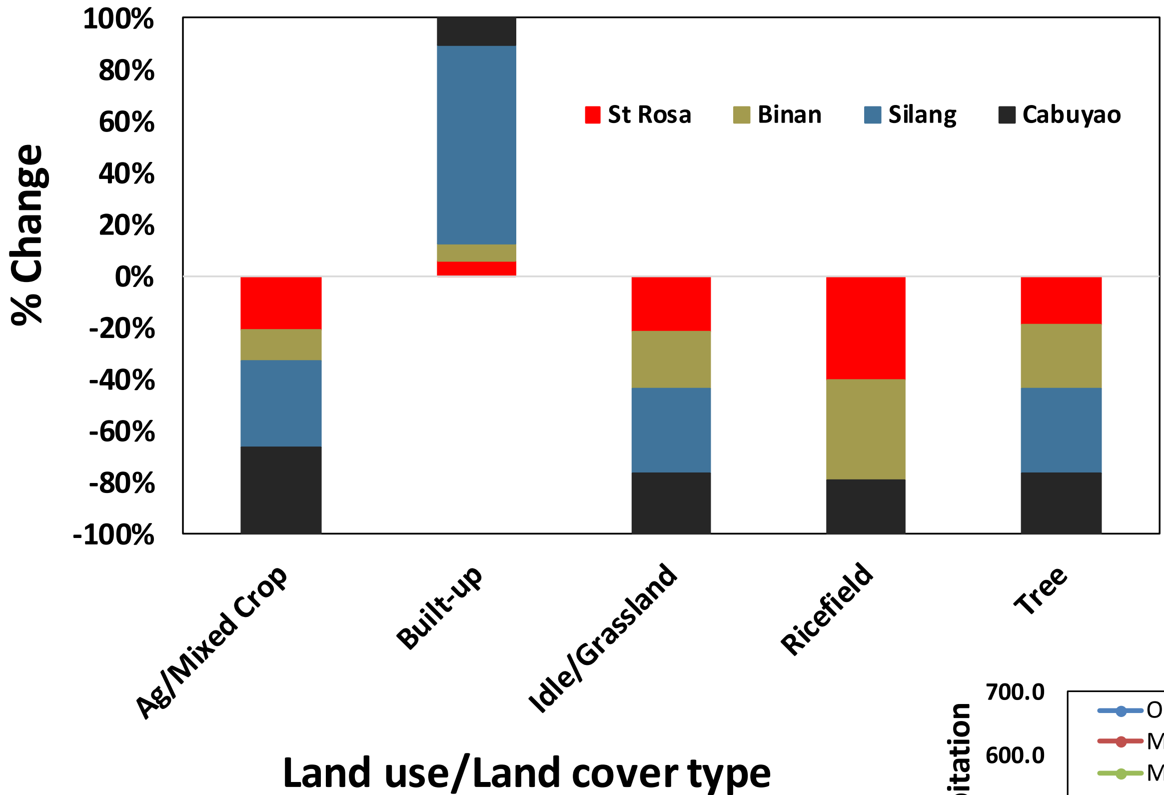


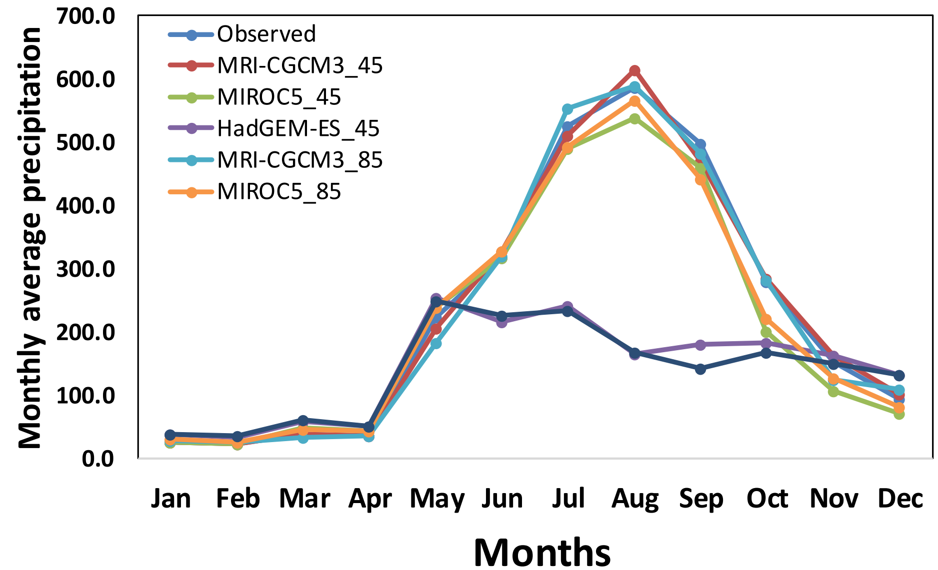
Population projection



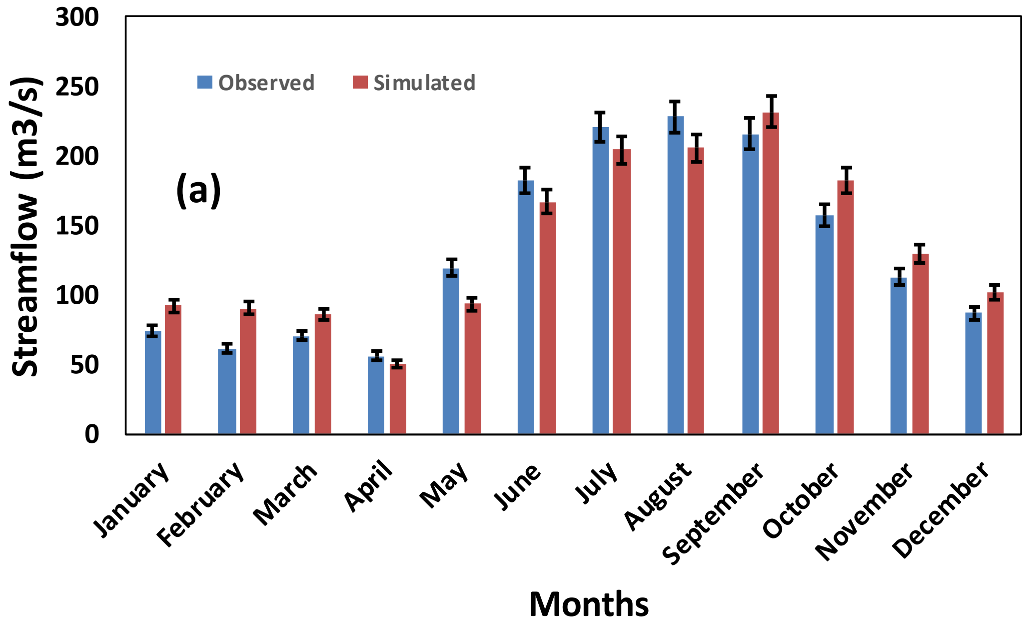
Source- Current Population (2013) from Philippine Statistics Authority,
Growth rate- UNDESA, 2015

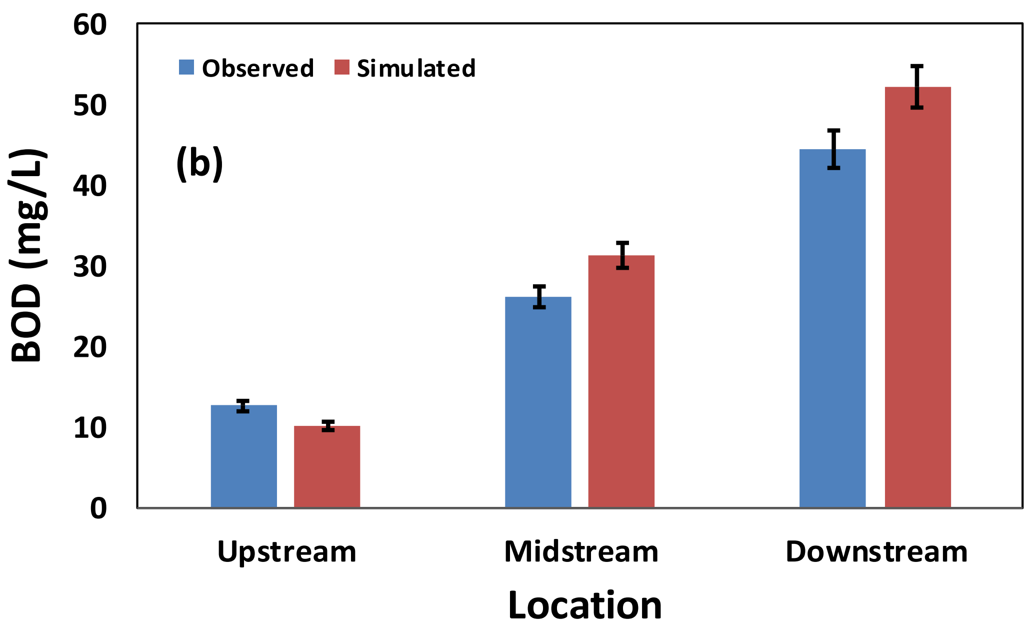
Climate and LULC projection





Validation



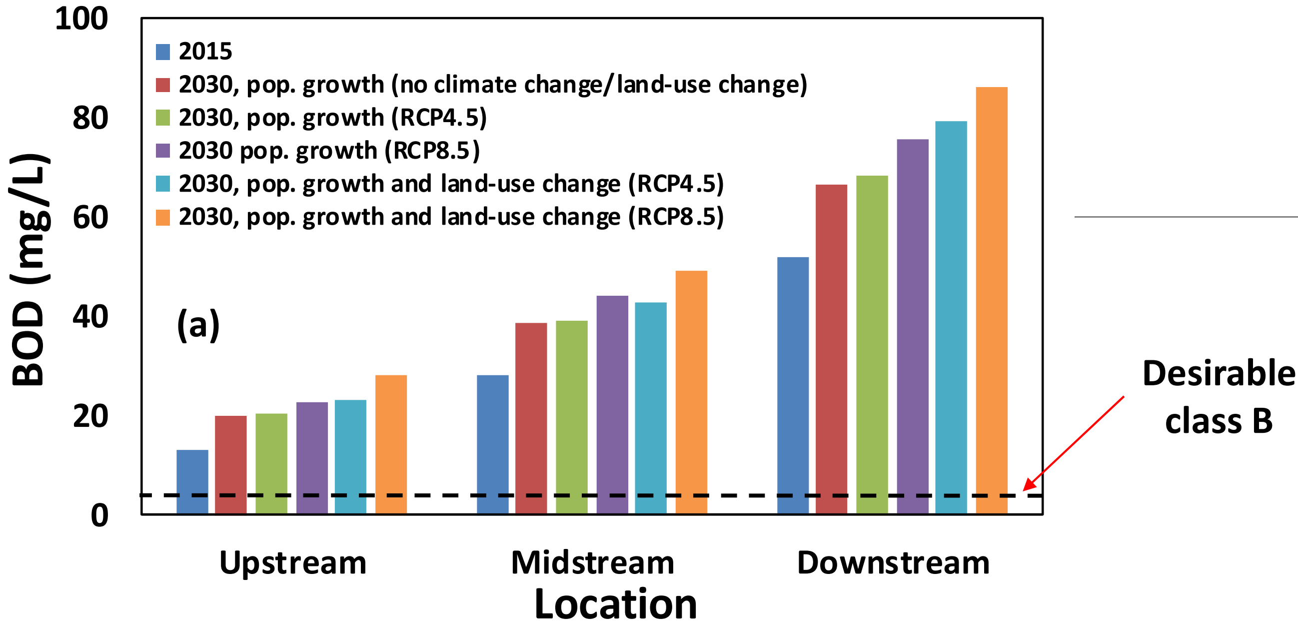


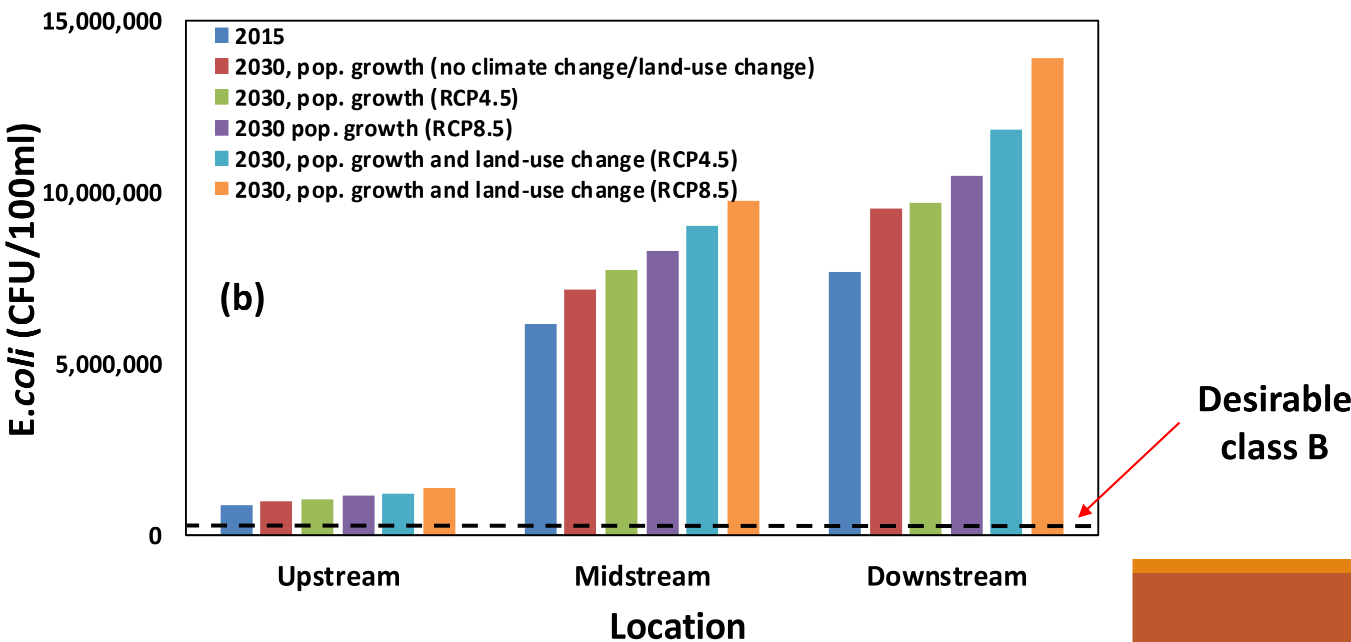
Parameters	Unit	Fishable (Class C)	Bathable (Class B)
BOD	mg/L	4	3
E.Coli. (*Fecal Coliform)	MPN/100ml	5000	500

Results

Simulated Water quality (considering Population growth, Climate change and LULC change)

Upstream
St Rosa US
St Rosa MS
St Rosa DS
Downstream





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Results

Estimation for order of contribution for different drivers on future water environment deterioration

Parameter	Average % increase (2015 to 2030)	% Contribution from Population growth	% Contribution from LULC change	% Contribution from climate change
BOD	76	66	23	11
E. Coli.	104	71	20	9

Table – Brief summary of result

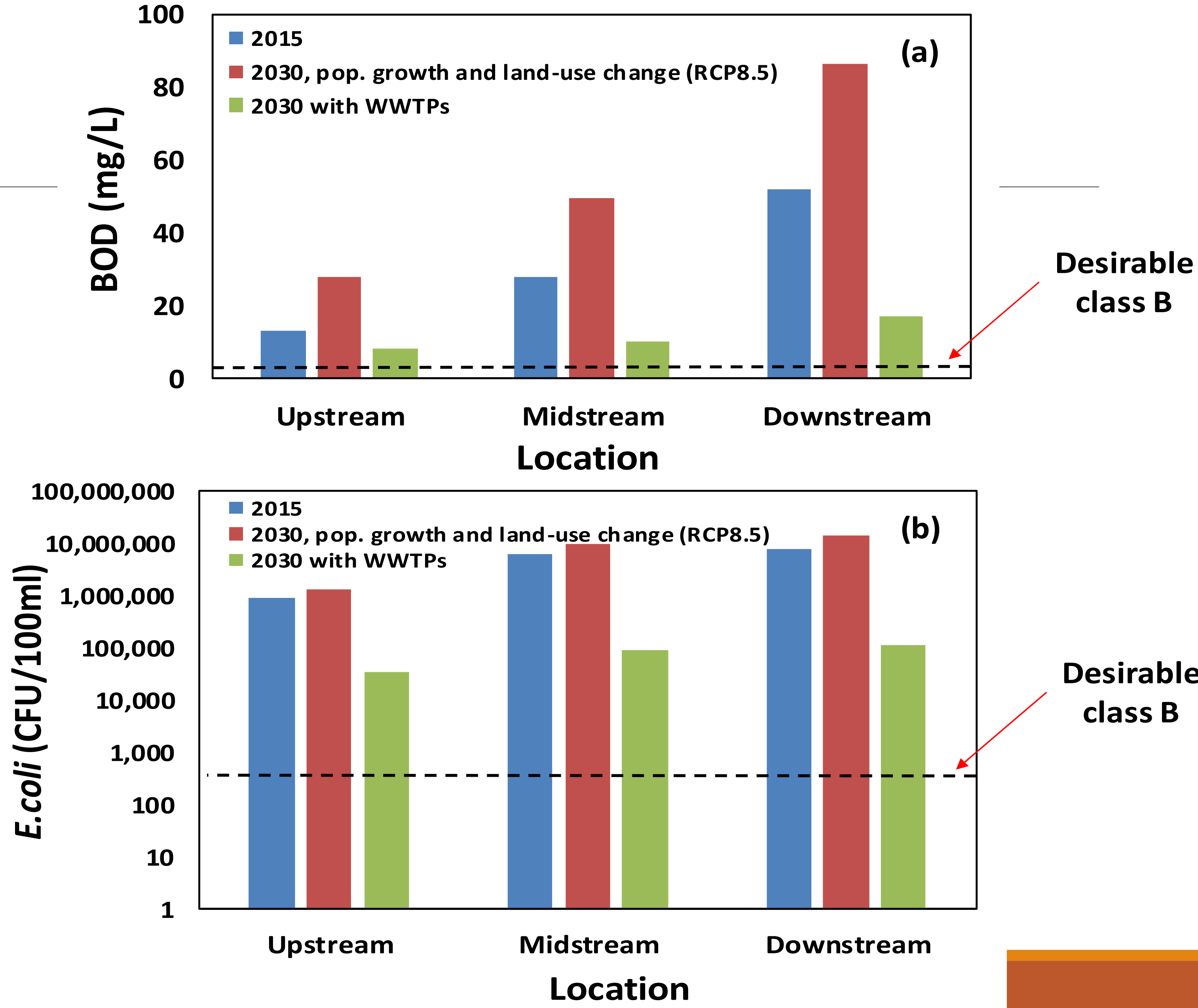
3. Climate change measures development

Identifying countermeasures with local governments

Summary of WWTPs as counter measures for scenario development

WWTP	Future Population (2030)	Wastewater Generated in Liter Per Day for the Year 2030@130 liter/capita/day	WWTP Capacity in Million Liter Per Day (MLD) Assumed for Numerical Simulation
WWTP 1 (will serve Santa Rosa and Cabuyao)	1,031,553	134,101,847	134
WWTP 2 (will serve Binan and Silang)	251,650	32,714,443	32

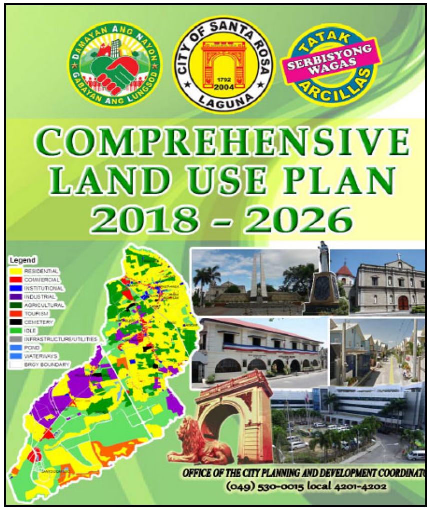
Results



100
80
60
40
20
0
BOD (mg/L)
2015
2030, pop. growth and land-use change (RCP8.5)
2030 with WWTPs
(a)
Upstream
Midstream
Downstream
Location
Desirable class B
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
E.coli (CFU/100ml)
2015
2030, pop. growth and land-use change (RCP8.5)
2030 with WWTPs
(b)
Upstream
Midstream
Downstream
Location
Desirable class B

4. Climate resilient land use planning

a) Target local policy documents



b) Capacity development

WEAP training for IWRM

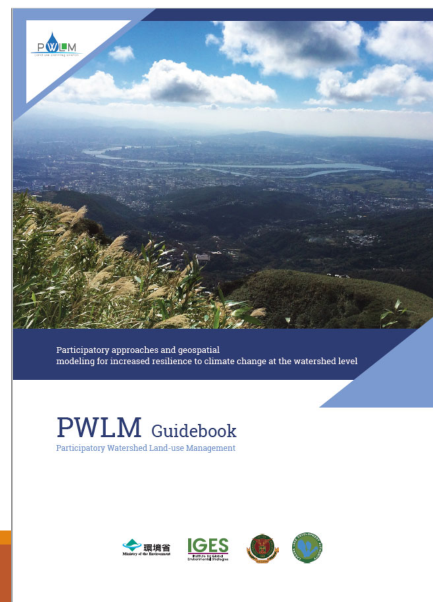
Goal- To train local officials for replicating same kind of activities in other watersheds

Target audience- Laguna Lake Development Authority (LLDA) officials, 3-4 officers each from six Local Government Units (LGUs), University of Philippines Las Banos students

Number of participants- 36

c) Develop guidebook

Stepwise detailed guidance for how to apply PWLM



Conclusion

- The PWLM approach provides an integrated framework for water resource management, where retrofitting models are being developed with regular feedbacks of different stakeholders to meet their need and to feel ownership of the simulated results.
- WEAP model can be applied to simulate various water quality management strategies to maintain stated water quality criteria.
- The order of average deterioration effect of water quality (both for BOD and E. *coli*) due to population growth, climate change and land use/land cover change were population growth > land use/land cover change > climate change.
- As currently there is no mitigation measures for improvement of water quality in the field, this study will help to identify possible locations to built infrastructure for treating wastewater being generated and improve the water quality.
- Since the result is being incorporated in local policy documents for Climate-resilient land-use planning like Comprehensive land use plan (CLUP) or Local climate change action plan (LCCAP), the positive outcome can be found in few years to come.

Application of socio-hydrology in the Sundarban region from India and Bangladesh

Objectives:

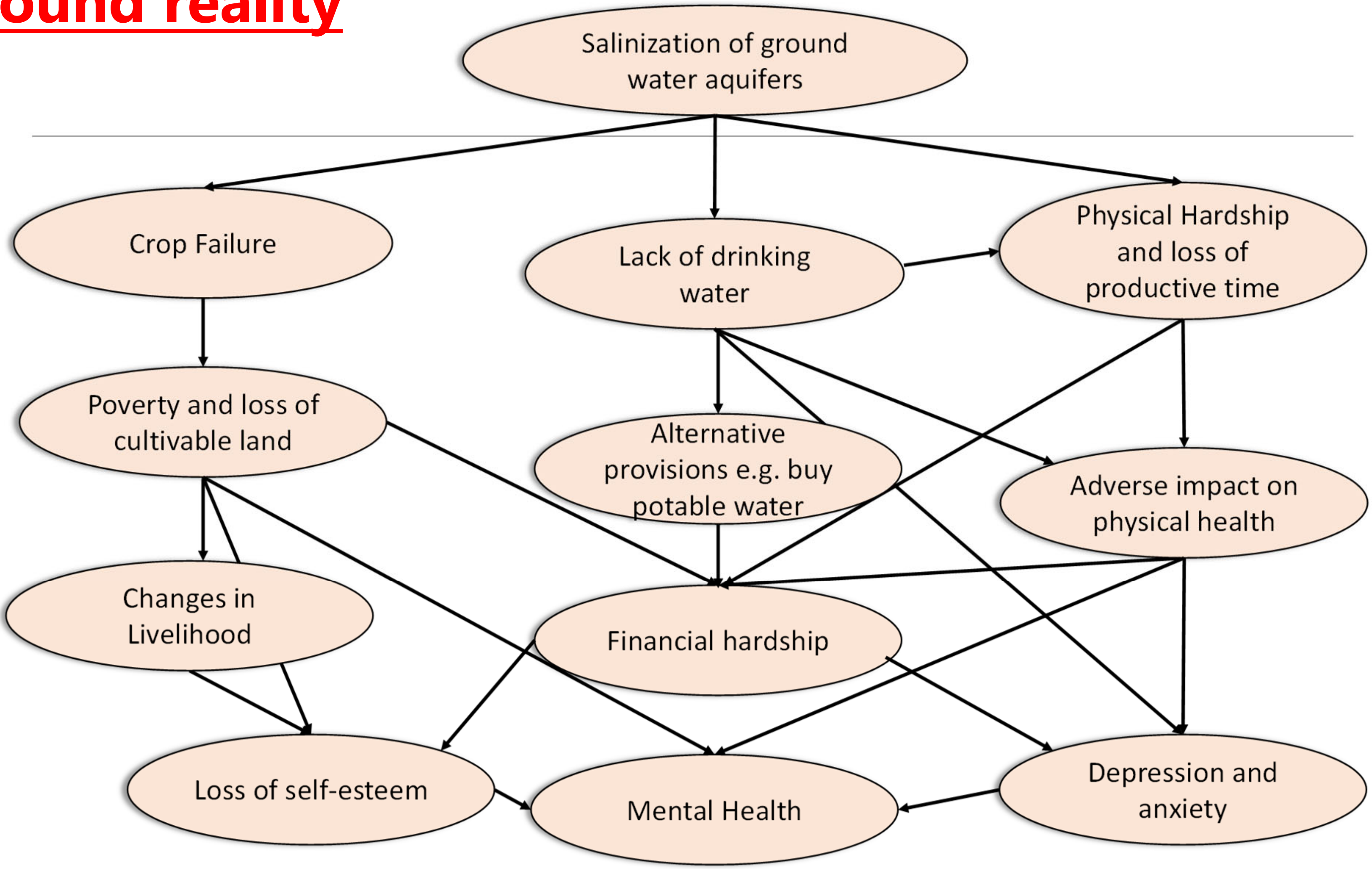
1. To advocate the importance of socio-hydrological research in the context of enhancing social adaptive capacity as well as for developing a resilient water environment Sundarban delta :Fraserganj (India), Dakshin Bedkashi (Bangladesh) (both from the Ganges-Brahaputra-Meghna Delta)

2. To explore how the nexus of human–water relations could be applied to improve adaptive measures to manage local water needs while mitigating undesirable changes to the hydrological cycle.

Why Sundarban?

1. Huge productive zone
2. Very prone to hydro-meteorological hazards (frequent extreme weather conditions)
3. Densely populated area and extreme effects on the communities because of their poor adaptive capacities (limited resources/infrastructure as well as institutional setup)

Ground reality



Case study from Fraserganj, India

More precisely, the research objectives are:

i. Analyzing the current socio-economic status (shift in occupation) over the decade under a hydrological context for the study area

ii. Predicting the sector-wise (household, agricultural and livestock) groundwater demand for different growth scenarios in 2050

iii. Identifying the way forward to achieve sustainable water resource management and human wellbeing

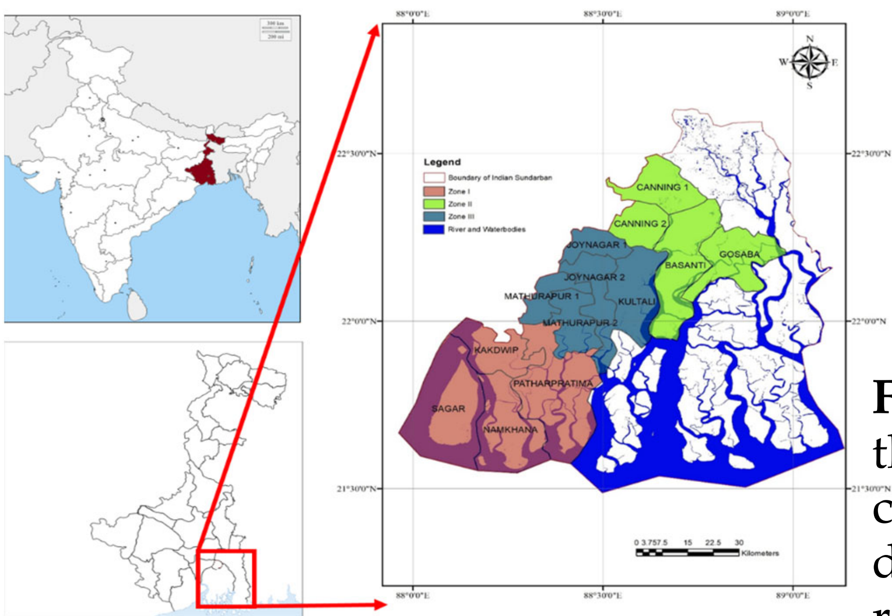


Figure. Location map of the study area, the Indian Sundarbans delta. The brown color signifies Zone I, the blue color designates Zone II and the green color represents Zone III.

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Table- List of parameters considered for this numerical simulation

Parameter	Value	Reference
Base year for modeling	2011	
End year for modeling	2050	
Human Population (cap)	3309526	Census India, 2011
Agricutural land irrigated by groundwater (Ha)	26000	District statistical abstract
Livestock Population (cap)	4082384	District statistical abstract
Human population growth rate	1.5%	Census India, 2011
Livestock population growth rate	1%	District statistical abstract
Agricultural worker (%)	76% (1991), 56% (2001), 54% (2011)	Census India, 2011
Non-Agricultural worker (%)	24% (1991), 44% (2001), 46% (2011)	Census India, 2011
Socioeconomic parameter (Literacy rate)	Described in Section 6.4	Census India, 2011
Hydroclimatic parameters (rainfall, groundwater level)	Described in Section 6.2, Section 6.3	Central Groundwater Board Annual Report

Scenarios:

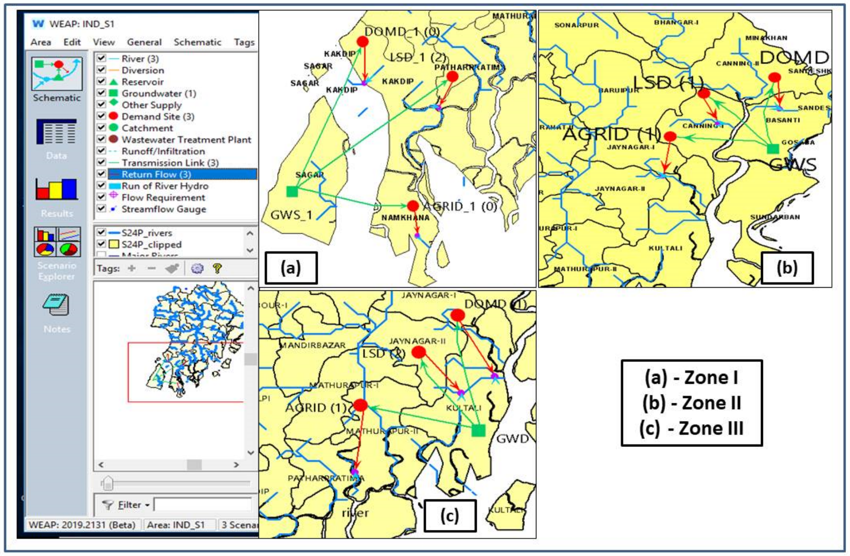


Figure Hydrological simulation model in the study area (Sundarbans).

- The reference scenario is described as the ongoing status of the system without any futuristic strategy and policy management.
- This is also helpful in distinguishing the demand sites and where more focus is to be given. Prior to the simulations, the demand priorities were defined to specify the importance of groundwater requirement in-demand sites and assure that demands are met properly.

Therefore, the three scenarios selected for this study are:

(a) Higher human growth rate (2.5%), livestock growth rate 1%, and agricultural groundwater demand decrease by 0.2 cubic meters with an interval of 5 years.

(b) Current growth rate of respective zones, livestock growth rate 1%, and agricultural groundwater demand decrease by 0.2 cubic meters with an interval of 5 years.

(c) Lower human growth rate (1%), livestock growth rate 1%, and agricultural groundwater demand decrease by 0.2 cubic meters with an interval of 5 years.

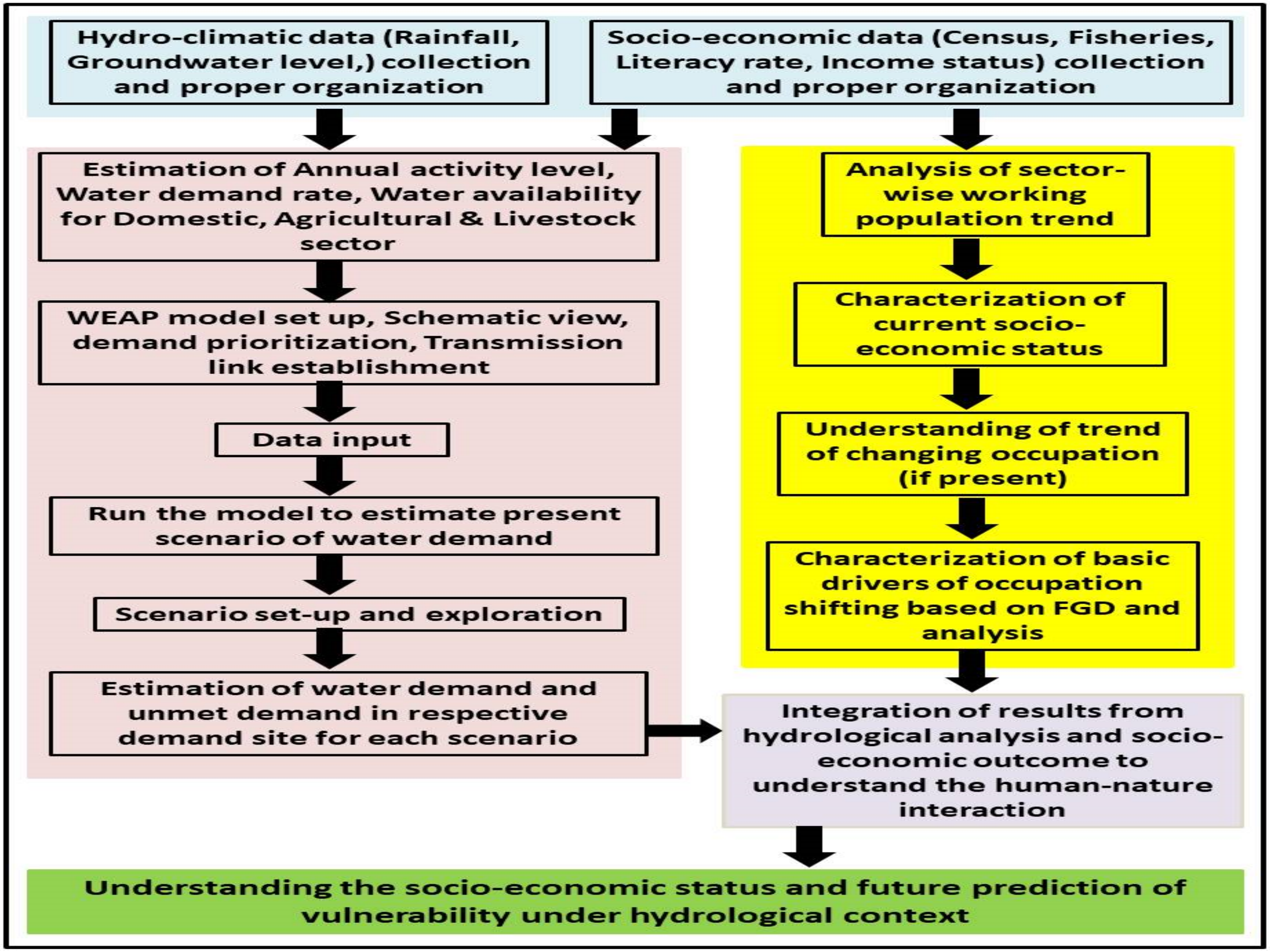


Figure- Methodology flowchart

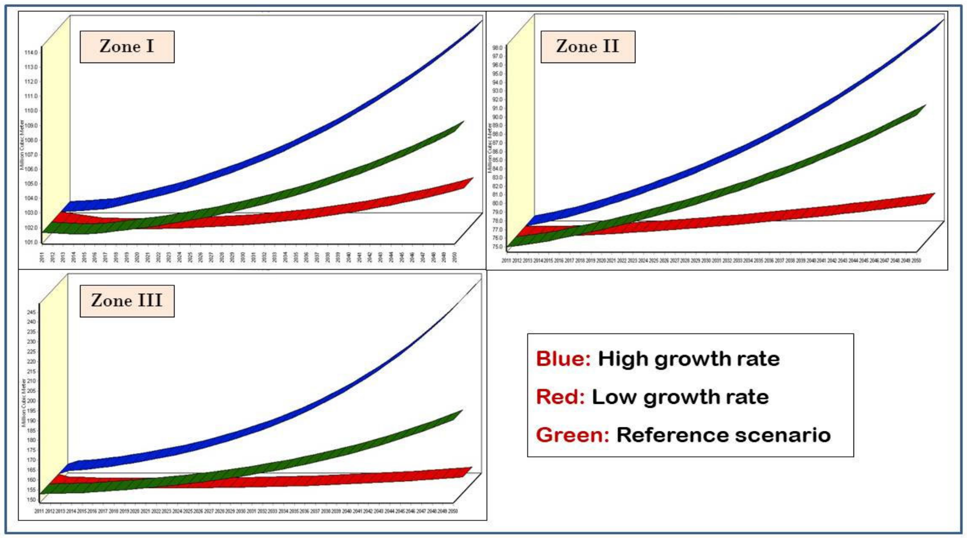


Figure Total groundwater demand under different scenarios in the study area.

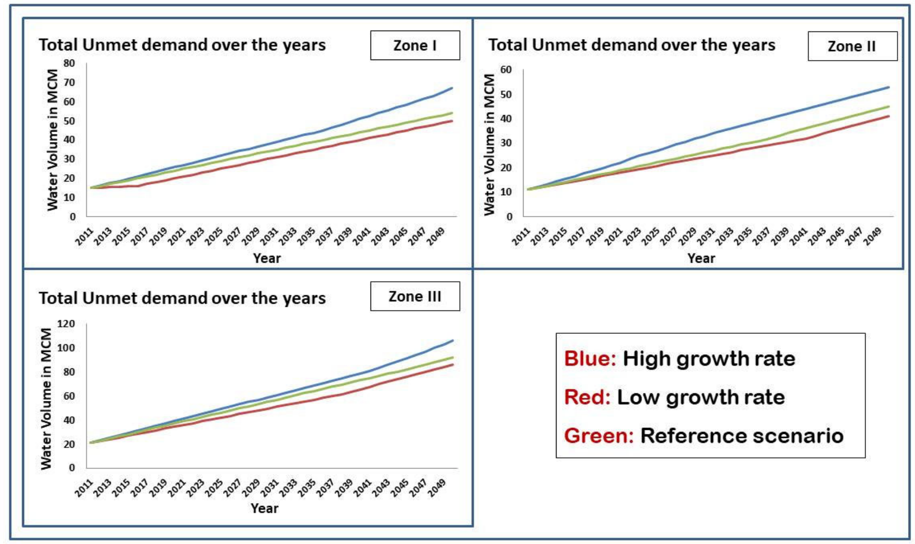


Figure -Zone-wise unmet demand under different scenarios.

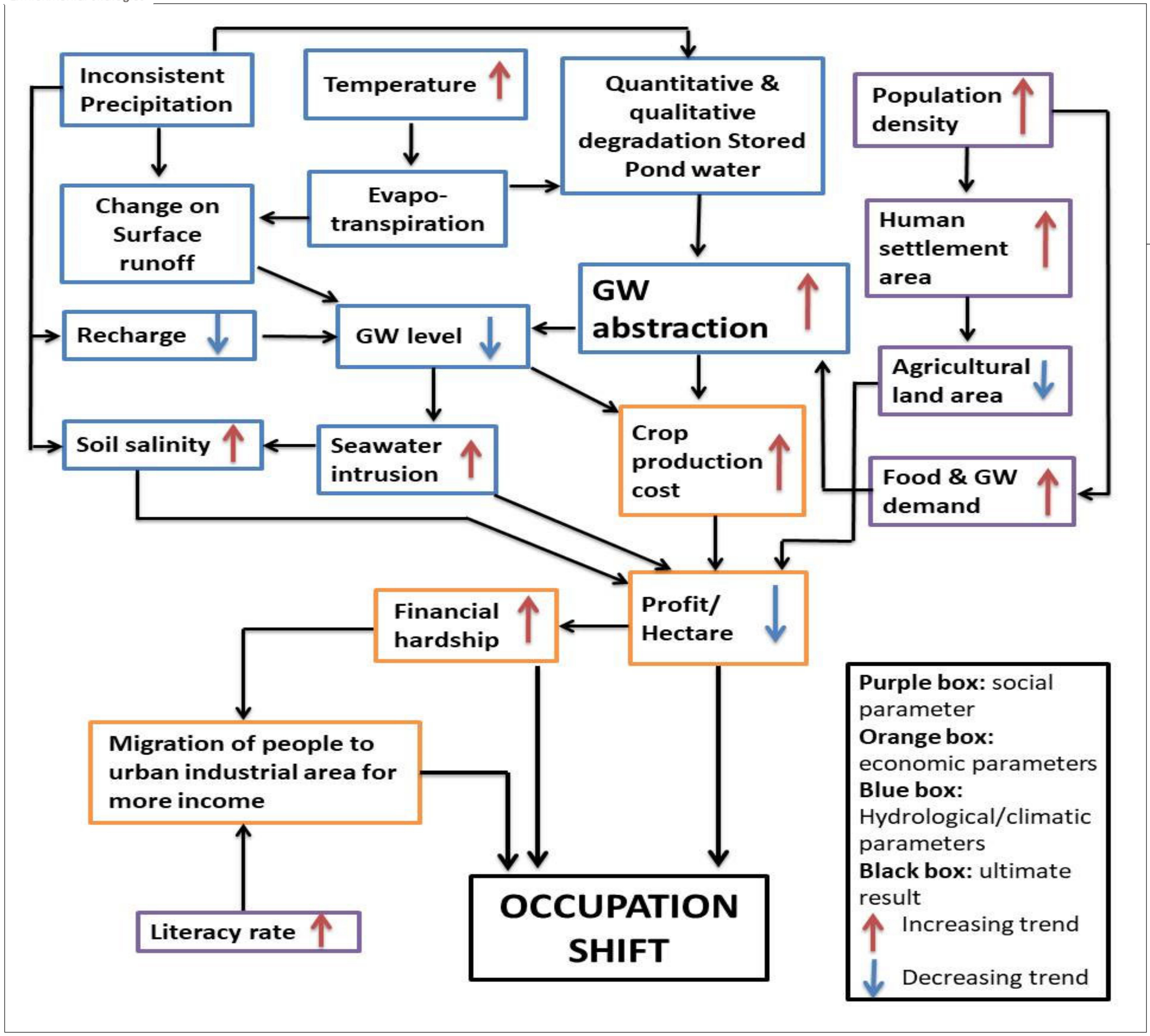


Figure - The drivers of socio-economic trend/status under hydroclimatic context in the study area.

For detail information- https://www.mdpi.com/2073-4441/13/12/1635

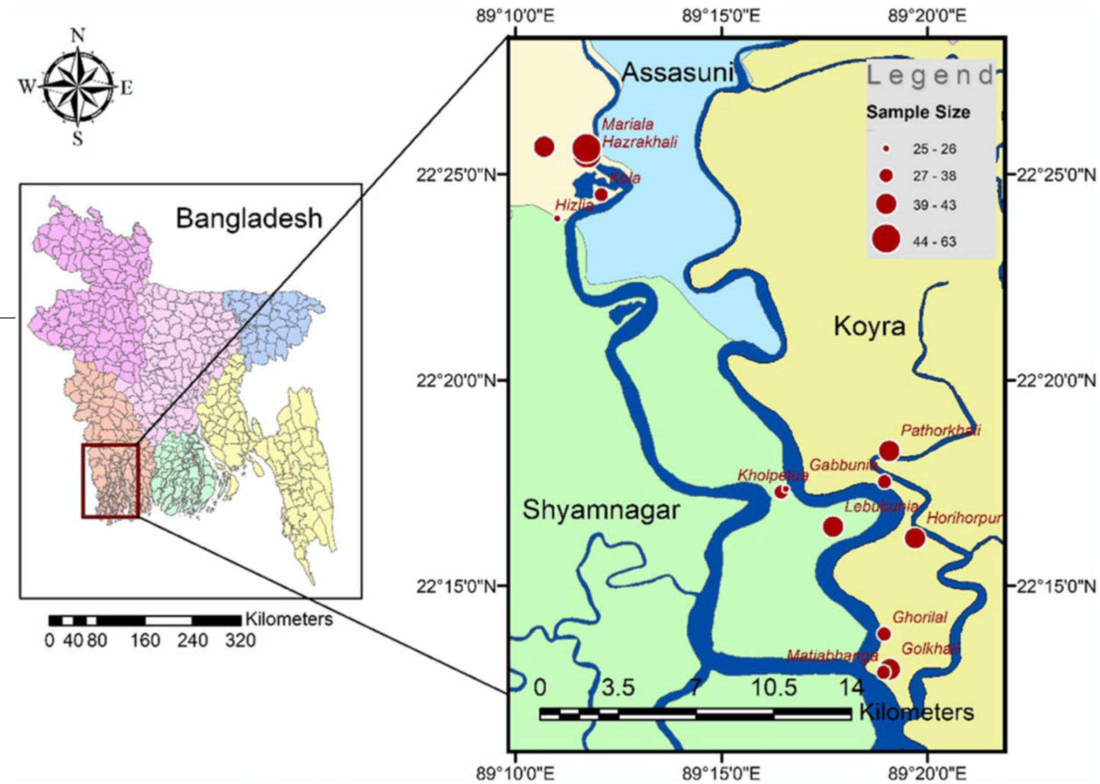
Conclusion

- This study addresses crucial hydrological queries regarding human–nature interaction along with socio-economic issues in a highly complex coastal ecosystem.
- With rapid LULC change, population growth, climate change → becoming uninhabitable (rapid salinization and contamination of freshwater aquifers → crop productivity/ aquaculture yield are further expected to decrease in the near future. Sundarbans is possibly the classic case where groundwater availability is a great limiting factor to socio-economic growth.
- The relationship between hydroclimatic factors and socio-economic vulnerability is prominent, and such a relationship is further magnified by low per capita income, uneven allocation of natural resources, an inefficient health care system, improper education, and several associated factors, ultimately leading to an inadequate adaptive response to stressors.
- As a result, the major occupation sectors (e.g., agriculture, fishery) are affected considerably, posing challenges to populations living there.
- Both qualitative and quantitative securities of natural resources are important for sustainable socio-economic wellbeing.
- The probable factors for occupation shifting are increasing cost of irrigation, profitable booming tourism industry, climate change (inadequate and inconsistent rainfall, cyclones, storms and increasing surface water temperature) acts as proper slow-burn with ever-lasting impact to promote this shifting.
- Therefore, the early estimation of vulnerability is crucial to mitigate the aftermath of stressors. Further analysis is required to estimate the groundwater exploitation with increasing demand and understand the impact of climate change. Additional studies are also required to design effective adaptation strategies, both for agriculture and other employment sectors.

The Case of Voluntary Environmental Non-migration despite Climate Risks in Coastal Bangladesh

Reference – Ahsan, N., et al., (2022) Promise, premise, and reality: The case of voluntary environmental non-migration despite climate risks in coastal Bangladesh. Regional Environmental Change, 22,1.

Despite confronting severe climatic risks, many people prefer to remain in climate hazard-prone areas rather than migrate. Environmental non-migration behavior, however, has gained relatively little research attention in the field of migration processes. This study aims to unveil the determinants motivating voluntary environmental non-migration decisions in coastal Bangladesh, an area highly exposed to flooding and other climate-related hazards (e.g., soil salinization).



Methodology- Systematic random sampling for household respondents for a questionnaire survey from 14 villages of two coastal districts: Khulna and Satkhira.

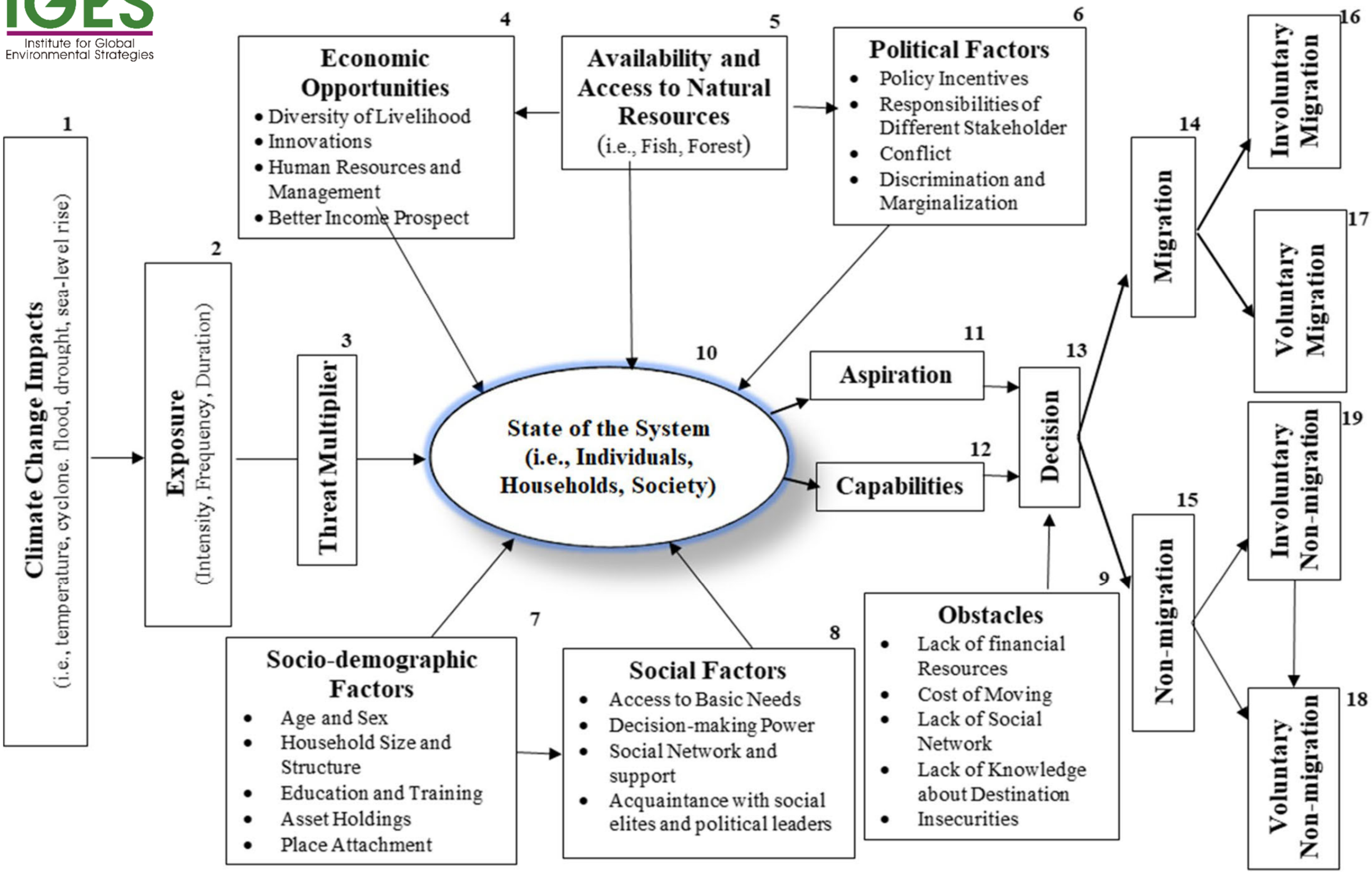


Fig- Major determinants of voluntary environmental non-migration decision

Key findings

- Applying a mixed method (i.e. both quantitative and qualitative) approach, major empirical results of this study suggest that even though all respondents lived in a similar situation in terms of climatic hazard and exposure, many respondents reported themselves as voluntary non-migrants.

- Furthermore, these non-migrants enjoyed higher socioeconomic and sociopsychological advantages and availed more local support from different government and non-government organizations than involuntary non-migrants.

- Again, mutual assistance, connection with social groups, natural resource access, sense of secured livelihood, stable societal atmosphere, and participation in decision-making
- in society appeared to build their higher degree of social capital compared to involuntary non-migrants.

- All these features lead to a favorable environment that ultimately drove the respondents to become voluntary non-migrants.

IGES
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Water related research in line with achieving sustainable water environment

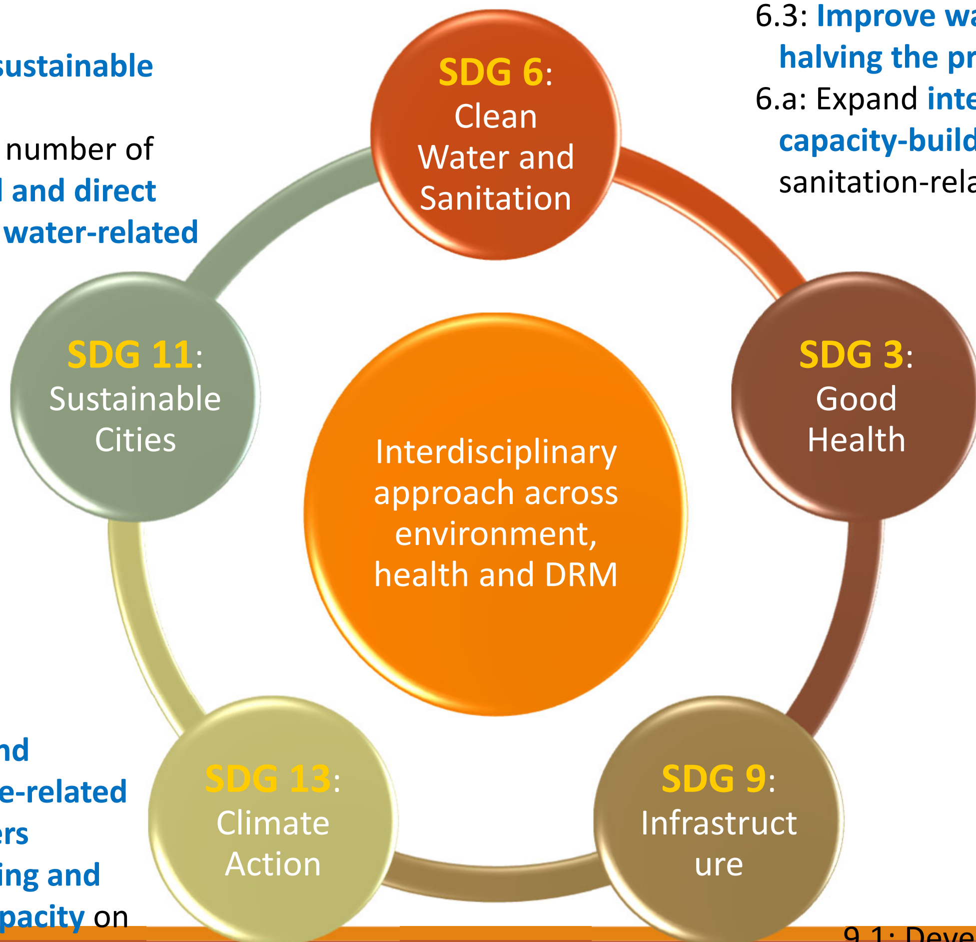
*Although water resource management is key to all SDGs, but more precisely I would like to work on following **SDGs with cross-sectoral coverage***

11.3: Enhance **inclusive and sustainable urbanization**

11.5: Significantly reduce the number of **deaths and people affected and direct economic losses caused by water-related disasters**

6.3: **Improve water quality by reducing pollution, halving the proportion of untreated wastewater**

6.a: Expand **international cooperation and capacity-building support** in water- and sanitation-related activities/programmes



3.9: Substantially reduce the number of **deaths and illnesses from water pollution**

13.1: Strengthen **resilience and adaptive capacity to climate-related hazards and natural disasters**

13.3 Improve **awareness-raising and human and institutional capacity** on climate change mitigation, adaptation, and impact reduction

9.1: Develop **quality, reliable, sustainable and resilient infrastructure**

Awareness of environmental importance

Thank you so much for your valuable time

Water is the “NEW OIL”