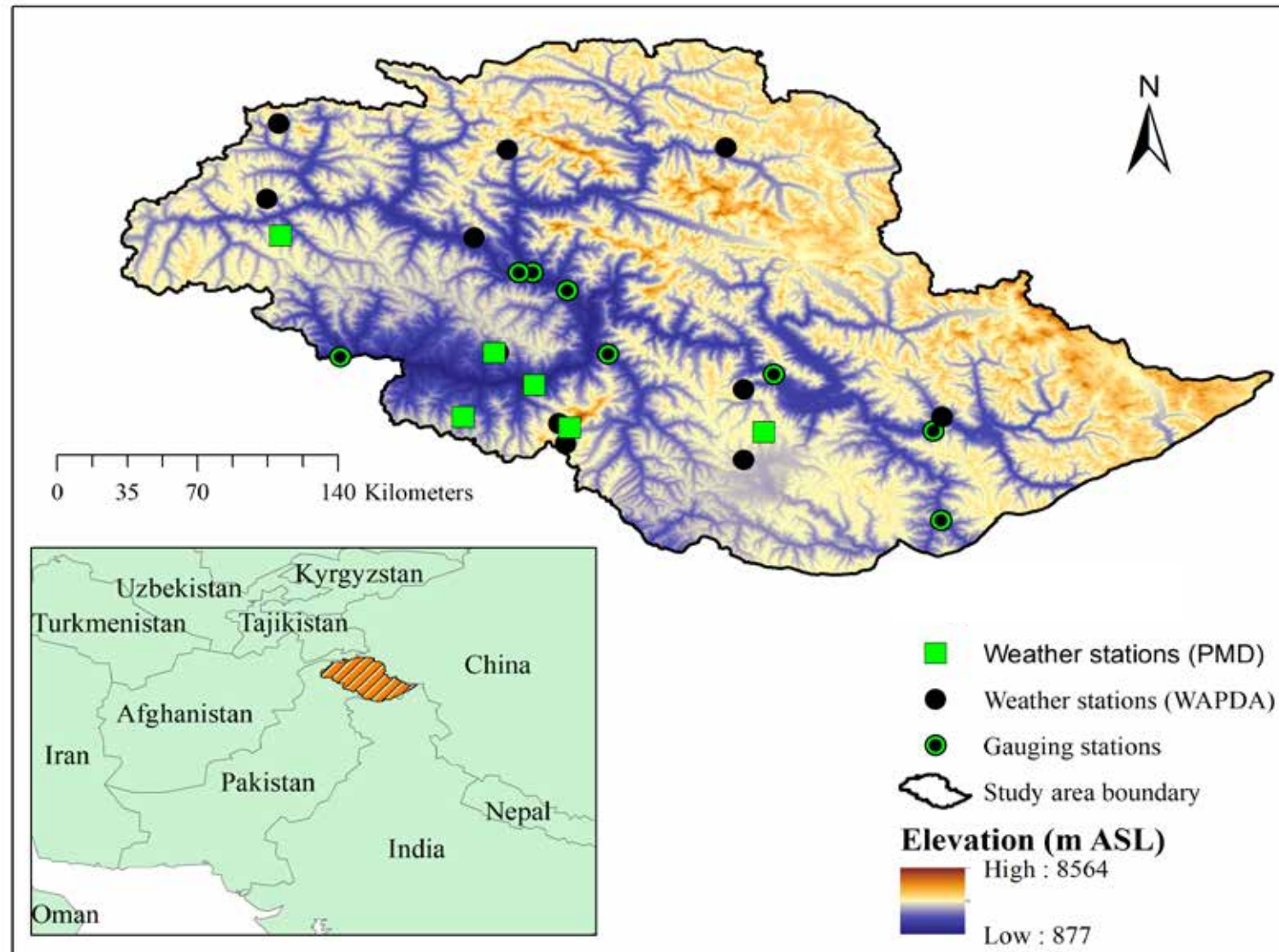# Projection of Indus River Flow under Changing Climate Conditions and its Implication to Future Hydropower Energy Generation

Hazrat Bilal[1], Chamhuri Siwar[1], Mazlin Mokhtar[1]

[1]The National University of Malaysia, UKM

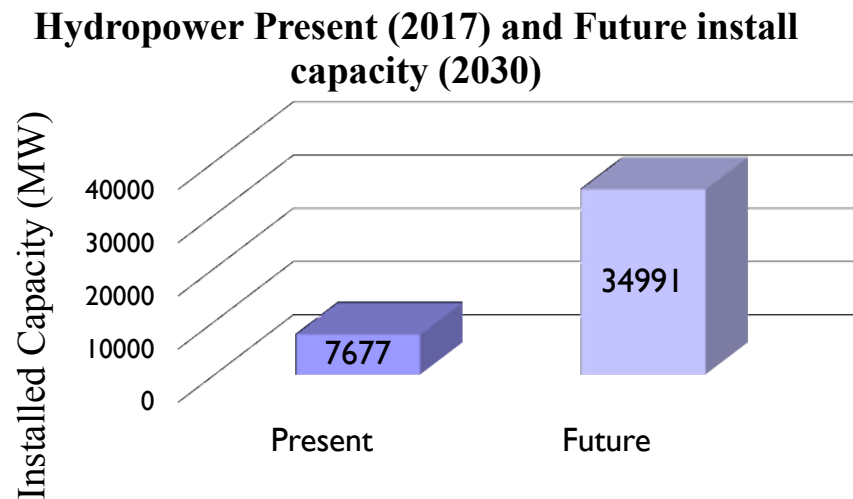UNIVERSITI KEBANGSAAN MALAYSIA

National University of Malaysia

Study Area

Electricity production and consumption

- Thermal 63.59%, Hydroelectric 30.8%, Nuclear 3.76, Renewable 0.27% (Wind, Solar, Biogas) import 0.41%.

- Household 48%, Industry 27%, Agriculture 9% and commercial 8% other government 8% (Energy Year Book 2018-2019).

Hydropower Present (2017) and Future install capacity (2030)

Installed Capacity (MW)

40000
30000
20000
10000
0

34991

7677

Present   Future

List of GCMs and RCMs used in this study.

|	RCM	Driving GCM	Institute	Domain
1	SMHI-RCA4	ICHEC-EC-EARTH	Swedish Meteorological and Hydrological Institute,	WAS-44
2	SMHI-RCA4	MOHC-HadGEM2-ES	Swedish Meteorological and Hydrological Institute,	WAS-44
3	SMHI-RCA4	MPI-M-MPI-ESM-LR	Swedish Meteorological and Hydrological Institute,	WAS-44
4	SMHI-RCA4	NCC-NorESM1-M	Swedish Meteorological and Hydrological Institute,	WAS-44

Snow Runoff Model-SRM

RCP 4.5

Snow accumulation   Snowmelt

RCP8.5

Snow accumulation   Snowmelt
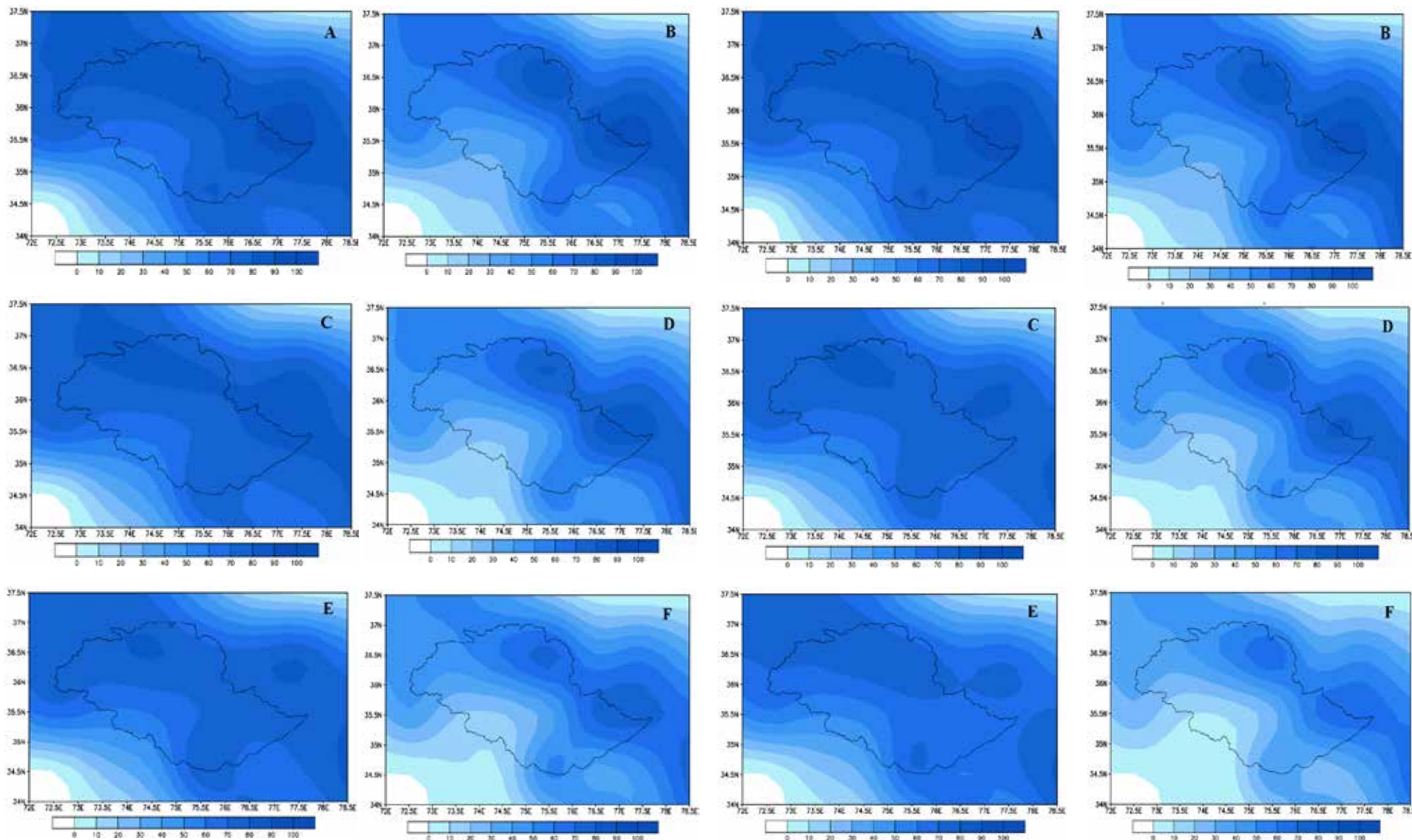
(A) average monthly snow covered area SCA (%) during snowmelt 1951-2005, (B) average monthly SCA during snow accumulation, (C) average monthly SCA during snow accumulation 2006-2065, (D) average monthly SCA during snowmelt 2006-2065, (E) average monthly SCA during snow accumulation 2066-2099, (F) average monthly SCA during snowmelt 2066-2099.
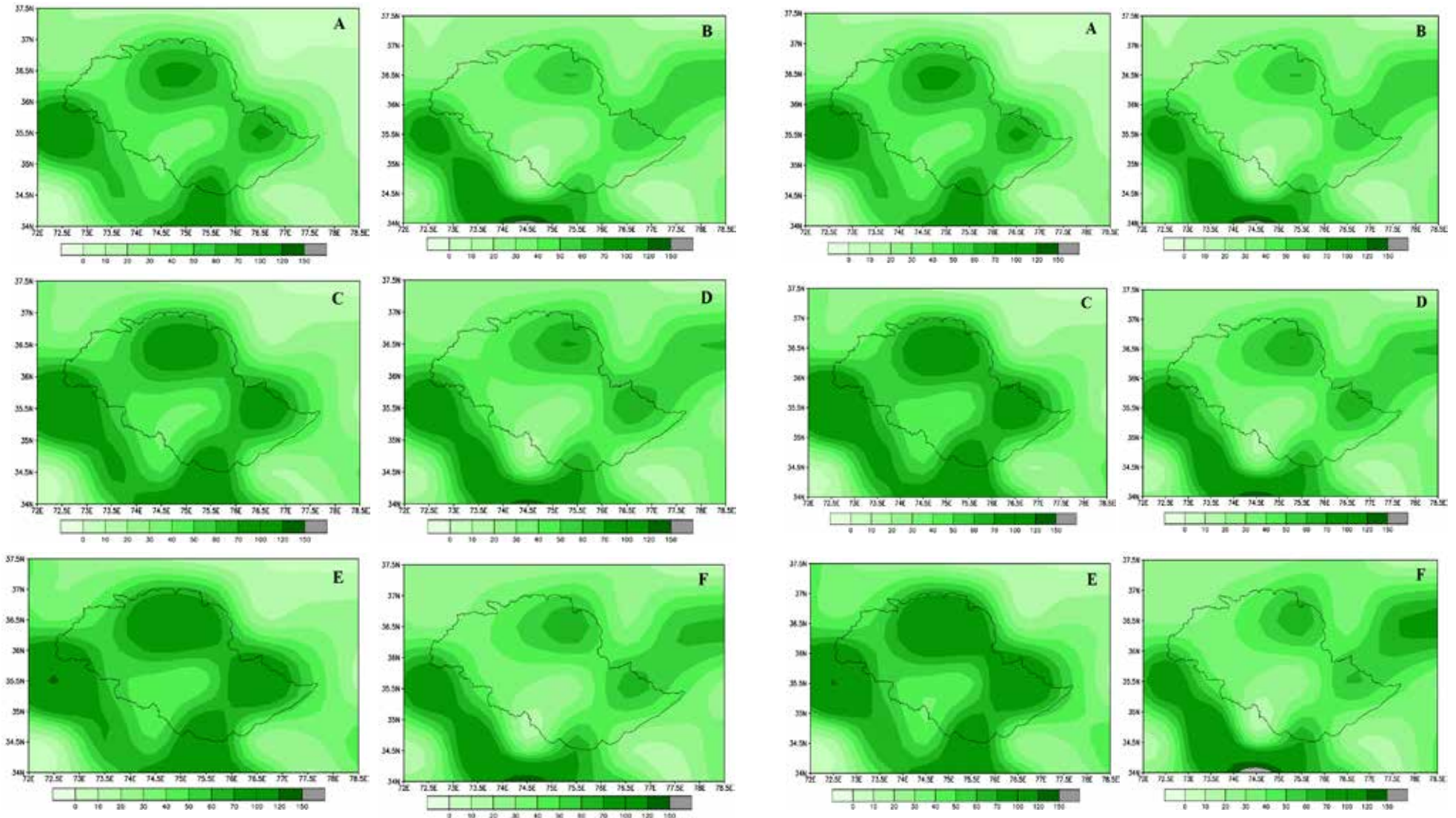
RCP 4.5

Snow accumulation Snowmelt

RCP8.5

Snow accumulation Snowmelt

(A) average monthly total precipitation (mm) during snowmelt 1951-2005, (B) average monthly total precipitation during snow accumulation, (C) average monthly total precipitation during snow accumulation 2006-2065, (D) average monthly total precipitation during snowmelt 2006-2065, (E) average monthly total precipitation during snow accumulation 2066-2099, (F) average monthly total precipitation during snowmelt 2066-2099.
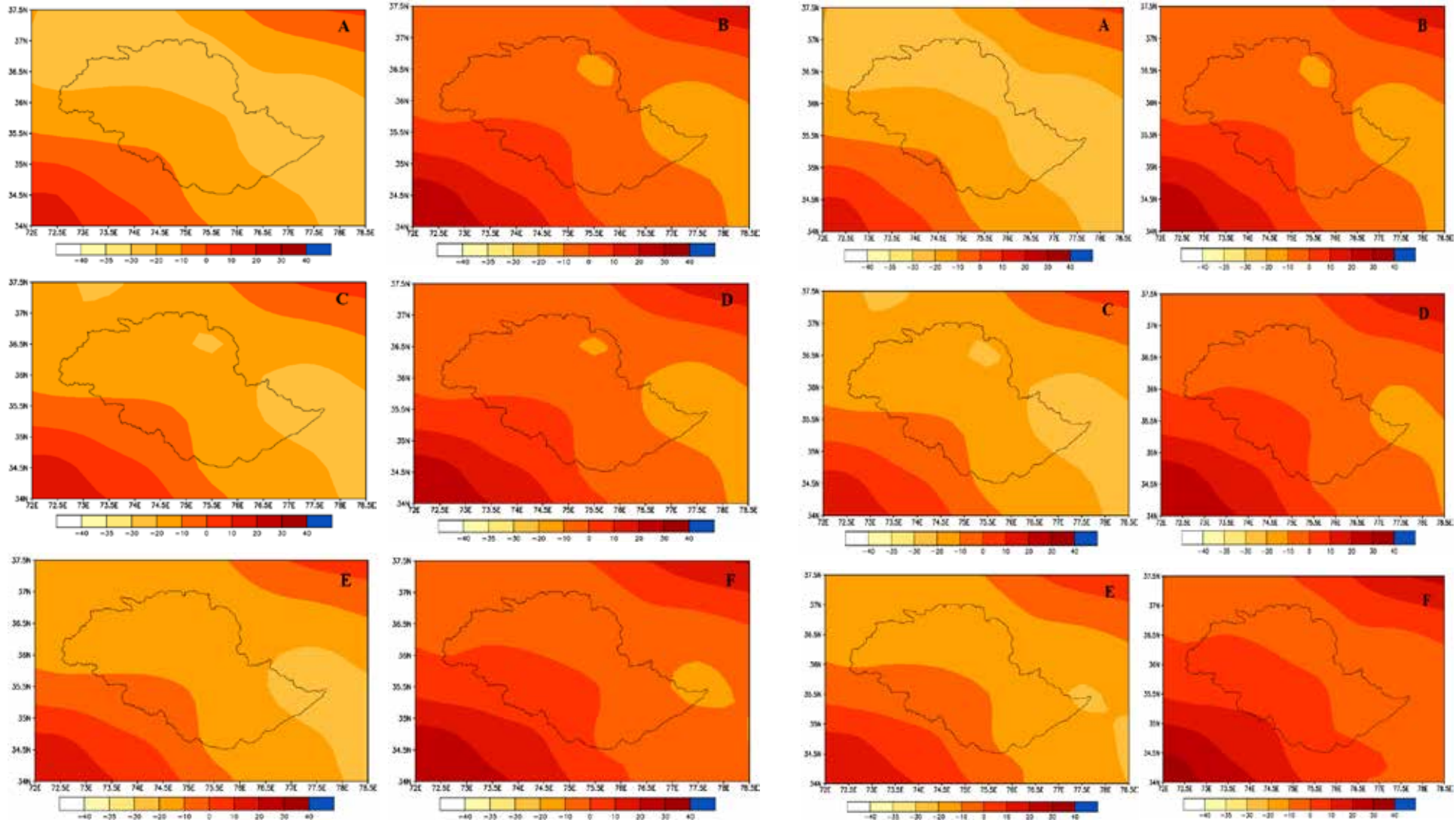
RCP 4.5

Snow accumulation   Snowmelt

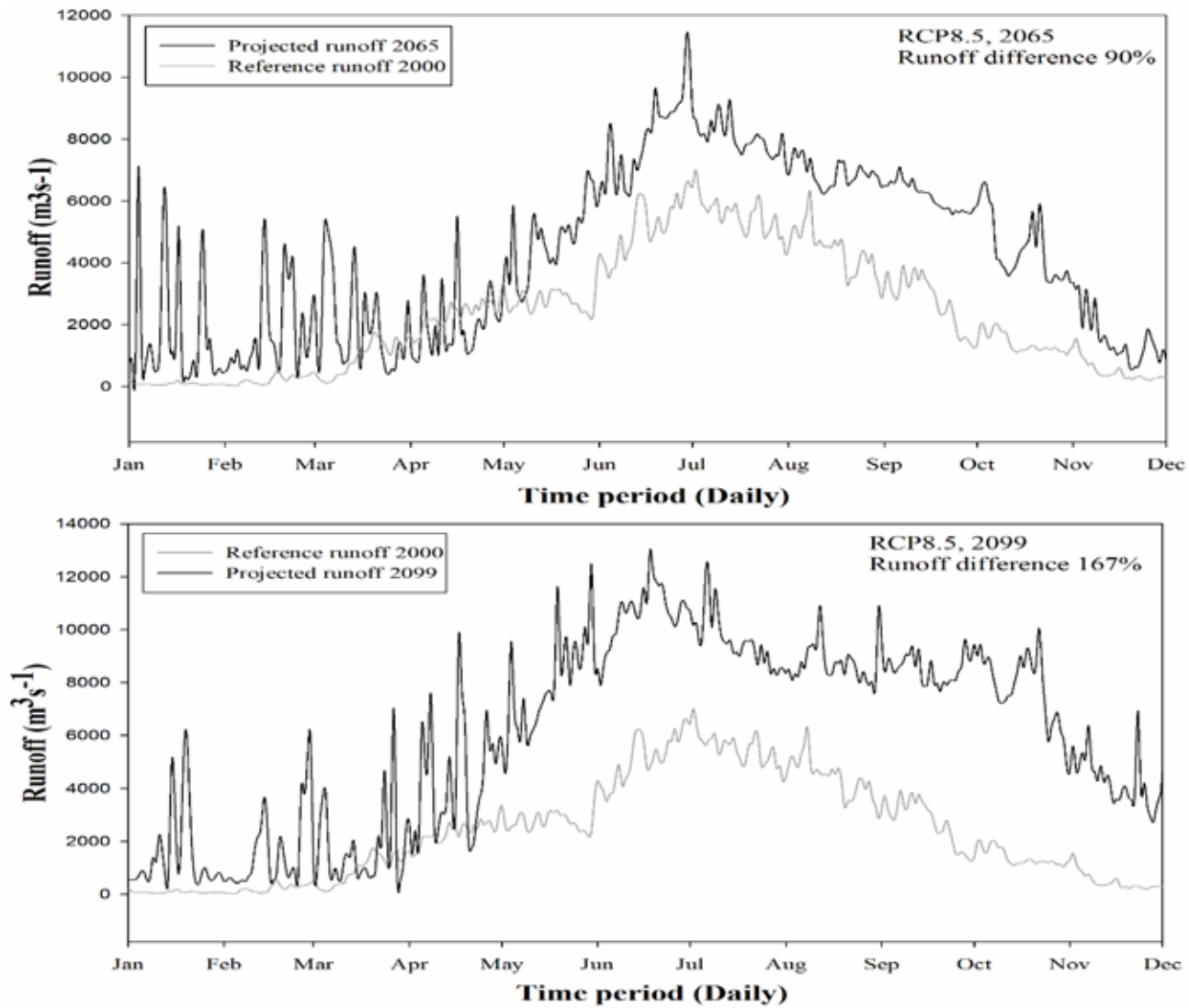**RCP8.5**

Snow accumulation   Snowmelt

(A) Mean monthly temperature [°C] during snowmelt 1951-2005, (B) Mean monthly temperature during snow accumulation, (C) Mean monthly temperature during snow accumulation 2006-2065, (D) Mean monthly temperature during snowmelt 2006-2065, (E) Mean monthly temperature during snow accumulation 2066-2099, (F) Mean monthly temperature during snowmelt 2066-2099.

Annual Runoff projection under RCP4.5
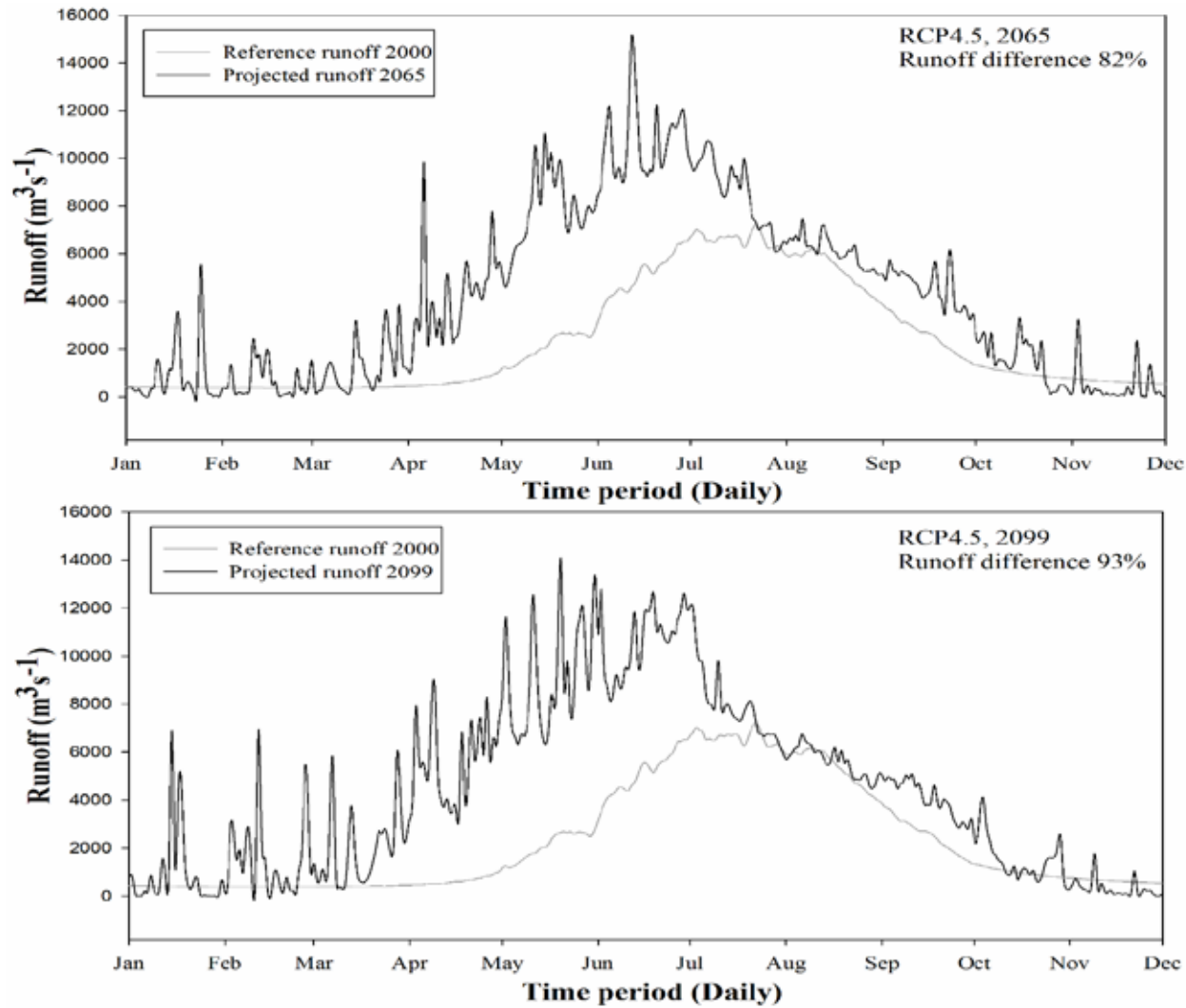
Annual runoff projection under RCP8.5

Projected hydropower generation under the RCP4.5 and RCP8.5 scenarios

Name	Planned	RCP4.5 2065	RCP4.5 2099	RCP8.4 2065	RCP8.5 2099
	Annual energy generation capacity (GWh)	Annual projected energy generation (GWh)	Annual projected energy generation (GWh)	Annual projected energy generation (GWh)	Annual projected energy generation (GWh)
Diamer	18097	32937	34927	34384	48319
Dasu	21495	39121	41485	40841	57392

Note: Energy generation is calculated for each hydropower plant with 60% generation efficiency.

Conclusion

- In the future more water will be available as a result of increase in the mean temperature.

- Increment in the Indus river flow will increase the hydroelectric power generation capacity of the planned future hydropower projects.

- The hydropower generation capacity of major future hydropower projects such as those from the Diamer Basha, Dasu and Bunji hydroelectric power stations are also expected to increase.

Thank You

Bilal.khn@gmail.com