Visualizing the impact of water availability and extreme events - enhancing water risk mapping through future climate change and urbanization scenarios.

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Project background & Case study introduction

PolyUrbanWaters - Project: Polycentric approaches to the management of urban water resources in South-East Asia → Interface between Water resources management and Urban planning

- Demand driven baseline assessment, vision building & concept development
- Three secondary/ tertiary cities/towns/villages in Laos, Cambodia and Indonesia
- Provincial urban centers in a monsoon climate

Figure 1: Location of case studies

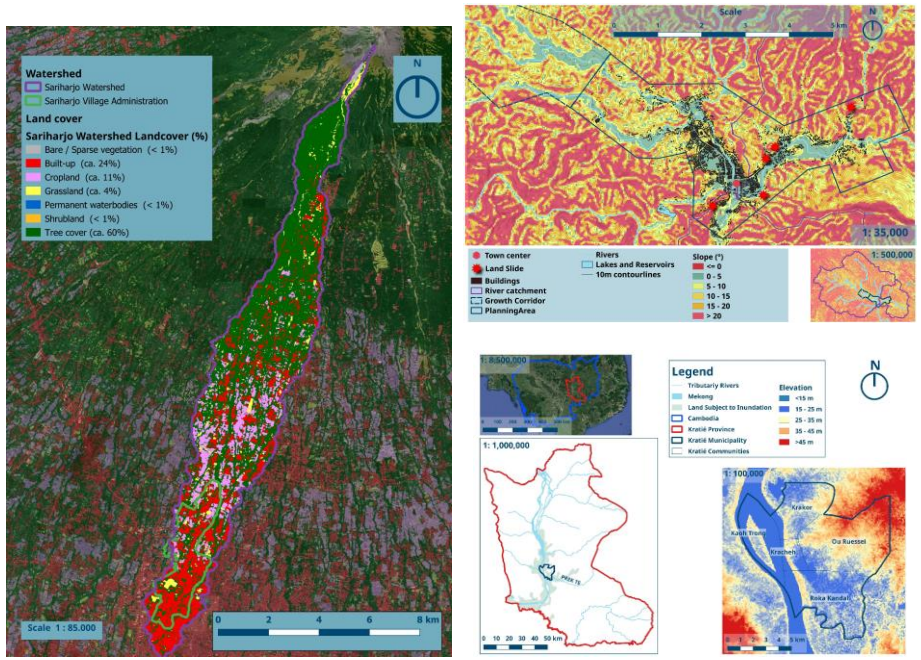

Figure 2: Living labs and context

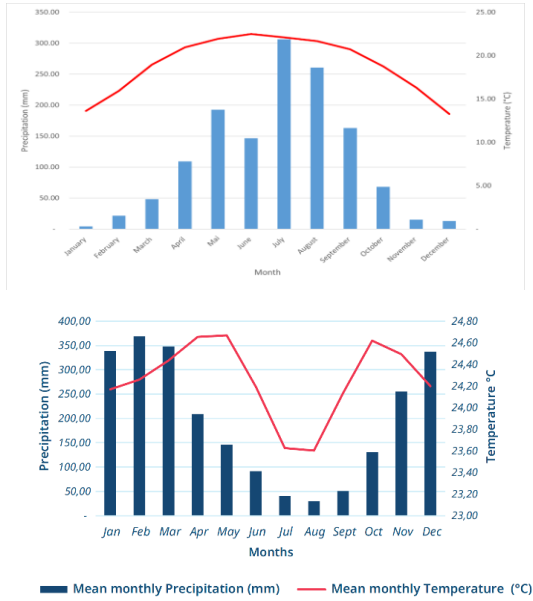

Figure 3: Seasonal monsoon climate in Sam Neua, Laos and Sleman, Indonesia

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Demand

- Limited ground data, coping capacities and -resources.
- No concrete risk maps or detailed knowledge of climate change impacts
- Deforestation, urbanization → Land reclamation & loss of water retention potential + Seasonal floods & droughts

→ Assessing **Hazard x Exposure x Vulnerability and climate change scenarios**

Figure 4: Land reclamation in Kratié Cambodia

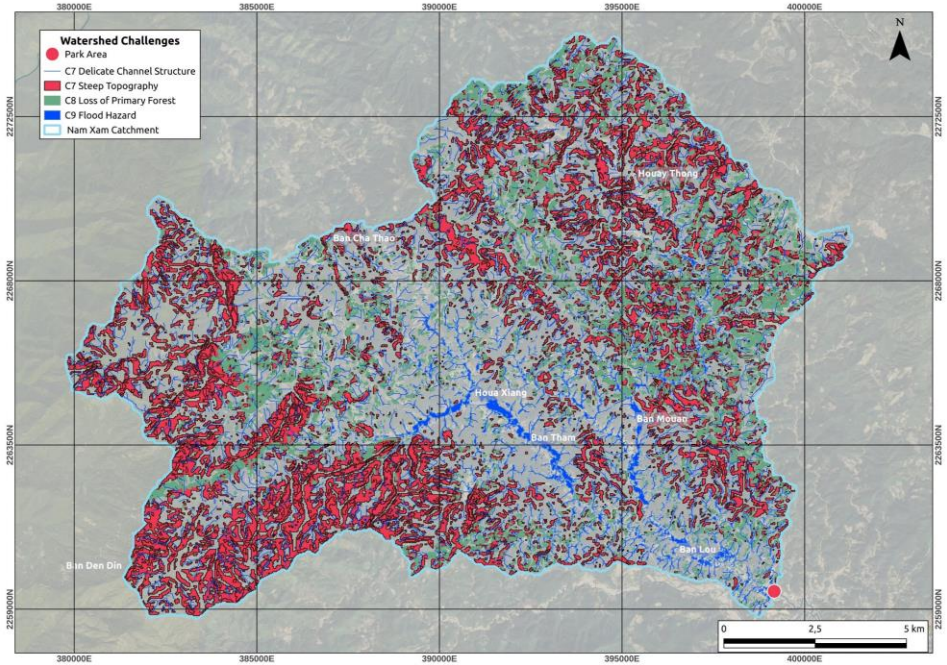

Figure 5: Challenges in a Sub-basin of the Nam Xam in Laos (edited by Juan Mercado Leal)

Hazard assessment

Hazard: " A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation" ([UNDRR] United Nations Office for Disaster Risk Reduction, 2020).

- Exceptional precipitation events with MSWEP (Beck et al., 2019) or water level peaks

→ flood inundation mapping with available Sentinel-1 images (Kiran et al., 2019)

- Slope-based land slide hazard (Boroumandi et al., 2015) with FABDEM+ (Hawker et al., 2022)
- Agricultural drought indicator VHI (Rojas et al., 2011)
- Weighted hazard categories

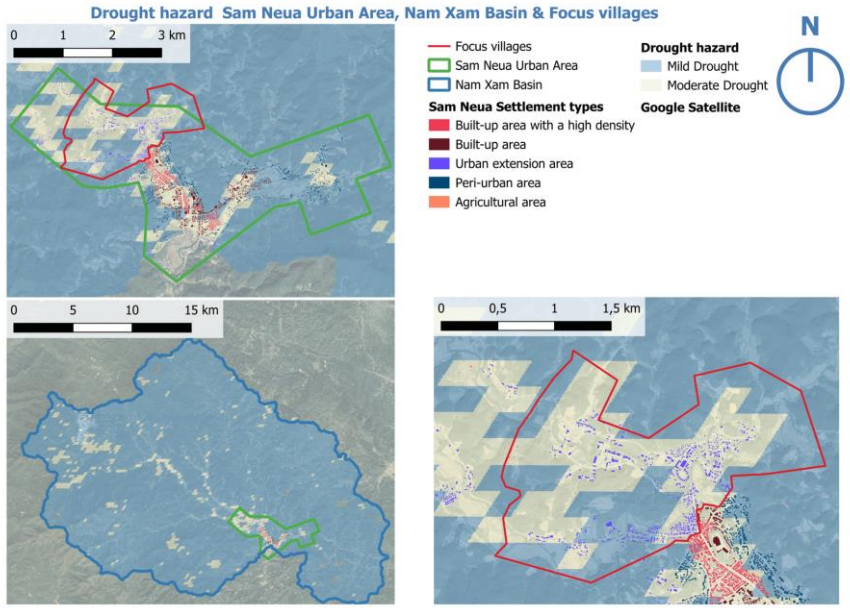

Figure 6: Flood, drought and slope hazards in Sam Neua Laos

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Combining hazard and exposure

Exposure: The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas ([UNDRR] United Nations Office for Disaster Risk Reduction, 2020).

- Buildings (Sirko et al., 2021) and agriculture land (Zanaga et al., 2022)

→ identification of exposed land cover to hazards

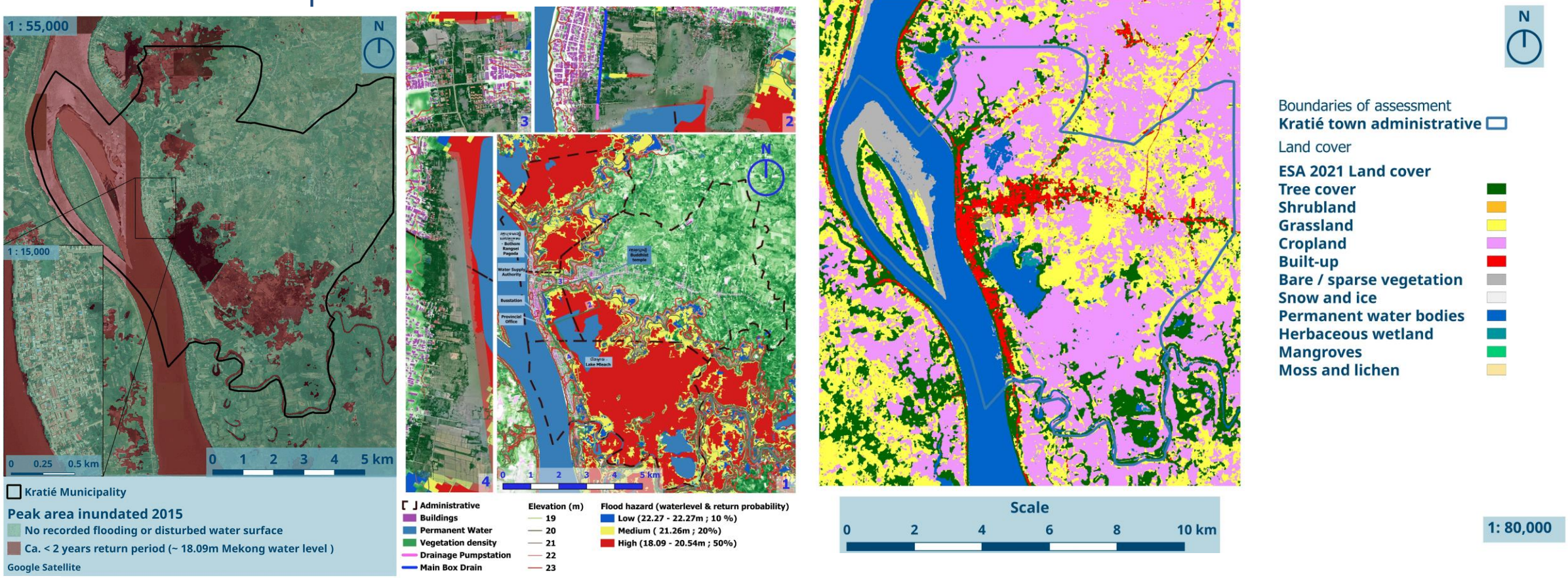


Figure 7: Flood inundation and – hazard and exposure in Kratié Municipality, Cambodia

Vulnerability assessment

Vulnerability: The characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard (UNEP, 2019)

- UAV images and development plans to evaluate degrees/ needs of adaptation

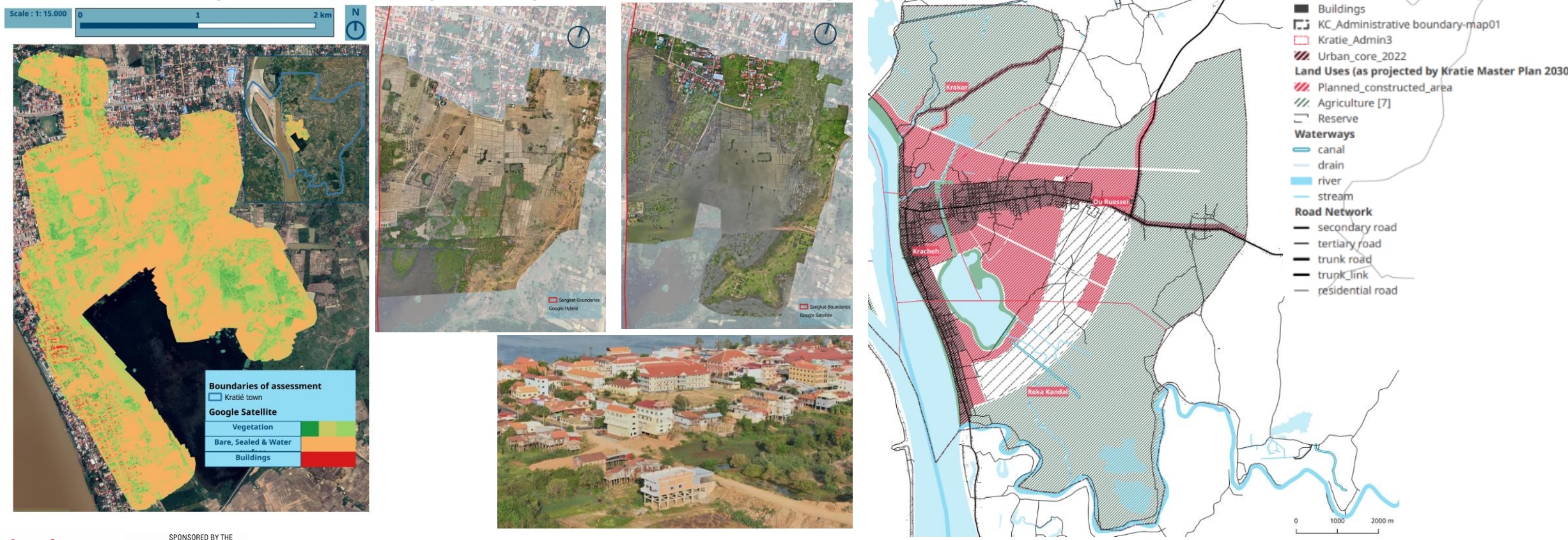


Figure 8: Vegetation corridors (GLI), flood season comparison orthomosaic and stilted/ unstilted houses & Masterplan 2030 in Kratié Municipality, Cambodia

Outlook

- Earth observation data / datasets were are crucial for mapping risk components in data scarce regions.
- Still very high amount of existing natural assets, but current/ original plans create vulnerability by outlining the urbanization of areas exposed to natural hazards and alter the natural water cycle

→ **Sam Neua:** Integration of information for Land use planning and concrete project development, Capacity development

→ **Kratié:** Use of Risk component mapping results for Flood Management & Green Space development plans and adapted transition pathways

Context

- *Frequent occurrence of climate extreme events (e.g., floods and droughts).*

+

- *High exposure and low resilience*

+

- *High vulnerability to Climate Change*

- *Intensity and frequency of extreme events*
- *Negative impacts on socio-economic indicators in the region*

Solution

Provide robust information on impacts of climate change on the different sectors

Limitations

- *Data scarce area*

+

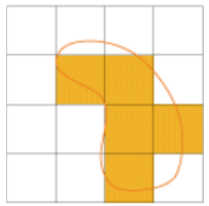
- *Complex climate (Asian Australian monsoon system)*

+

- *Coarse GCMs resolution*

+

- *Unavailable high resolution multi model climate simulation*



Objectives

Use of high- resolution downscaled climate models

CORDEX- SEA (RCP)

WORLDCLIM (CMIP6)

Forecasting of Precipitation and temperature

Forecasting of discharge

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Study areas

Nam Xam watershed and Sam Neua village

Prek Te watershed and Kratie village

Boyong watershed and Sariharjo village

Methodology

Input

T **P**

CORDEX- SEA: CMIP5 Downscaled future climate projections.

- ✓ ***Time resolution:*** *Monthly time series* ***2021- 2050****.*
- ✓ *Spatial resolution:* ***25 Km***
- ✓ *Scenarios : RCP 4.5 & RCP 8.5*

- **WorldClim: CMIP6 Downscaled future climate projections.**
- ✓ ***Time resolution:*** *Monthly averaged values over 20 years for near term* ***2021- 2040.***
- ✓ *Spatial resolution: 30 seconds*
- ✓ *Scenarios : SSP2 4.5 & SSP5 8.5*

Ensemble mean multi models

Bias correction using Chirps for P and ERA5 LAND for T

Forecasted monthly time series

Trend analysis

Seasonality analysis

Forecasting discharge using the GR2M model

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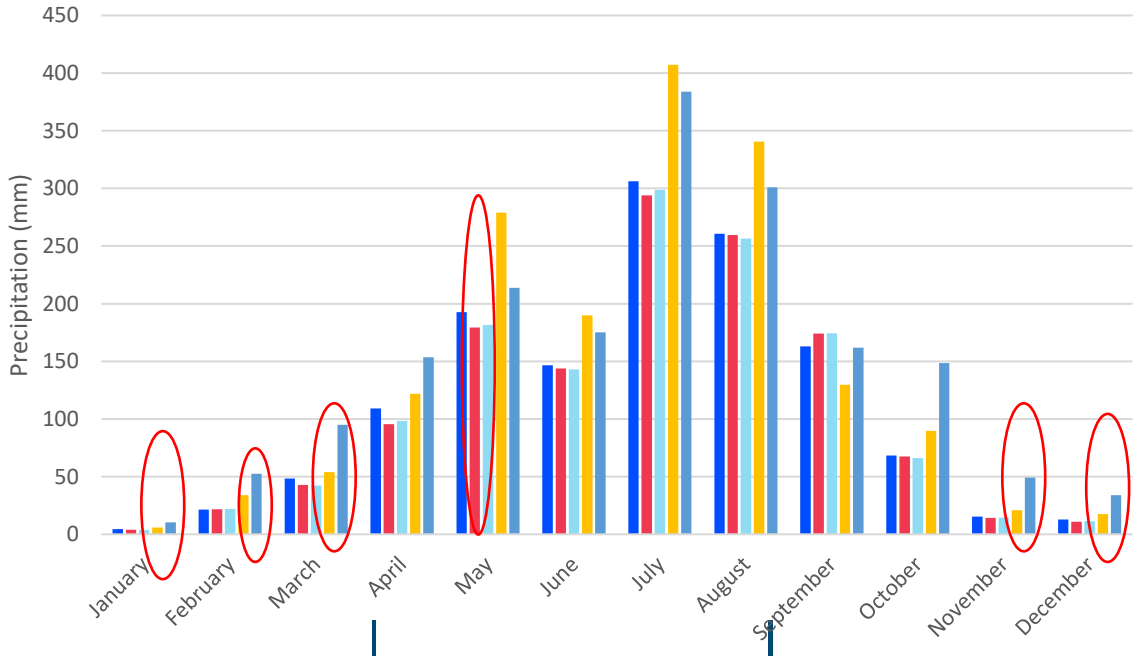
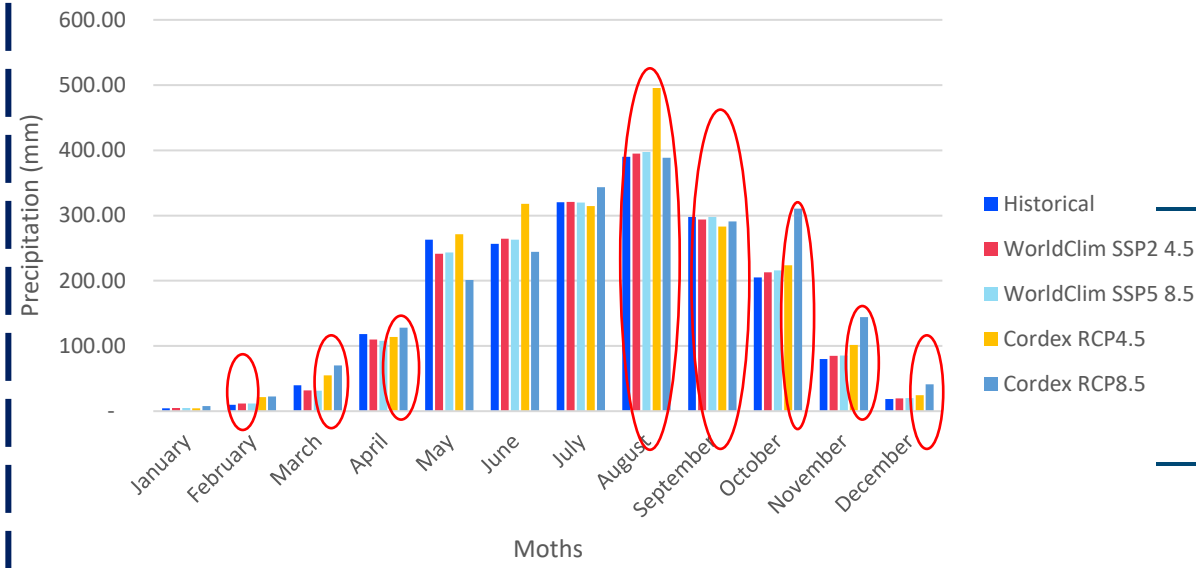
Results

- Overall, both Cordex-SEA and WorldClim captured the climatic complexties of the 3 case studies ***(hydrological cycle, Seasons shift).***
- ***Cordex-SEA :***Wetter climate, especially in dry seasons for Prek Te/Kratie, Nam Sam/ Sam Neua.
- **WorldClim :** dryer climate, with the exception of Prek Te/ Kratie with minimum increase.
- Large uncertainties when moving from watershed scale to village scale.

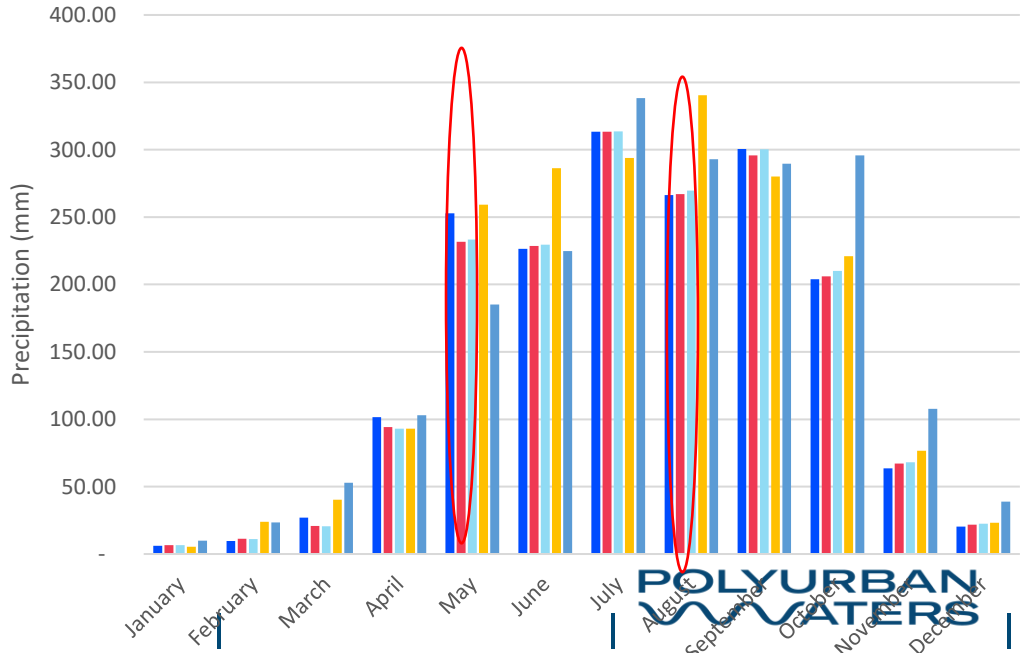
Nam Xam - Laos



Prek Tewatershed - Cambodia.

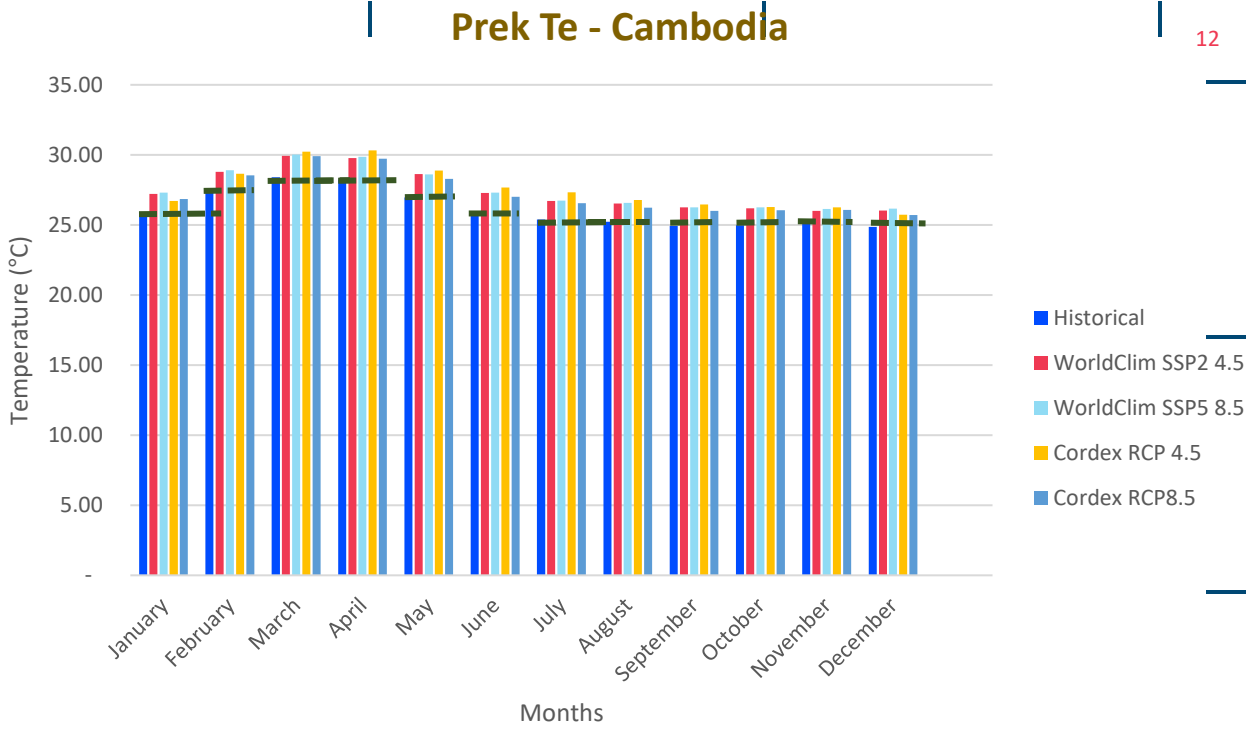


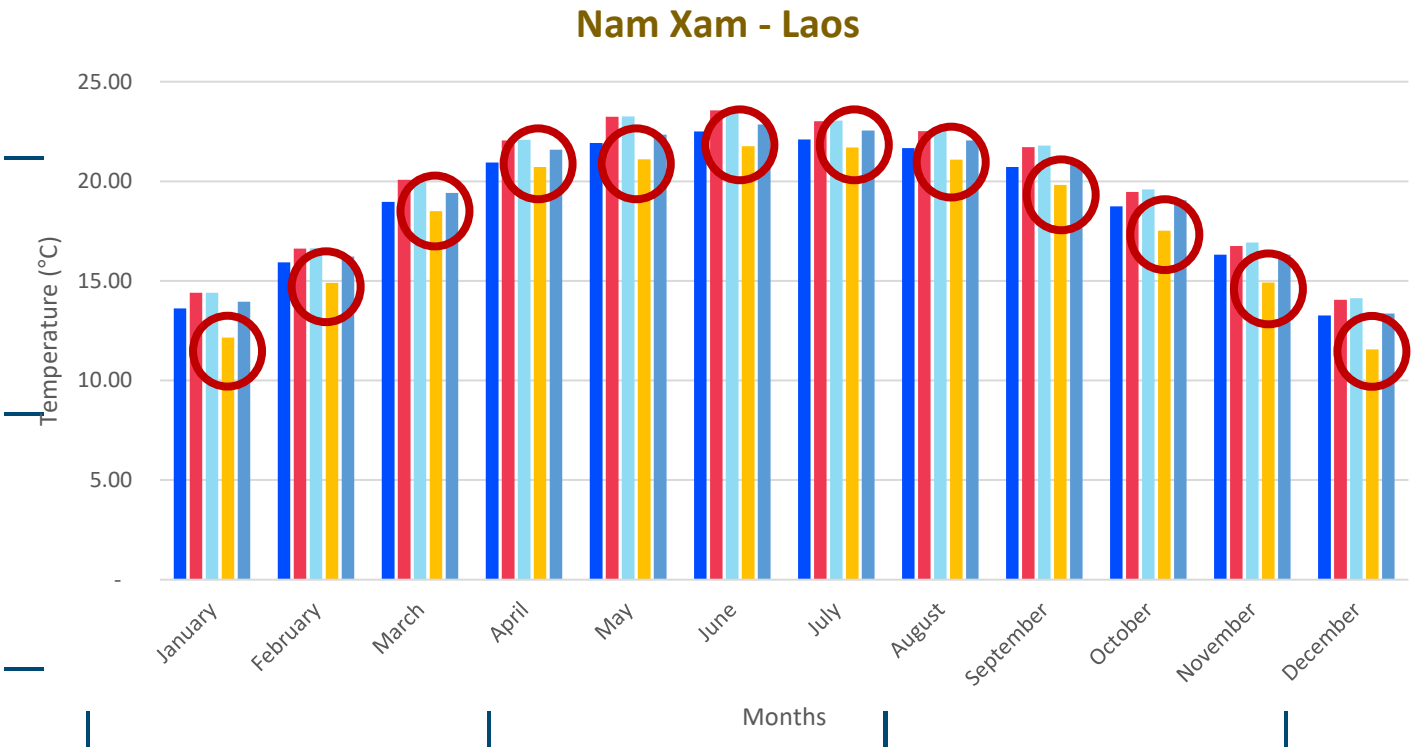
Kratie – Cambodia.

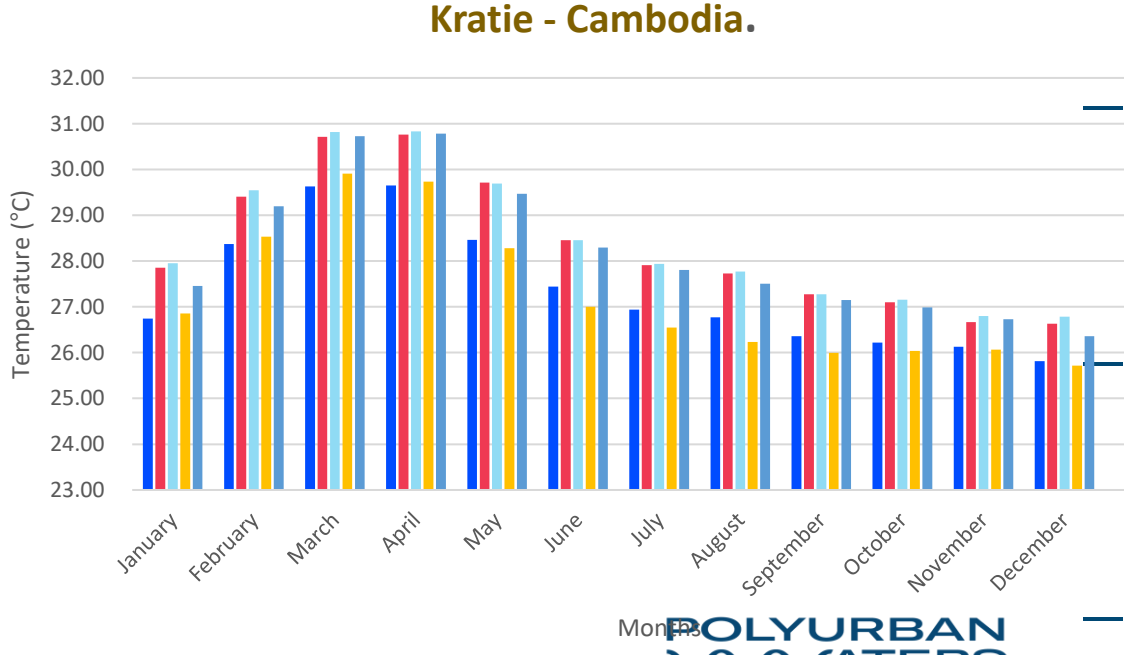


Results

- ***Temperature: warmer climate (exception for Nam Xam/ Sam Neua in Laos and Sariharjo village).***
- **Large uncertainties** when moving from watershed scale to village scale specifically for the CORDEX-SEA.







Results

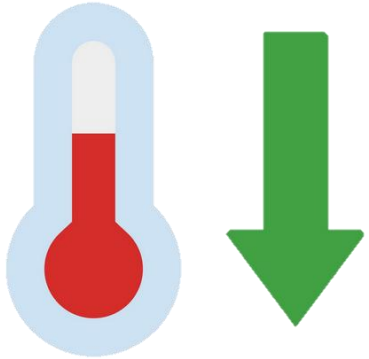
CORDEX- RCP 8.5 for three case studies :

Dry season

Wet season

WorldClim & Cordex- SEA: Contradiction

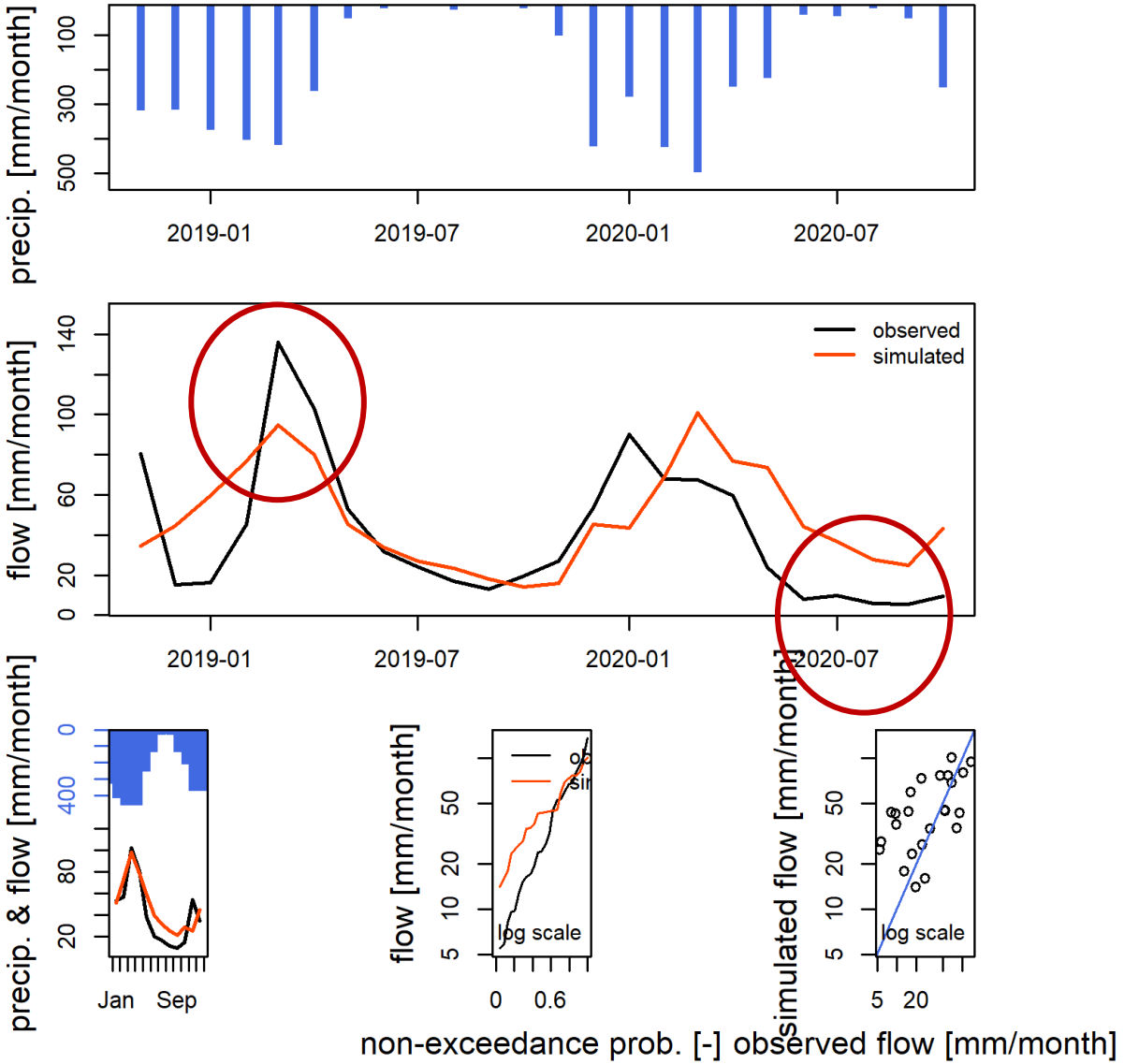
CORDEX- RCP 4.5 for Nam Xam and Sam Neua in :



Dry season

Results of hydrological modelling

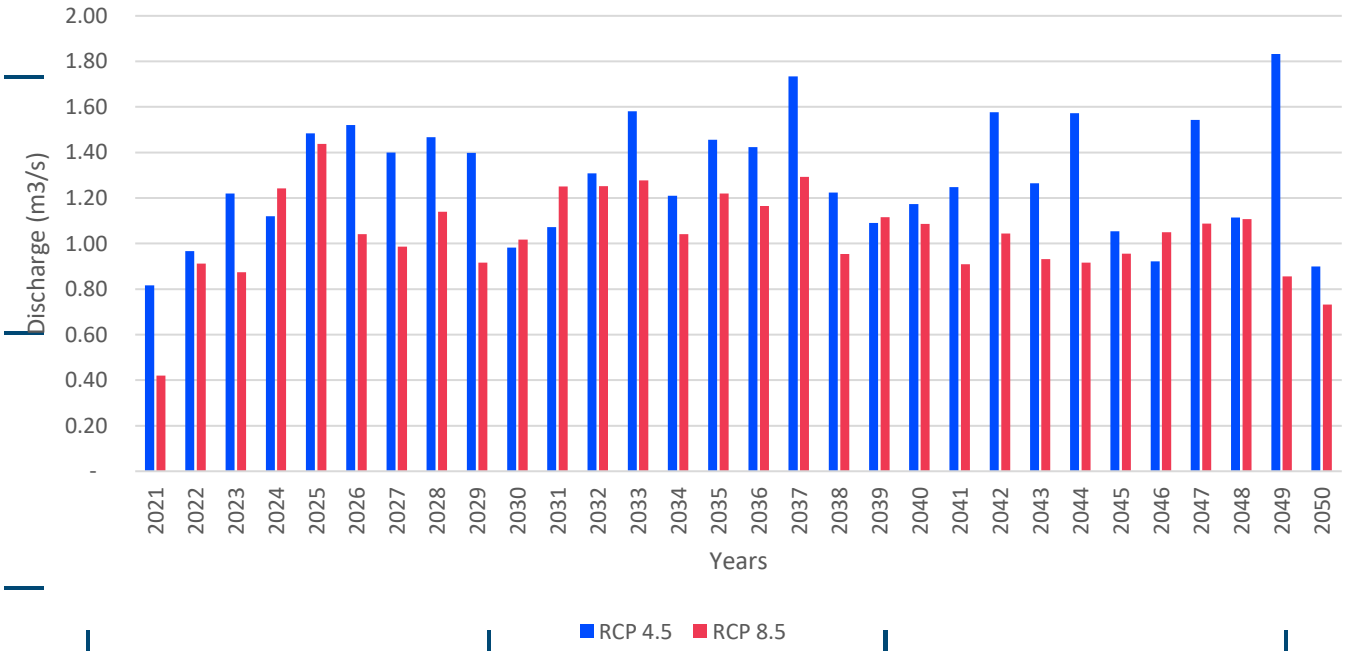
- **Model:** GR2M
- **Calibration period:** 2011-2018
- **Validation period:** 2018- 2020
- NSE = 0.35
- Model able to simulate the runoff response to a precipitation event.
- Difficulty to simulate / model extreme events (very low or very high discharge)



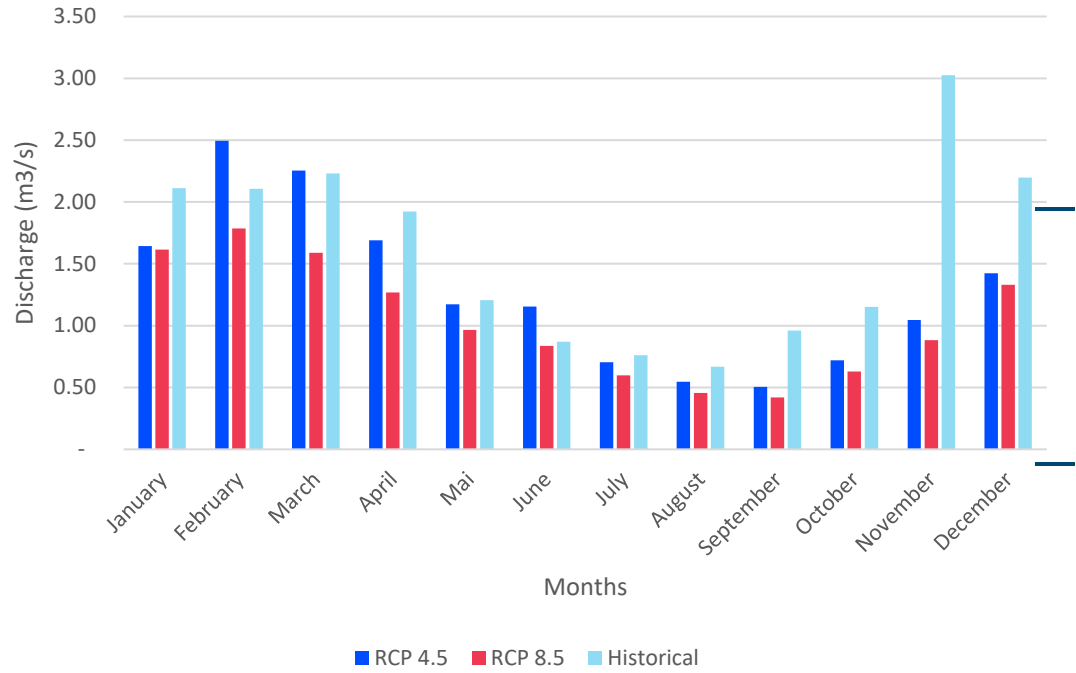
Results of hydrological modelling

Forecasted discharge with low mean monthly values than historical values, especially during the wet season and for RCP 8.5.

Temporatl distribution of forcasted mean yearly discharge in Boyong watershed.



Temporatl distribution of forcasted mean monthly discharge in Boyong watershed.



RCP 4.5 : Extremely high values for some years (e.g. 2049, 2037)

RCP 8.5 : Extremely low values for some years (e.g., 2021, 2049. 2050).

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Conclusions

For the three case studies:

1. WorldClim predict a slightly drier climate with less precipitation especially the ending of dry season and the beginning of the wet season.
2. Cordex-SEA: Wetter climate.

Seasonality :

Cordex-SEA RCP8.5 predicted shift, with less precipitation during the wet season and the more precipitation in the dry season

- **Prek Te/ Kratie- Laos, Nam Xam/ Sam Neua-Laos:**

Warmer climate with more increase pronouced using WorldClim.

Exception with CORDEX- RCP 4.5 due to the expectation of cooler temperatures during the dry season.

- **Boyong / Sariharjo:**

Warmer weather except small change RCP 4.5

For streamflow prediction in Boyong:

1. Less ability to predict the extreme events and this might be due the low accurancy of input data.

Acknowledgement

This work stands in a long line of ideas developed by researchers of the research group “Integrated Land and Water Management”, headed by Prof. Dr. Lars Ribbe, founding dean of the Faculty of Spatial Development and Infrastructure Systems, University of Applied Science Cologne in Germany.

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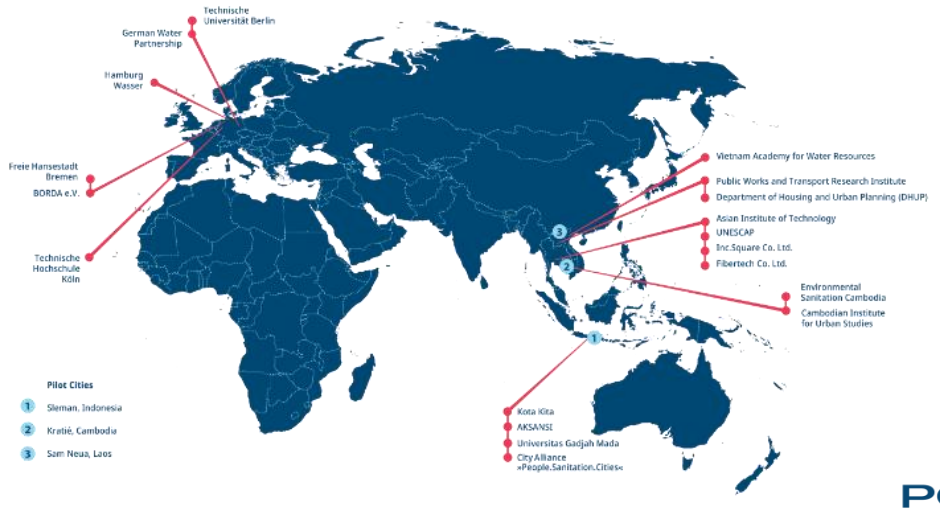
Thank you for your attention!

Q &A

Learn more about related work at the TH Cologne website (→ Virtual 360° walks) or www.polyurbanwaters.org

A cooperation network, which consists of academic institutions, municipalities, local and national government agencies, civil society and private sector from Indonesia, Cambodia, Laos, Thailand, Vietnam and Germany



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