THA 2022 International Conference on

Moving Towards a Sustainable Water and Climate Change Management After COVID-19

26-28, January 2022

Impacts of Climate Change and Dam Construction on Rice Damages in the Cambodian Floodplain of the Mekong River Basin

Sophal Try, PhD

JSPS Research Fellow

Innovative Disaster Prevention Technology and Policy Research Lab.

DPRI | Kyoto University

Email: trysophal001@gmail.com / try.sophal.35n@st.kyoto-u.ac.jp

Background of Climate Change

- *Climate change* refers to the significant long-term changes in the global climate.
- Climate change is generally caused by *human activities*, driving the increase of greenhouse gases (GHGs).
- Climate change, one among current global hot issues, is the main factor in driving the change in global water cycle, particularly *spatio-temporal pattern* of *precipitation* and *evapotranspiration*.
- Therefore, the climate change currently threatens its impact on *river flow* and *flood inundation* characteristics worldwide.

Background of Climate Change

SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Extreme heat

More frequent

More intense

Heavy rainfall

More frequent

More intense

Drought

Increase in some regions

Fire weather

More frequent

Ocean

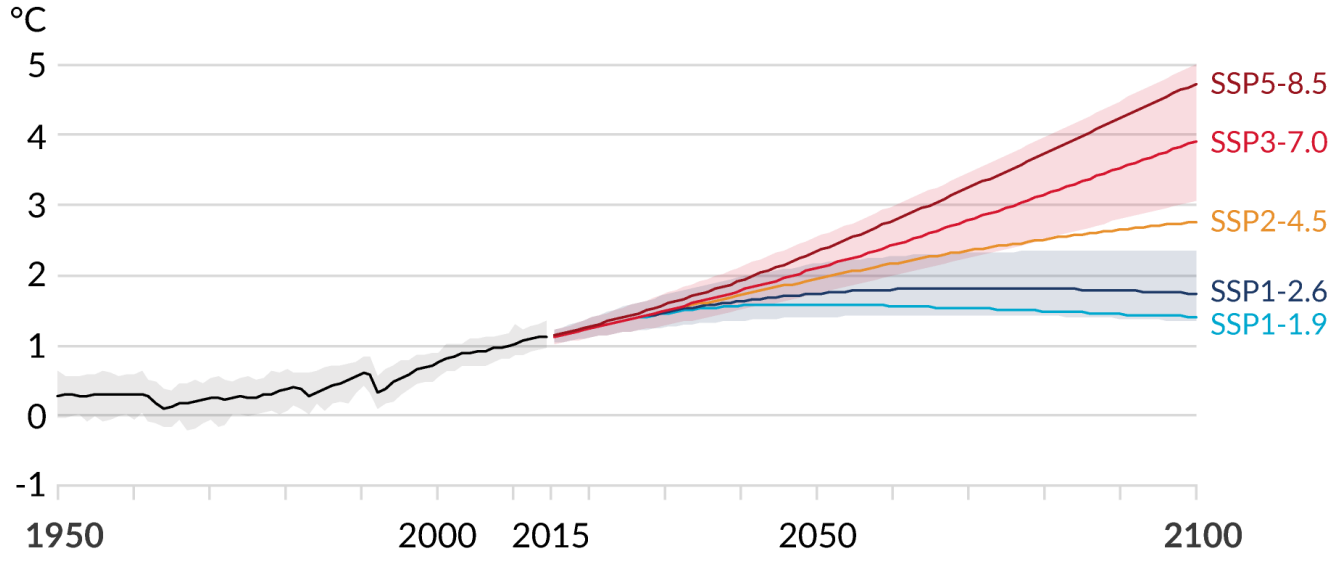
Warming

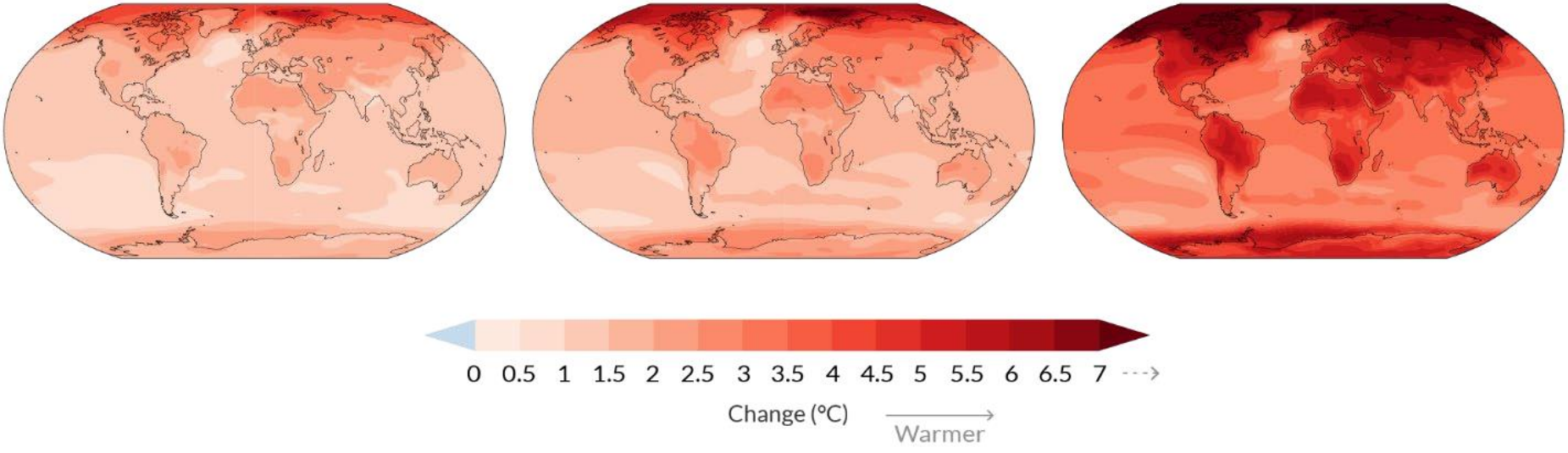
Acidifying

Losing oxygen

(IPCC, 2021)

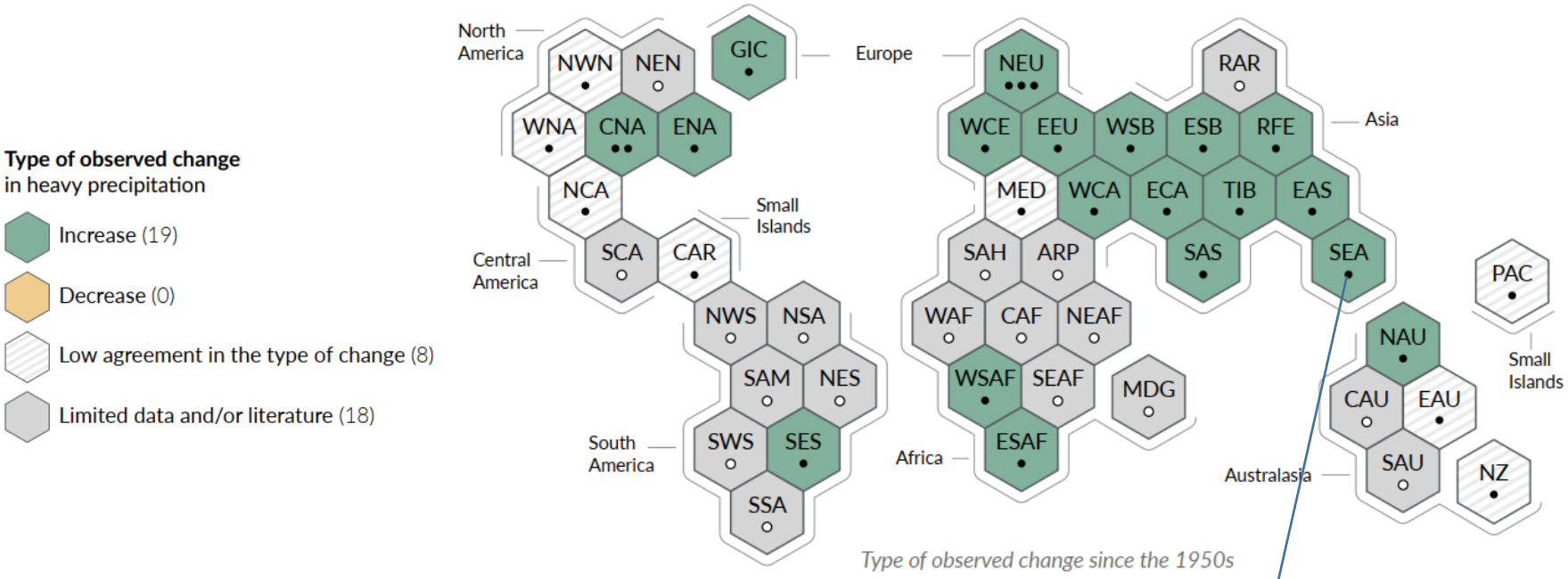
Global Surface Temperature Change





(IPCC, 2021)

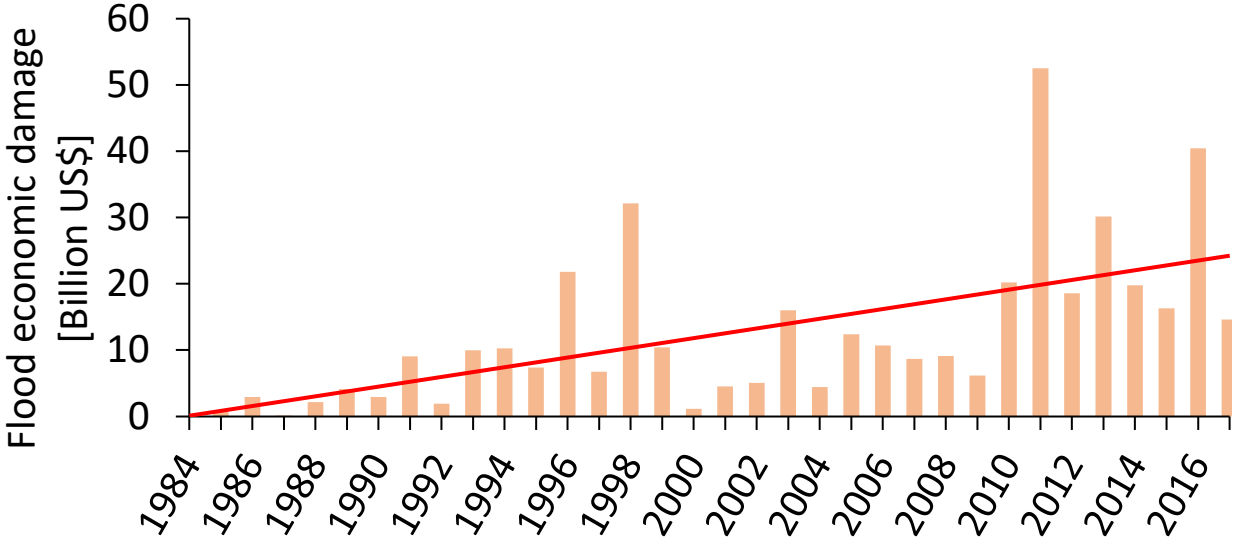
New IPCC AR6 Is Available Now [CMIP6 GCM]

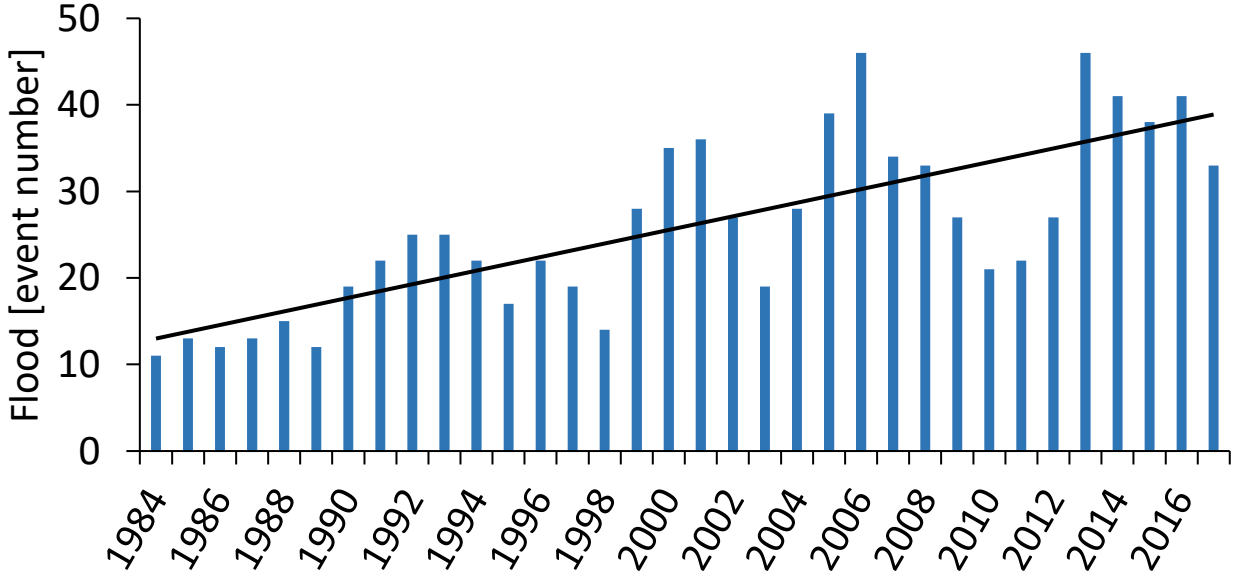


Intergovernmental Panel on Climate Change AR6, 2021

Southeast Asia (SEA) is one the vulnerable area to be affected by increase of heavy precipitation.

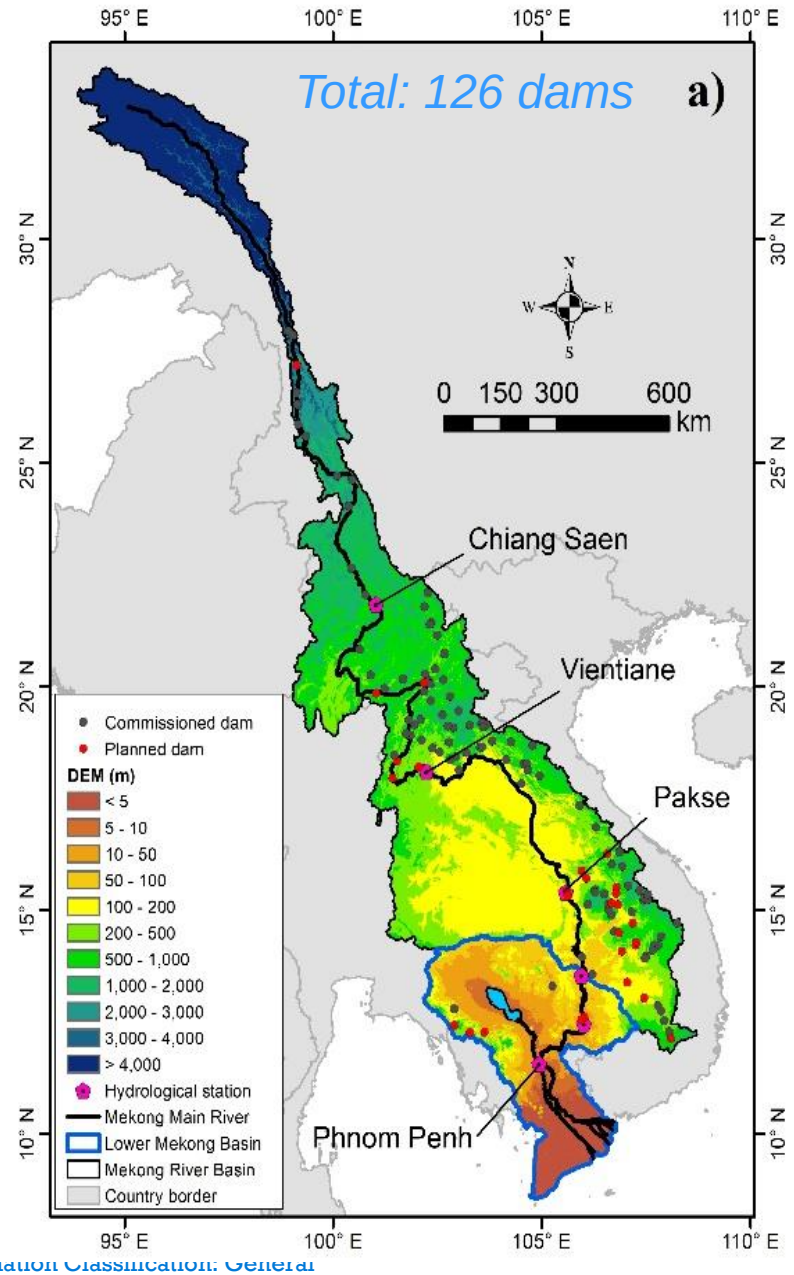
Flood Information in 4 Lower Mekong Countries

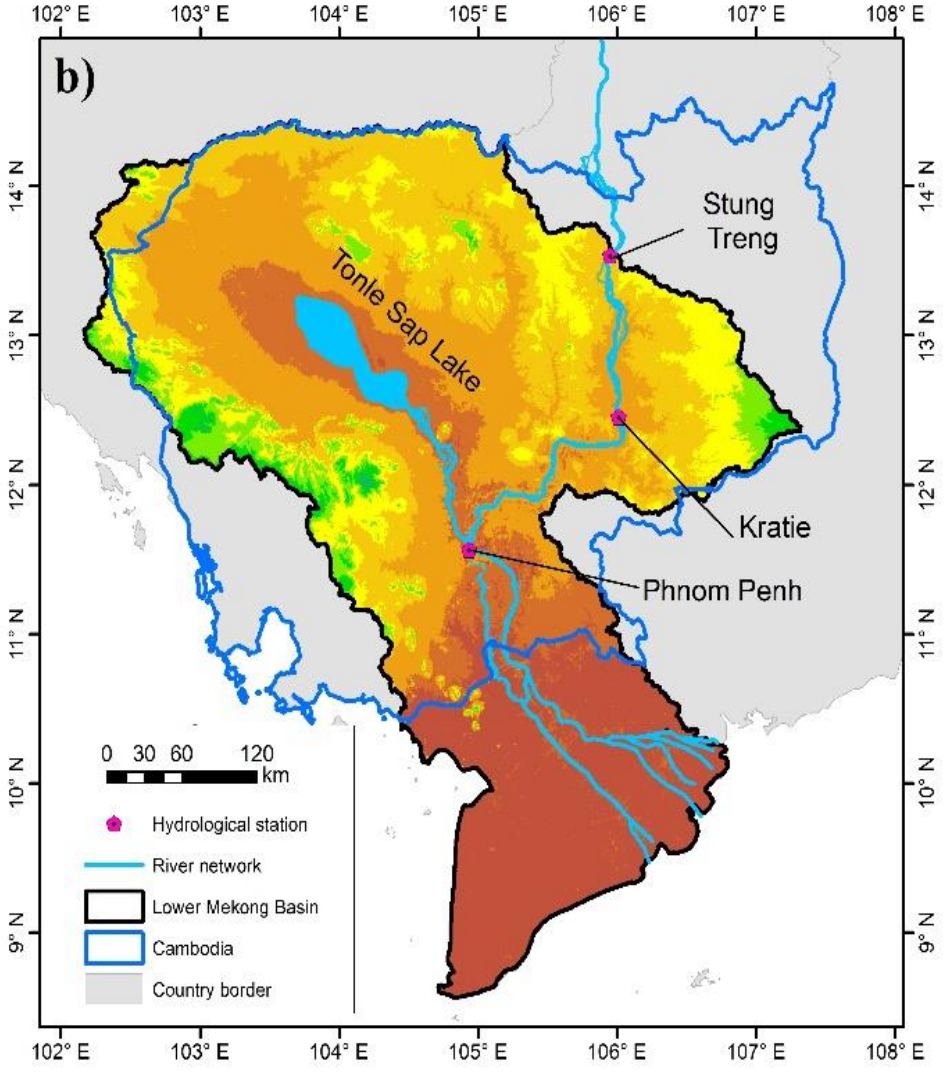




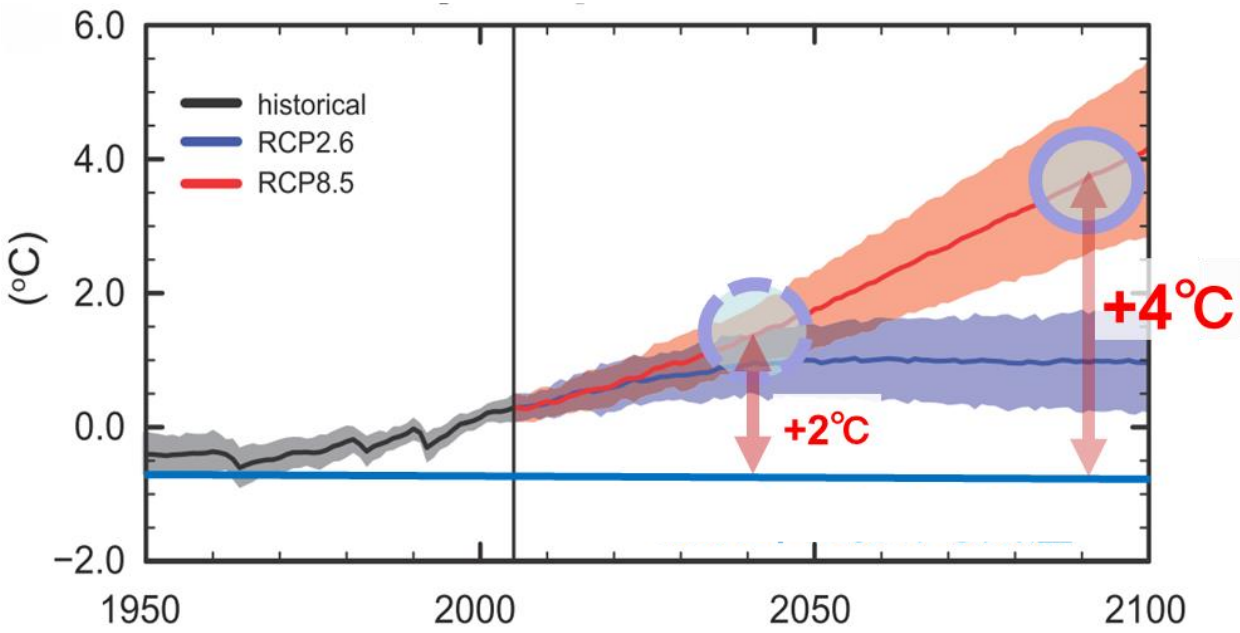
(source: EM-DAT database)

Study Area and Dam Construction





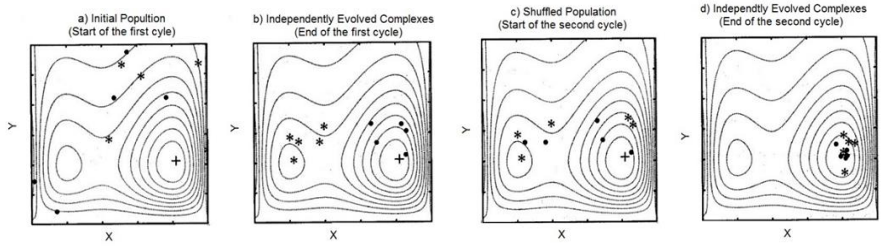
d4PDF Dataset



- d4PDF: projected under *global mean surface temperature* 4 degrees warmer than the pre-industrial climate.
- d4PDF data considered SST from *six CMIP5 model* outputs: CCSM4, GFDL-CM3, HadGEM2-AO,MIROC5, MPI-ESM-MR, and MRI-CGCM3 namely as CC, GF, HA, MI, MP, and MR respectively.
- Historical climate (1951-2010): *100 ensemble members* (6000-year)
- Future climate (2051-2110): *90 ensemble members* (6-SST x 15 members: 5400-year).

~ Meteorological Research Institute, Japan

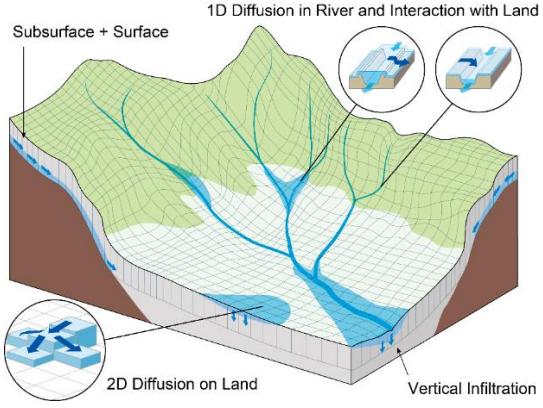
Rainfall-Runoff-Inundation (RRI) Model



Shuffled Complex Evolution (SCE-UA) Optimization Algorithm (Duan et al., 1994)

Input

- Topography
- Rainfall
- Land Use
- River Geometry
- ET



Schematic Diagram of RRI Model (Sayama et al., 2012, 2015)

Output

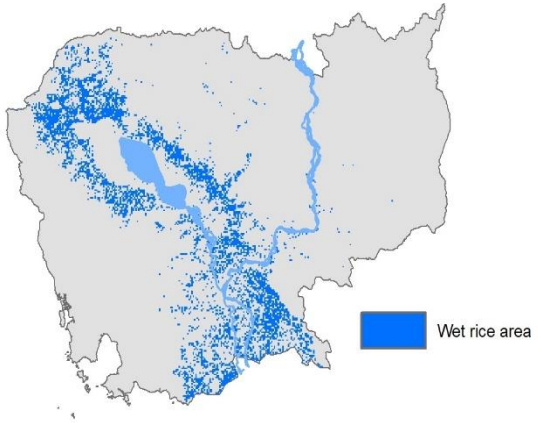
- Discharge
- Water Level
- Inundation

Rainfall-Runoff-Inundation (RRI) model has important features:

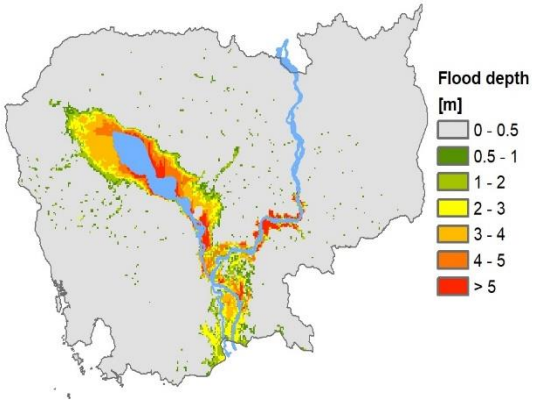
- Simulate rainfall-runoff and flood inundation simultaneously
- Deal with slopes and river channel separately
- Be able to consider surface flow and subsurface flow
- 1D diffusive wave for river routing and 2D diffusion for slope

Research Framework

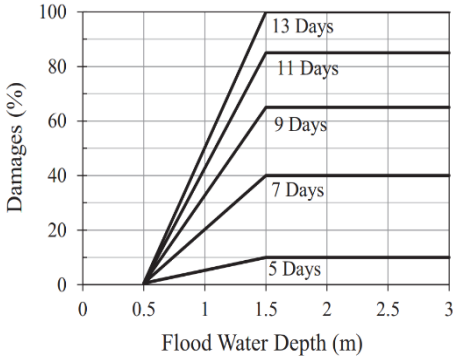
Exposure



Hazard



Vulnerability



Wet rice area

Spatiotemporal flood inundation depth

Flood damage curve for rice crop

Rice yield

Economic Damage Value = Rice Yield × Damage Area × Yield Loss

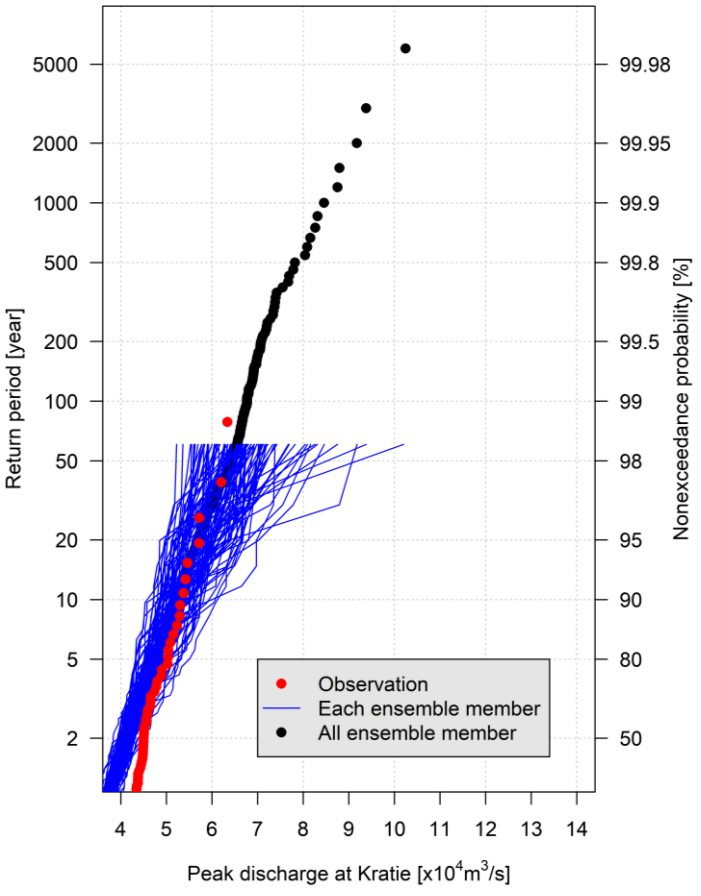
Historical agricultural economic damage

Flood extreme events under future climate change impact

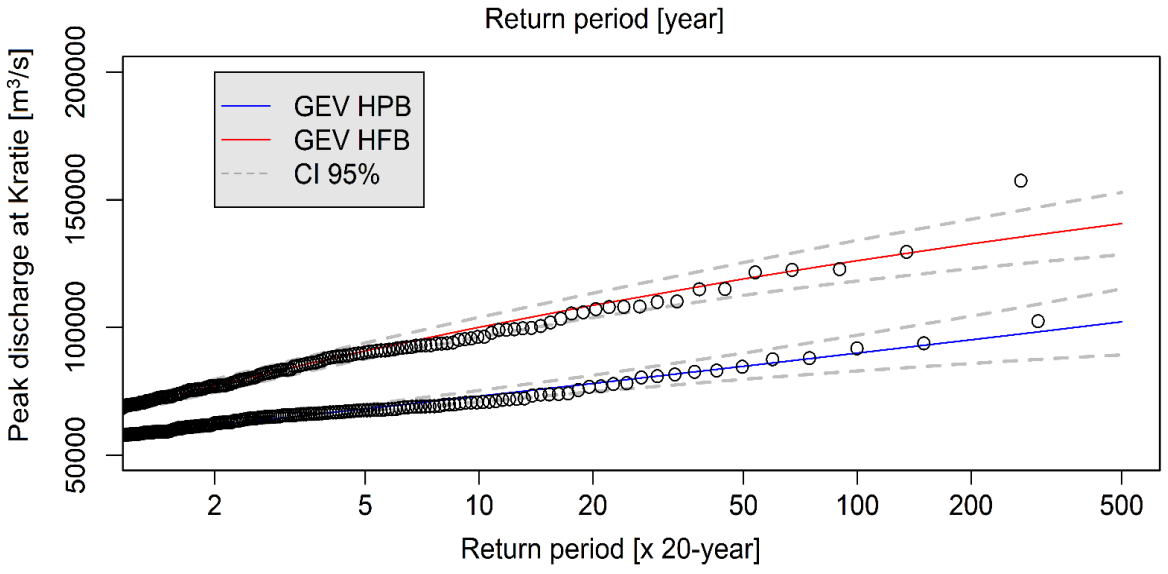
Future dam construction

Future potential agricultural economic damage

Extreme Flood Frequency



Comparison of probability plot of annual peak discharge at Kratie.



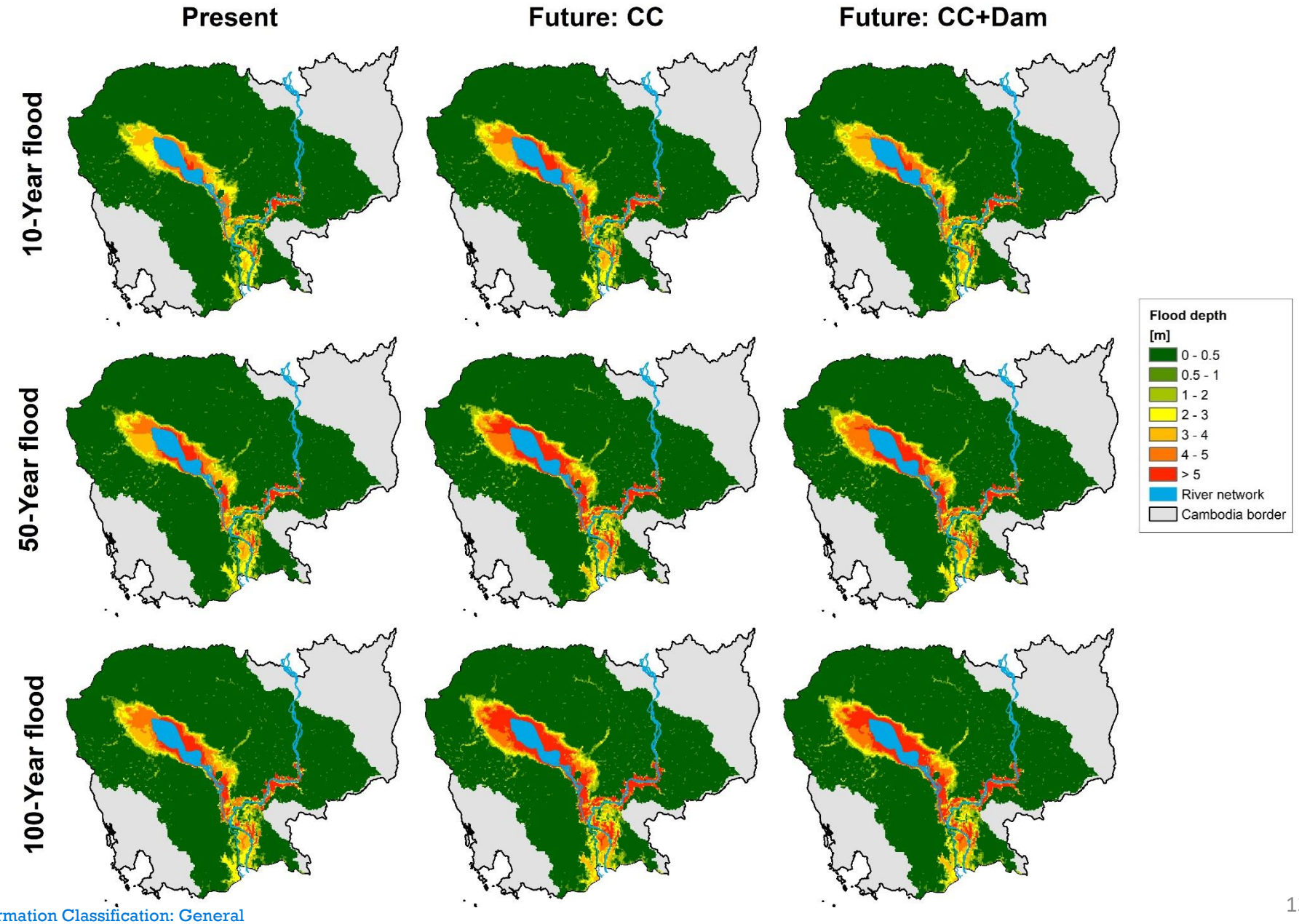
Comparison of probability from Present to Future Climate

Try et al., (2020). Projection of extreme flood inundation in the Mekong River basin under 4K increasing scenario using large ensemble climate data. Hydrological Processes, 34, 22.

Verification of Damage Estimation

Flood event	Total flood area [M ha]	Simulated damage area [ha]	Referenced damage area [ha]	Total simulated damage [M US$]	Referenced total damage [M US$]	Reference sources
2000	2.30	420,470	402,940[a]	147.53	155.10[b]	[a]Reported by Ros et al., (2011) [b]Calculated by Shrestha et al., (2014)
2006	2.19	438,200	-	148.65	123.40[c]	[c]Calculated by Shrestha et al., (2014)
2009	1.83	209,400	-	59.49	56.50[d] 60.00[e]	[d]Reported by RGC, (2010) [e]Reported by ADB, (2012)
2011	2.39	563,640	400,000[f] 583,480[g]	198.33	179.60[f] 189.00[g] 197.00[h]	[f]Reported by ADB, (2012) [g]Calculated by Shrestha et al., (2019) [h]Calculated by Kwak et al., (2015)

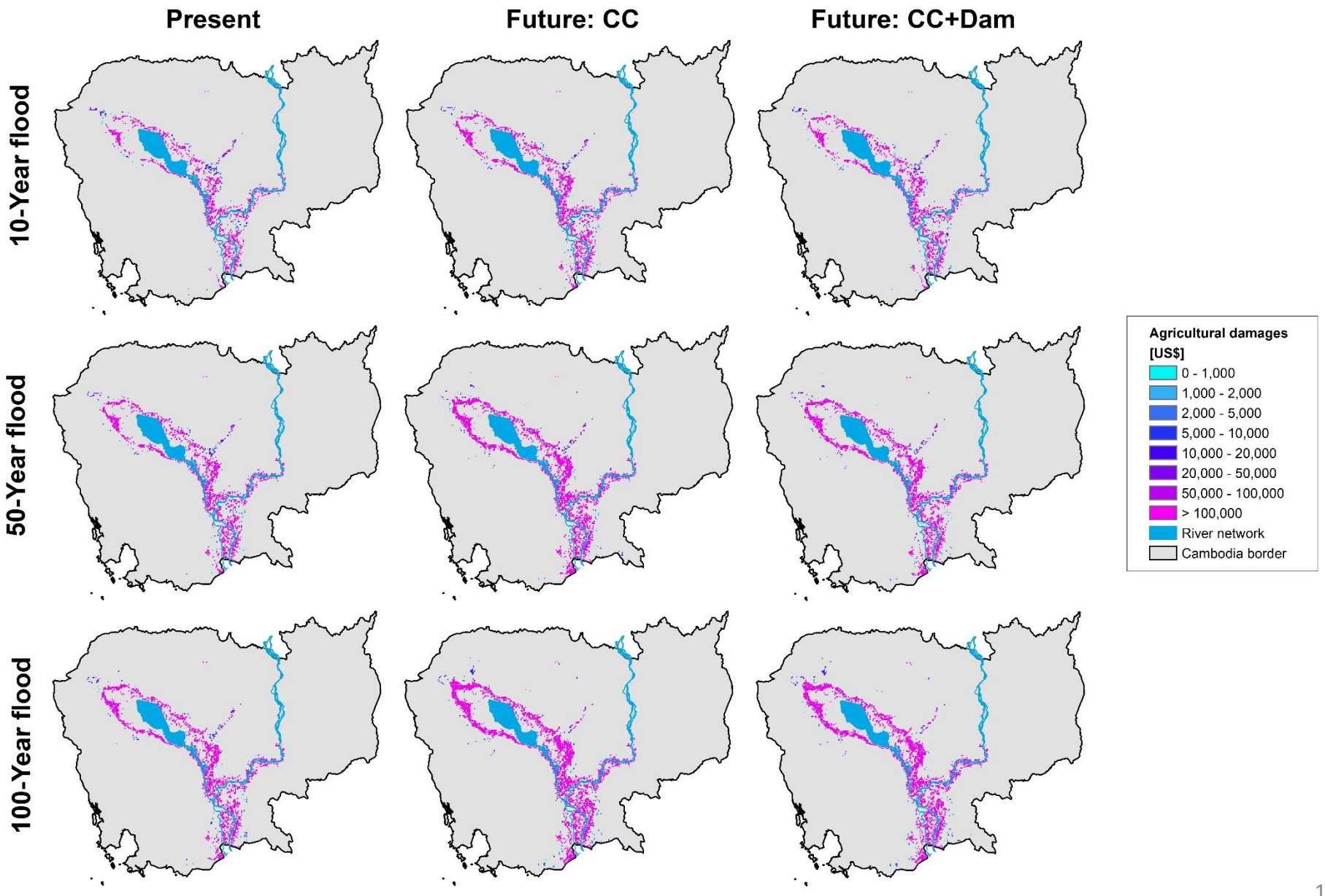
Changes of Extreme Flood Events



Changes of Extreme Flood Events

Extreme event	Climate scenario	Period	Annual peak discharge [m^3/s]	Total flood area [$\times 10^6$ ha]	Total flood volume [$\times 10^9$ m^3]
10-year flood	HPB	1951-2010	50,980	2.20	68.99
	HFB_4K	2051-2110	61,768 ***(+21%)***	2.46 ***(+12%)***	86.74 ***(+26%)***
	HFB_4K_dam	2051-2110	54,327 ***(+7%)***	2.36 ***(+7%)***	78.10 ***(+13%)***
50-year flood	HPB	1951-2010	61,588	2.46	86.45
	HFB_4K	2051-2110	77,103 ***(+25%)***	2.80 ***(+14%)***	110.35 ***(+28%)***
	HFB_4K_dam	2051-2110	68,507 ***(+11%)***	2.70 ***(+10%)***	101.58 ***(+18%)***
100-year flood	HPB	1951-2010	67,400	2.59	95.43
	HFB_4K	2051-2110	89,331 ***(+33%)***	3.03 ***(+17%)***	125.79 ***(+32%)***
	HFB_4K_dam	2051-2110	81,734 ***(+21%)***	2.96 ***(+14%)***	118.88 ***(+25%)***

Changes in Flood Damages



Changes in Flood Damages

Extreme event	Climate scenario	Period	Damage area [$\times 10^3$ha]	Agricultural damage [Million US$]
10-year flood	HPB	1951-2010	478.68	160.35
	HFB_4K	2051-2110	590.73 ***(+23%)***	211.15 ***(+32%)***
	HFB_4K_dam	2051-2110	539.56 ***(+13%)***	188.05 ***(+17%)***
50-year flood	HPB	1951-2010	589.40	210.26
	HFB_4K	2051-2110	784.41 ***(+33%)***	289.25 ***(+38%)***
	HFB_4K_dam	2051-2110	708.48 ***(+20%)***	260.77 ***(+24%)***
100-year flood	HPB	1951-2010	659.98	239.69
	HFB_4K	2051-2110	900.82 ***(+36%)***	332.21 ***(+39%)***
	HFB_4K_dam	2051-2110	852.65 ***(+29%)***	314.87 ***(+31%)***

Summary and Conclusion

- The future projection of climate change under 4K warming scenario shows a ***significant increase*** of ***flood magnitude and damages*** of extreme flood events (i.e., 10, 50, and 100-year events) in the Cambodian floodplain of the Lower Mekong.
- The ***future development of dam*** for the whole Mekong Basin would reduce the river flow and flood inundation, flood damage in the Cambodian floodplain.
- The ***climate change effect*** would be more significant than ***dam reduction*** lead to increase the flood inundation magnitude in the future projected periods.
- ***Appropriate activities*** and ***countermeasures*** should be prepared in for response and adaptation to reduce the possibility of these severe extreme flood events.

Floating Village, Tonle Sap Lake, Cambodia