Enhancing Resilience to future Hydro-meteorological extremes in the Mun river basin in Northeast of Thailand (ENRICH project)

Special Session 12

"Climate Change Risk and Countermeasures: Building Resilience for Sustainable Development"

11 September 2023

Dibesh Khadka
Asian Institute of Technology (AIT)
Thailand

XVIII World Water Congress
International Water Resources Association (IWRA)
Beijing, China | September 11-15, 2023

Overview

- Warming of about 1°C since pre-industrial levels and will reach 1.5 °C by 2030-2050 (*IPCC, 2021; WMO, 2019*)

- Global warming is expected to intensify global water cycle, exacerbate extreme events (*Chen et al., 2017*)

- Increase in frequency and severity of hot extremes since 1950s is "Virtually Certain" and of heavy precipitation events "High Confidence" (*IPCC, 2021)*

- Many recent extreme events are directly attributable to Climate Change
  - Extreme Precipitation in Yangtze-Huai, China in June-July 2016 *(Sun and Miao, 2018)*
  - Extreme heatwaves in southern Europe in 2017 *(Kew et al., 2019)*
  - East African droughts of 2017 *(Funk et al., 2019)*
  - Central Europe flooding of 2021 *(Lehmkuhl et al., 2022)*


Source: AP


Source: Reuters

Flooding in Greece
Sep, 2023

Flooding in China
July 2023


Source: Reuters


Source: Reuters

Overview

ENRICH project: Enhancing Resilience to future Hydro-meteorological extremes in the Mun river basin in Northeast of Thailand

- **Funded by:** The National Research Council of Thailand (NRCT) (RDG6130025) & the Natural Environment Research Council (NERC) (NE/S002901/1) under the Newton Fund program
- **Duration:** 3.5 Years (September 2018 – March 2022)
- **Implemented by:**
  - Asian Institute of Technology (AIT), Thailand
  - University of Exeter (UoE), United Kingdom

Overall Objectives

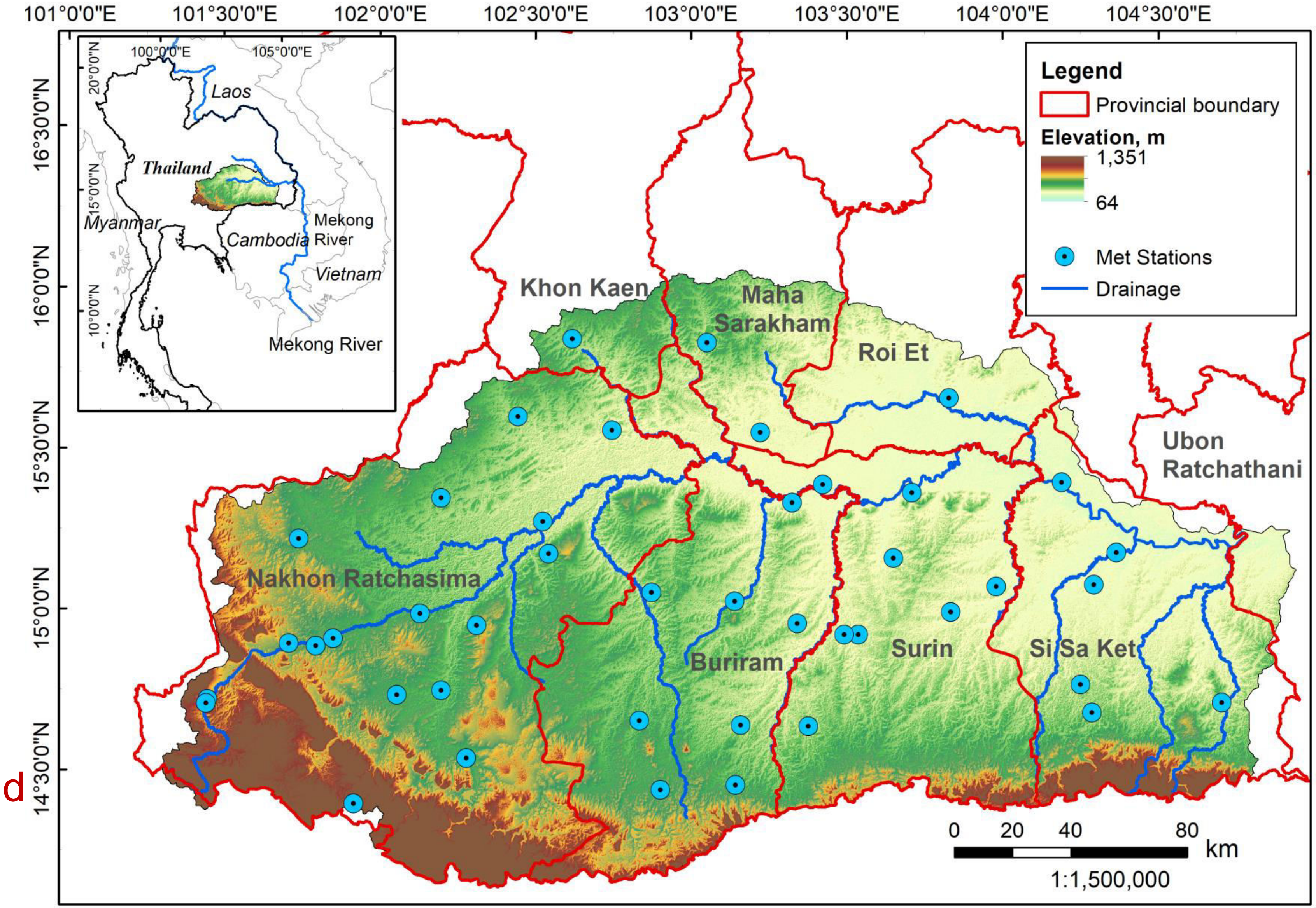
- To understand the impact of the combined stressors of climate variability, climate change and land-use change on hydro-meteorological extremes in the Mun River basin; and
- To recommend suitable adaptation measures for droughts to enable sustainable management of water resources and improve water security in the coming decades.

Four Work Packages (WPs)

- WP1: Land-use Change
- WP2: Climate Variability and Climate Change
- WP3: Hydro-meteorological Extremes
- WP4: Adaptation Strategies for Droughts Based on Synthesis of the Results

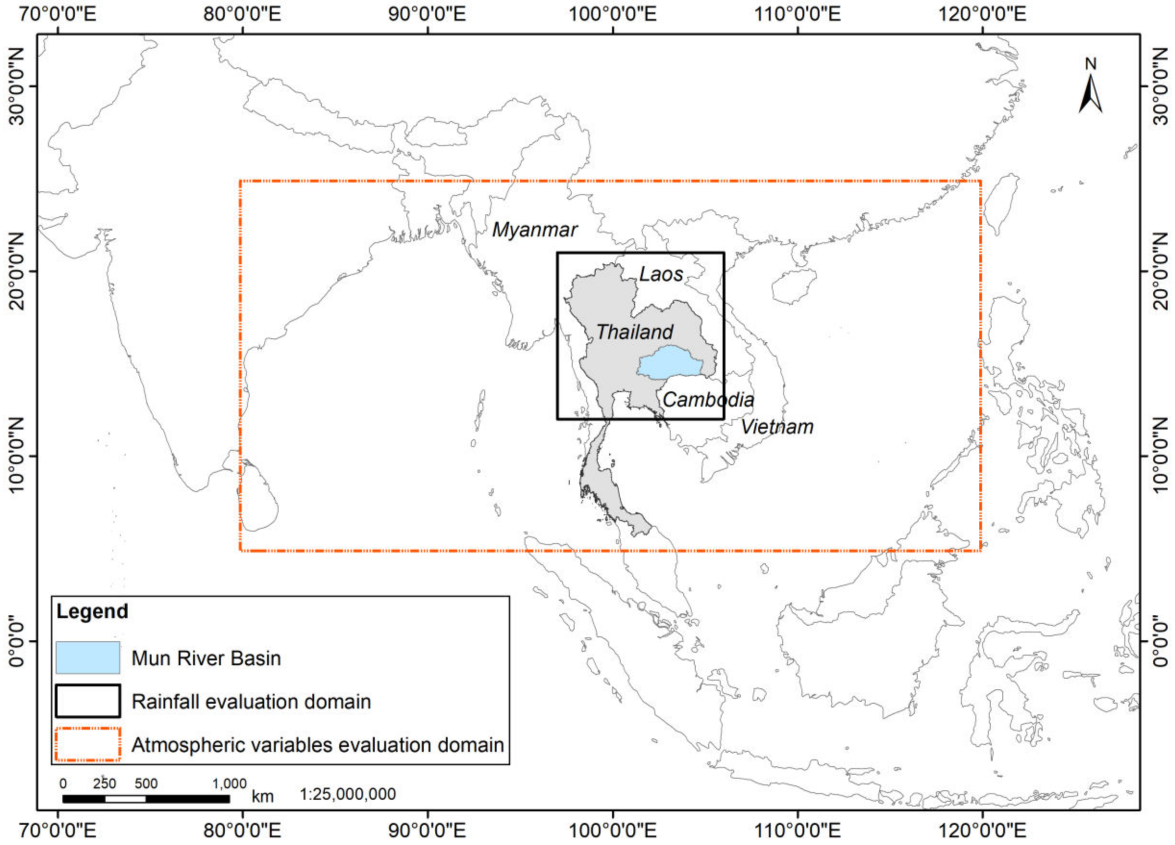
Study Area

- **Mun River Basin**
  - A major tributary of Mekong
  - Located in northeast Thailand
  - Catchment area of **53,800 km^2**
- **Comprises mainly 4 provinces**
  - Nakhon Ratchasima,
  - Buriram,
  - Surin, and
  - Si Sa Ket
- **Agriculture**
  - Main livelihood activity
  - 75% of area under cultivation
  - Sandy-loam soil
- **Drought-prone region** in Thailand



Results

Evaluation of climate models

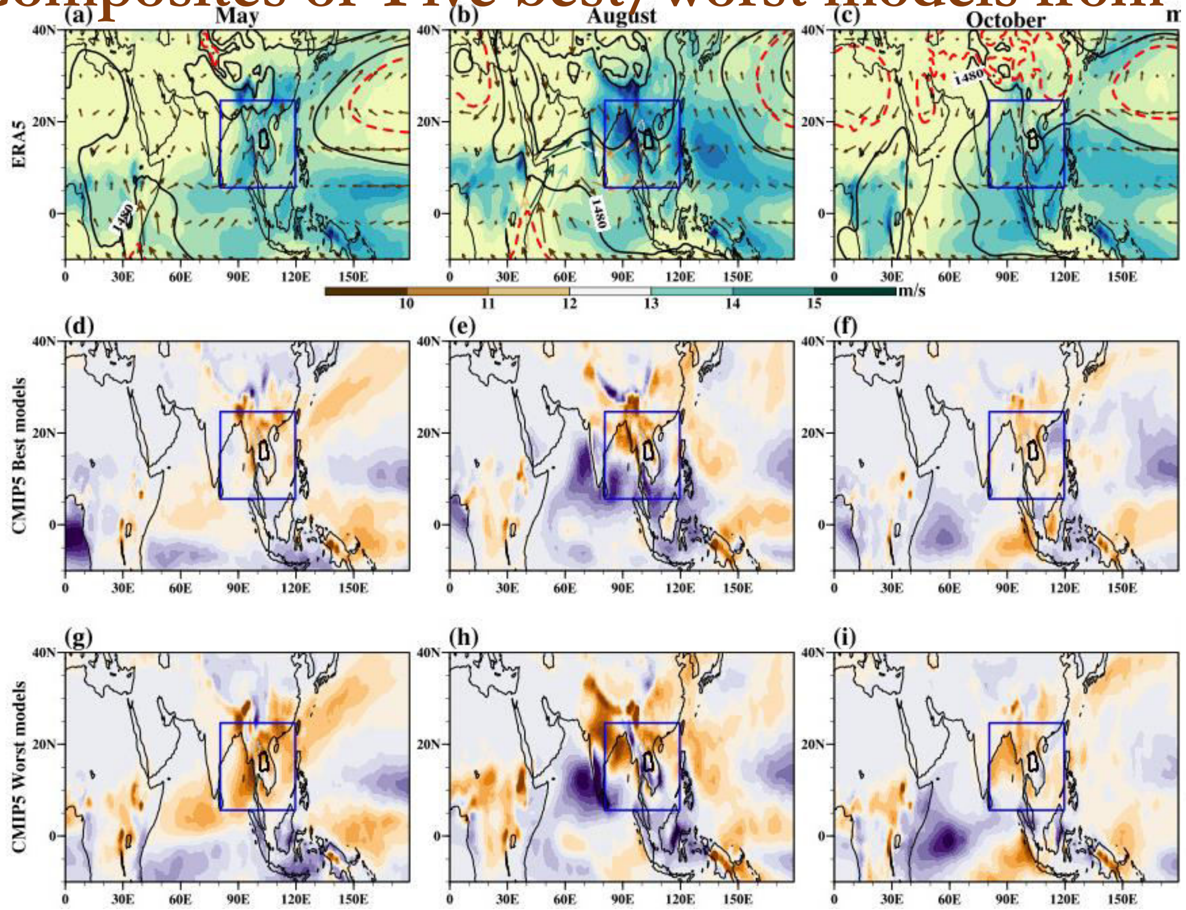


Performance evaluation of 28 CMIP5 and 32 CMIP6 climate models using 25 surface and largescale atmospheric variables

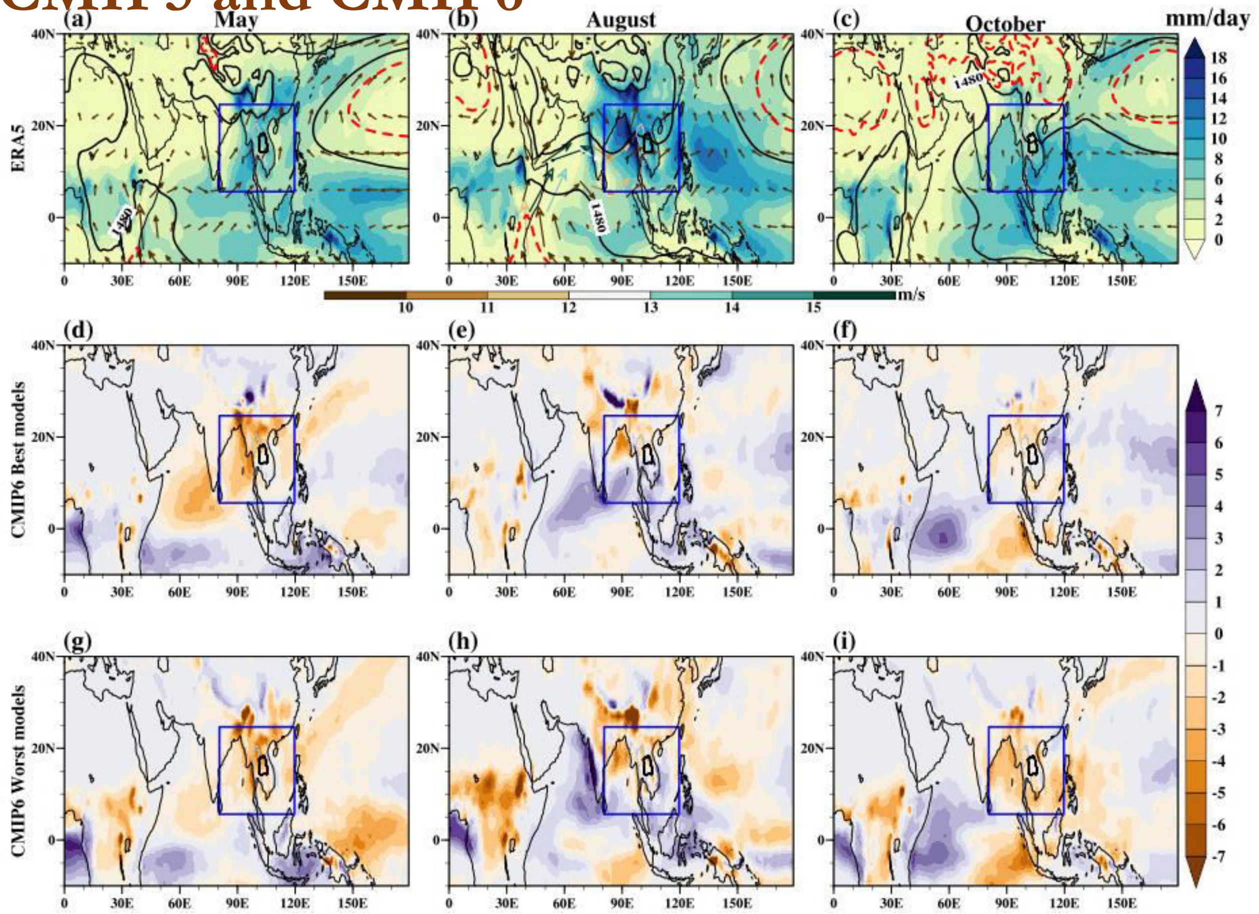
Rank	CMIP5 GCMs	CMIP6 GCMs
1	MPI-ESM-MR	EC-Earth3-CC
2	CCSM4	NorESM2-MM
3	MIROC5	EC-Earth3
4	CMCC-CM	TaiESM1
5	CNRM-CM5	HadGEM3-GC31-MM
6	HadGEM2-AO	CMCC-ESM2
7	MIROC4h	HadGEM3-GC31-LL
8	FGOALS-s2	CESM2
9	NorESM1-M	GFDL-ESM4
10	CanESM2	UKESM1-0-LL
11	ACCESS1-0	CMCC-CM2-HR4
12	BNU-ESM	NorESM2-LM
13	HadGEM2-ES	CESM2-FV2
14	EC-EARTH	MPI-ESM1-2-HR
15	GFDL-CM3	MIROC6

Results

Composites of Five best/worst models from CMIP5 and CMIP6



CMIP5 models (Rainfall Biases)



CMIP6 models (Rainfall Biases)

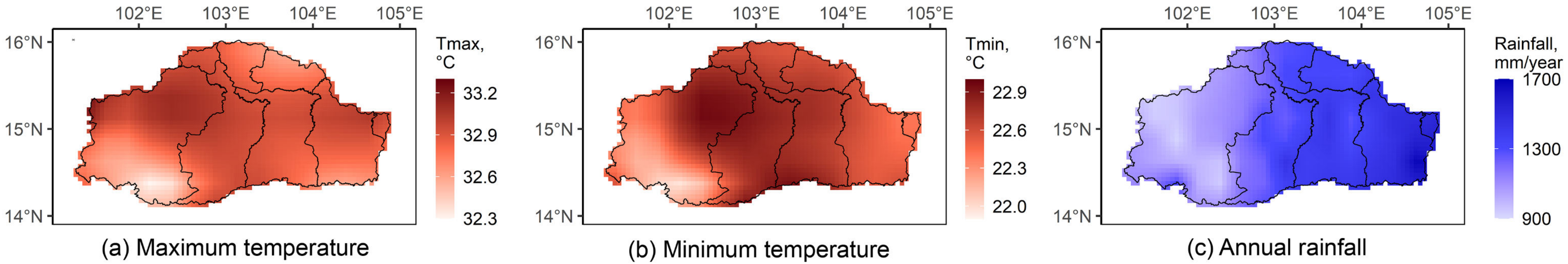
- Composite of best models have less biases during all phases of summer monsoon.
- Biases in CMIP6 composites are even lesser than in CMIP5 composites

Further details

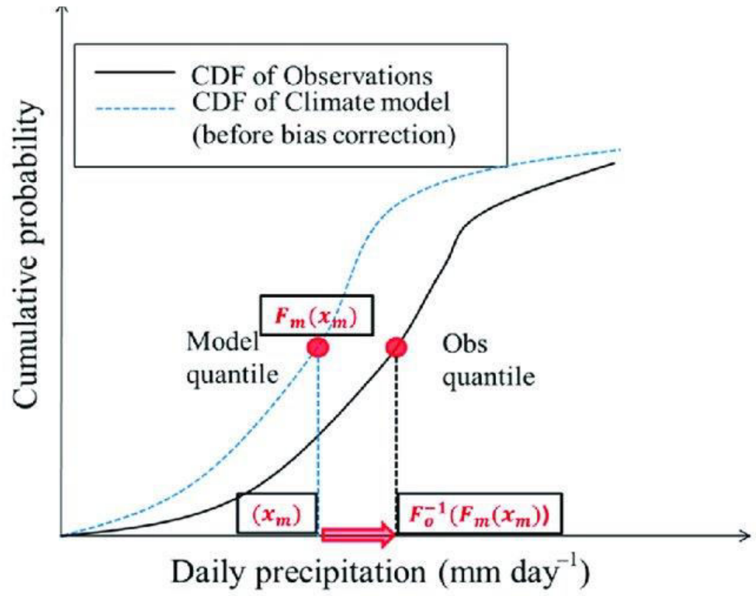
Khadka, D., Babel, M. S., Abatan, A. A., Collins, M. (2022) 'An evaluation of CMIP5 and CMIP6 climate models in simulating summer rainfall in the Southeast Asian monsoon domain', International Journal of Climatology. John Wiley & Sons, Ltd, 42(2), pp. 1181–1202. doi: https://doi.org/10.1002/joc.7296.

Results

Observed climate and future projection

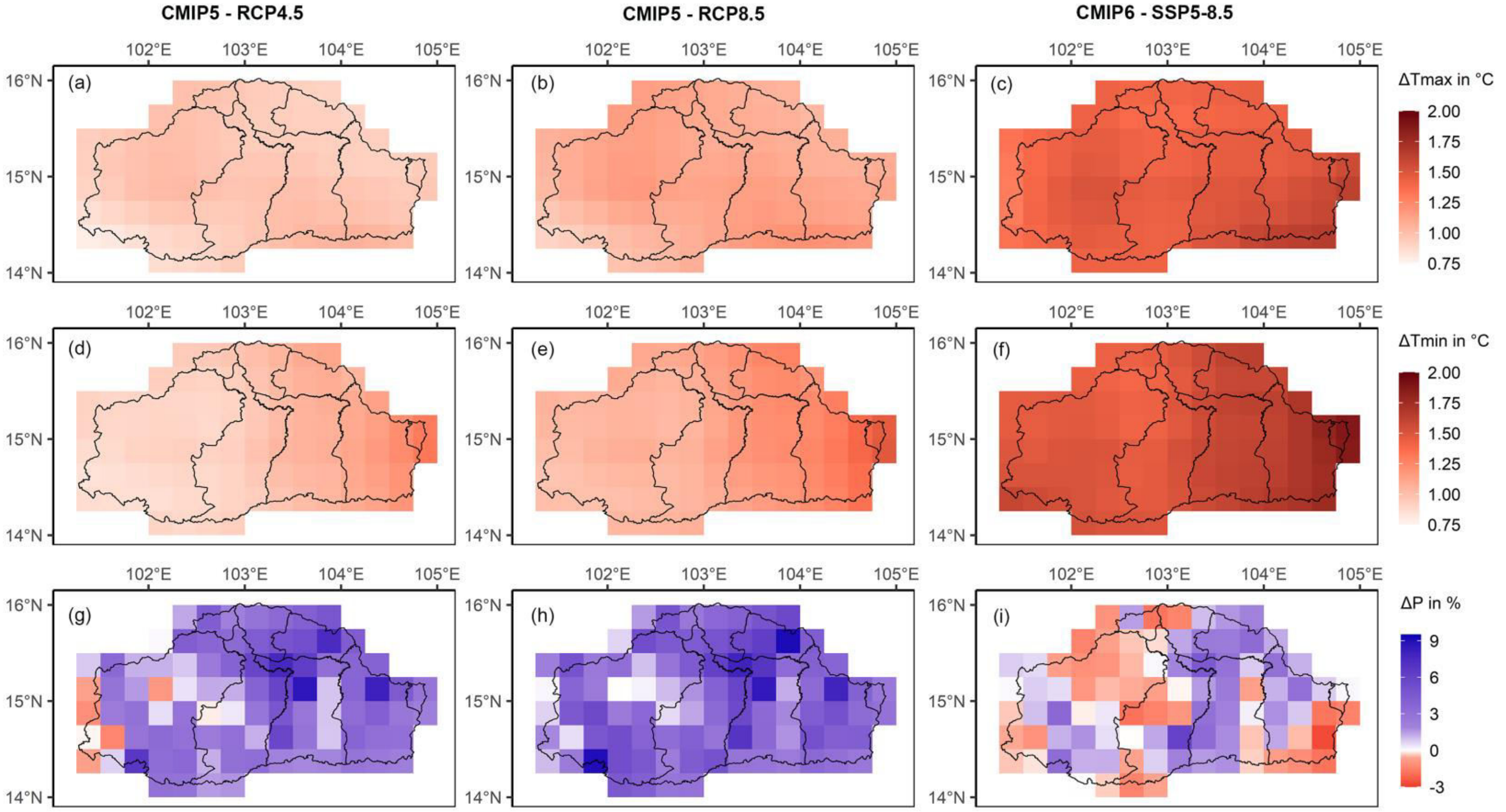


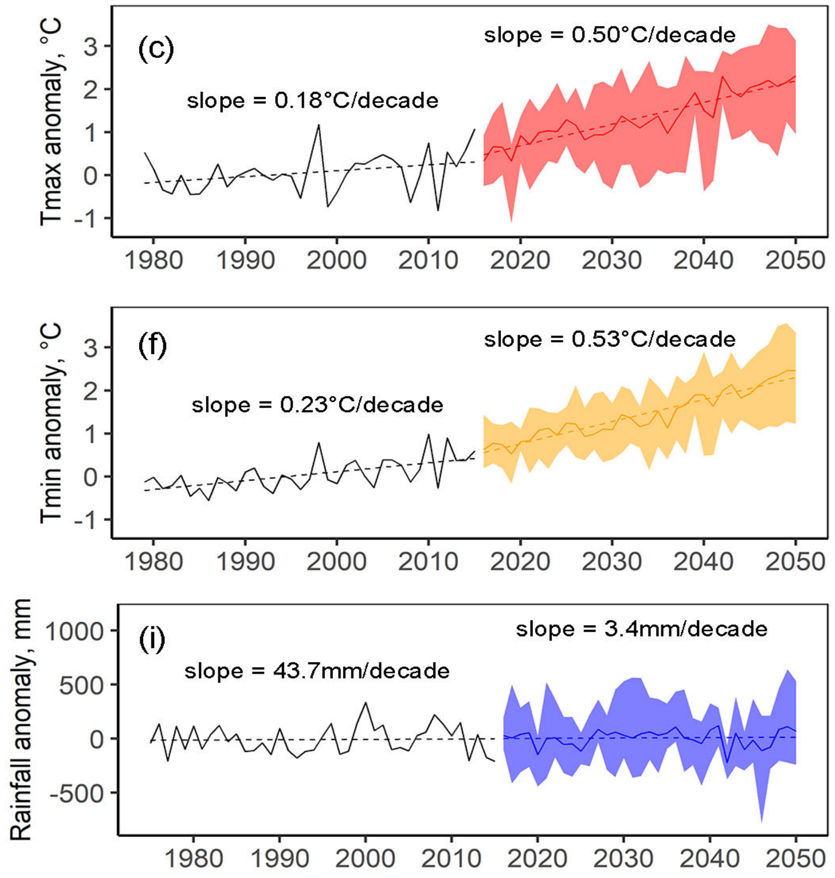
- **Monsoonal circulation** is the main driver of the seasonal rainfall
- **3 distinct seasons** (Summer: Mar-May, Rainy: Jun-Oct, Winter: Nov-Feb)
- Near-future projections for **2021-2050** and compared with **1981-2010**
- Three cases based on CMIP and scenario
  (i) **Case A**: **CMIP5** multi-model ensemble under **RCP4.5 scenario**,
  (ii) **Case B**: **CMIP5** multi-model ensemble under **RCP8.5 scenario**, and
  (iii) **Case C**: **CMIP6** multi-model ensemble under **SSP5-8.5 scenario**



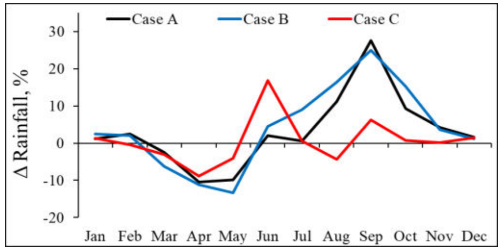
Results

Projected change in mean climate in 2021-2050 compared to 1981-2010 (using MME)





- Projected increase in Tmin > Tmax
- Monthly rainfall will decrease during the summer season (March to May) and increase during the rainy season (June to October)

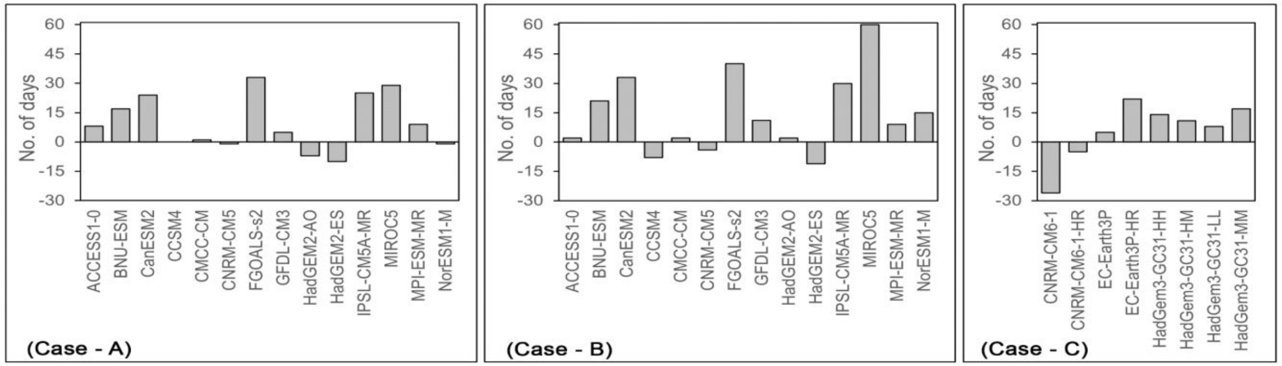


Results

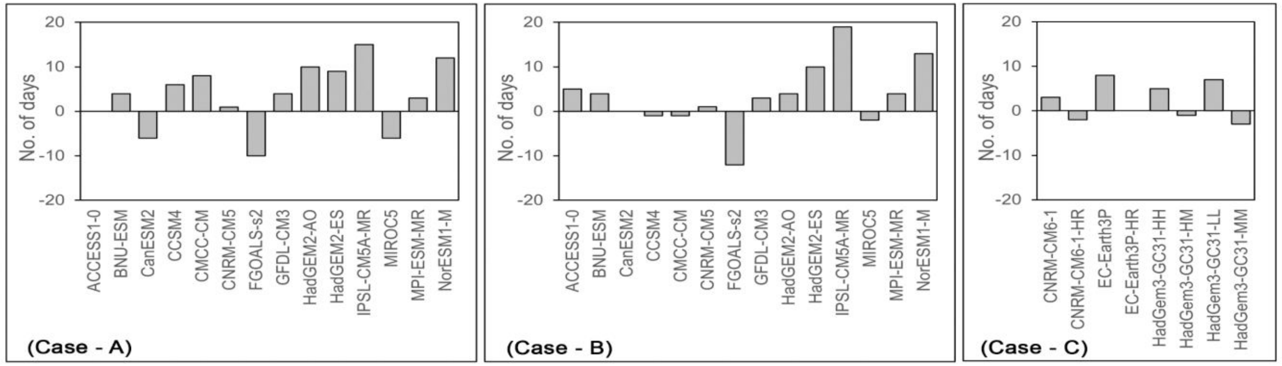
Projected change in the onset, retreat, and the length of the rainy season

- Delayed onset
  - 9/14 models for Case A
  - 11/14 models for Case B
  - 6/8 models for Case C
- Delayed retreat
  - 10/14 models for Case A
  - 9/14 models for Case B
  - 4/8 models for Case C

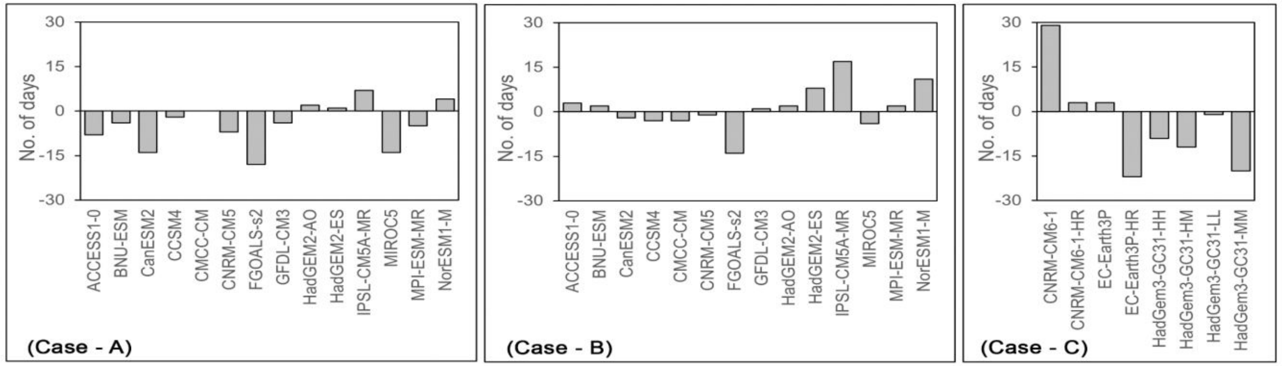
Major implications for agricultural activities since cultivation is primarily rainfed



(a) Projected shift in the onset date of the rainy season



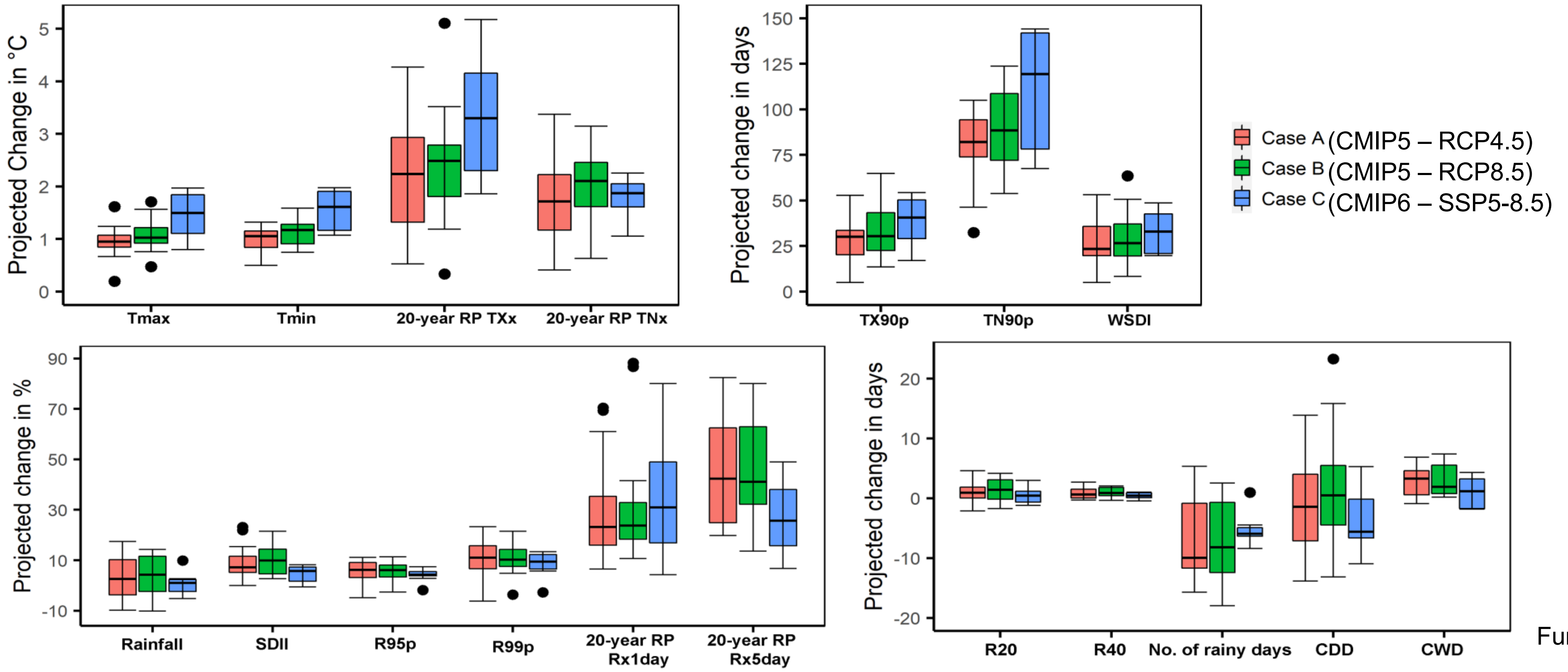
(b) Projected shift in the retreat date of the rainy season



(c) Projected change in the length of the rainy season

Results

Climate extremes in near-future



- Increase in temperature extremes > mean temperature
- Increase in number of warmer nights will be more than twice compared to warmer days
- Rainfall intensity on average will increase between 5-10%
- Annual number of rainy days will decrease by 6-8 days

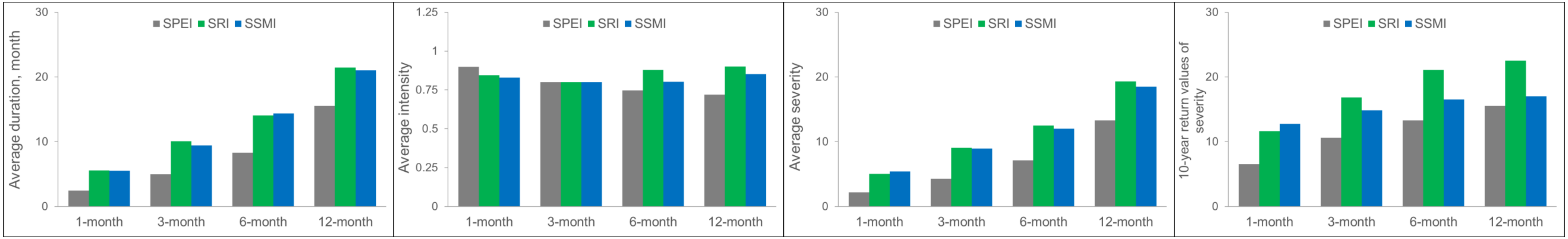
Further details

Khadka, D., Babel, M. S., Collins, M., Shrestha, S., Virdis, S. G. P., Chen, A. S. (2022) 'Projected changes in the near-future mean climate and extreme climate events in northeast Thailand', International Journal of Climatology. John Wiley & Sons, Ltd, 42(4), pp. 2470–2492. doi: https://doi.org/10.1002/joc.7377.

Results

Drought Assessment

- Meteorological Droughts – Standardized Precipitation Evapotranspiration Index (SPEI)
- Hydrological Droughts – Standardized Runoff Index (SRI)
- Agricultural Droughts – Standardized Soil Moisture Index (SSMI)



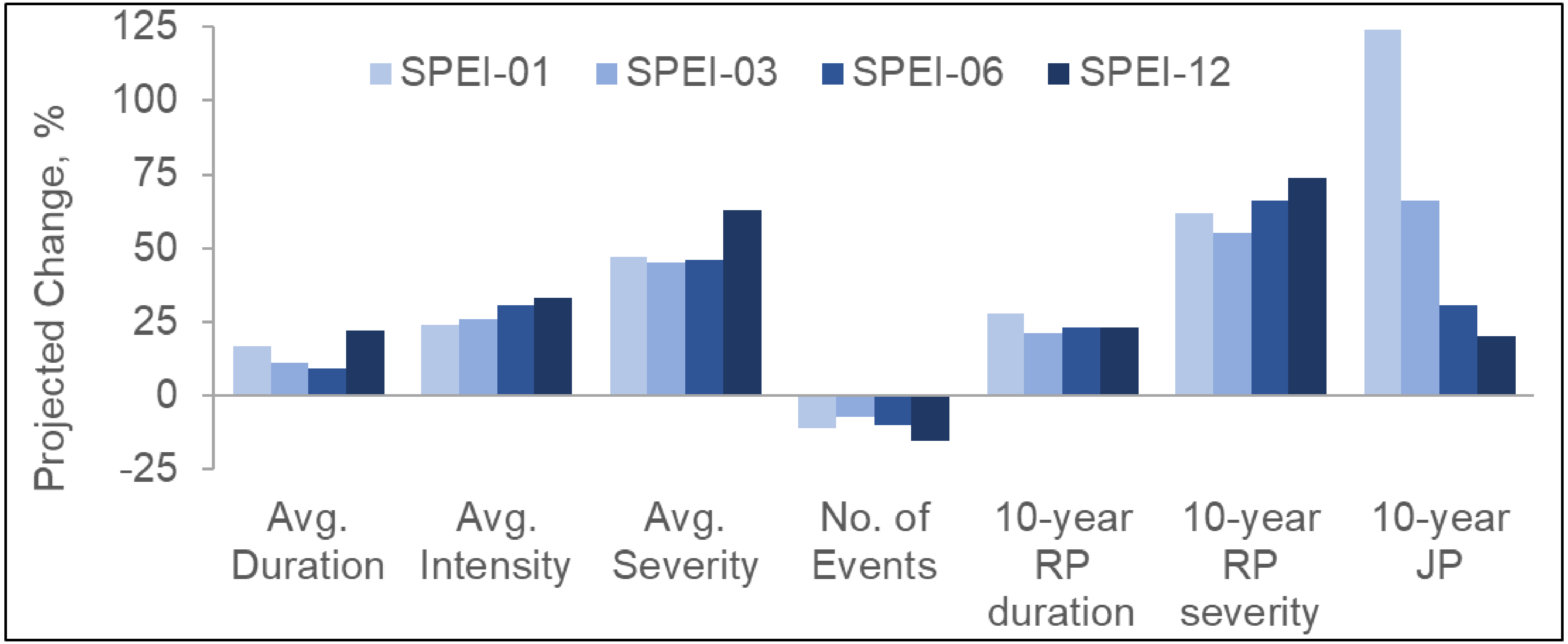
- Higher variability of rainfall results in higher number of meteorological droughts with shorter duration.
- The rainfall variability when propagating through the hydrological processes is attenuated and thus the hydrological and agricultural droughts are lesser in number but are longer in durations and higher in severities.

Further details

Khadka, D., Babel, M. S., Shrestha, S., Virdis, S. G. P., Collins, M. (2021) 'Multivariate and multi-temporal analysis of meteorological drought in the northeast of Thailand', Weather and Climate Extremes, 34, p. 100399. doi: https://doi.org/10.1016/j.wace.2021.100399.

Results

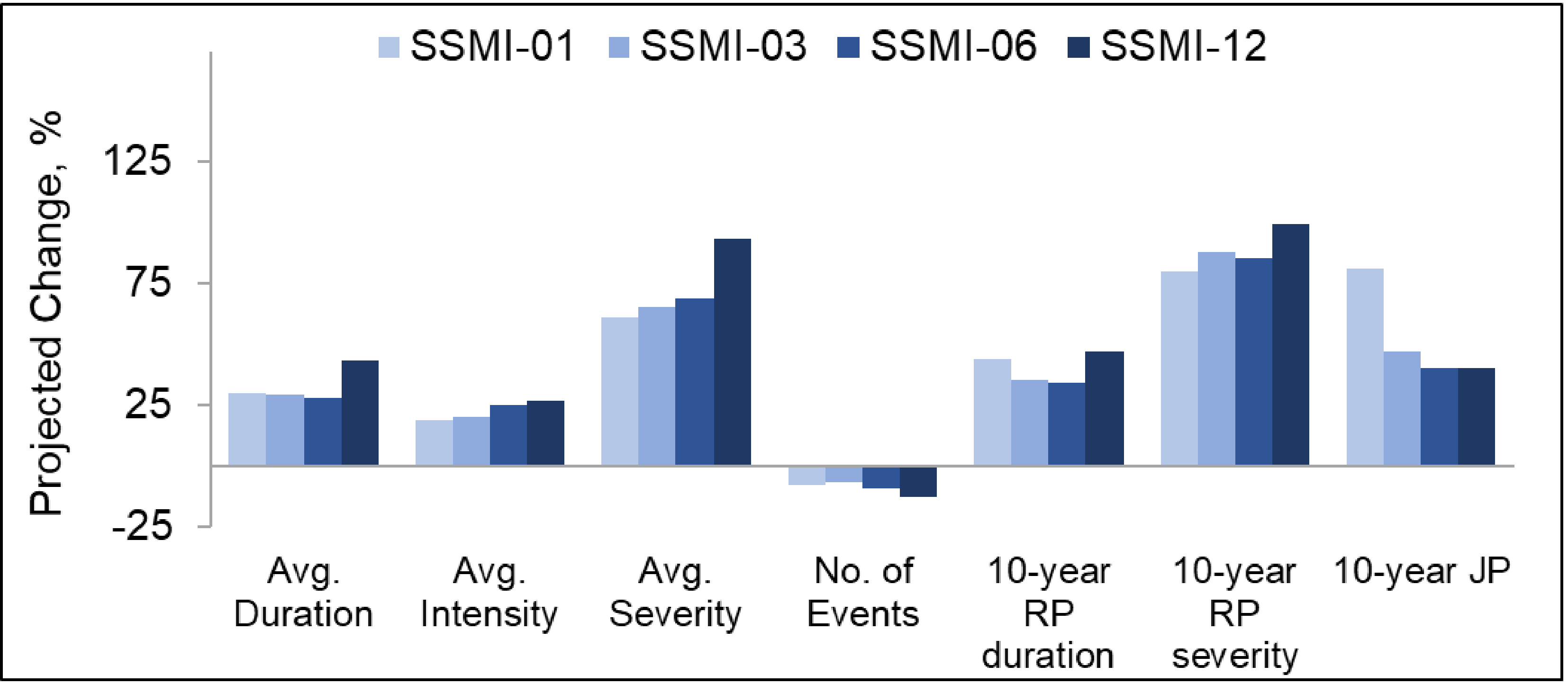
Future drought Assessment under climate change – Meteorological

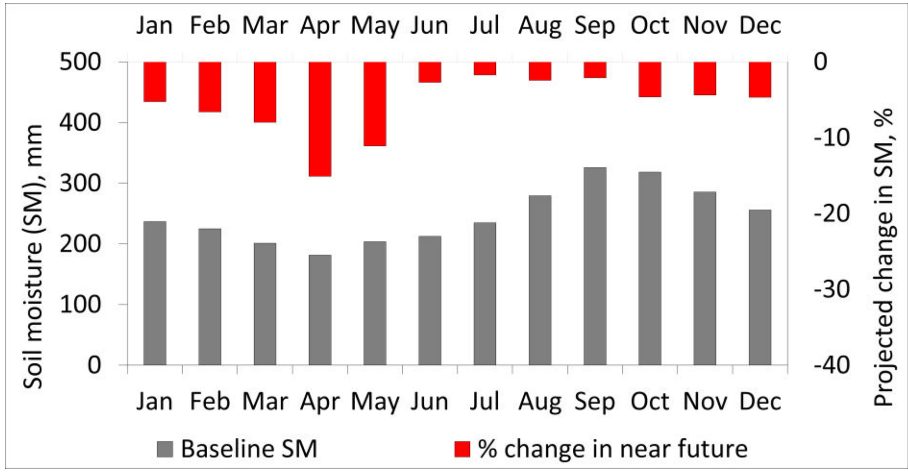


- Droughts will be **longer and more severe** in the near-future period (2021-2050) w.r.t. baseline
- **Increase** in **Evapo-transpiration demand (4%)** and higher **rainfall variabilities (35%)** are driving factors for future droughts

Results

Future drought Assessment under climate change – Agricultural





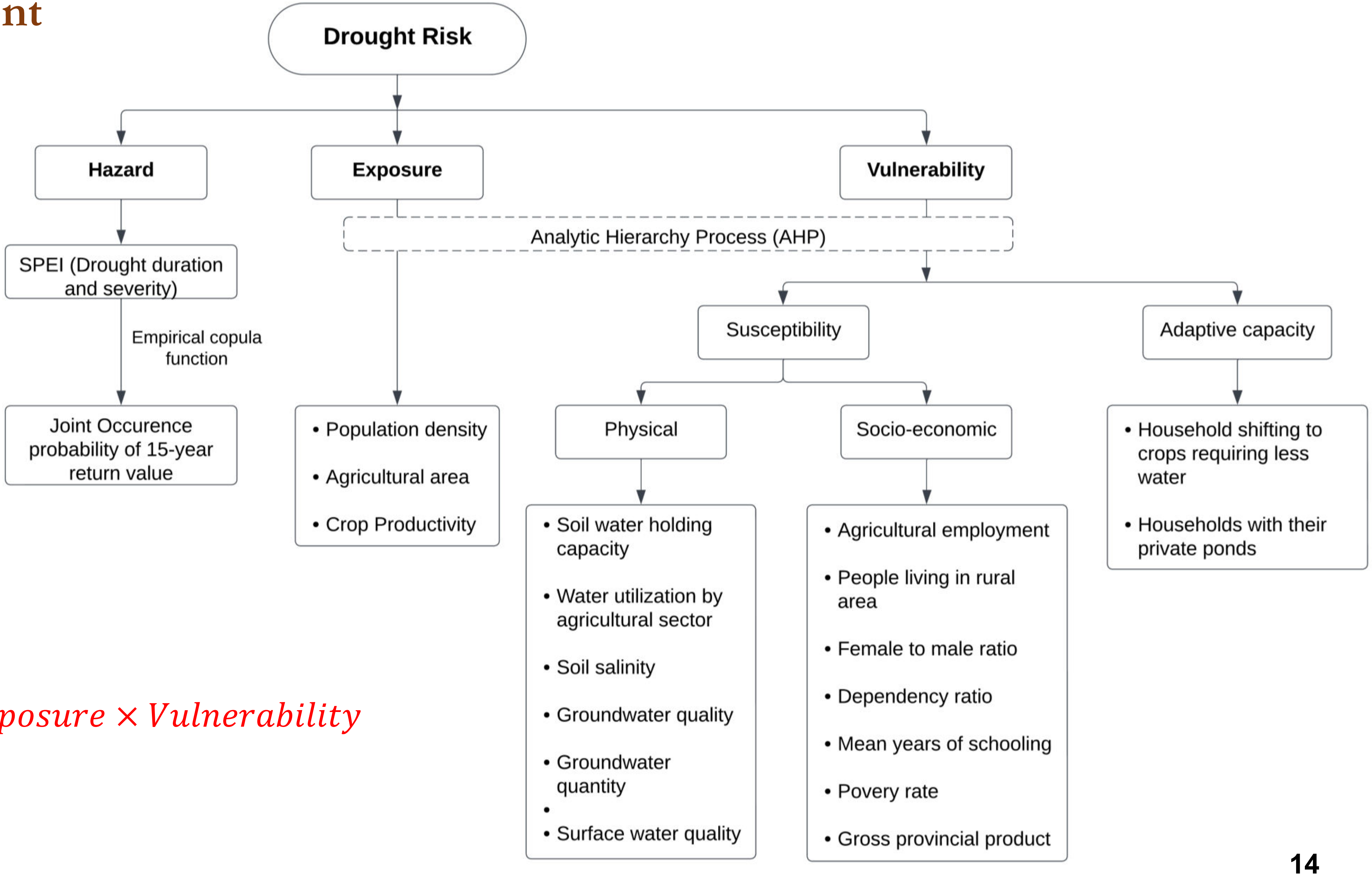
Soil moisture in future will decrease due to

- Increase in evaporative demands due to temperature rise
- Increase in the surface runoff predominantly due to increase rainfall intensities thus less opportunities for infiltration

Projected increase in the Severities and Durations of agricultural droughts are higher than for meteorological droughts

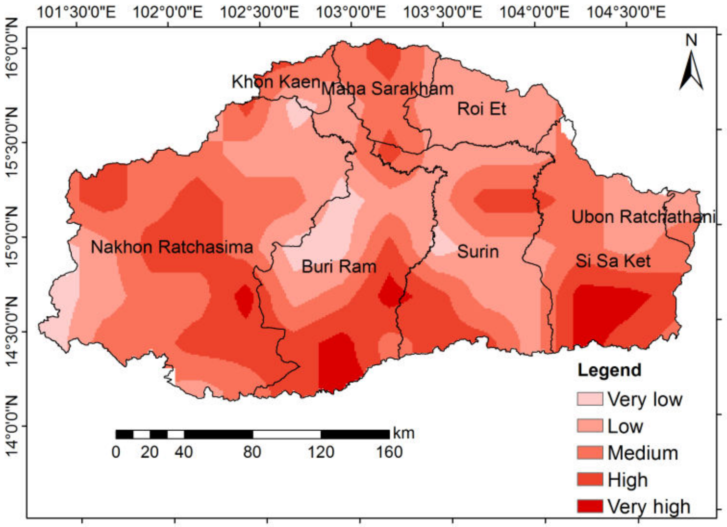
Results

Drought Risk Assessment

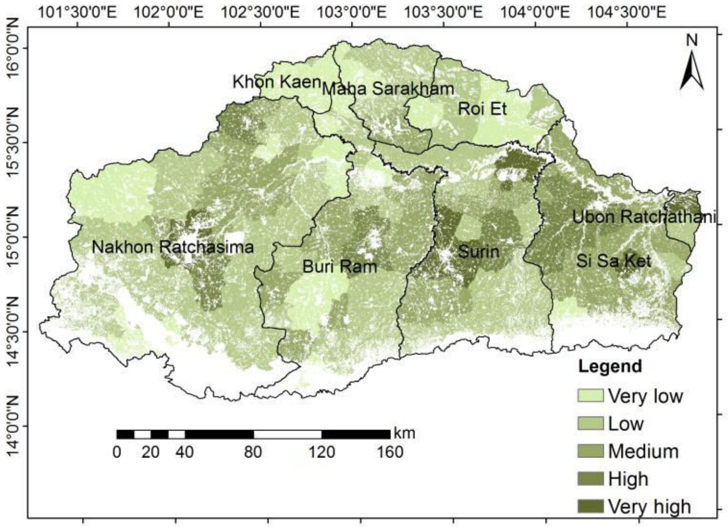


$$Risk = Hazard \times Exposure \times Vulnerability$$

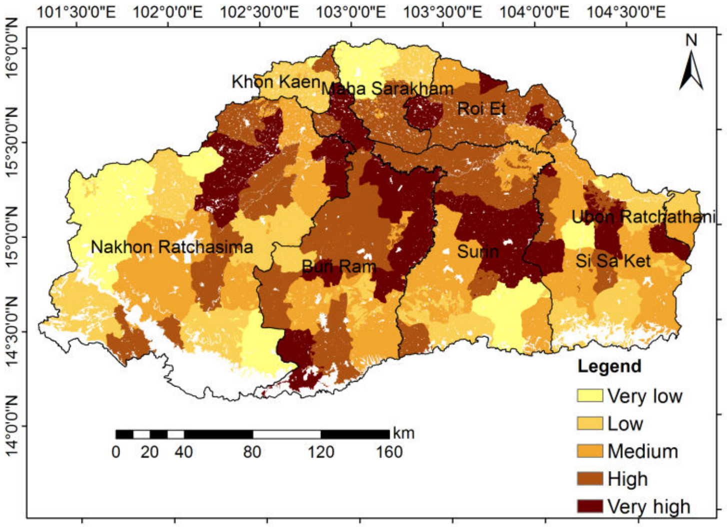
Results



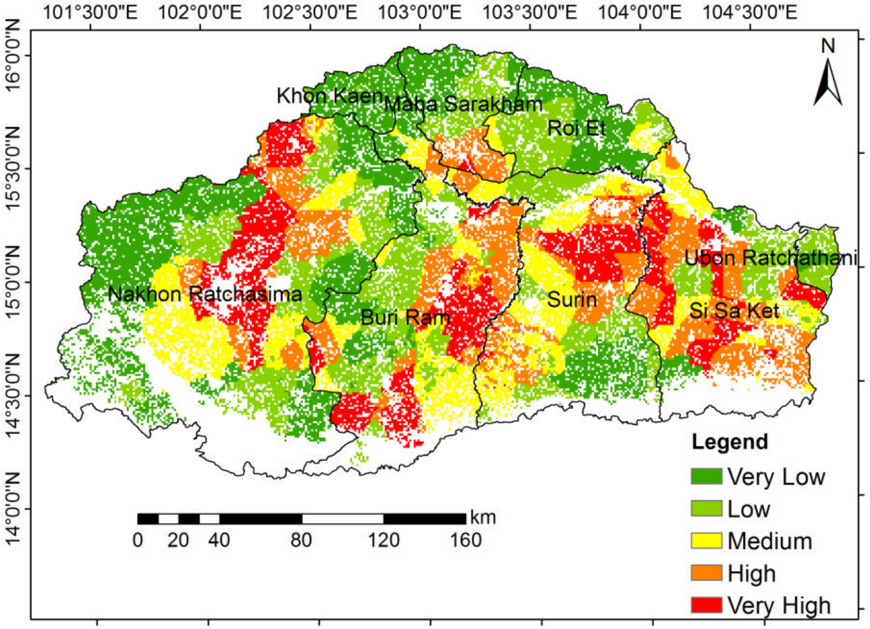
Hazard



Exposure



Vulnerability

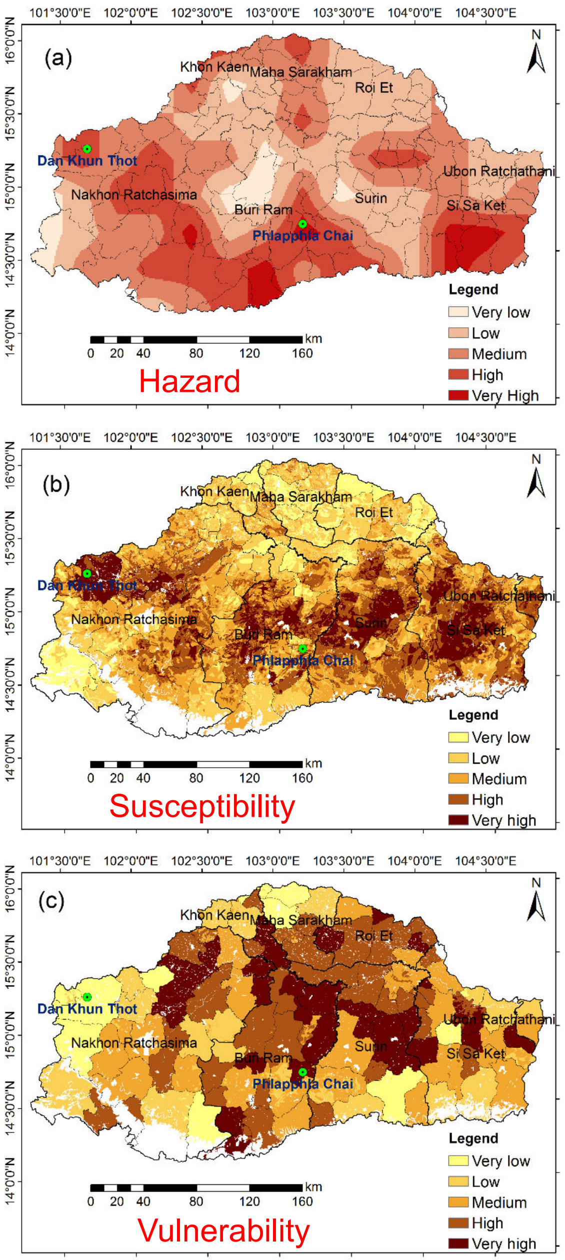


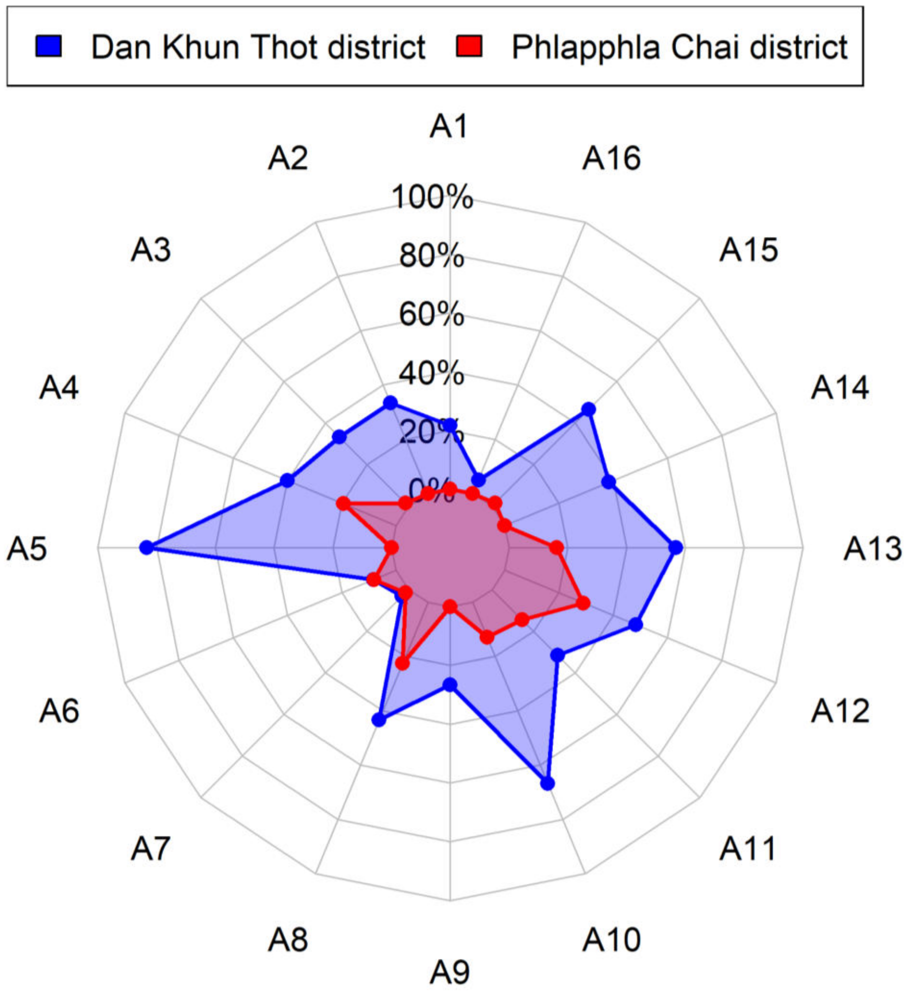
Drought Risk

Level of Risk	**% of basin area**
Low to very low	32%
Medium	12%
High to very high	22%
No risk	33%

Results

Household survey of 120 families in two hot spot districts





Code	Adaptation measures
A1	Restriction of the irrigation of some crops
A2	Capacity building of relevant stakeholders such as strengthen water-user groups and farmer union
A3	Reservoir regulation
A4	Repair and complete distribution system of existing irrigation project
A5	Use of climate information to better manage agriculture in drought-prone regions
A6	The subsurface floodwater harvesting system (Manage aquifer Recharge: MAR)
A7	Conjunctive use of groundwater
A8	The ecosystem management practices of afforestation, restorestation, and conservation of forests
A9	Soil improvement
A10	Building farm ponds
A11	Shifting to crop requiring less water
A12	Use seed from previous yields
A13	Shift cropping pattern
A14	Mix planting
A15	Sprinkler or drip irrigation
A16	Adopt new farm management practices such as rice ratooning, AWD

Results

Recommended adaptation strategies and measures for the Mun river basin

S.N.	Strategies/ Measures	Description	Examples	References
1	Strategy -1: Enhancing water supply and water efficiency			
	Measure 1.1	Farm ponds Repair and complete the distribution system of existing irrigation projects.	Buriram in Northeastern Thailand, Bangladesh, Vietnam, South Africa, Africa	(Eludoyin et al., 2017; Ramamasy and Baas, 2007; UNISDR, 2009; van Steenbergen et al., 2011)
	Measure 1.2	Implement the subsurface floodwater harvesting system (Manage aquifer Recharge: MAR)	Australia, Southwest Iran, Lower Northern Thailand, India, and Uzbekistan	(Charlesworth et al., 2002; Glendenning et al., 2012; Karimov et al., 2013; Pavelic et al., 2015, 2012; Sharda et al., 2006)
2	Strategy-2: Change or improve farm management practices			
	Measure 2.1	Shifting the beginning of the growing season	Surin in Thailand, Malawi, Bangladesh, Nigeria	(Eludoyin et al., 2017; Stringer et al., 2009)
	Measure 2.2	Shift to short-duration varieties and/or crops with less water requirement	Swaziland, Botswana, Malawi, Bangladesh, Tajikistan	(Ramamasy and Baas, 2007; Stringer et al., 2009; UNISDR, 2009)

Thank you