The Mekong River Basin under Environmental Change: Evidence from Modeling Studies

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- Case studies
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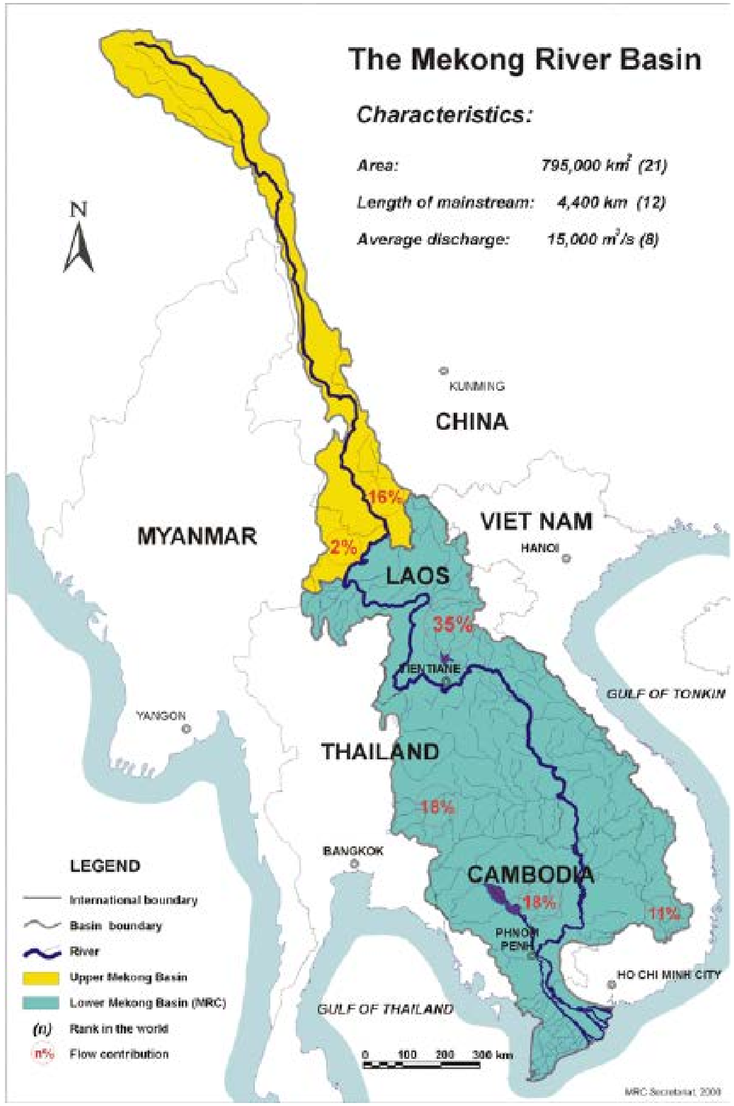
  - o Songkhram River Basin, Thailand (Climate & land use change and its impact on streamflows and water quality)

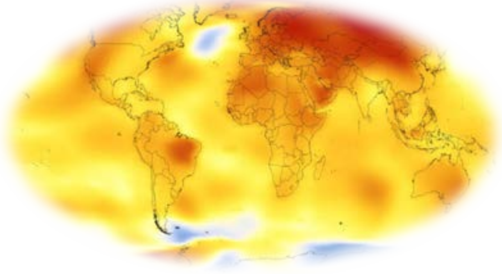
- Key challenges and ways forward

Mekong River Basin



- Transboundary River Basin shared by 6 countries: China, Myanmar, Thailand, Laos, Cambodia and Vietnam
- The Mekong River Basin is a living place for more than 60 million people settling mainly along the main river and its tributaries.
- The 4,400 km long Mekong River collects and supplies water for a large basin of nearly 795,000 km^2.
- The Mekong River plays an important role in the supply of water resources for food production, energy generation and ecological sources.

Environmental Issues in Mekong River Basin



Climate Change

Landuse Change

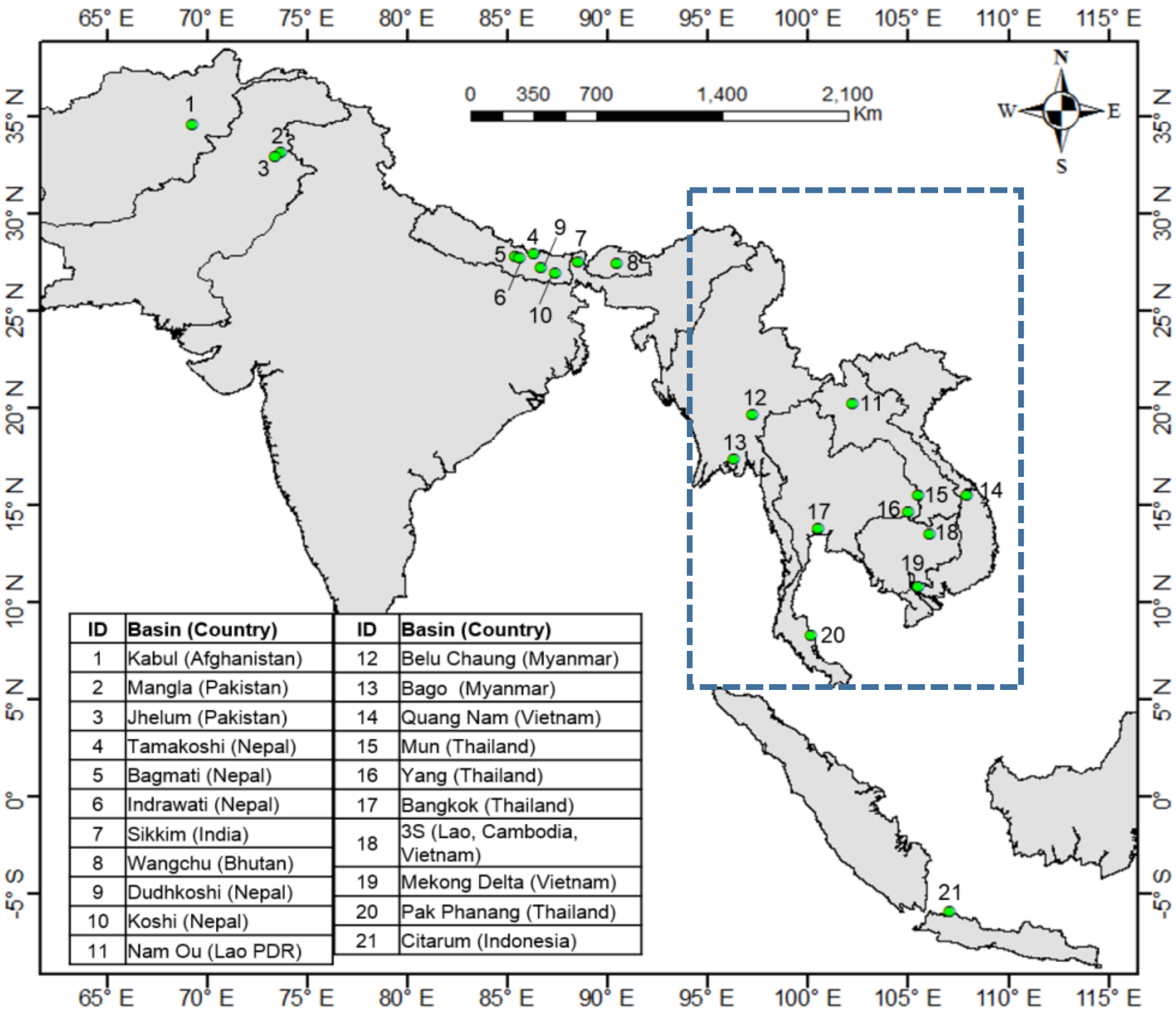
Dam Development

Water Resources Management Questions

How the changes (climate change, landuse change and hydropower development) impact the water resources?

How to manage water resources under climate change, landuse change and hydropower development?

Study Areas in Mekong Basin

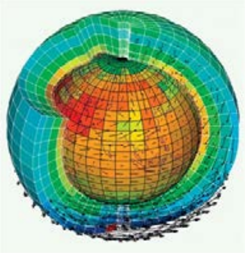


No.	Basin, Country	Location (Lat, Long)	Area (km^2)	Altitude (masl)	Climate	Rainfall (mm/yr)
1	Kabul, Afghanistan	34.52, 69.17	76,908	5,000	Arid	1,035
2	Mangla, Pakistan	33.13, 73.63	33,342	4,000	Sub-	1,200
3	Jhelum, Pakistan	32.93, 73.37	33,342	3260	Sub-	1265
4	Tamakoshi, Nepal	27.88, 86.27	2,926	4,082	Sub-tropical	1,900
5	Bagmati, Nepal	27.78, 85.30	3,750	1,400	Sub-tropical	1,300
6	Indrawati, Nepal	27.67, 85.56	1,240	3,200	Sub-tropical	3,000
7	Sikkim, India	27.52, 88.50	7,096	3,800	Sub-	3,050
8	Wangchu, Bhutan	27.45, 90.43	4,000	2,500	Sub-tropical	2,200
9	Dudhkoshi, Nepal	27.23, 86.60	3,718	4,650	Sub-	1,930
10	Koshi, Nepal	26.90, 87.30	69,300	4,032	Tropical-	1,800
11	Nam Ou, Lao PDR	20.22, 102.20	26 ,180	1,150	Tropical	1,700
12	Belu Chaung,	19.66, 97.20	8,329	760	Tropical	1,273
13	Bago, Myanmar	17.33, 96.29	4,883	30	Tropical	2,500
14	Quang Nam, Vietnam	15.53,107.92	10,438	690	Tropical	2,700
15	Mun, Thailand	15.47, 105.48	119,180	530	Tropical	1,080
16	Yang, Thailand	14.62, 105.00	4,145	300	Tropical	1,390
17	Bangkok, Thailand	13.75, 100.50	1,569	2	Tropical	1,500
18	3S (Laos, Cambodia,	13.50, 106.00	78,529	1,060	Tropical	2,450
19	Mekong Delta	10.77, 105.49	39,734	0.3	Tropical	1,727
20	Pak Phanang, Thailand	8.30, 100.12	422	4	Tropical	2,200
21	Citarum, Indonesia	-5.93, 107.00	6,080	800	Tropical	2,300

Location map of selected basins for climate and landuse change impact and adaptation studies

Methodology of Impact Assessment (Modeling Chain)

Future Climate Projection

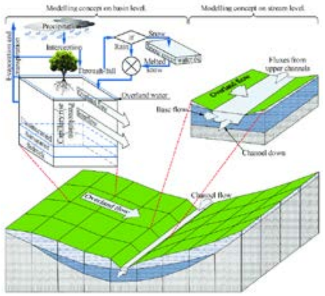


- Global Climate Model (GCMs)
- Regional Climate Model (RCMs)

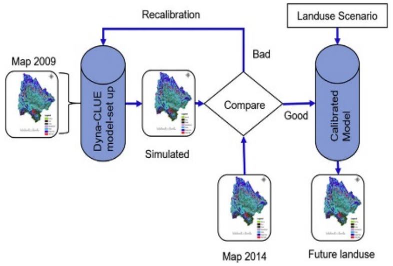
Downscaling/ Bias Correction

- Future climate at local/basin

Hydrological Modeling

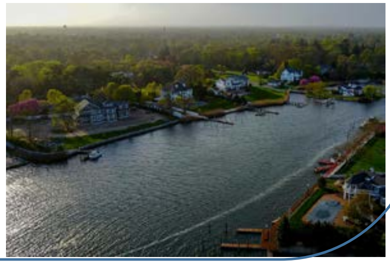


Landuse Modeling



Reservoir Modeling

Water Quality Modeling



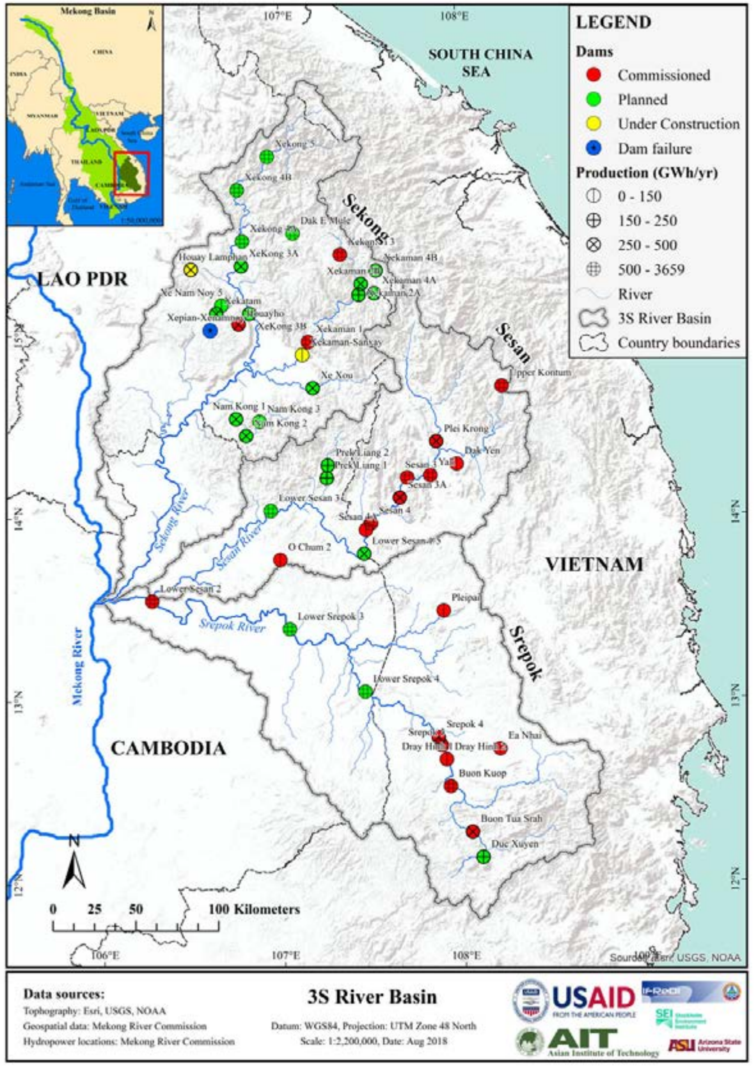
Results

- Future climate
- Future landuse
- Future streamflow
- Future hydropower
- Future water quality

Case Study 1

Assessment of Climate Change and Hydropower Development Impact on Hydrology of the Sekong River Basin in Cambodia, Laos and Vietnam

Hok Panha, M.Eng



Project: Connecting climate change, hydrology & fisheries for energy and food security in Lower Mekong Basin

Funding: USAID (PEER Program Cycle 6)

Period: 2017-2020

USG Partner: Prof. John Sabo, ASU, USA

Website: www.connect-chf.com

USAID FROM THE AMERICAN PEOPLE | AIT Asian Institute of Technology | SEI STOCKHOLM ENVIRONMENT INSTITUTE | IFReDI | ASU Arizona State University Future H₂O

Dr. Sangam Shrestha, AIT

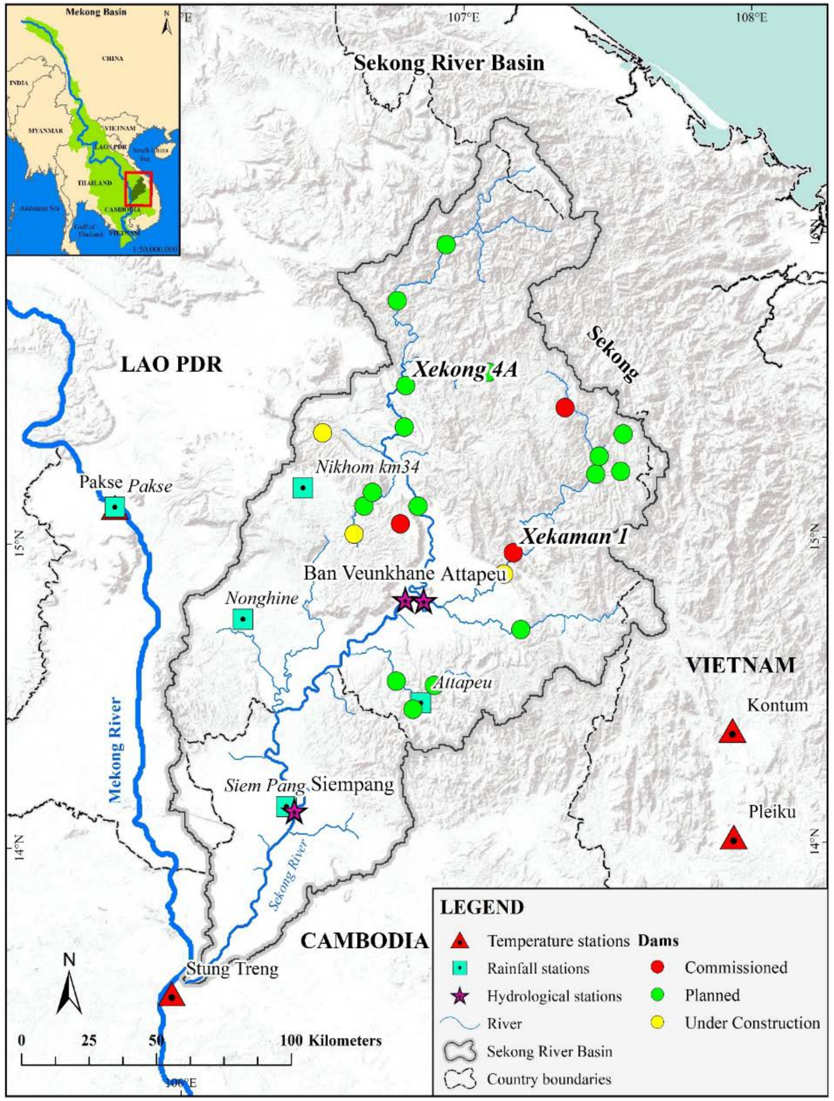
Dr. Vilas Nitivattananon, AIT

Dr. Thanapon Piman, SEI

Dr. Cheng Phen, IFReDI

Prof. John Sabo, ASU

Sekong River Basin (Cambodia, Laos and Vietnam)



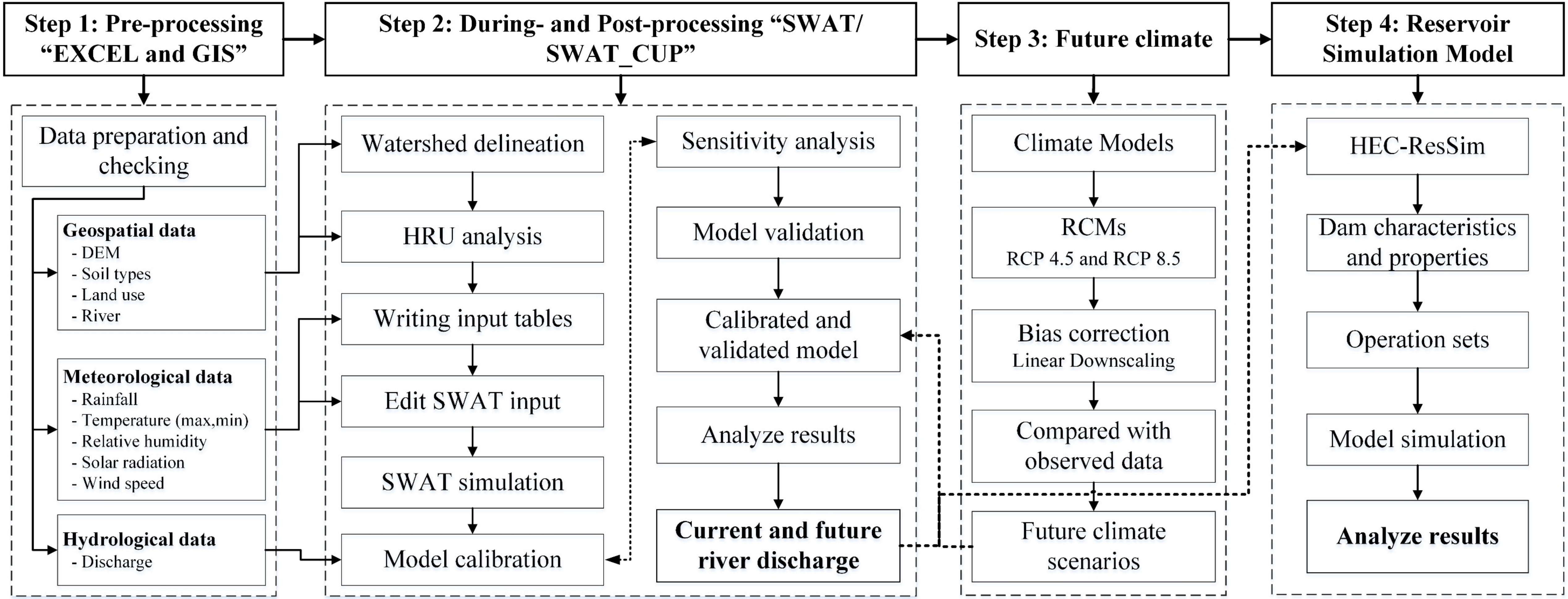
- Second largest basin among the 3S Basins containing 36% of the entire drainage area, transboundary tributary of the Mekong River
- Population: 330,000 (in 2012)
- Area; 28,816 km^2
- Average annual rainfall:1,400 to 2,900 mm
- The Sekong River inhabits: 300-350 fish species
- Currently, the basin has only three large hydropower dams. However, five more are under construction and another 16 under consideration.

Water Resources Management Questions

What will be the future climate in the Sekong River Basin?

How the climate change and hydropower development affects hydrology of the Sekong River Basin?

Methodology



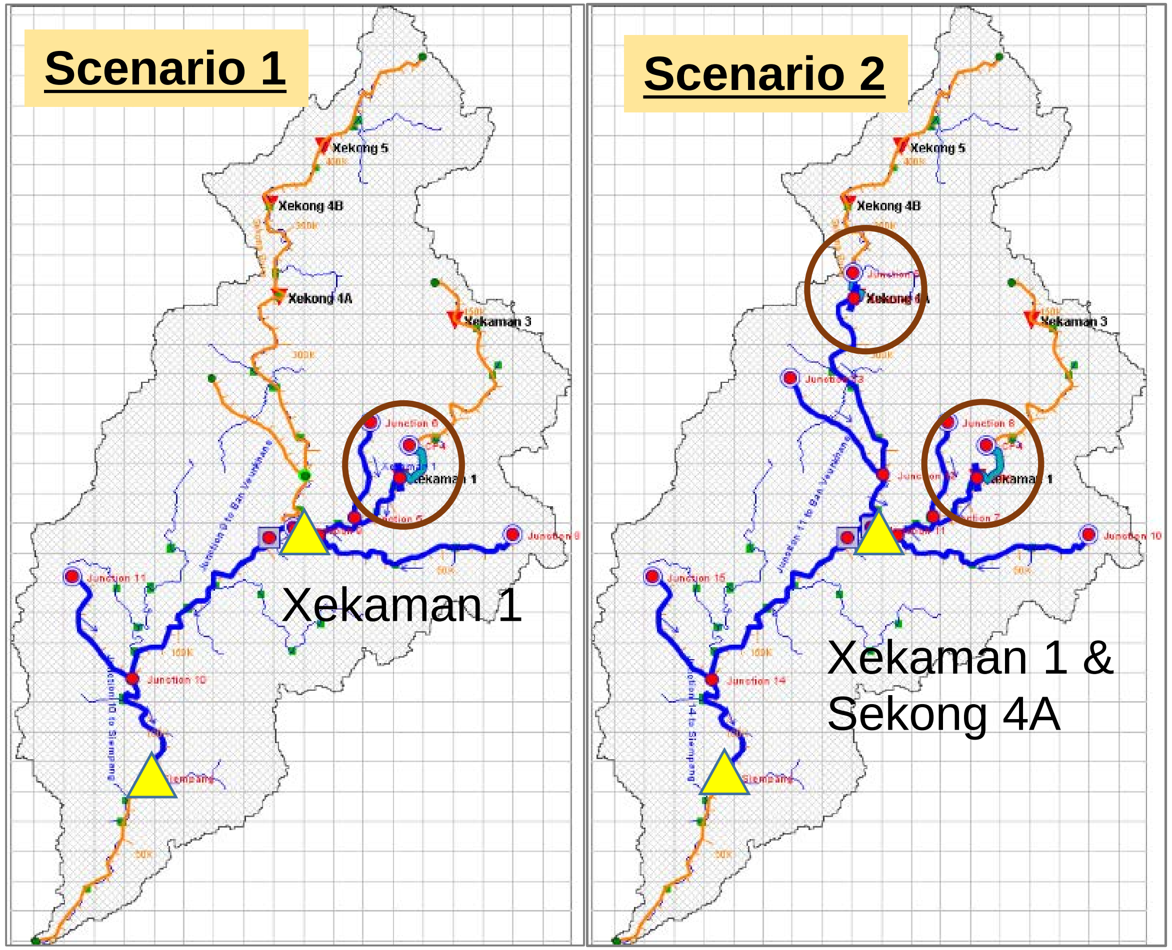
Data

Data type	Time	Frequency	Sources
Topography (DEM)	-	-	http://srtm.csi.cgiar.org
Land cover map (2003)	-	-	Mekong River Commission (MRC)
Soil types map (2003)	-	-	Mekong River Commission (MRC)
Meteorological data	1980–2011	Daily	MRC, Ministry of Water Resources and Meteorology (MOWRAM), and Department of Meteorology and Hydrology (DMH)
Hydrological data (discharge)	2001–2011	Daily	MRC, MOWRAM, and DMH
RCM data	1970–2099	Daily	http://cccr.tropmet.res.in/home/cordexsa_datasets.jsp
Dam characteristics	-	-	Piman et al., (2013) and feasibility study

Features	RCMs "Project: CORDEX"				
	ACCESS	CNRM	MPI	BCCR	REMO2009
Research Institute	Commonwealth Scientific and Industrial Research Organization, Australia				Helmholtz-Zentrum Geesthacht, Climate Service Center Germany
Vintage	2015	2015	2015	2015	2015
Resolution	0.5° × 0.5°	0.5° × 0.5°	0.5° × 0.5°	0.5° × 0.5°	0.5° × 0.5°
Driving GCM model	ACCESS1.0	CNRM-CM5	MPI-ESM-LR	NorESM-M	IPSL-IPSL-CM5A-LR

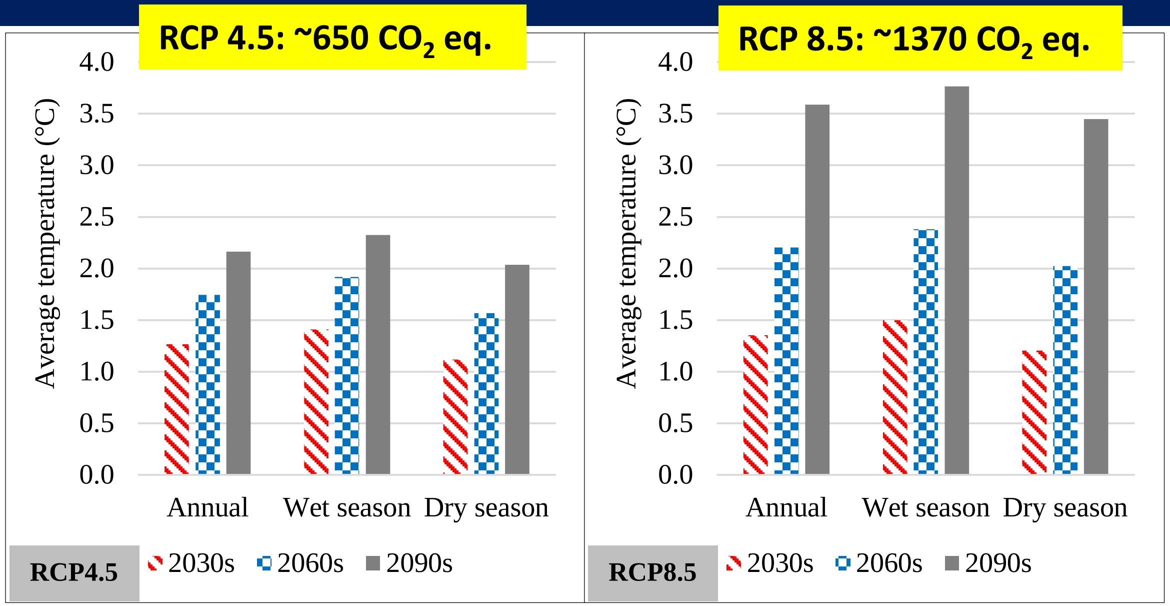
Name	Status	Drainage area (km^2)	Full supply level (m.msl)	Low supply level (m.msl)	Live storage (MCM)	Designed discharge (m^3/s)	Designed head (m)	Installed capacity (MW)	Mean energy (GWh)
Xekaman 1	Existing	3,580.0	230.0	218.0	1,683.0	336.6	99.0	290.0	1,096.0
Xekong 4A	Planning	5,182.0	200.0	180.0	654.9	400.4	50.1	175.0	785.1

Methodology



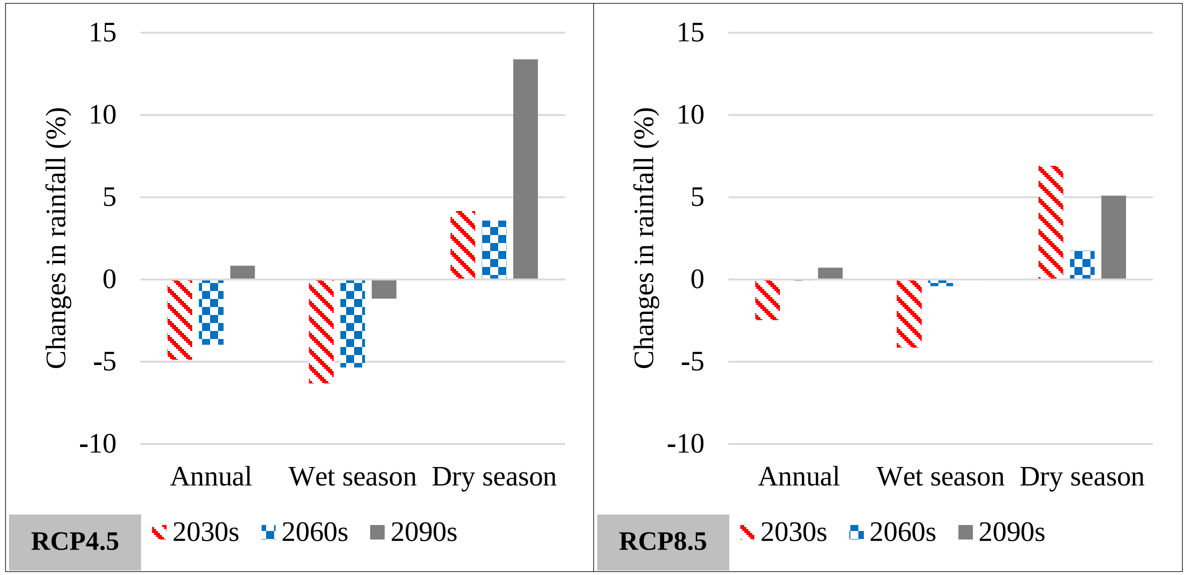
Reservoir operation schematic for the Xekaman 1 hydropower dam “Scenario 1” (left) and Xekaman 1 and Sekong 4A hydropower dams “Scenario 2” (right)

Future Climate

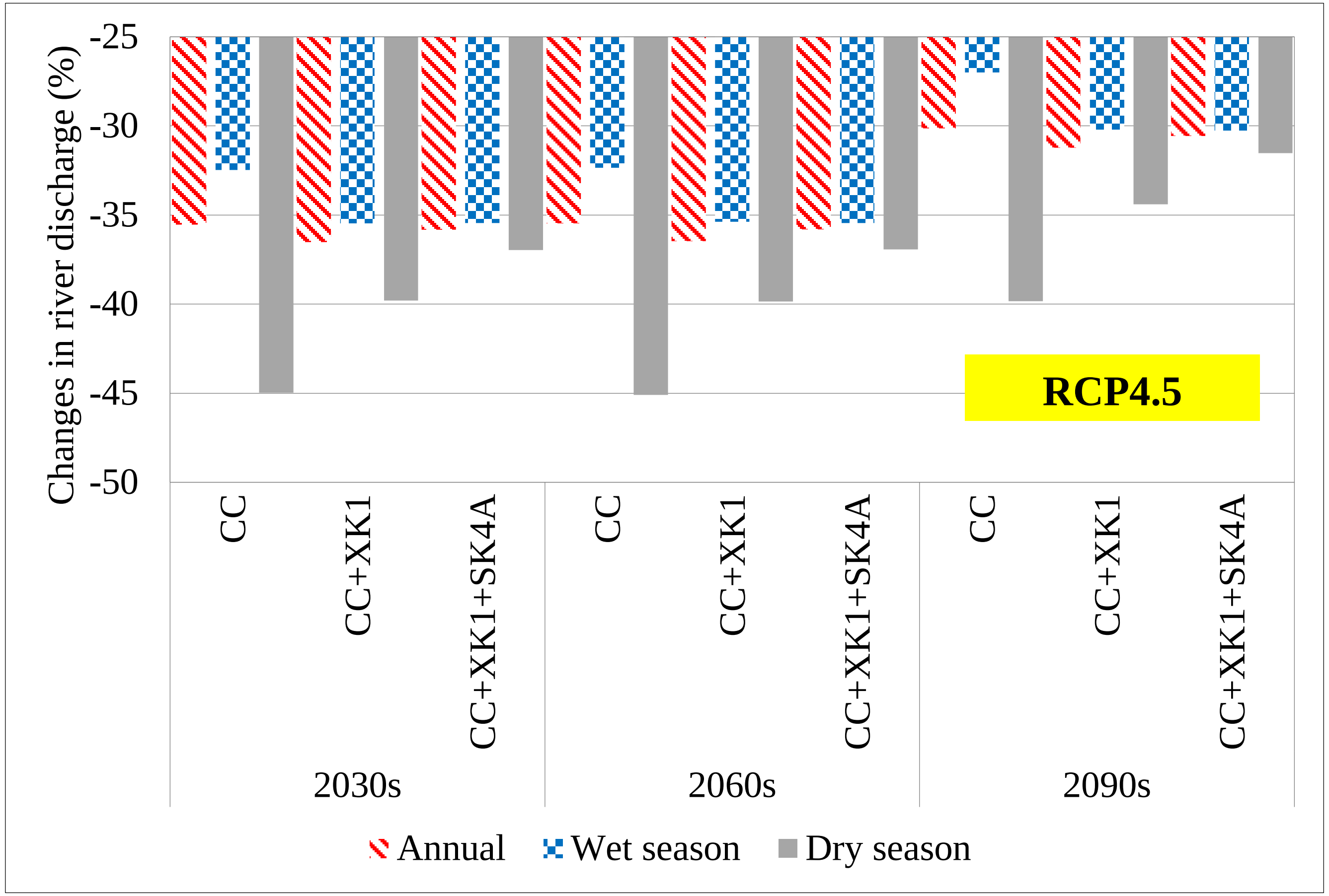


- Average annual temperature in projected to increase >2°C and 3.5°C by 2090s under RCP 4.5 and RCP 8.5, respectively.
- Higher increase in wet season temperature.

- Average annual and wet season rainfall is projected to decrease and dry season rainfall is projected to increase in future under RCP 4.5 and RCP 8.5, respectively.
- Higher increase in dry season rainfall.



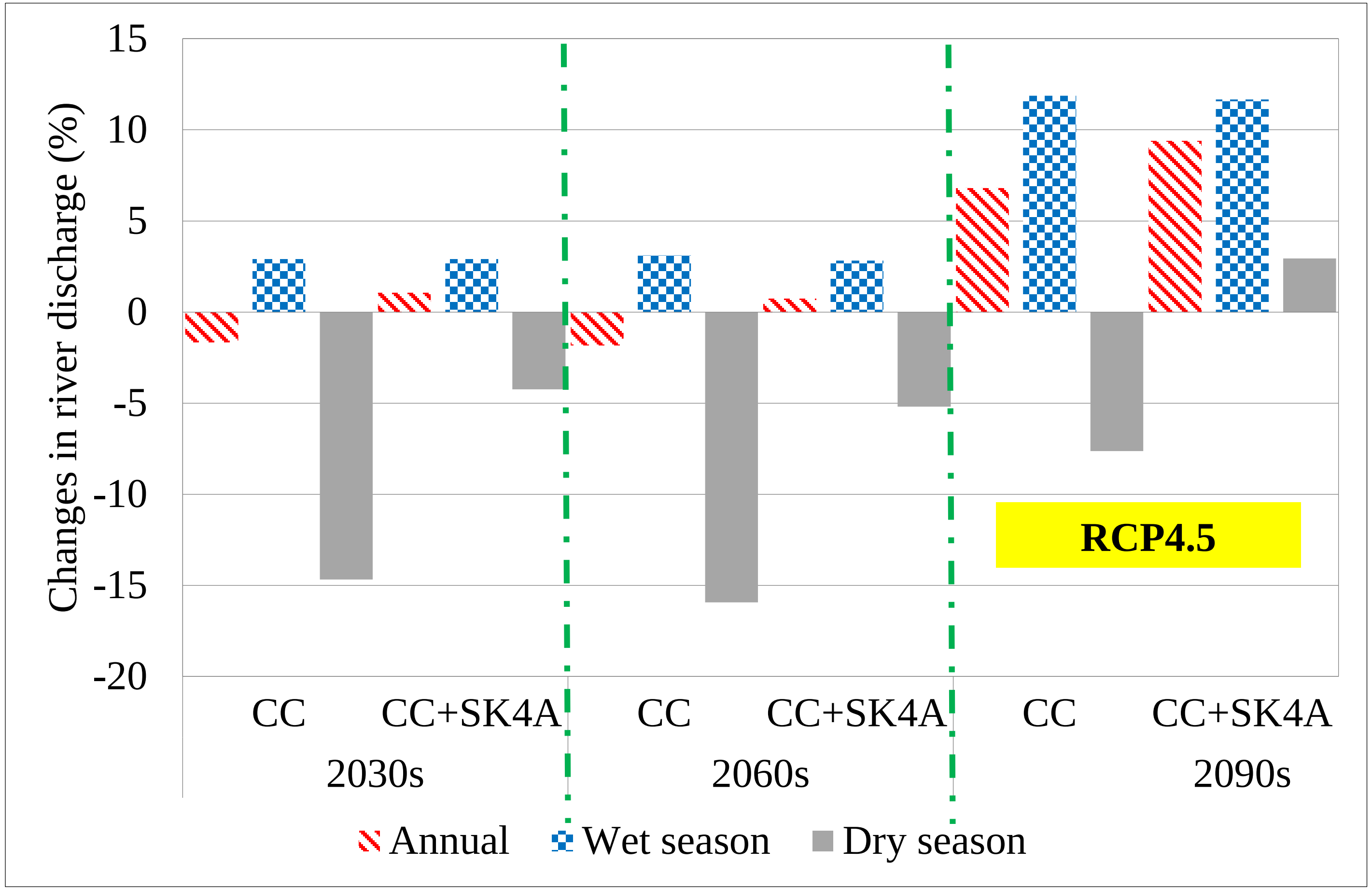
Change in River Discharge



Scenarios	Description
CC	Climate change only
CC+XK1	Climate change and Xekaman 1 hydropower (Existing)
CC+XK1+ SK4A	Climate change and Xekaman 1 (Existing) + Sekong 4A (Planed) hydropower

- Changes in discharge at **Siempang** (downstream) in the 2030s, 2060s, and 2090s from ensemble RCMs under RCP4.5 in the Sekong River Basin

Change in River Discharge



Scenarios	Description
CC	Climate change only
CC+SK4A	Climate change and Sekong 4A (Planed) hydropower

Changes in discharge at **Attapeu** (upstream) in the 2030s, 2060s, and 2090s from ensemble RCMs under RCP4.5 and RCP8.5 in the Sekong River Basin

Conclusions

- Sekong River Basin is expected to be warmer with variability of rainfall in future.

- Climate change and hydropower operation will reduce the river discharge at the downstream (Siempang) in future.

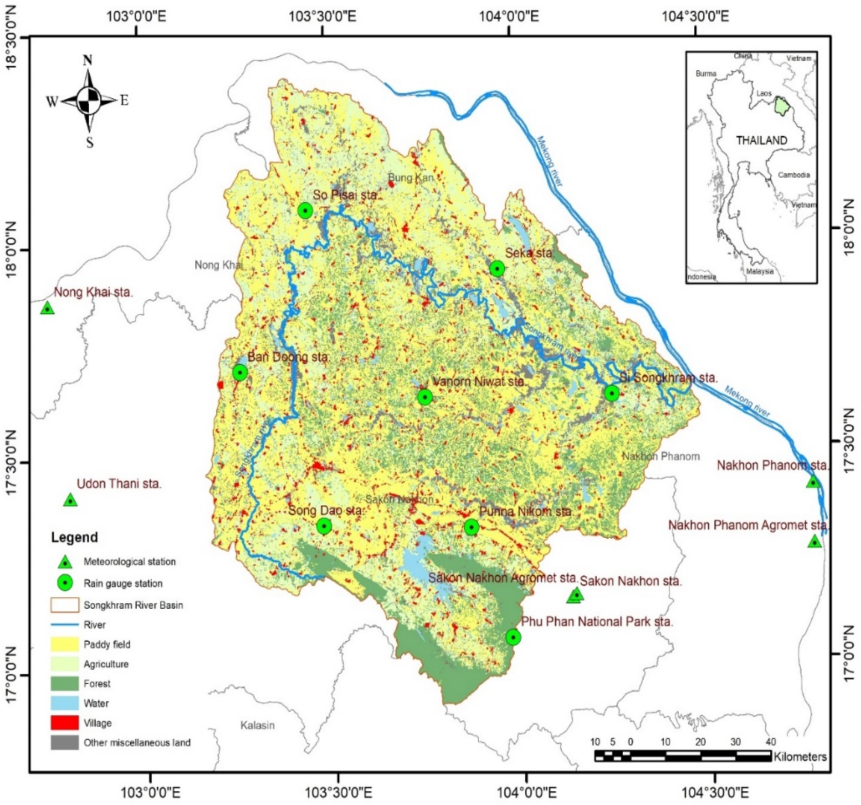
- In upstream (Attapeu) annual and dry season river discharge is expected to decrease and wet season discharge is expected to increase in near and mid future.

- River discharge is seen to be more impacted by climate change compared to hydropower operation in future.

Case Study 2

Assessment of Climate and Land use Change Impact on Streamflow and Water Quality in the Songkhram River Basin, Thailand

Binod Bhatta, M.Eng



Project: Building Capacity and Strengthening Community Participation for Water Resources Management and Wetland Ecosystem Restoration in the context of Climate Change in Lower Songkhram River Basin, Thailand

Funding: HSBC

Period: 2015-2018

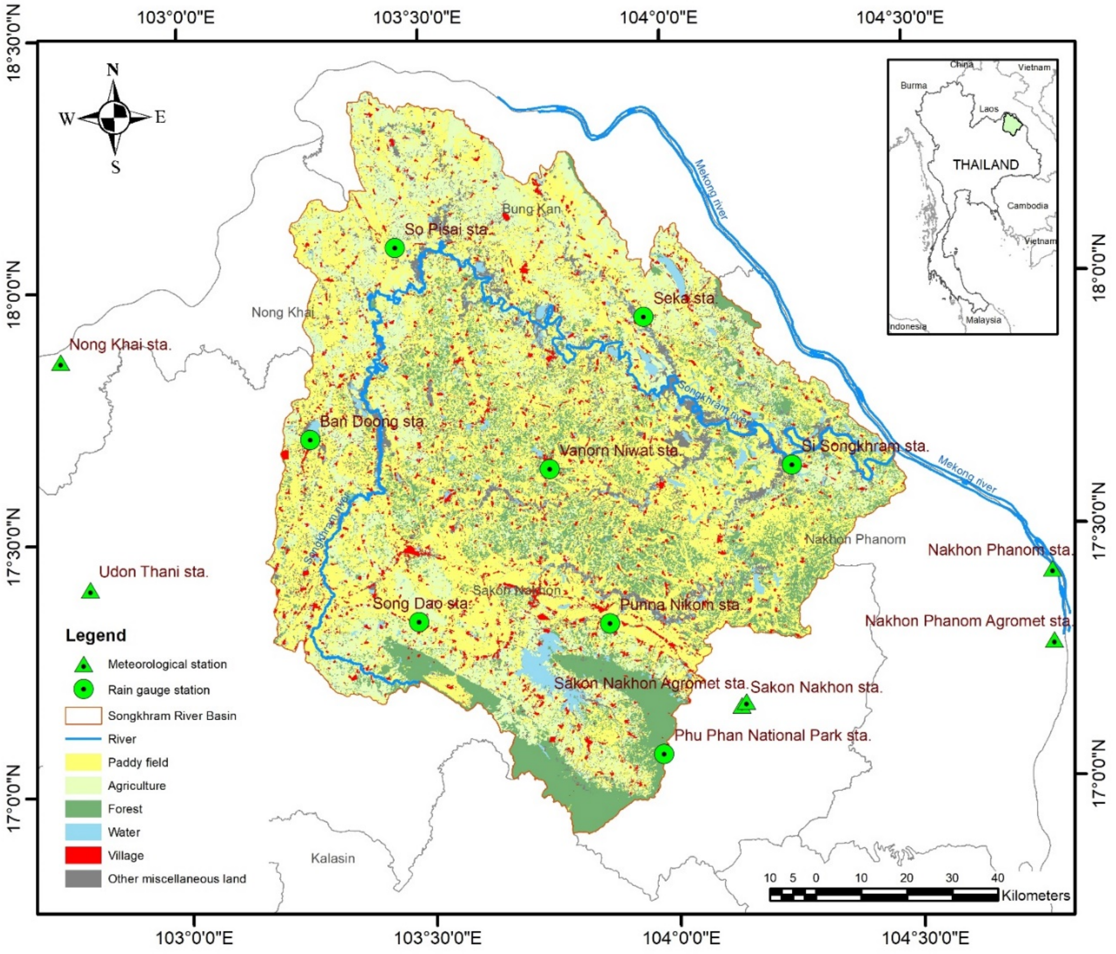
Partner: WWF- Thailand

Website: www. wetlandwatchthailand.org

Dr. Sangam Shrestha,
AIT

Mr. Amornwatpong Khemratch,
WWF

Songkhram River Basin (SRB), Thailand



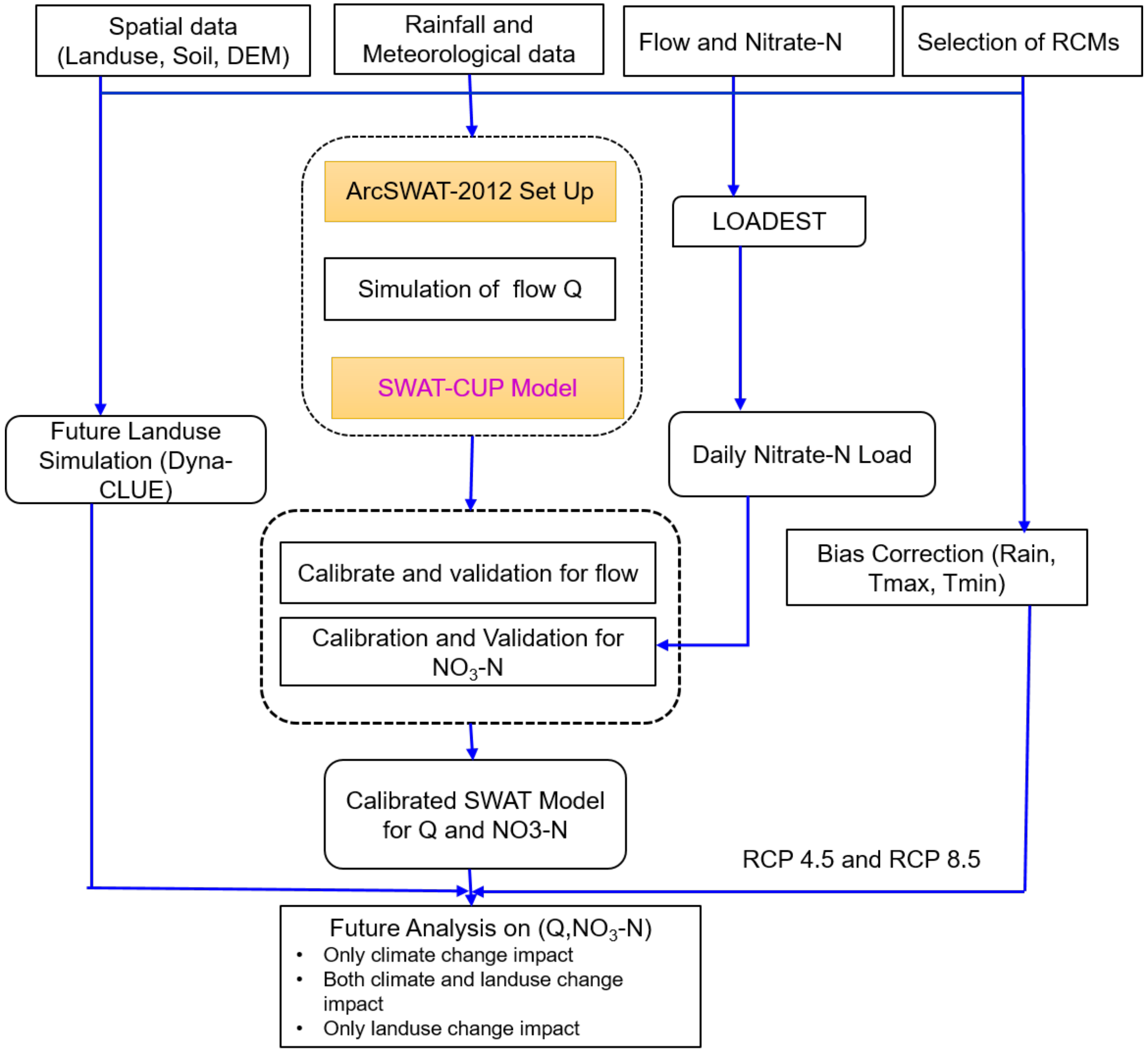
- Second largest basin in Northeast Thailand
- Population: 1.94 million (in 2000)
- Drainage area: 12,880 km^2 , total length of river: 420 km, flows to Mekong River
- Temperature: 10- 40º C
- Annual rainfall: 1200mm (South); 2100mm (North) [90% rainfall in monsoon]
- Annual average flow $350 m^3/s$ ~(860mm)
- Landuse: 48% Agriculture
- Wetland of International Importance

Water Resources Management Questions

What will be the future climate and landuse and landcover in SRB?

How the climate change and landuse& land cover change impact the streamflow and water quality of SRB?

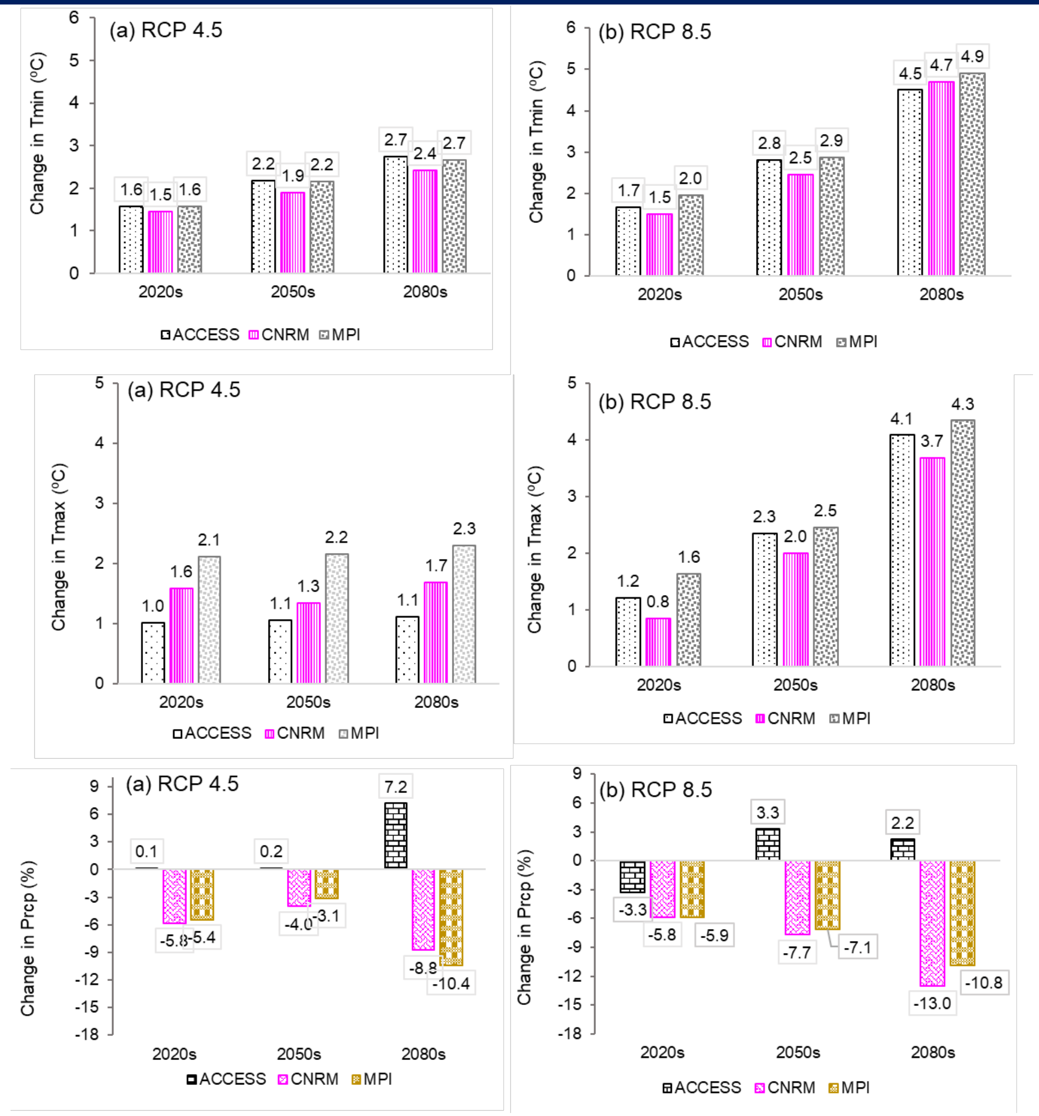
Methodology



Data

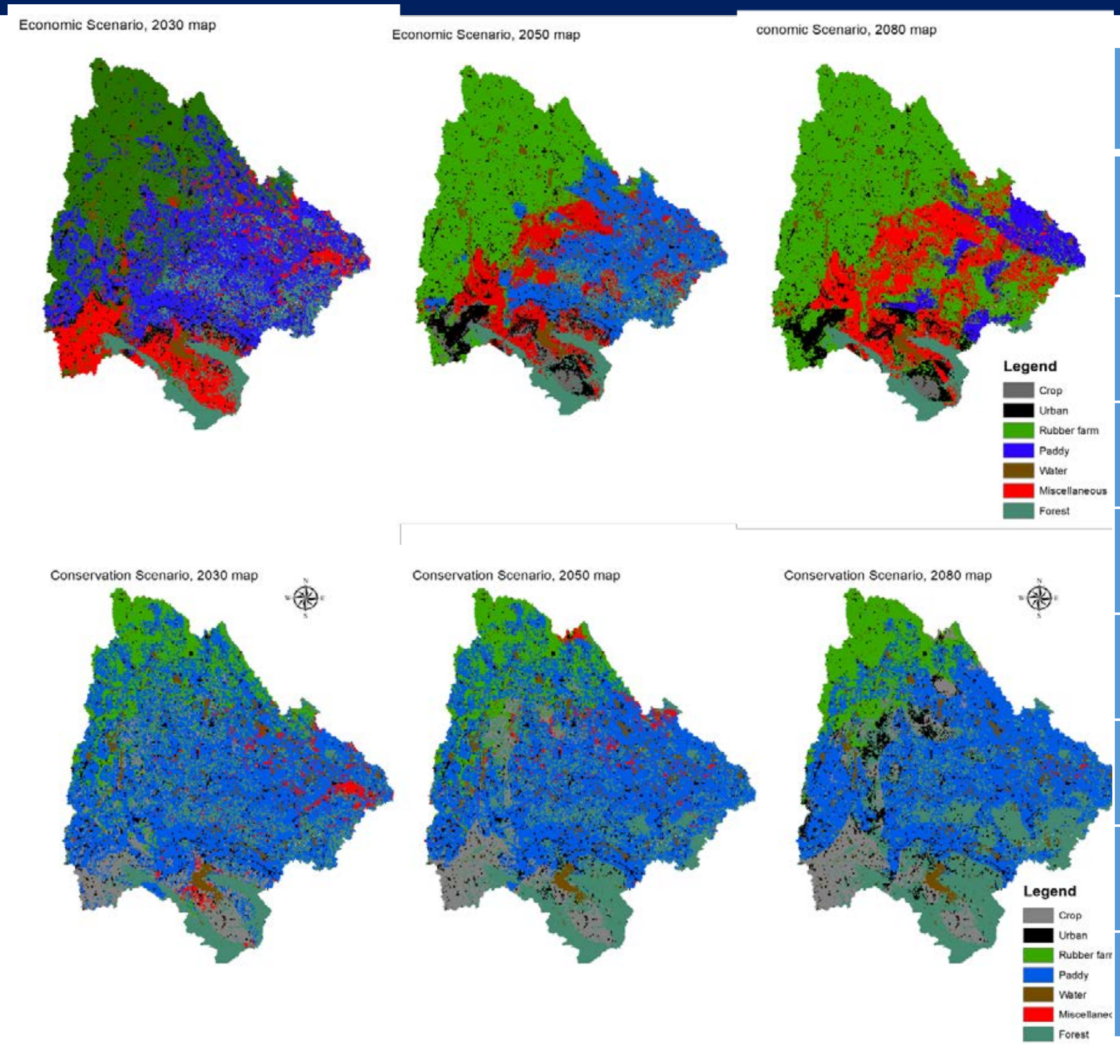
SN	Data	Source/Developer	Spatial/ Temporal Resolution		Number/Time Period
Physical characteristics of the catchment					
1	Elevation	ASTER GDEM version 2	30 m/-		-
2	Soil	FAO/UNESCO—the digital soil map of the world	1:5,000,000/-		-
3	Landuse	Land Development Department (LDD) Thailand	1 km/-		2 maps—2009, 2014
Time series observations					
1	Meteorology	Thai Meteorological Department (TMD)	Point/Daily		30 (rain stations), 6 (climatic stations)/1975–2014
2	Hydrology	Royal Irrigation Department (RID) Thailand	Point/Daily		1 station/1990 –2014
3	Water Quality	Pollution Control Department (PCD) Thailand	Point/3 to 4 times a year		9 stations/2005– 2015
RCMs data for future climate projections				Parent GCM	
1	ACCESS-CSIRO-CCAM	Collaboration for Australia Weather and Climate Research, Australian Government	0.5^0/ Daily	ACCESS1.0	RCP 4.5 and 8.5 / 1975–2099
2	CNRM-CM5-CSIRO-CCAM	National Centre for Meteorological Research	0.5^0/ Daily	CNRM-CM5	RCP 4.5 and 8.5 / 1975–2099
3	MPI-ESM-LR-CSIRO-CCAM	European Network for Earth System Modelling	0.5^0/ Daily	MPI-ESM-LR	RCP 4.5 and 8.5/1975–2099

Future Climate



- Minimum temperature (Tmin) likely to increase by 2.7 and 4.5 °C by 2080s under RCP 4.5 and RCP 8.5 respectively.
- Maximum temperature (Tmax) likely to increase by 2.3 and 4.3 °C by 2080s under RCP 4.5 and RCP 8.5 respectively.
- Rainfall is projected to decrease in future. However it is projected to increase by 7% and 2% by 2080s under RCP 4.5 and RCP 8.5 respectively (ACCESS).

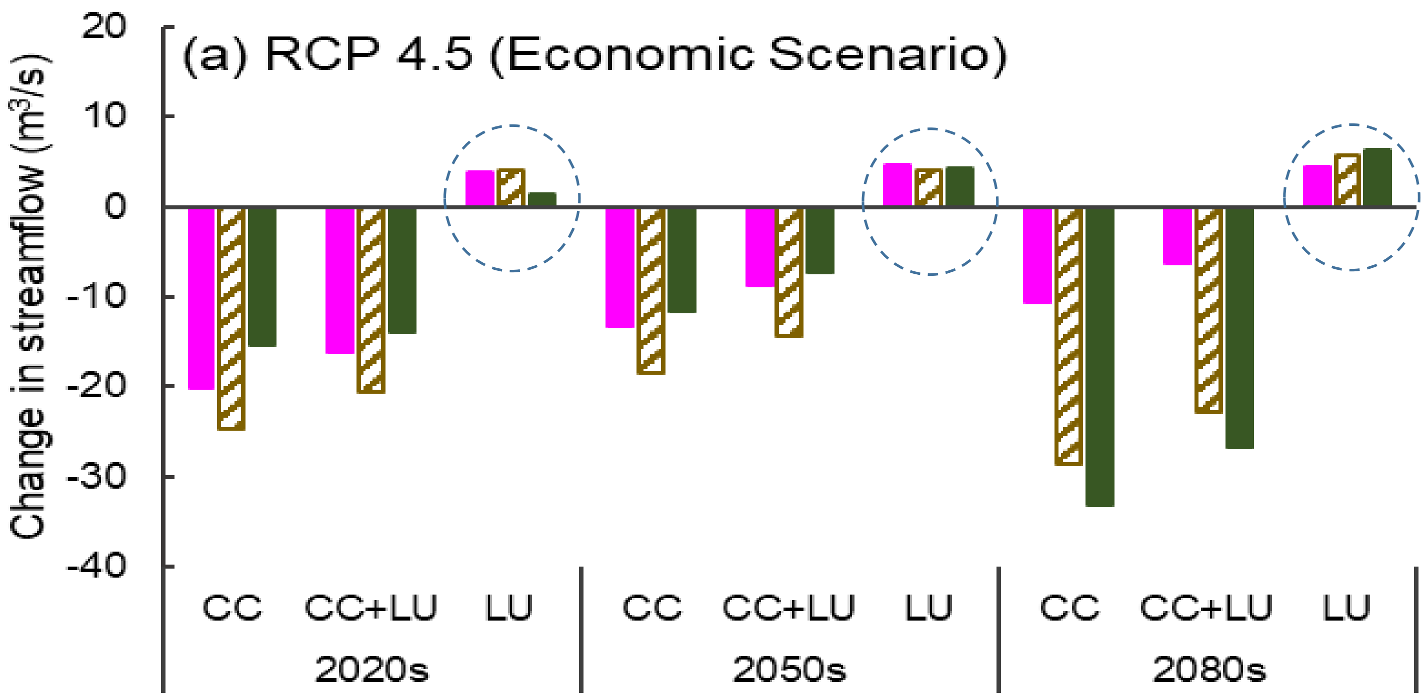
Future Landuse



Projected landuse area (km²) in the SRB during the years 2030, 2050, and 2080, and relative changes (%) with respect to the baseline area of 2009

Landuse type (km²)	Economic			Conservation		
	2030	2050	2080	2030	2050	2080
Crop (764.2)	0 (-100)	337.5 (-55)	125.2 (-84)	1155.43 (51)	1150.2 (50)	1281.43 (67)
Urban (492.4)	***642.24 (30)***	***994.12 (102)***	***1081.81 (120)***	483.5 (-2)	546.4 (11)	853.12 (74)
Rubber farm (1876.27)	***3954.9 (110)***	***4814.37 (156)***	***6807.25 (262)***	1768.7 (-6)	1571.84 (-16)	1601.75 (-15)
Paddy (6165.38)	4139.68 (-33)	2757.56 (-55)	966.5 (-84)	6205.3 (1)	5831.6 (-5)	4987.2 (-20)
Water (639.74)	633.87 (-1)	633.87 (-1)	633.87 (-1)	633.87 (-1)	633.87 (-1)	633.87 (-1)
Miscellaneous (747)	1655.2 (122)	1840.06 (146)	2556.37 (242)	362.75 (-51)	274.25 (-64)	13.12 (-98)
Forest (2192.3)	1797.06 (-18)	1445.5 (-34)	652 (-70)	***2213.4 (1)***	***2814.75 (28)***	***3452.5 (58)***

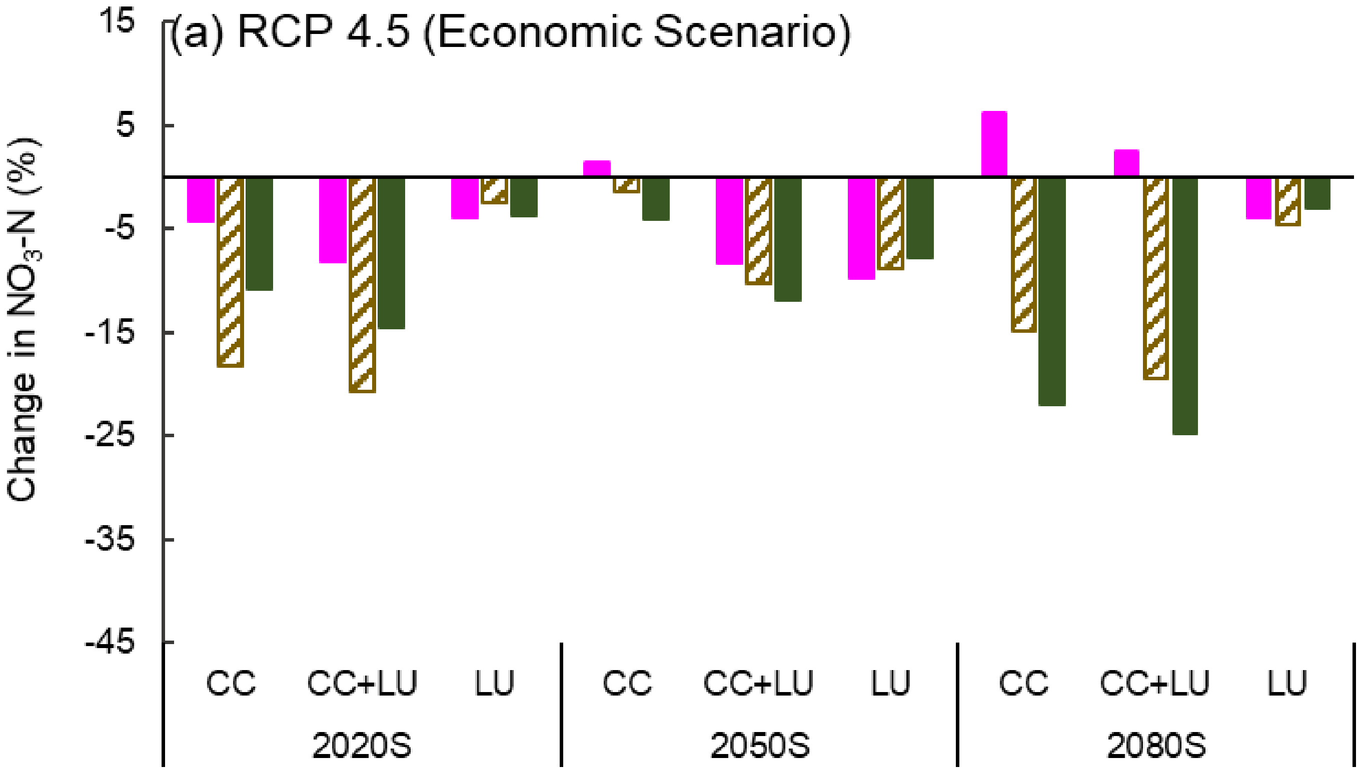
Climate change and landuse change impacts on streamflow



CC: Climate change only
CC+LU: Climate change and land use change
LU: Landuse change only

- Streamflows is projected to decrease under climate change and combined impact.
- Streamflow is projected to increase under landuse change only.
- The magnitude of impact of climate change and combined impact is greater than landuse change impact.

Climate and landuse change impacts on nitrate-nitrogen loading



CC: Climate change only
CC+LU: Climate change and land use change
LU: Landuse change only

- Nitrate nitrogen loading is projected to decrease under individual and combined impact of climate change and land use change scenarios in future.
- The magnitude of impact of climate change and combined impact is greater than only landuse change impact.
- Higher reduction of nitrate nitrogen loading under combined impact of climate and landuse change.

Conclusions

- SRB is expected to be warmer and drier in future.
- Annual streamflow is expected to decrease but with variations in seasonal flow under climate change. Under climate change scenarios (only), summer and rainy seasons streamflow are expected to decrease whereas winter season flows are expected to increase in future.
- Streamflow is projected to decrease under combined impact of climate and landuse change. However streamflow is projected to increase under landuse change scenarios only in future.
- Nitrate-nitrogen loadings is expected to decrease in future. The decrease is lesser under only landuse change scenario compared to combined and climate change scenarios only.

Key Challenges and Ways Forward

- Challenges in reducing uncertainty in impact assessment studies
- Challenge with the impacts to crosscutting issues
- Multi-level impact assessment and adaptation studies
- Towards interdisciplinary approach for cumulative impact assessment

Thank you!

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