PREFACE

The main motivation for writing this thesis is a profound interest in development and climate change research. The question of how to address the impacts of climate change on development is a challenging and vital area of theoretical and applied research. The aim of the two individual papers in the Ph.D. thesis is to address this aspect from different angles. The emphasis is on how climate change impacts will influence rural livelihoods and existing and ongoing development programs, projects, and planning efforts. Additionally, it is explored how adaptation to climate change can be considered in the context of general development efforts to ensure sustainable development paths.

Urbanization is trending in today's world; it is estimated that more than half the world's population would migrate to cities in the next thirty years. Water comes under the most critical natural resources on Earth, supporting plant and animal life. Water problems in India are stressed due to rising population and climate change. The studies showed that the changing climate and intense human activities would complicate the situation endangering these natural resources. So being an engineer, it is our responsibility to provide clean, healthy and sustainable sources of the primary resources to our next generations. To support sustainable uses of water, an appropriate model is required, and it is essential to know the behavior of the trend.

The north-central part of India is extremely affected by climate change, and the Ganges River basin, the most crucial river for such regions, is stressed by extreme anthropogenic activities. Therefore, in this thesis, the study area is two northern Indian states, Uttar Pradesh and Jharkhand, which is also a part of the Ganges River catchment covers. Data used in this work are daily, monthly, and yearly meteorological data from 1901 to 2018, Digital. The software used in the present work is MATLAB, a mathematical tool for programming, ArcGIS 10.5

for digitizing the Spatio-temporal maps. The non-parametric methods and equation Mann-Kendall, Spearman rho, Sen's slope method, and linear regression technique were used in the trend analysis. Before the application of the methods, the obtained time series data has been properly analyzed. As the first step of modeling, the basics of trend have been understood, and then the Novel tool has been developed, Variable Sized Cluster Analysis (VSCA).

A novel analysis procedure referred to as variable-sized cluster analysis (VSCA) was developed to identify trends and change points in precipitation time series. The procedure involved station-scale rainfall data of 118 years from eighteen divisional districts of Uttar Pradesh (UP) and five divisional districts of Jharkhand, India. In contract with the traditional Mann Kendall (MK) test, which yields a monotonic trend for the whole span of time, VSCA enables to detection of multiple change points while characterizing the pattern of precipitation trends over the historical time period. The Pettit Mann Whitney (PMW) test was also modified to graphically represent multiple change points which confirmed the results of VSCA. Thus, VSCA demonstrated the unified strength of MK and PMW tests. The 3-D figures, drawn for visualizing the changing trend of precipitation, utilized a 118-year long time series dataset with the minimum size of data cluster as 10, which resulted in the right triangular shape of the graphs due to the repeated application of MK test to variable-sized data clusters.

In the last step of this research, an analysis of the impact of climate change was done, and preventive measures are suggested to reduce anthropogenic activities.

A major part of the thesis has been published and accepted in the SCI-indexed Journals like the Journal of Hydrologic Engineering (ASCE), Earth Systems and Environment (published), and Arabian Journal of Geosciences (under review).