Assessment of climate change impacts on semi-arid watersheds in Peru

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Abstract

Low seasonal precipitation and high demand for water use for agriculture, mining, industry, power generation and human consumption have made water resources management a concern in the Arequipa Region of Peru, which may be worse under future climate projections. In this study, the hydrologic response to climate change is evaluated within the Quilca-Vitor-Chili River Basin in the Arequipa Region of Peru. The Soil and Water Assessment Tool (SWAT) is used to develop a watershed model based on topographical, land cover, soil, and climatic (precipitation and temperature) data, while taking into account anthropogenic inter-basin transfers. The model is calibrated and validated for current conditions. Three climate scenarios derived from Atmosphere-Ocean General Circulation Model (AOGCM) simulations for both Representative Concentration Pathways (RCPs) 4.5 and 8.5 are obtained from the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset. Surface runoff and water yield associated with future climate scenarios are calculated for two near (2010-2039) and far (2040-2069) futures. Results of this study will provide a guideline for developing water policy in the region in order to mitigate negative impacts of climate variations in the region.

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MOTIVATION

- Low seasonal precipitation and high demand for water use
- High spatial variation in precipitation (Figure 1)
- Need for water regulation and diversion to mitigate impact of future climate variations

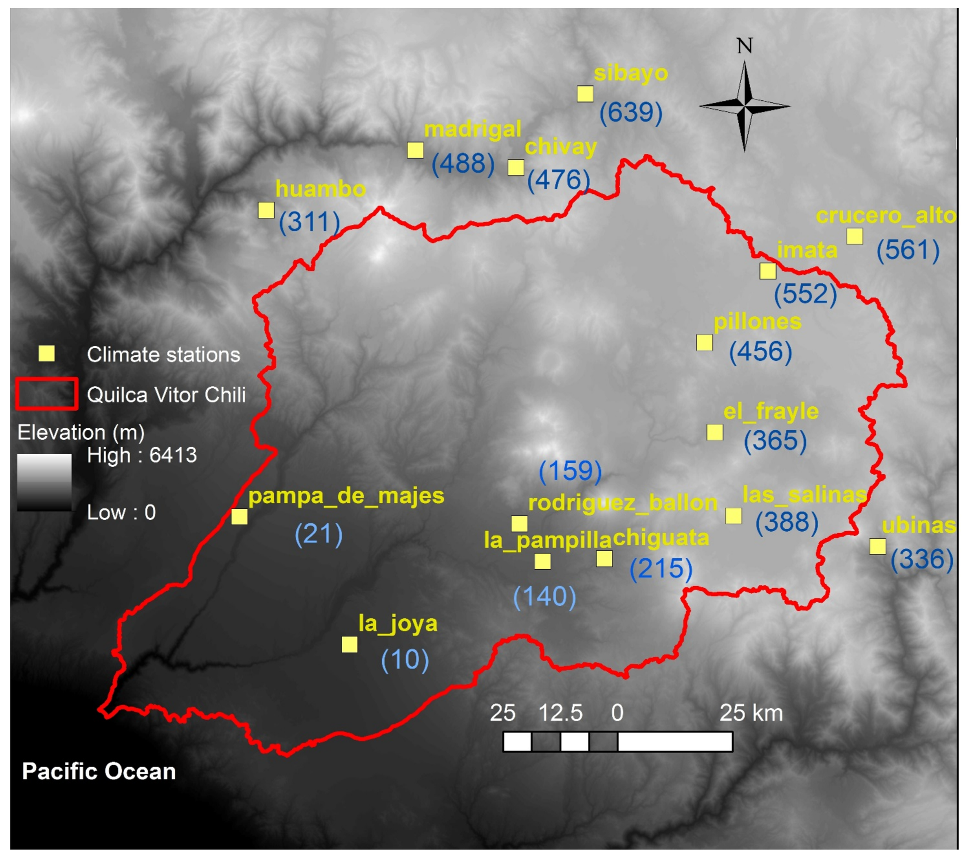

Figure 1. Average annual precipitation (mm) in the region (2008-2017)

OBJECTIVES

- ➢ Develop hydrological model to simulate water cycle
- ➢ Evaluate hydrologic response to climate change

STUDY AREA

Quilca-Vitor-Chili River Basin in Arequipa in Peru

- Area: 13,549 km^2
- Major City: Arequipa (population of over 850,000)
- Four reservoirs for water regulation
- Two water diversions from Camana River Basin
- One water withdrawal for irrigation project

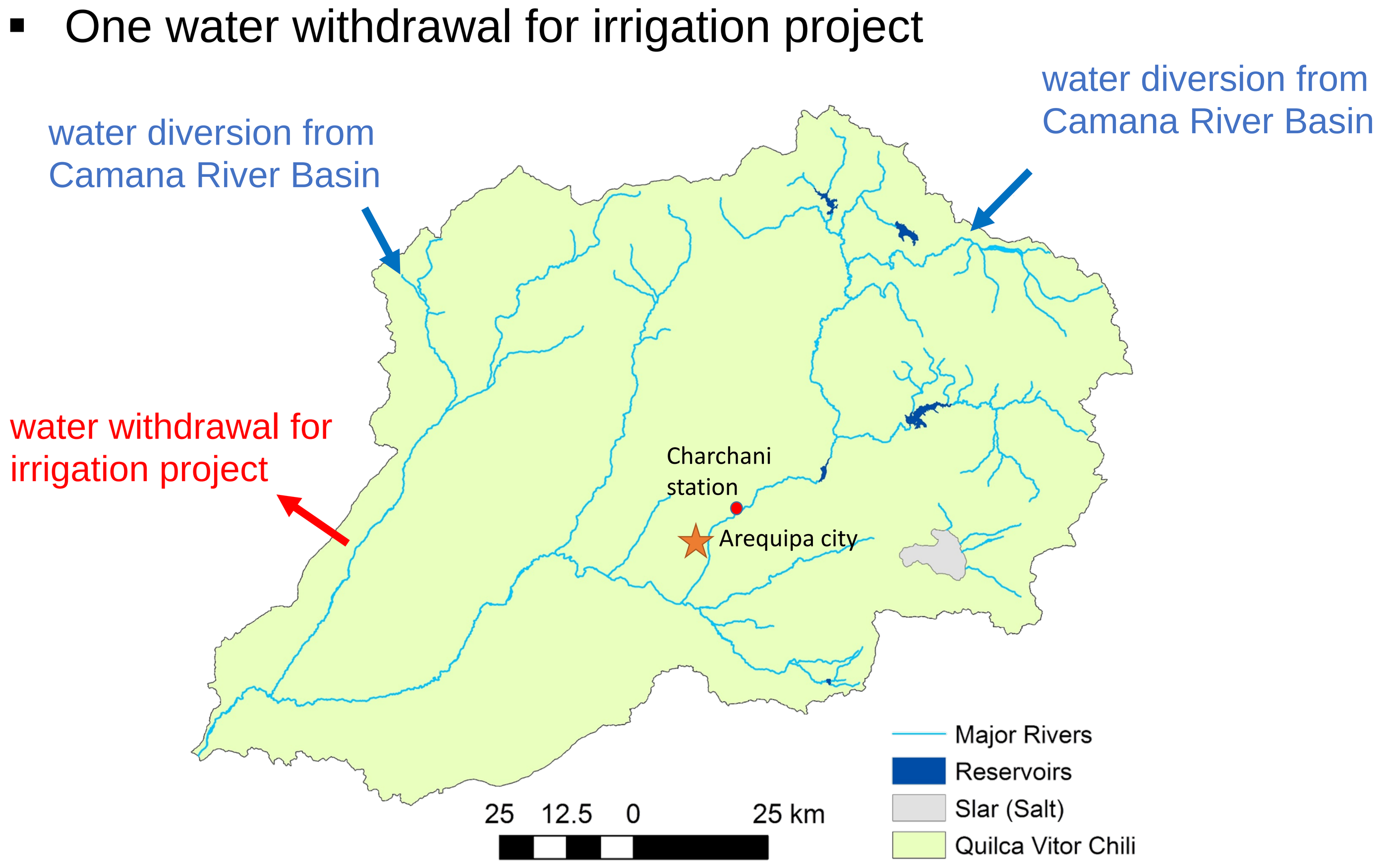

Figure 2. Major rivers, water bodies, and water regulations in Quilca-Vitor-Chili River Basin

HYDROLOGIC MODELING

Soil and Water Assessment Tool (SWAT)

- Physically based, semi-distributed watershed/water quality model
- SWAT Inputs layers:

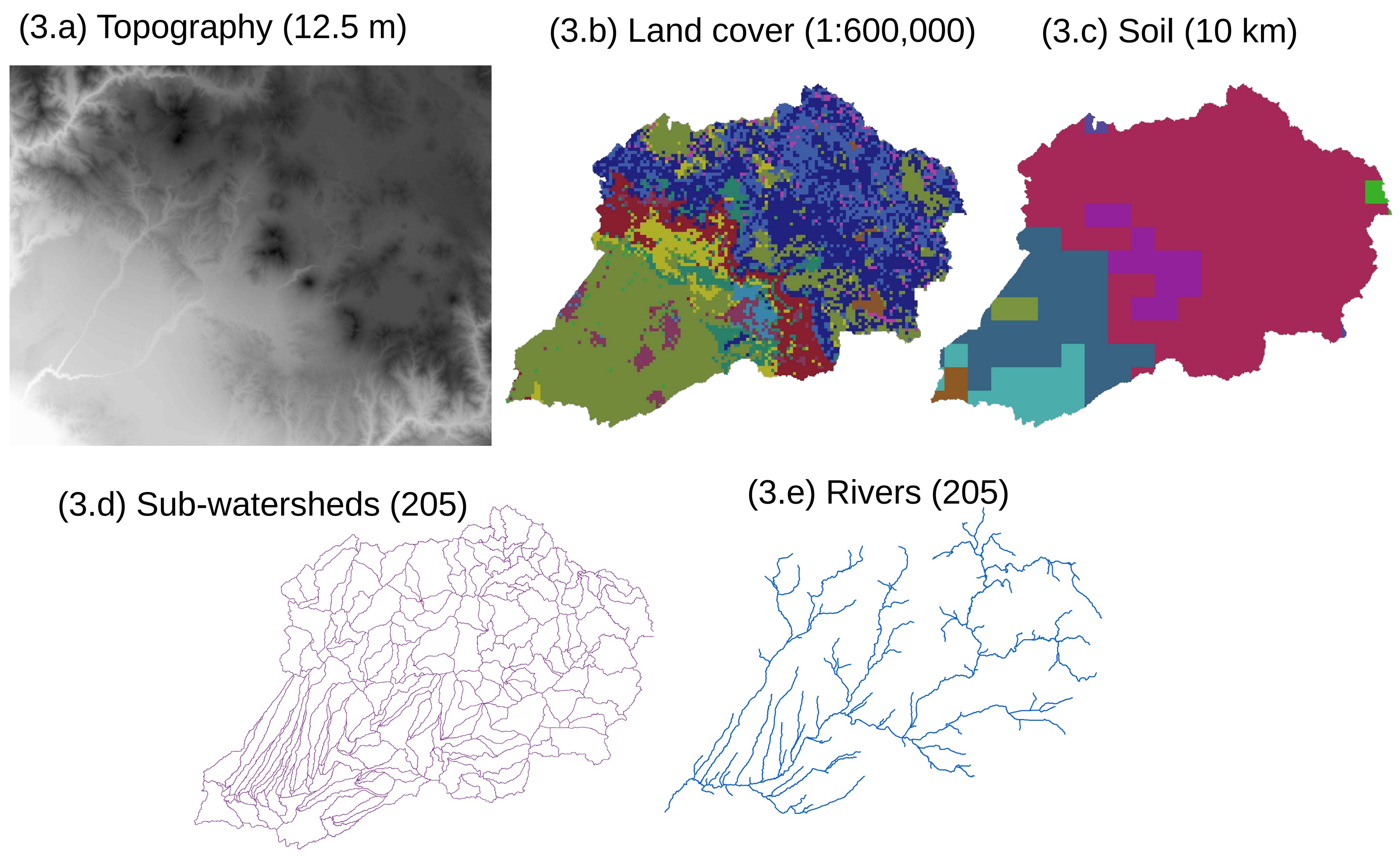

Figure 3. SWAT input layers

- SWAT Inputs Databases:
  1) Daily climate (precipitation and temperature) for 15 stations
  2) Point source discharges (2 points) and withdrawal (1 point)
  3) Reservoirs daily release rates

CLIMATE SECENARIOS

NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP)

- General Circulation Model (GCM) runs conducted under the Coupled Model Intercomparison Project Phase 5 (CMIP5)
- Resolution: 0.25 degrees (-25 km * 25 km)
- Three climate models: 1) CNRM-CM5, 2) MPI-ESM-MR, 3) MRI-CGCM3
- Two Representative Concentration Pathways (RCPs): 1) 4.5, 2) 8.5
- Two periods of simulations: 1) Near future (2010-2039), 2 Far future (2040-2069)

RESULTS

➢ Hydrologic Model Performance

- SWAT model calibrated for 2009-2013
- Calibration point: Charchani station
- Model performance:

  NSE: 0.53

  PBIAS: -3.79 %

  R^2: 0.58

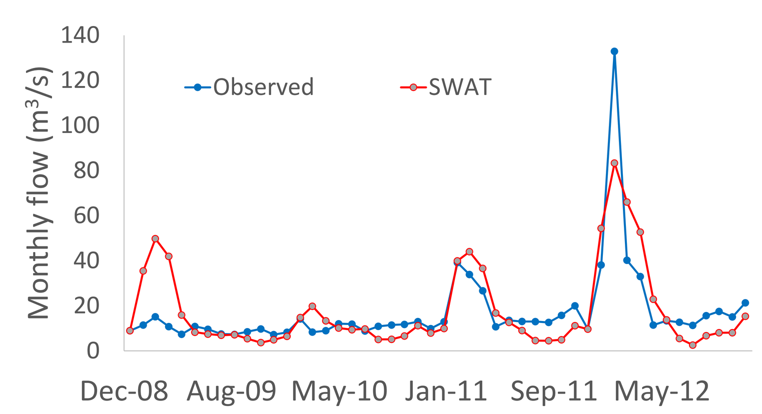

Figure 4. SWAT model calibration

➢ Current Condition

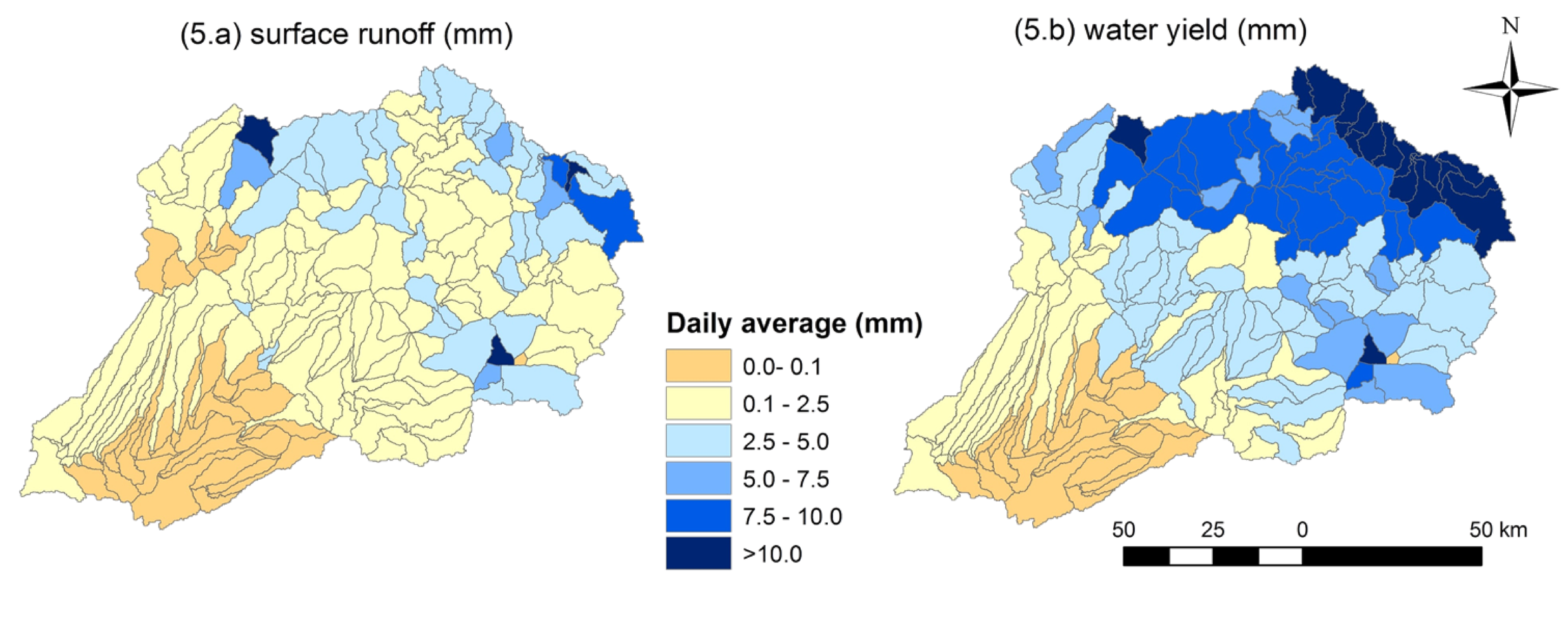

Figure 5. Daily average of surface runoff (mm) and water yield (mm) at sub-watershed level for current condition (2009-2017)

➢ Future Scenarios

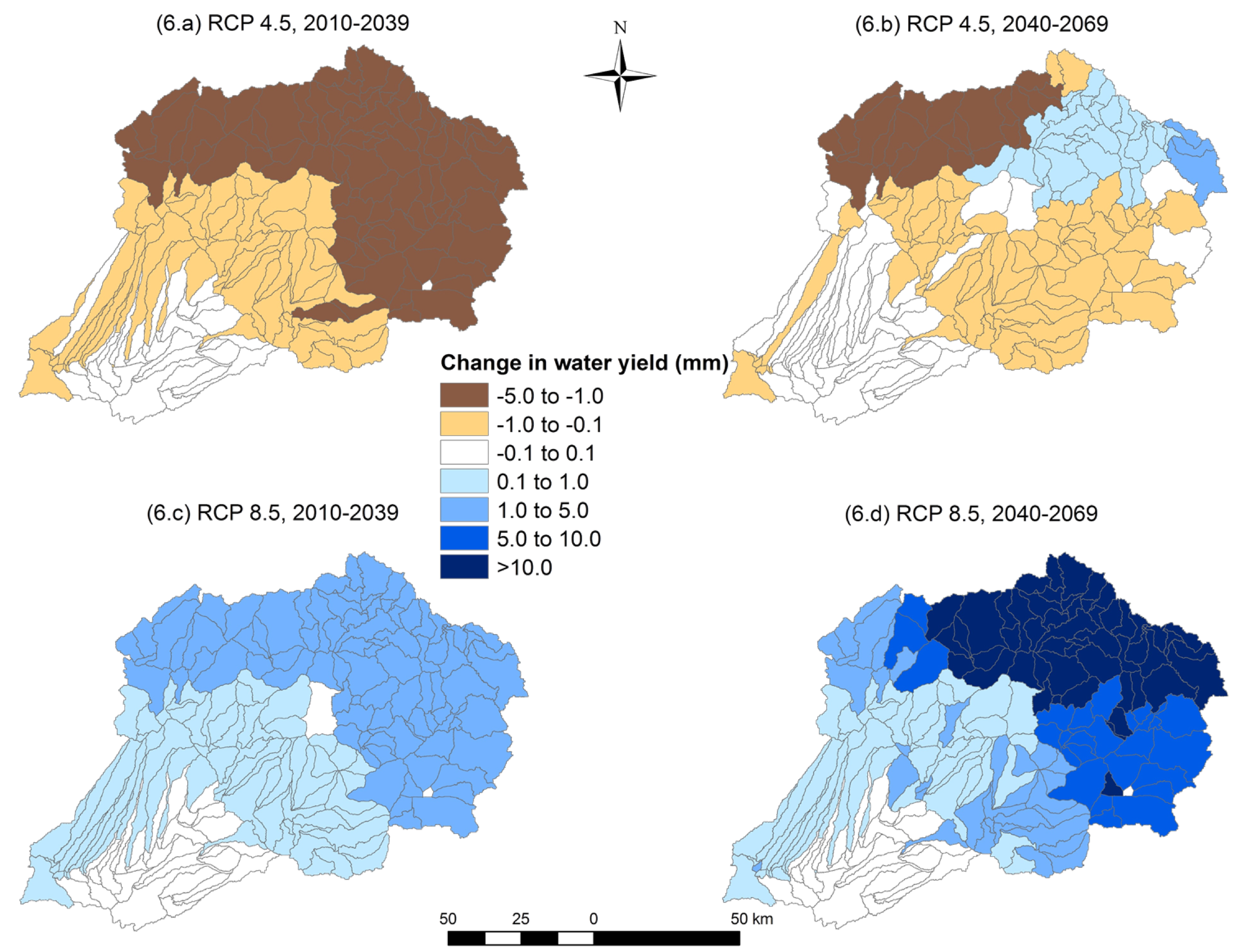

Figure 6. Ensemble average of daily water yield (mm) at sub-watershed level

CONCLUSIONS

- ➢ Slight increase in surface runoff and water yield are predicted in high attitude headwaters, especially for RCP 8.5 in far future (2040-2069)
- ➢ All models predicted low water supply in low altitude catchments
- ➢ Incorporation of water diversions and withdrawals into future simulations will provide more accurate picture of water availability and will be subject of future research

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