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Indian National Committee on Large Dams

Response to hydroelectric generation under the impact of Climate Change
A case study of Mugu Karnali Hydroelectric Project

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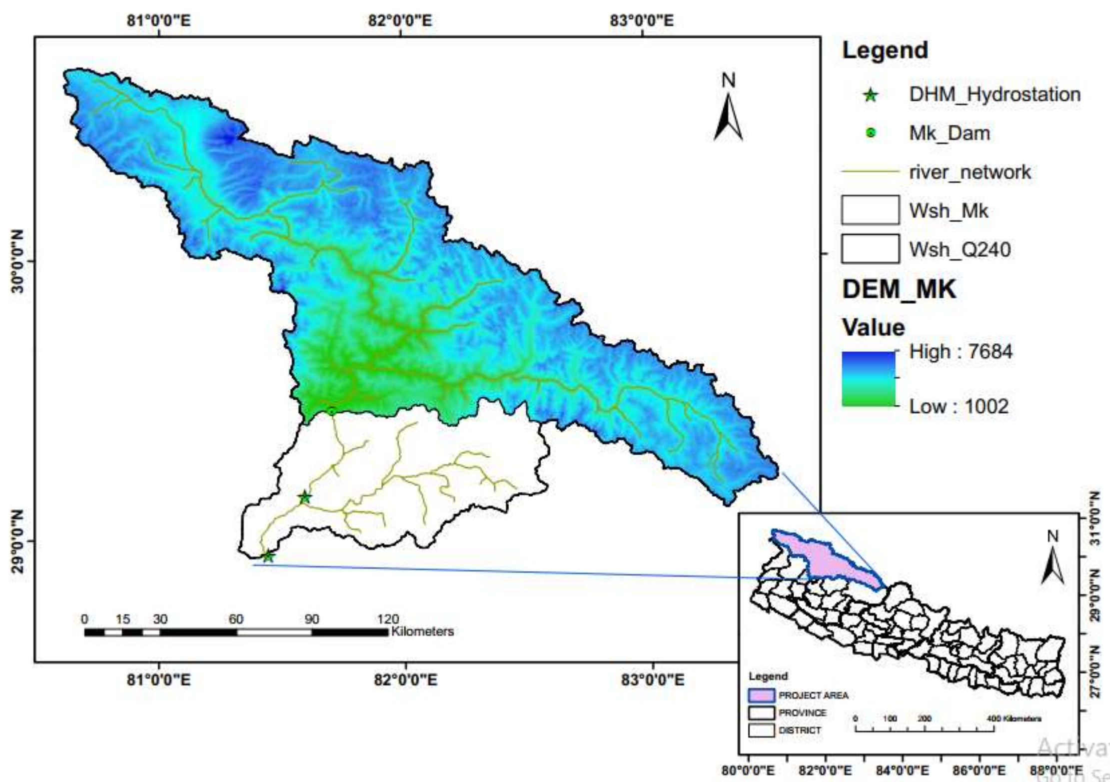
INTRODUCTION

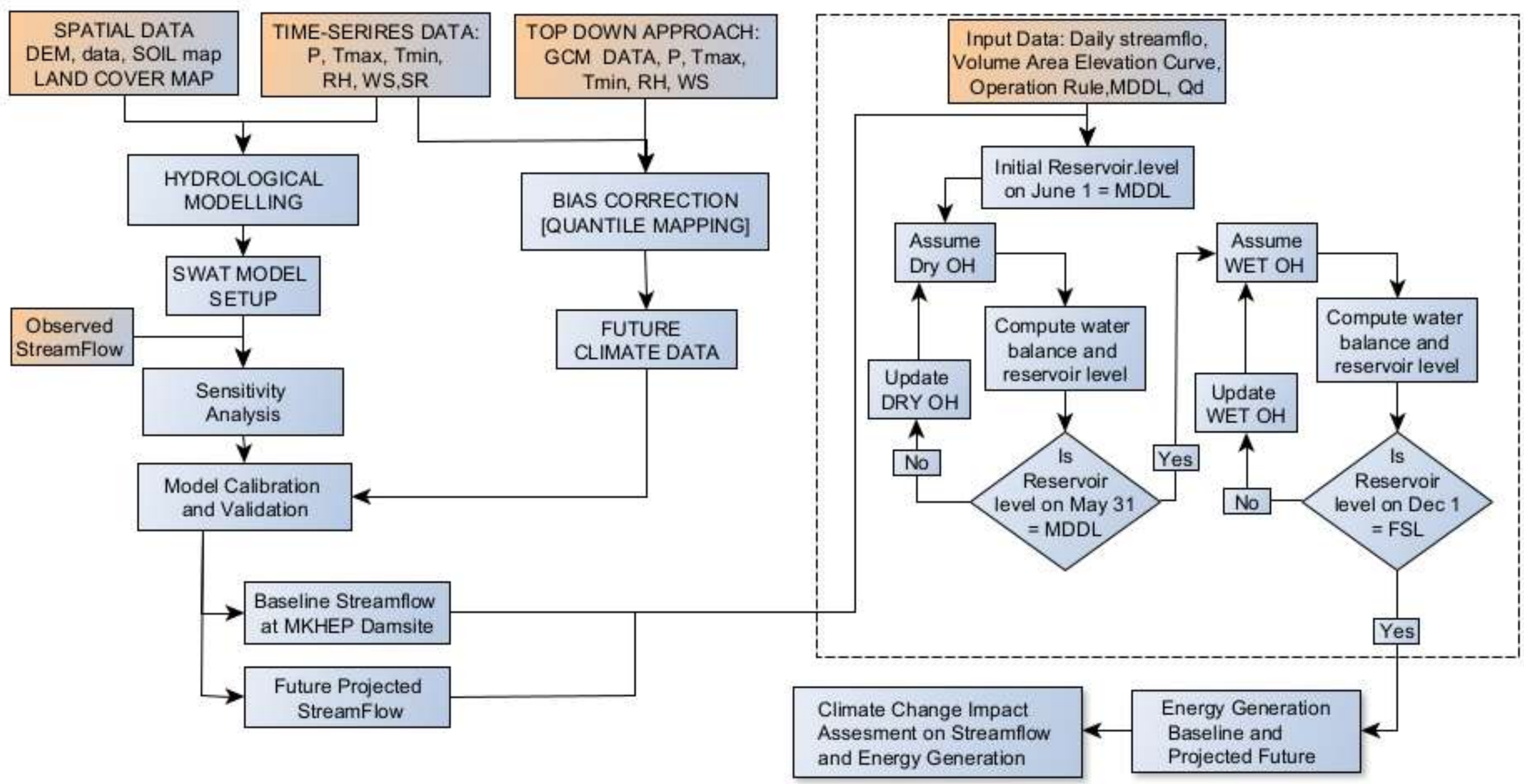
- Nepal is endowed with abundant water resources draining approximately 222 billion m^3 of water annually into the ocean (Sharma & Awal, 2013).
- Because of mountainous topography with wide variation of altitude in short stretch, and rivers flowing with high discharge favors the development of hydropower.
- As the Integrated Nepal Power Supply (INPS) is dominant with ROR projects.
- Electricity demand projected to rise at 8.34% annually (NEA).
- Recently, the peak demand has raised up to about 1700MW on December 2021.
- Thus, larger storage projects are envisaged as means of sustainable hydropower development.
- The water resource projects are sensitive to capital investment as well as climate.
- Several studies in Nepalese river basins (Bajracharya et al., 2018; Devkota et al., 2015; Pandey et al., 2019) reported significant change in hydrological behavior under the influence of climate change (CC).
- The runoff changes subjected to climate change induced variation in rainfall, temperature, glacier retreat, drought etc. may have caused diminishing effect in annual energy (Shrestha et al., 2021) in some project.
- So, this study focuses on the probable impacts of climate change in hydropower projects with the case study of MKHEP.

STUDY AREA

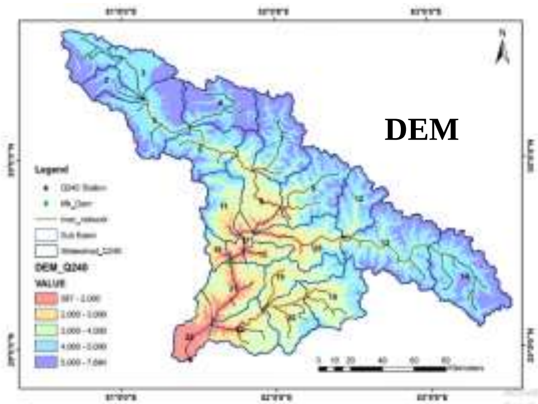


- The Mugu Karnali Hydroelectric project (MKHEP) currently being studied by GON lies in North-western part of Nepal.
- The catchment of the study region is about 16,083.6 km^2 with topography ranging from 1,002 to 7,684 masl.
- Majority of the watershed lying above 3,000masl.
- The average annual precipitation in the watershed is 792mm with 70.0% of rainfall occurring in wet season. The mean monthly temperature ranges between -4.4 ^{0}C ~ 30 ^{0}C.
- The proposed full supply level is 1350 masl.
- The proposed design discharge is 725m^3/s.

METHODOLOGY



INPUT DATA


DEM
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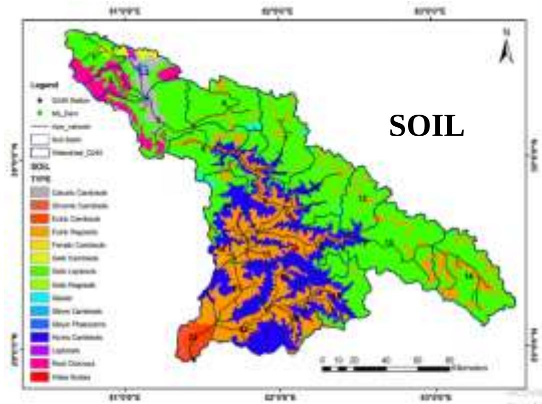
Kilometers


SOIL
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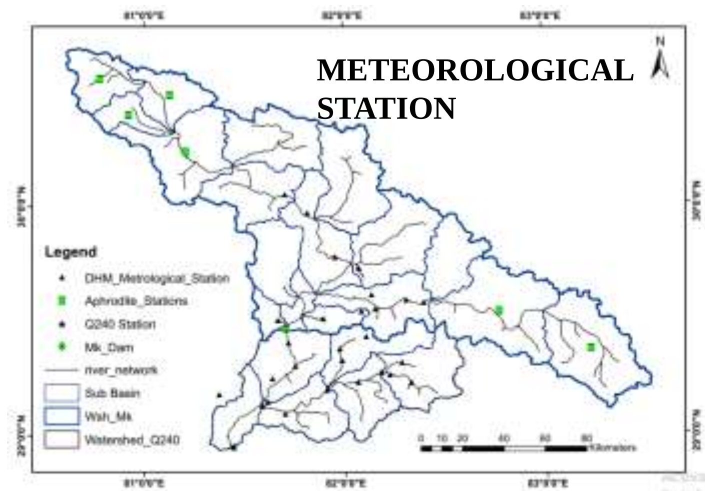
METEOROLOGICAL STATION
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DHM_Metrological_Station
Aphrodite_Stations
Q240 Station
Mk_Dam
river_network
Sub Basin
Wsh_Mk
Watershed_Q240
0 10 20 40 60 80
Kilometers


SLOPE
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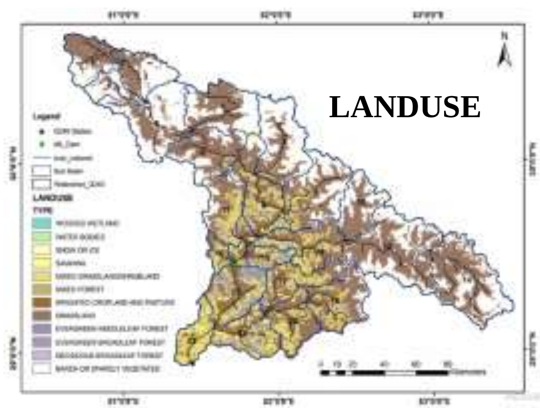
Legend


LANDUSE
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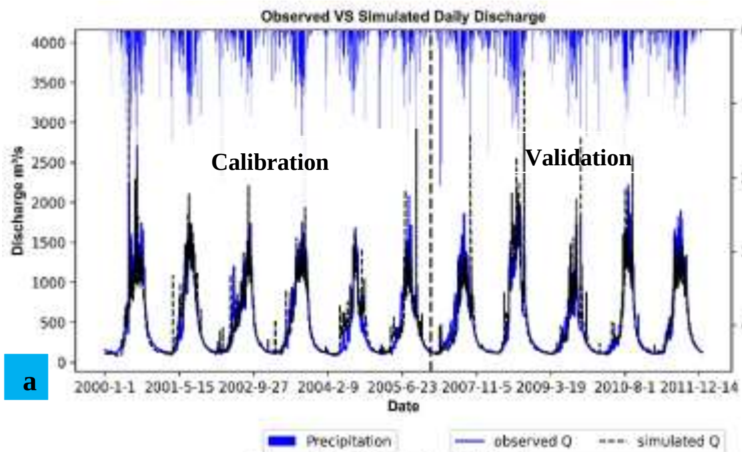
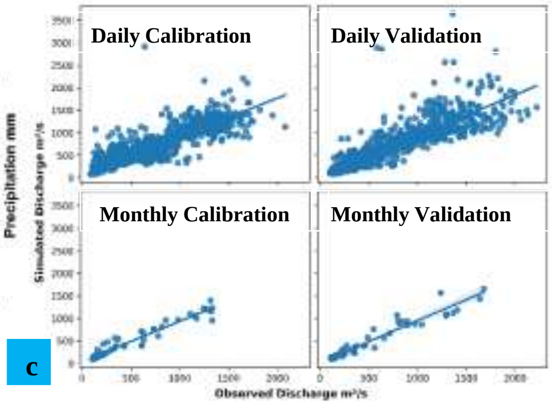
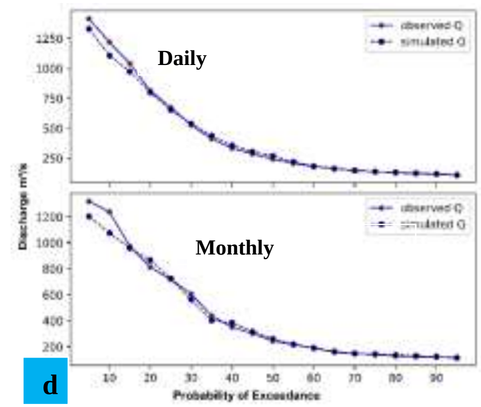
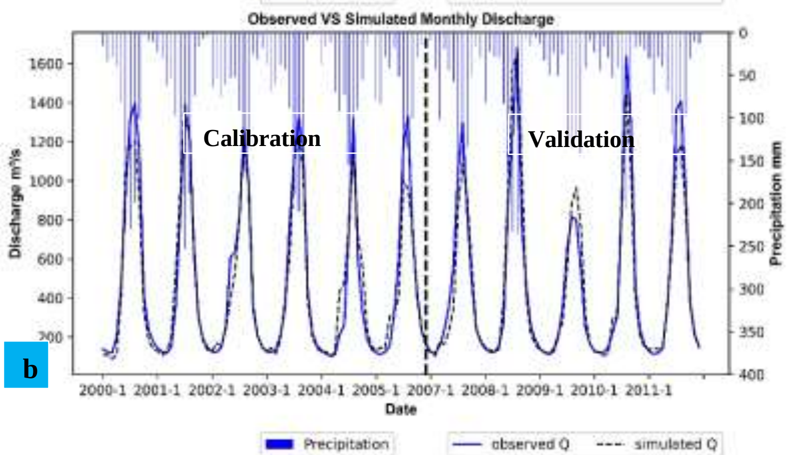
MODEL CALIBRATION AND VALIDATION









Performance Measure	Calibration [2000-2005]		Validation [2007-2011]	
	Daily	Monthly	Daily	Monthly
Nash-Sutcliffe efficiency	84.34	93.99	82.85	93.86
P-BIAS	3.1	3.05	2.58	2.47
R^2	0.85	0.97	0.82	0.96

ANALYSIS SCENARIO

- The five GCMs viz. ACCESS-CM2, EC-EARTH3, INM-CM5-0, MPI-ESM1-2-HR and MRI-ESM2-0 developed under latest designed Coupled Model Intercomparison Project (CMIP6) is used to project the future climate.
- The outputs of these GCMs are considered for two shared socioeconomic pathways i.e. SSP245 and SSP585
- These GCMs are chosen based on its application in South Asian region by Almazroui et al., 2020 and Mishra et al., 2020.
- The multi modal ensemble (MMEs) of these GCMs are used to analyze future climatic condition as MMEs reduces the uncertainties associated with model and generate outputs consistent with local (Ahmed et al., 2019; Hughes & Farinosi, 2020; Wang et al., 2018)
- The simulated streamflow (projected) were then synthesized in terms of long-term annual average and seasonal values for three future periods: near-future (NF) (2021–2045), mid-future (MF) (2046–2070), and far-future (FF) (2071–2095)
- The considered seasons are DJF (December-January-February), MAM (March April-May), JJAS (June-July-August-September) and ON (October-November).

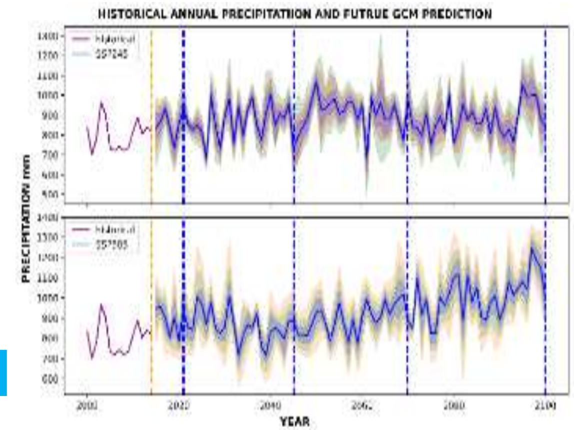
FUTURE CLIMATE PROJECTION

- The trend of projected annual precipitation is not clear.

- The projected maximum and minimum temperature in both the scenarios shows a rising trend.

- The projected precipitation is increasing across all seasons except for DJF season under SSP245.

- Highest rise is observed in MAM season.



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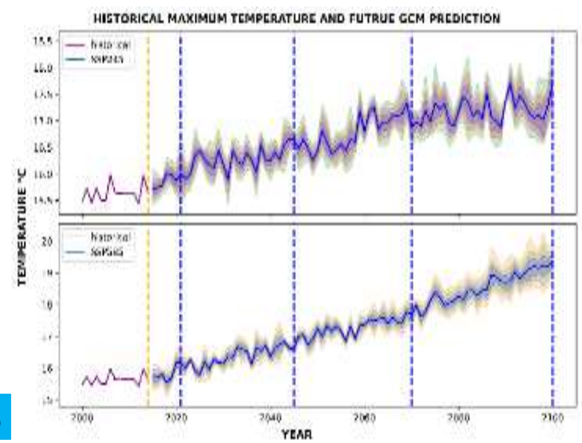

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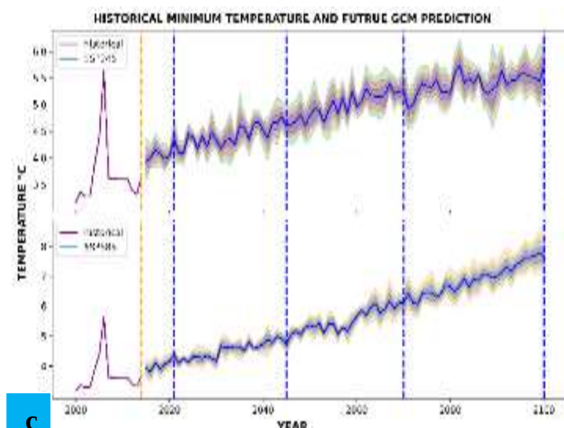

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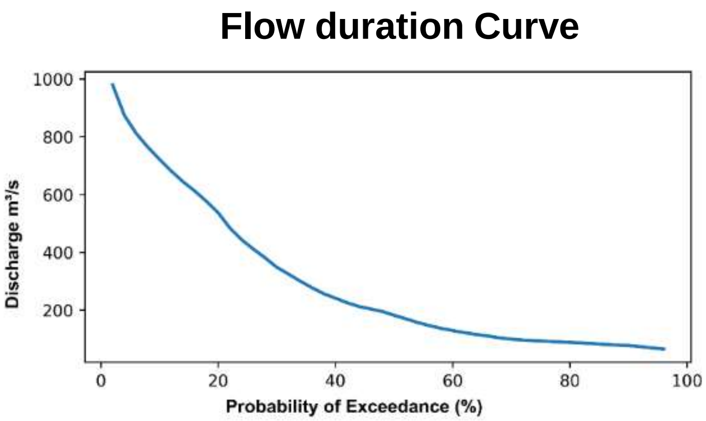
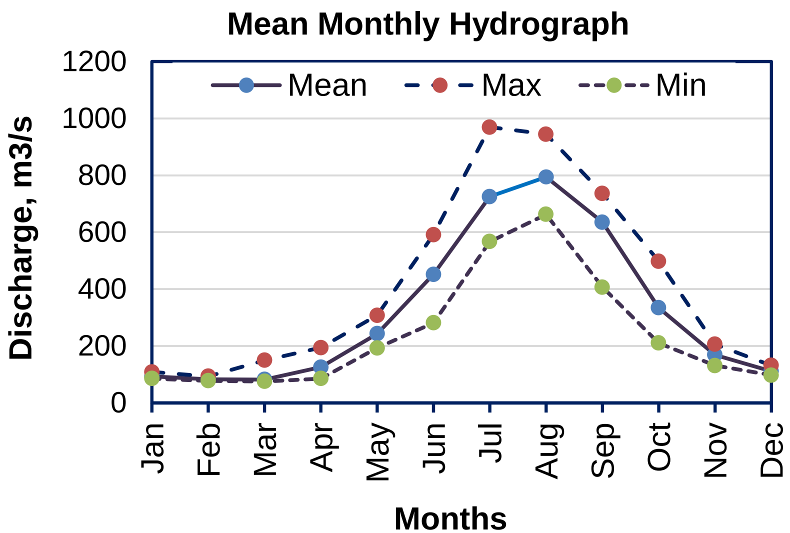
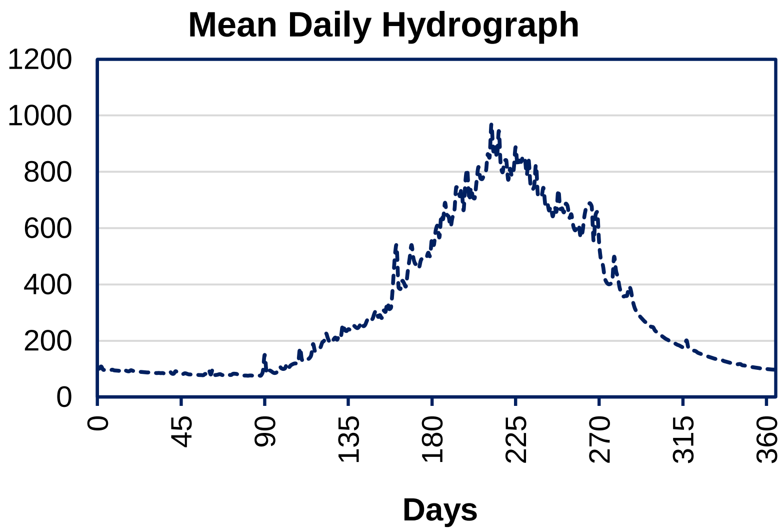
PREDICTED STREAMFLOW

- The mean annual discharge derived at the project site is 321.91 m^3/s with minimum and maximum discharge as 50.62 m^3/s and 1,269m^3/s respectively.

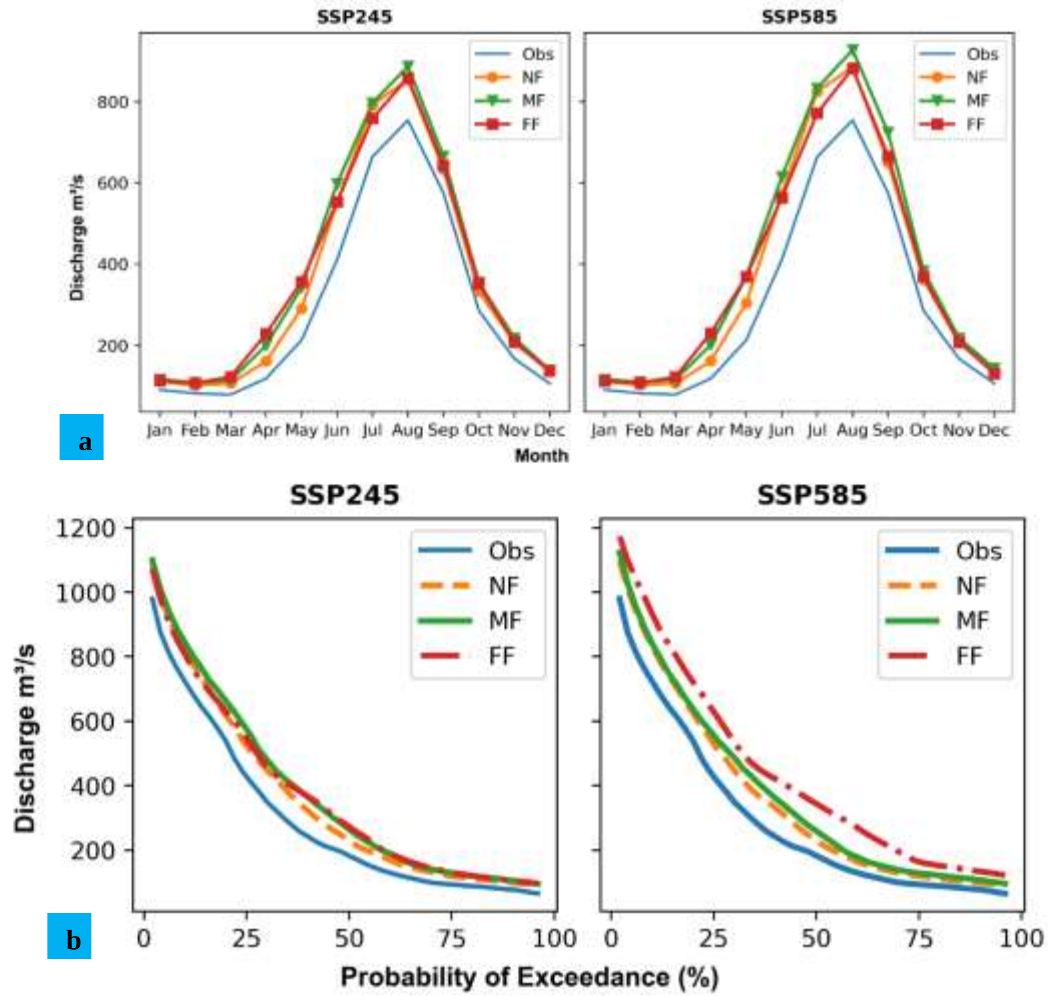






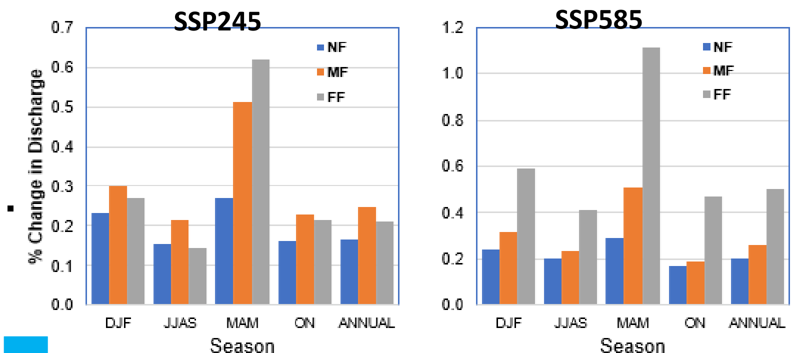
CLIMATE CHANGE IMPACT ON STREAM FLOW

- Less difference during low flow period but differences expand during high flow period.
- The difference between estimated and observed flow is small for the high probability of exceedance



CLIMATE CHANGE IMPACT ON STREAM FLOW

- Projected discharge is increasing across all seasons, however higher flows in MAM season is projected as a result of high precipitation in MAM season than other.
- Flows in DJF season with declining precipitation also has higher flows.
- High percolation is projected in future that contributes to the base flow in DJF season.
- High precipitation may induce increased frequency of wet soil conditions that are conducive to percolation (Pandey et al., 2019).



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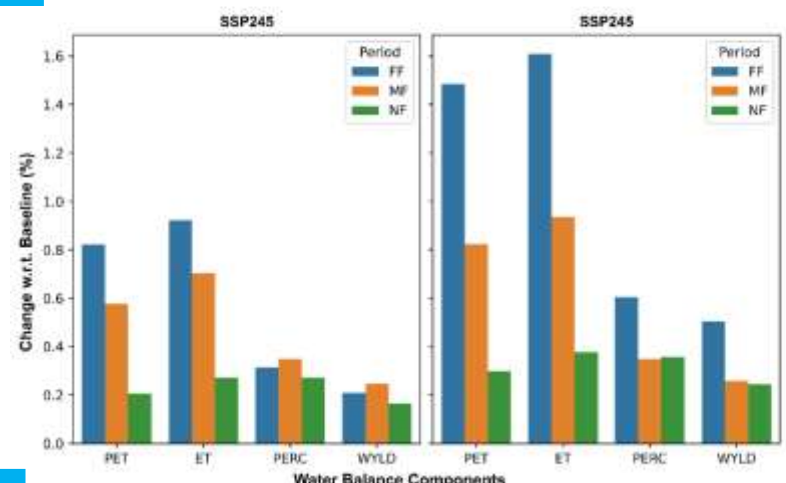

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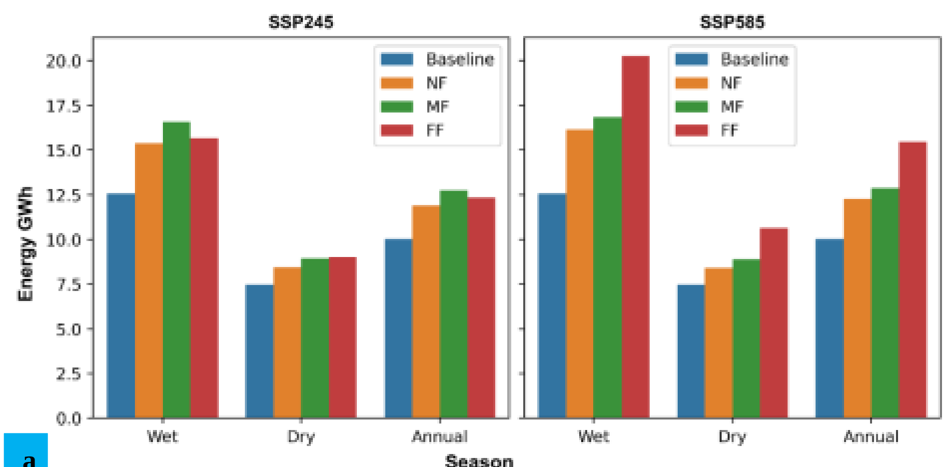
CLIMATE CHANGE IMPACT ON ENERGY

- Present Energy: 5581GWh (Annual), 2131 GWh (Dry)

- Future Annual Energy Generation increases by 18.4%, 26.2% and 22.1% in NF, MF and FF under SSP245 scenario whereas there is increased generation by 21.9%, 27% and 52.1% for three corresponding future periods under SSP585 scenario.



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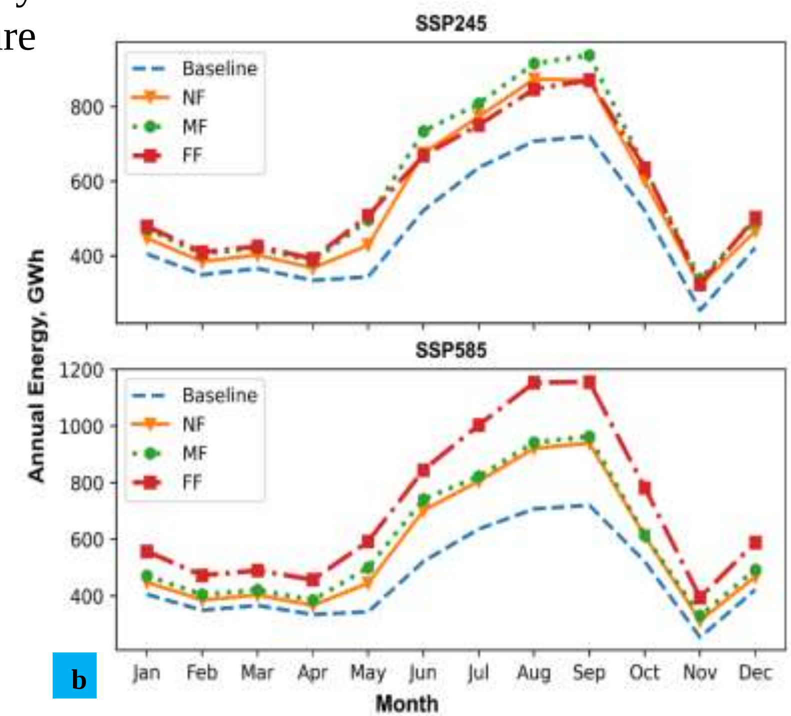

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CONCLUSION AND RECOMMENDATIONS

- The mean annual and seasonal precipitation are expected to increase except for DJF season.
- Increasing trend is observed for the mean annual and seasonal temperature (min and max).
- The average annual discharge is anticipated to increase from the baseline 321.9m^3/s differing by about 10.0%, 17.0% under SSP245 and SSP585 scenario in NF, MF and FF.
- Very high increase (35%) in annual discharge is anticipated for SSP585 for FF.
- The increasing tendency is steady across all seasons with higher difference projected in pre-monsoon (MAM).
- The projected discharge responded to the increase in precipitation.
- The energy production is anticipated to increase across all months and seasons as a result of increasing projection of stream flow.
- The annual energy will increase by in all NF, MF and FF under both SSP245 and SSP585 scenario.
- The reservoir may be filled quicker along with increased hours of plant operation due to high inflow and higher erosion however the impact of sediment, extreme flow etc. need to be studied in details.

Thank You