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ASSESMENT OF CLIMATE CHANGE IN THE NORTHERN REGION OF INDIA FROM 1901 TO 2020 THROUGH THE APPLICATION OF GEOSPATIAL TECHNOLOGIES

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Abstract : Throughout its history, the Earth has experienced significant fluctuations in its climate. These fluctuations have been driven by both periodic and episodic natural factors, including changes in orbit and volcanic activity, which have been amplified by feedback mechanisms inherent in the climate system. These natural forces have led to significant alterations in the global climate over various timeframes.

The climate of the Indian subcontinent is influenced by intricate interactions among the atmosphere, ocean, land, and ice systems across different spatial and temporal scales. Moreover, there is evidence suggesting that human activities have contributed to changes in the regional climate in recent decades. The consequences of anthropogenic climate change, such as heightened heat events, shifts in monsoon patterns, and rising sea levels, pose grave threats to the lives and livelihoods of those inhabiting the subcontinent. Therefore, it is imperative to comprehend the underlying reasons for climate change in India and how these changes are expected to progress in the future.

In sum, "Assessment of Climate Change in the Northern Region of India from 1901 to 2020 through the Application of Geospatial Technologies" provides a brief overview of the mean climate of the northern region of India and sets the context for comprehending the crucial elements of climate change in the area.

IndexTerms - Monsoon, Climate Change, Geospatial Technologies, Precipitation, Land Cover, Temperature

INTRODUCTION:

Climate change is now the most momentous environmental issue. It has far-reaching influence on biodiversity and climatic conditions of the earth. Gradually, climate change will be a pervasive actor in the cost of health care, the price of food and access to water. In India, the scaring form of climate change is visible in varied forms such as floods, droughts,

cyclones, and changing monsoon patterns. According to the Global Climate Risk Index, India is the sixth most vulnerable country in the world and tops the list in terms of the total number of people affected by climate-related disasters. However, at the state level, the northern region of India provides an interesting and unique geography to study climate change mainly because of the presence of the Himalayas in the north. The Himalayas play a crucial role in generating the climate of the region. For example, it acts as a barrier for the cold winds coming from Central Asia in the winter and from South Asia in the summers. The growing season

in the region is also determined by the axis of the Himalayan range and the shifting of the Inter-Tropical Convergence Zone (ITCZ).

Over the past few decades, the increasing melting of glaciers has become a major focus of climate change research in India. The glaciers are retreating in many places, and the magnitude of the retreat is expected to rise as more data become available. The retreats have been widely adopted as an early effect of global climate change. Also, the region has seen a rapid decline in snowfall days and snowfall. The spatial pattern of snowfall and the length of the snow cover in the region have also changed. For example, the geospatial analysis showed that the snow line on average has moved 100 meters upwards. It not only suggests a change in climatic conditions but also raises concerns about the shrinking natural water storage. These changes may have serious repercussions for the rural and urban society in the region. For example, the 2010 flash flood in Leh, a Himalayan town, took many lives and caused extensive damage to infrastructure. It occurred after a glacial lake outburst flood which took place due to the breaching of a terminal moraine. The moraine dam lake was formed as a result of accelerated melting of glaciers in the last decade.

Such events certainly require innovative and interdisciplinary research to decipher the complexities of regional climate change in a precise manner. In the background of the above research gaps and opportunities, the proposed study aims to systematically investigate the climate change in the northern region of India and bridge these gaps by employing geospatial technologies. This will be achieved by integrating remote sensing, climate data, geographic information system, and global positioning system (GPS) to grasp and visually representing the geographical and time-related characteristics of the climate.

The study will focus on changes in temperature, precipitation, spatial distribution, and extreme weather events. It will also investigate the implications of climate change on the regional ecosystem, particularly on the forest and water resources. Furthermore, the research methodology will provide the scope to explore the human responses and adaptations to climate change. The results of the study will contribute to our understanding of the changing climate and provide a scientific base for policymakers to develop appropriate strategies. Also, the study will provide transferable knowledge and practical experiences on the application of geospatial technologies to the complex and dynamic nature of regional climate change. As a result, capacities in the field of climate change research will be improved, and more trained professionals will be available to take the country to the next step of climate-resilient, sustainable, and low-carbon development.

REVIEW OF LITERATURE:

Defining Climate Change

Importance of Geospatial Technologies

Potential Studies

Climate change is a pressing issue in India, and the northern region is particularly vulnerable.

This review explores the potential of geospatial technologies in assessing climate change in

this area from 1901 to 2020.

- Traditional methods for climate analysis rely on point-based data from weather stations. Geospatial technologies offer a wider perspective.
- Geographic Information Systems (GIS) and remote sensing allow researchers to analyse spatial and temporal variations in climate data.
- For example, satellite imagery can be used to track changes in snow cover, glacial retreat, and land cover, all indicators of climate change.

Several studies likely exist that utilize geospatial technologies to assess climate

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change.
• These studies might focus on various aspects of climate change, including:

o Trends in temperature and precipitation: Analysing historical data to identify trends in warming, changes in rainfall patterns, and increasing frequency of extreme weather events.

o Changes in glacial extent: Monitoring the retreat of glaciers in the Himalayas using satellite imagery and elevation data.

o Impacts on land cover: Assessing changes in vegetation cover, deforestation, and desertification using remote sensing techniques.

Limitations and Future Directions

- Data availability and quality can be limitations, especially for historical periods.
- Integrating geospatial data with climate models can provide more robust projections

for future climate scenarios.

By analysing existing research, this review can pave the way for further exploration of climate change in North India using advanced geospatial techniques. This knowledge is crucial for developing adaptation strategies and mitigating the negative impacts of climate change on the region's environment and population.

1. **METHODOLOGY AND DATABASE USED:**
   - **Climate Research Unit(CRU) dataset**
   - **Indian Meteorological Department(IMD) dataset**

Climate models from the CMIP5 database:

Model	Institute
ACCESS1.0	Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia and Bureau of Meteorology (BOM), Australia
CMCC-CM	CMCC, Italy
CMCC-CMS	
CNRM-CM5	Centre National de Recherches Meteorologiques, France
CSIRO-Mk3-6-0	CSIRO, Australia
Inm-cm4	Institute for numerical mathematics, Russia
IPSL-CM5A-LR	Institute Pierre-Simon Laplace, France
IPSL-CM5A-MR	
MPI-ESM-LR	Max Planck Institute, Germany
MPI-ESM-MR	

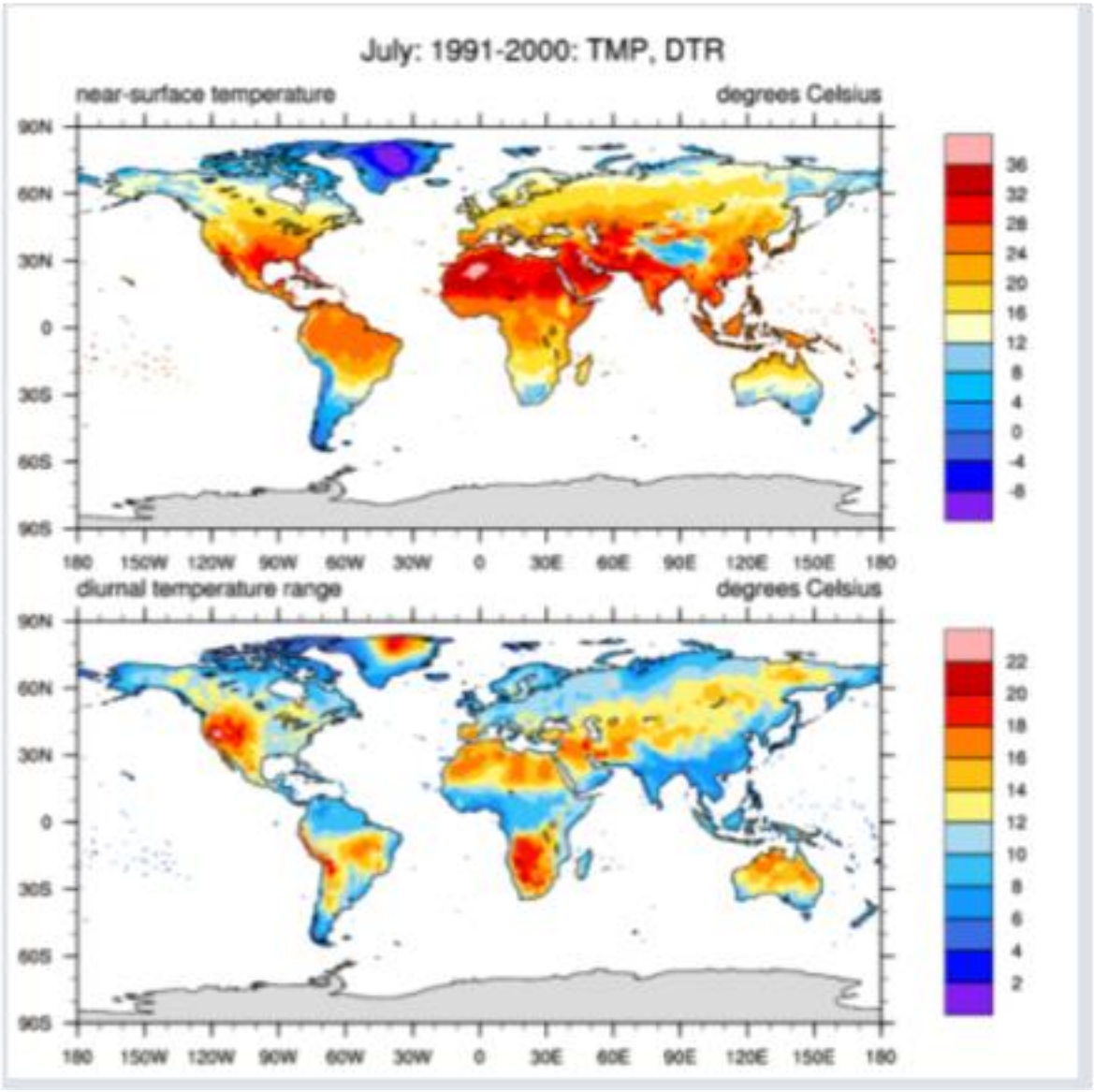
Climate models from the CMIP6 database:

Model	Institute
BCC-CESM2-MR	BCC, China Meteorological Administration, China
CAMS-CSM1-0	CAMS, China
CANESM5	Canadian Centre for Climate Modelling and Analysis, Canada
CESM2	National Science Foundation, Department of Energy, NCAR, USA
EC-Earth3	EC-Earth brings together 27 research institutes from 10 European countries, Europe
EC-Earth-Veg	
IPSL-CM6A-LR	IPSL, France

MIROC6	Atmosphere and Ocean Research Institute, NIES and Japan Agency for Marine-Earth Science and Technology, Japan
MRI-ESM2-0	Meteorological Research Institute, Japan
IITM-ESM	IITM, India

RESEARCH ANALYSIS

The CRU TS data series, short for Climatic Research Unit Timeseries, comprises monthly records of precipitation, daily maximum and minimum temperatures, cloud cover, and other parameters spanning Earth's land regions from 1901 to 2015. This dataset is spatially gridded at a resolution of 0.5x0.5 degrees, derived from the analysis of more than 4000 individual weather station datasets. While many of the input records have been standardized for consistency, the dataset itself does not exhibit strict homogeneity. Trends in air temperature across extensive regions closely resemble those observed in datasets such as CRUTEM4. The



precipitation data have been utilized to evaluate global precipitation patterns and to develop gridded drought indices like the sc-PDSI and the SPI. With its diverse array of variables, this dataset facilitates numerous additional investigations into climate variability and extreme events.

When possible, studies of trends consider whether the trends are physically consistent with other variables from independent data sets.

Figure 1 : CRU: July climatological mean temperature (TMP) and diurnal temperature range (DTR) for 1991-2000

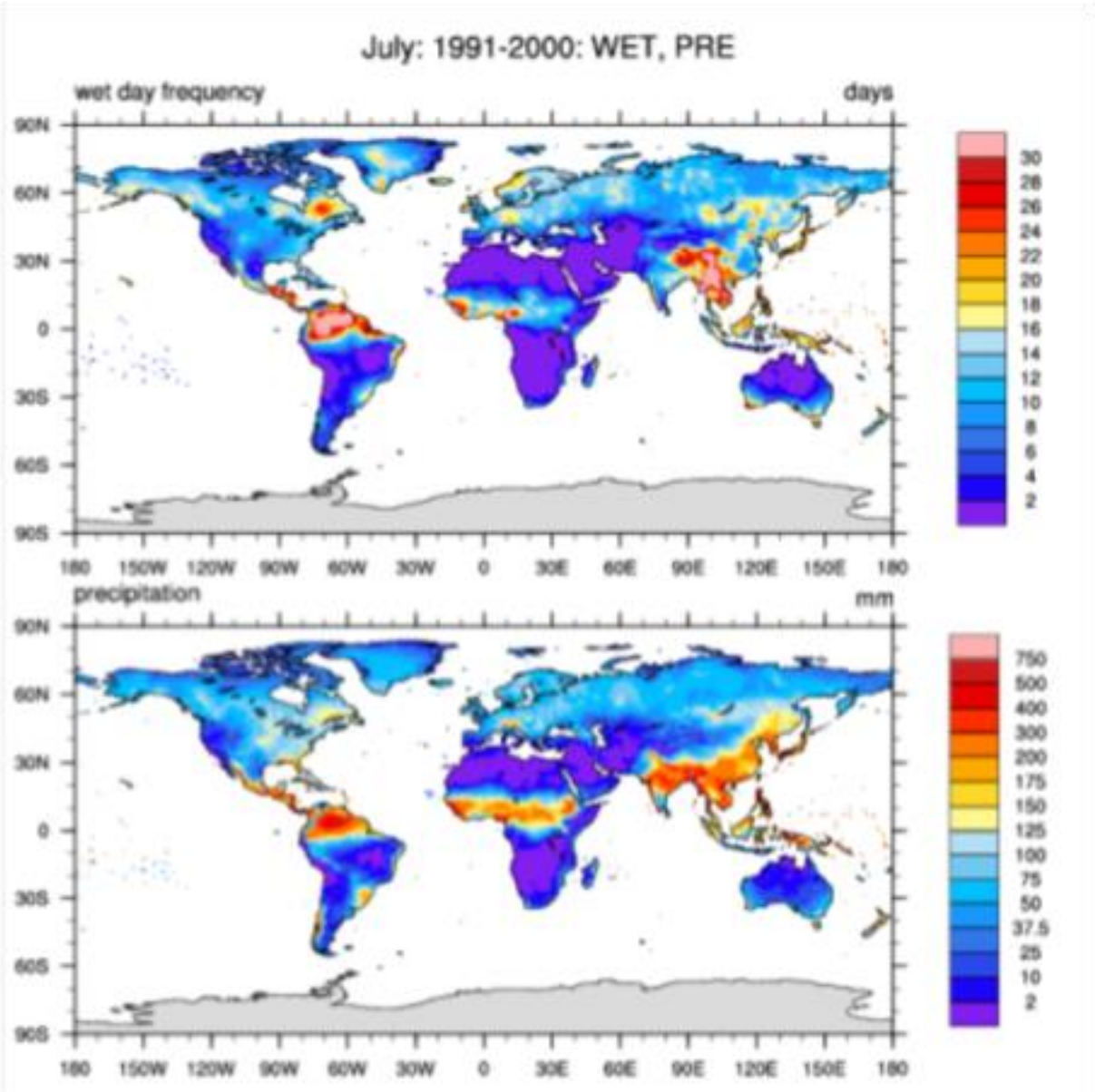


Figure 2: CRU: July climatological wet day frequency (WET) and precipitaGon (PRE) for 1991-2000.

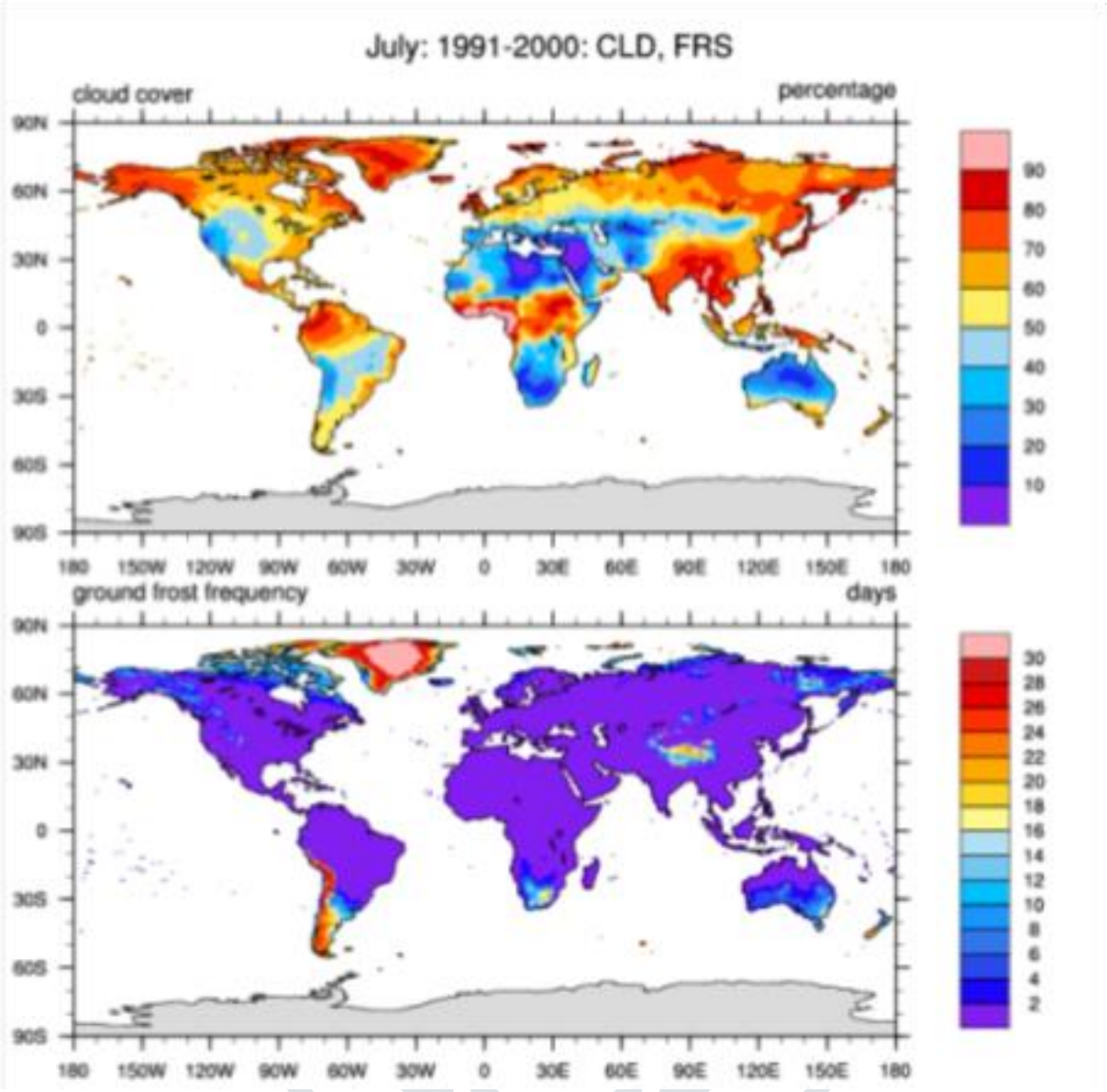


Figure 3: CRU: July climatological cloud cover (CLD) and ground frost frequency (FRS) for 1991-2000.

Strengths

- Gathers station data from various sources for multiple variables and standardizes them into a unified format.
- The station data is employed to calculate variables like potential evapotranspiration, diurnal temperature range, and the frequency of frost and rain days.

Limitations

- While a significant portion of the input data underwent homogenization, the dataset itself lacks strict homogeneity. Exercise caution when interpreting trends derived from it.
- Fewer stations used than GPCC substantially.

CONCLUSION

In conclusion, it is imperative to recognize climate change as a component of a multifaceted system. Evaluating the advantages and drawbacks of various policy measures is essential, as their implications extend

beyond just mitigating and adapting to climate change. This underscores the need for ongoing research efforts, interdisciplinary collaboration, and close coordination between researchers and policymakers to translate knowledge into actionable strategies.

This report has analysed the current and projected climate change trends in India using geospatial technologies, data and model studies. The resulting impacts on infrastructure, the environment, and public health could obstruct India's developmental objectives and hinder its economic progress.

Addressing these challenges demands the creation of regularly updated regional assessments of climate change and its consequences. It also requires assessing the effectiveness of existing policies, drawing insights from sustainable practices both domestically and internationally, and dynamically responding to scientific advancements.

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