National Mission on Himalayan Studies (NMHS)

PERFORMA FOR THE HALF YEARLY PROGRESS REPORT

(Reporting Period *from* **July 2018** *to* **December 2018**)

1. Project Information

Project ID	NMHS/2015-16/LG05/05
Project Title	**Dynamics of Himalayan Ecosystem and Its Impact under Changing Climate Scenario in Western Himalaya**
PI and Affiliation (Institution):	**Dr. A. P. Dimri** School of Environmental Sciences, Jawaharlal Nehru University New Delhi
BTA	Water Resource Management
Project Partners:	1. IIT Mumbai, Maharashtra 2. National Institute of Hydrology, Roorkee, Uttarakhand 3. National Centre for Medium Range Weather Forecasting, Noida, UP 4. Indian Institute of Science, Bangalore, Karnataka

2. Project Objectives

1. Develop extensive database for climate and ecological processes across the elevation gradients
2. Regional climate modelling with sub-grid orographic forcing, extreme hydrological events, biodiversity dynamics for the present (1970-2010)
3. Regional climate model simulations for climate change scenarios (upto ~2100)
4. Identify ecological restoration strategies to adapt to future climatic scenarios

3. Half Yearly Progress

Quantifiable Deliverables	Monitoring indicators	Progress made against deliverables in terms of monitoring indicators
1	2	3
Development of world class field observatories and long-term ecological and climate monitoring systems in Ganges and Indus sub-regions (2 basins), by combining citizen science with field work by research teams.	• **No of long term monitoring systems** established in 2 basins	
Integrated and synthetic assessment of vegetation and faunal response to climate change in 3 different Himalayan watersheds.	• Assessment reports of watershed **(Nos.)**	

Engagement with local communities to develop long-term citizen science based monitoring programs for ecological and climatic changes.	• Models and knowledge products developed and published out of the projects **(Nos.)**	
Develop models that can provide more reliable projections for ecological changes, weather and extreme climatic events for the western Himalayan region.	• Communities engaged in monitoring program (Nos.)	• The projected behaviour of the rainfall and temperature are studied over western Himalayas. The increase in the extreme rainfall events over the foothills of Himalayas arereported *(refer Appendix 1)* • 01 Article has been published.
Develop specific approaches to ensure participation of women in citizen science and outreach programs.	• Women participation in science outreach program **(Nos.)**	

Appendix 1

Part-1 Assessment of present and future climate change over Kashmir Himalayas, India

Climate change particularly over the mountainous basins requires detailed understanding of the present and projected temperature and precipitation regimes; which is helpful for better water resource management, cryospheric resources, hydropower generation, natural hazard risk assessment, and ecosystem response. Improper representation of the model topography over valley/ridge leads to biases in global and regional climate models (GCMs/RCMs). In this study uses the statistical downscaling model (SDSM) to calibrate and validate Canadian Earth System Model (CanESM2) outputs. The outputs are validated against the corresponding in situ observations available at six meteorological stations within the Kashmir basin in western Himalayas.The three Representative Concentration Pathways (RCPs) were divided into three future time slices of 2030s, 2060s, and 2090s for the analysis. Downscaled climate data reveals increase of the mean maximum temperature in the range of 0.3–2.3 °C and the mean minimum temperature increase from 0.3–1.9 °C under different RCPs when compared with the baseline period of 1980–2010. An increasing trend from 2 to 17% at different meteorological stations under different RCPs has been observed in precipitation. Highest seasonal variability for both temperature and temperature are found for autumn.

(a) (b)

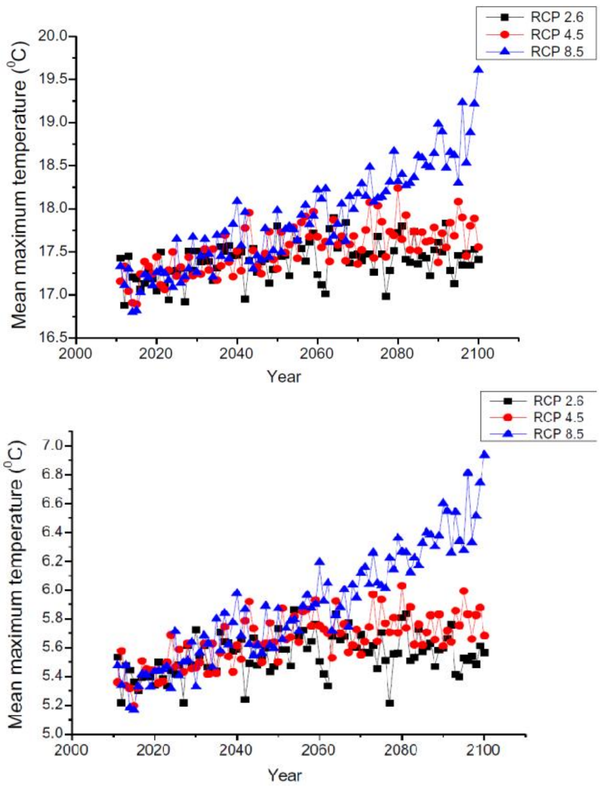

Fig. (a) Projected change in the maximum temperature in three RCPs for Kashmir Himalayas (averaged over six meteorological stations) and (b) same as (a) but for minimum temperature. (Shafiq et al., 2019).

Part-2 Observed Evidence for Steep Rise in the Extreme Flow of Western Himalayan Rivers

The Western Himalayan (WH) rivers are affected by global warming and most of the models are projecting increase of the river flow till the end of the century. The increasing rainfall leads to flood, which causes loss of human life as well as property damage. The observational data shows the doubling of the occurrences of extreme flow during the period of 1980-2003 with an increasing trend in annual maximum streamflow. This streamflow change is due to the increasing precipitation extremes occurring during both the summer and the winter monsoon. The analysis further depicts stepwise increase of 'chi-gradient' in Bhagirathi and Sutlej rivers, indicative of a landscape responding to extreme precipitation and contributing to severe floods.

These results highlight the severity of hydroclimatic changes underway in the WH region, and also advocates about the critical need for a hydro-infrastructure and an operational flood forecasting system over WH. This will benefit more than 17-million inhabitants from increasing flood hazards.

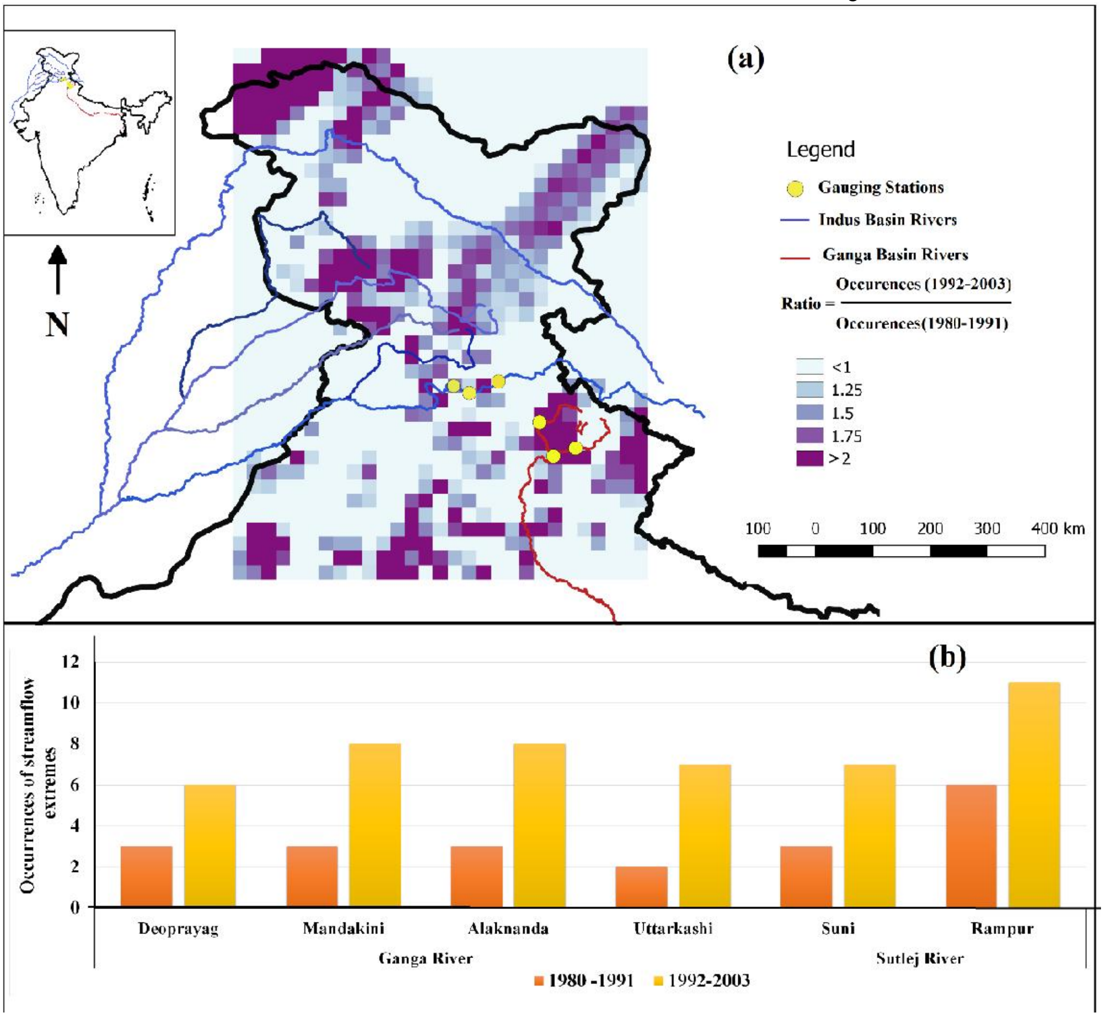

Fig. **a**) Ratio of occurrences of extreme rainfall between the two periods (1992 to 2003) and (1980 to 1991). The occurrences are counted based on the threshold value of long term mean of annual maxima. **b**) Occurrences of streamflow extremes and its consistent increase during recent decades. (Submitted in Geophysical Research Letters).

Part-3 Comparative analysis of two rainfall retrieval algorithms during extreme rainfall event-A case study on Cloudburst,2010 over Ladakh (Leh), Jammu and Kashmir

Intense rainfall events lead to floods and landslides in the Western Himalayas (WH). Extreme events like the cloudbursts are orographically locked intense convective phenomena producing abrupt high-intensity rainfall over a small area. Accurate prediction and early warming of these cloudburst events is important to reduce the loss of human life as well as property loss. However, due to lack of ground observation and smaller spatial extend, these events often go unreported over remote and unpopulated hilly areas. The present study examines a cloudburst occurred at Ladakh (Leh) in the WH in the early hours of 5 August 2010 using remotely sensed rainfall data from Tropical Rainfall Measuring Mission (TRMM) and Kalpana-1.The storm lasted for two days starting from 3 August 2010; followed by flash floods. Rain-band propagation over the region are studied from Kalpana-1 3-hourly rainfall estimates using Indian Satellite (INSAT) Multi-Spectral Rainfall Algorithm (IMSRA) and TRMM rainfall estimates using TRMM 3B42 algorithm. Quantitative and qualitative assessment and comparison of these two products is made. It is observed that there is decrease in satellite brightness temperature (BT) during the rainfall event. Initiation of rainfall occurs at about <255K. Maximum of 16.75 mm/hr rainfall is observed over the Jammu and Kashmir at 21 GMT from TRMM 3B42 estimates while Kalpana-1 IMSRA underestimates the rainfall observations with respect to Indian Meteorological Department (IMD) rainfall estimates. Spatial correlation at 5% significant level are evaluated and similarities in rainfall estimates based on rainfall retrieval algorithms is made during the cloudburst event. Mean and standard deviations depicts that TRMM 3B42 and IMD rainfall estimates are closer in terms of spatial signature, but estimates of rainfall from Kalpana-1 underestimates the mean and standard deviation signature. In view of orographic contribution, it has been observed that linear fit is the better than non-linear with less rainfall bias at 90% confidence bound over the region.

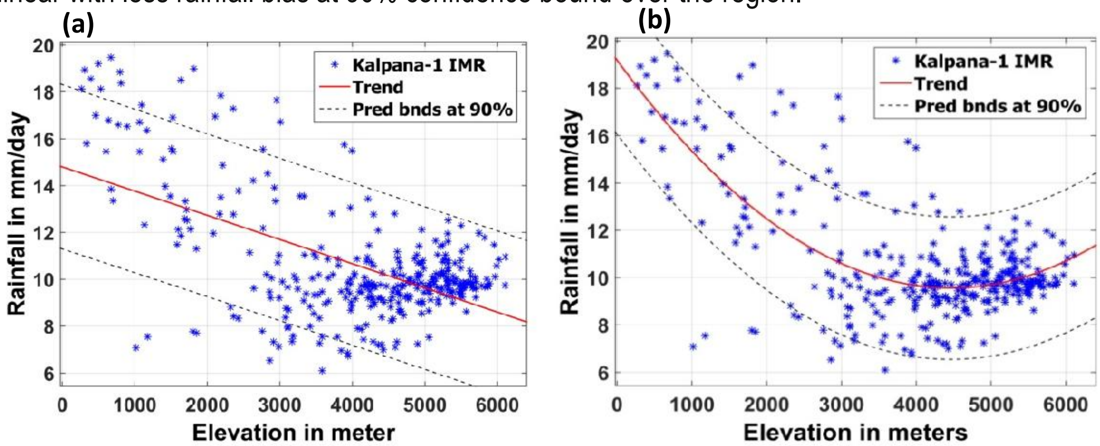

Fig. 1 Elevation vs. rainfall for Jammu and Kashmir. Fig. 1 (a) and (b) shows linear and non-linear trend of rainfall with elevation respectively at 90% confidence level. Red line indicates the trend. (Submitted in Natural Hazards).

Part-4 Rainfall over the Himalayan foot-hill region: Present and Future

Uttarakhand is an Indian state situated in the Himalayan foot-hill states of India, with a spatial coverage of 51125 sq.km. This region is rich in biodiversity and also having potential for agro-climate, hydro power generation, food-processing, tourism, etc. This study analyses the spatio-temporal rainfall distribution over the state during Indian summer monsoon. Observed and modelled rainfall are examined for the present climate and the projected rainfall trends are also analysed under three different Representative Concentration Pathways (RCPs). The orographic response as well as the elevation dependent rainfall pattern are examined using APHRODITE, Tropical Rainfall Measuring Mission (TRMM 3B42) and India Meteorological Department (IMD) gridded rainfall datasets during monsoon. It is found that rainfall pattern breaks near 3100 m elevation. The TRMM 3B42 rainfall underestimates more than 3mm/day rainfall whereas, APHRODITE overestimates rainfall below 4.5 mm/day with respect to IMD.

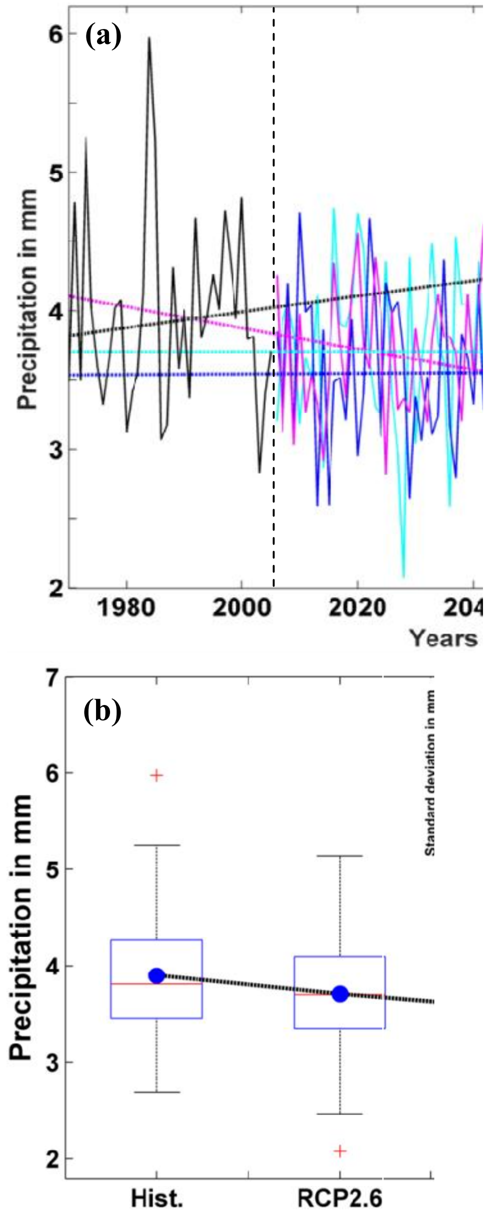

Fig. 1 (a) Area average historical and future precipitation for Uttarakhand under different RCPs (RCP2.6, RCP4.5 and RCP8.5) and dotted lines represents their trends. Fig.10(b) represents mean (blue dots) and standard deviations (blue bars) of area averageprecipitation under historical period (1970-2005), RCP2.6, RCP4.5 and RCP8.5 scenarios for future climate projections over Uttarakhand. (Submitted in Journal in Earth System Sciences).

Table 1: Contribution of seasonal rainfall from APHRODITE, TRMM3B42 & IMD Estimates for Uttarakhand along elevation belts.

Elevation in meter	Rainfall Source	June	July	August	September
<500	APHRODITE	14%	34%	34%	18%
	TRMM3B42	13%	35%	32%	20%
	IMD	14%	30%	36%	20%
500-1000	APHRODITE	14%	34%	34%	18%
	TRMM3B42	13%	35%	33%	19%
	IMD	13%	30%	38%	19%
1000-2000	APHRODITE	16%	33%	33%	18%
	TRMM3B42	14%	34%	32%	20%
	IMD	15%	30%	36%	19%
2000-3000	APHRODITE	15%	33%	34%	18%
	TRMM3B42	13%	35%	33%	19%
	IMD	16%	29%	37%	18%
3000-4000	APHRODITE	16%	33%	33%	18%
	TRMM3B42	15%	34%	30%	21%
	IMD	15%	29%	35%	21%
4000-5000	APHRODITE	16%	34%	32%	18%
	TRMM3B42	15%	34%	29%	22%
	IMD	15%	28%	35%	22%
>5000	APHRODITE	16%	33%	33%	18%
	TRMM3B42	14%	34%	31%	21%
	IMD	16%	28%	33%	23%