

# Climate Change Impact Assessment and Flood Risk Evaluation Using Statistical DownScaling Model: A Case Study of Nashik City

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**Abstract:** This study examines the potential impacts of climate change on rainfall patterns and flood risk in Nashik, a city situated along the banks of the Godavari River in India. Leveraging the Statistical Downscaling Model (SDSM), the research generates localized climate projections under different Representative Concentration Pathway (RCP) scenarios to assess the future challenges and risks faced by the city. The study utilizes historical data on rainfall, maximum temperature ( $T_{max}$ ), and minimum temperature ( $T_{min}$ ) to calibrate the SDSM model. Future climate projections are then developed for two time periods (2024-2050 and 2051-2099) under the RCP 4.5 and RCP 8.5 scenarios, allowing for an in-depth analysis of the potential changes in precipitation and temperature patterns. The results indicate that Nashik is likely to experience a moderate increase in rainfall, particularly during the monsoon season, under both RCP scenarios. However, the RCP 8.5 scenario, representing a high-emission pathway, shows more pronounced changes, including a sharper rise in  $T_{max}$  and  $T_{min}$ , suggesting a trend towards hotter and wetter conditions in the long term. These projections have significant implications for urban flood risk, water resource management, and the need for climate-resilient planning and adaptation strategies. Based on these findings, the research provides a comprehensive set of recommendations for Nashik, including upgrading drainage infrastructure, implementing nature-based solutions, and enhancing community awareness and preparedness. The methodological approach and insights from this study can also inform climate adaptation efforts in other flood-prone regions, contributing to the development of more sustainable and resilient urban environments. Overall, this report presents a comprehensive and well-structured analysis of future climate projections and flood risk assessment for Nashik city. The study utilizes a robust methodological approach, combining historical data analysis, state-of-the-art climate modelling techniques, and a thorough validation process to ensure the reliability of the findings.

**Index Terms**— Climate Change, SDSM, Nashik, Flood Risk, RCP Scenarios, Rainfall Projection.

## I. INTRODUCTION

Nashik is a city located on the banks of the Godavari River, which makes it highly vulnerable to recurrent flooding events. Historical records have shown that Nashik experiences severe annual floods, posing significant threats to lives, infrastructure, and economic activities.

As a rapidly growing urban centre, Nashik is likely to face increasing climate-related challenges, such as changes in rainfall patterns and temperature extremes.

Understanding the potential impacts of climate change on the city's hydrology and flood risk is crucial for developing effective adaptation and mitigation strategies.

The use of advanced modelling techniques, like the Statistical Downscaling Model (SDSM), allows for the generation of localized climate projections that are more relevant for urban planning and decision-making. These projections can provide valuable insights into the magnitude and timing of future climate-related risks, enabling the city to prepare and respond accordingly.

The findings from this study can directly inform Nashik's urban planning, infrastructure development, and flood management strategies.

By incorporating climate projections into their decision-making processes, the city can enhance its resilience and ensure the long-term sustainability of its communities and assets.

This research contributes to the growing body of knowledge on the impacts of climate change on urban areas, particularly in the context of flood-prone regions in India.

The methodological approach and recommendations can serve as a reference for other cities facing similar climate-related challenges, fostering knowledge-sharing and collaborative solutions.

Overall, this study on Nashik's climate projections and flood risk assessment is a crucial step in empowering local authorities, urban planners, and policymakers to make informed decisions and build climate-resilient communities.

## II. STUDY AREA:

The study area for this research is Nashik, a city in Maharashtra, India, located along the Godavari River. Nashik's geographical setting is closely tied to the river's course, which significantly influences the city's development and landscape.

Nashik is situated at an elevation of 565 meters above mean sea level and is considered a hill station. The city has a cultivated area of approximately 9 lakh hectares and is divided into 13 Talukas comprising 1628 villages.

The Godavari River, originating in the Trimbak Hills to the west of Nashik, flows through the northern part of the city. This river plays a crucial role in shaping Nashik's geography, water resources, agriculture, and overall ecosystem.

### Key geographical features of Nashik include:

1. The Trimbak Hills, which mark the source of the Godavari River.
2. Prominent riverbanks and ghats along the Godavari, serving cultural, religious, and recreational purposes.
3. Fertile plains along the river supporting extensive agricultural activities.
4. Urban development influenced by the river's presence, with residential and commercial areas often extending towards the riverbanks.
5. Several bridges spanning the Godavari, facilitating transportation and connectivity.
6. Floodplains, which are crucial for mitigating the impact of seasonal flooding.

The close association between Nashik and the Godavari River presents both opportunities and challenges, particularly concerning flood risk and the need for sustainable development practices.

**Climate projection studies for Nashik are crucial due to the city's unique geographical setting and its close relationship with the Godavari River. These studies can be impactful in several ways:**

**1. Flood Risk Assessment:** By analyzing future climate scenarios, particularly changes in rainfall patterns, the study can help predict potential flood events and their intensities. This is especially important given Nashik's vulnerability to annual flooding.

**2. Urban Planning:** Climate projections can inform long-term urban development strategies, helping to create more resilient infrastructure and guiding decisions on land use, especially in flood-prone areas.

**3. Water Resource Management:** Understanding future rainfall and temperature patterns can aid in better management of water resources, crucial for both urban water supply and agricultural irrigation in the region.

**4. Agricultural Adaptation:** As Nashik is an important agricultural hub, climate projections can help farmers and policymakers prepare for potential changes in growing seasons and crop suitability.

**5. Disaster Preparedness:** By simulating various flood scenarios using tools like SDSM software, the study can contribute to developing more effective early warning systems and evacuation plans.

**6. Policy Formulation:** The findings from climate projection studies can inform evidence-based policymaking, helping local authorities to develop targeted climate adaptation and mitigation strategies.

By studying future scenarios, this research aims to contribute not only to local flood mitigation in Nashik but also to the broader discourse on effective flood management strategies that can be adapted for other flood-prone regions globally.

## III. LITERATURE

Wilby et al. [31] Has article discusses the Statistical Downscaling Model (SDSM), a tool released in 2001 for producing high-resolution climate change scenarios. The paper traces the conceptual and technical evolution of SDSM based on over 170 documented studies worldwide. SDSM is found to provide reliable estimates of extreme temperatures, seasonal precipitation totals, and areal precipitation behaviour. However, there are limitations in estimating extreme precipitation amounts in dry seasons. The article notes a preponderance of research in Canada, China, and the UK, with a focus on water and flood risk management. It emphasizes the need for attention to physically meaningful quantities and acknowledges chronic uncertainty in boundary forcing. Emmanuel Rukundo et al. [39]: This study evaluates the combined effects

of climate change and urbanization on flood hydrographs. General Circulation Models (GCMs) were applied to determine global climate change over the next 100 years, considering various developmental trends and greenhouse gas emission scenarios. A statistical downscaling methodology was used to assess the local impacts on urban flooding.

X.S. Qin et al. [53]: This paper presents a combined approach using statistical downscaling and hydrological modelling to assess the impact of climate change on flood frequencies in southern China. The study integrates weather generators and hydrological models to simulate future flood scenarios under changing climatic conditions. Saira Munawar et al. [46]: This study compares the performance of two statistical downscaling models, SDSM and LARS-WG, in projecting future climate variables for the Jhelum River basin in India. The models were evaluated based on their efficiency in simulating temperature and precipitation patterns under different RCP scenarios. Haider Ali et al. [40]: This research analyses the impact of climate change on extreme precipitation events and subsequent flood risks across the Indian subcontinent. The study uses historical data and climate models to project future flood frequencies under various emission scenarios. Ahmad Rajabi et al. [34] This paper assesses the uncertainties in climate change projections using the SDSM model for the Kermanshah region. The study focuses on predicting climate parameters such as precipitation and temperature over an extended period, considering large-scale weather signals. Declan O'Shea et al. [38]: This study presents a framework for assessing flood risks under climate change using a scenario-neutral approach. The method involves a bottom-up analysis to identify key drivers of flood risk without relying on specific climate scenarios. M.R. Goodarzi et al. [42]: This research investigates the effects of climate change on flood frequency and zoning in the Azarshahr basin, Iran, using the SWAT hydrological model and GIS tools under the RCP 8.5 scenario. The study evaluates changes in temperature, precipitation, and maximum discharge. Sipra Mohaptra et al. [48]: This paper applies the SDSM model to predict future rainfall patterns in the Brahmani River basin, Odisha, India. The study uses historical rainfall data and statistical downscaling to project rainfall distribution for future years. Nils Eingruber et al. [45]: This study analyzes trends in extreme precipitation and flood events in the Rur catchment, western Germany, until 2099. The research employs the SDSM and Soil Water Assessment Tool (SWAT) models to simulate future climate scenarios and assess flood risks. Theresa Zimmermann et al. [50]: This paper discusses the significance of linking climate change adaptation (CCA) and disaster risk reduction (DRR) in Mumbai, India. It analyzes policies, plans, institutions, and interventions related to DRR and CCA, using interviews and field studies to assess flood risk governance at the municipal level.

#### IV. METHODOLOGY:

The methodology adopted in this study involves a comprehensive approach to understanding and projecting future climate scenarios for Nashik using the Statistical Downscaling Model (SDSM).

**A. Data collection and processing:** The study begins by gathering historical data on rainfall, maximum temperature (Tmax), and minimum temperature (Tmin) for the period of 1980-2023 from the Indian Meteorological Department (IMD). This data is extracted using Python programming, which serves as a versatile tool for processing and analysing hydrological and meteorological information.

To project future climate conditions, the research utilizes Coupled Model Intercomparison Project Phase 6 (CMIP6) Global Climate Models (GCMs). These GCMs provide large-scale atmospheric variables, which are then downscaled using the SDSM to generate local-scale climate scenarios for Nashik.

The SDSM software is employed through a series of steps, including setting up the model parameters, conducting predictor analysis to identify the most relevant large-scale variables, calibrating the model, and generating future climate scenarios under different Representative Concentration Pathways (RCPs).

**B. Scenario development:** The study explores two RCP scenarios: RCP 4.5 (stabilization scenario) and RCP 8.5 (high emission scenario). The future projections are made for two time periods: 2024-2050 (near future) and 2051-2099 (far future).

To validate the model's performance, the study compares the modelled historical data (1980-2023) with the observed data, ensuring the reliability of the SDSM for future climate projections. The analysis of the future scenarios focuses on the changes in rainfall, Tmax, and Tmin, as well as their interconnections, to assess the potential impacts on Nashik's flood risk and water resource management.

#### V. RESULT AND DISCUSSION:

The results and discussion section of this study on climate projections for Nashik presents a comprehensive analysis of the potential changes in rainfall, maximum temperature (Tmax), and minimum temperature (Tmin) under different future scenarios. (includes graph and tables).

### 1. Validation of Historical Data (1980-2023):

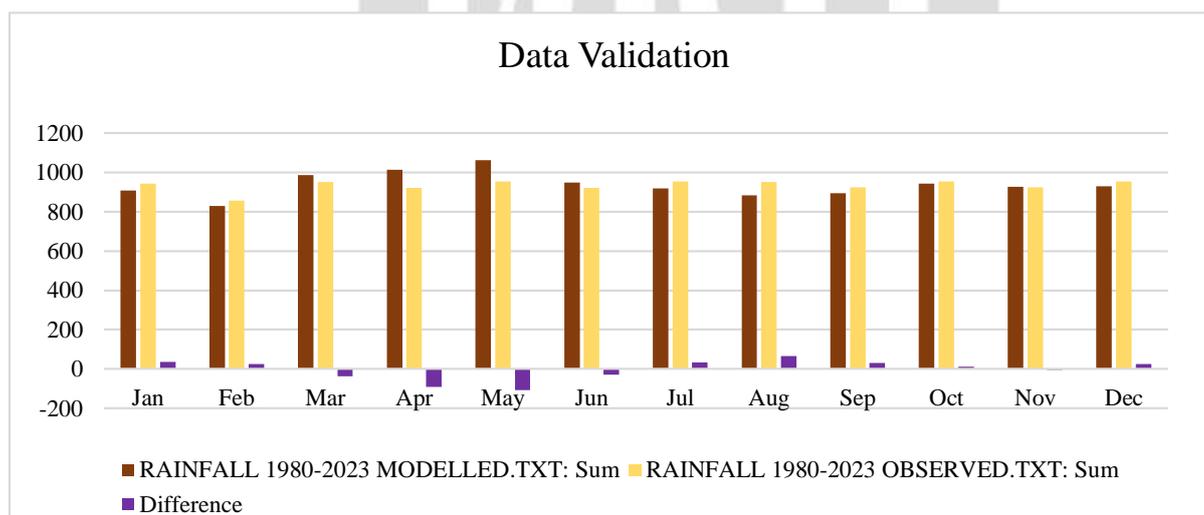
The study validates the historical rainfall data for the baseline period (1980-2023) using the Percentage Bias (PBIAS) metric, which shows a close match between the observed and modelled values.

The validation analysis confirms the reliability of the SDSM model for future climate projections in Nashik.

**Table 1:** Shows Difference in Percentage Between Observed and Modelled Values

Months	Observed Values	Modelled Values	% Difference	Remark
Jan	906.161	943.725	3.98	Very Good
Feb	829.127	854.94	3.02	Very Good
Mar	985.722	949.972	-3.76	Very Good
Apr	1013.69	921.71	-9.98	Very Good
May	1060.76	952.962	-11.31	Good
Jun	949.27	920.395	-3.14	Very Good
Jul	919.389	952.666	3.49	Very Good
Aug	883.514	950.015	7.00	Very Good
Sep	893.381	923.109	3.22	Very Good
Oct	942.305	954.05	1.23	Very Good
Nov	927.286	922.411	-0.53	Very Good
Dec	929.182	953.586	2.56	Very Good

**Graph 1:** Shows Data Validation



### 2. Rainfall Projections:

- a. Results of comparing modelled historical data (1980-2023) Vs Future projection for year (2024-2050) under two climate scenarios RCP4.5 (stabilization scenario) and RCP8.5 (high emission and worst-case scenario):

**Table 2:** Shows Rainfall Analysis Summary for year periods 1980-2023 Vs 2024-2050 with RCP 4.5 Vs RCP 8.5

Months	Rainfall 1980-2023	Rainfall Rcp4.5 2024-2050.	Rainfall Rcp8.5 2024-2050	Difference Of Rainfall with Rcp4.5 2024-2050 1980-2023 in mm	Difference Of Rainfall with Rcp8.5 2024-2050 & 1980-2023 in mm	Difference Of Rainfall Rcp8.5 & Rcp4.5
Jan	906.161	918.101	918.956	11.94	12.795	0.855
Feb	829.127	858.787	855.268	29.66	26.141	-3.519
Mar	985.722	1007.3	1006.7	21.578	20.978	-0.6
Apr	1013.69	1031.77	1037.33	18.08	23.64	5.56
May	1060.76	1074.43	1076.15	13.67	15.39	1.72
Jun	949.27	965.315	967.892	16.045	18.622	2.577
Jul	919.389	940.399	938.155	21.01	18.766	-2.244
Aug	883.514	891.792	889.779	8.278	6.265	-2.013
Sep	893.381	909.397	908.305	16.016	14.924	-1.092
Oct	942.305	976.71	973.103	34.405	30.798	-3.607
Nov	927.286	947.547	945.46	20.261	18.174	-2.087
Dec	929.182	941.546	941.735	12.364	12.553	0.189

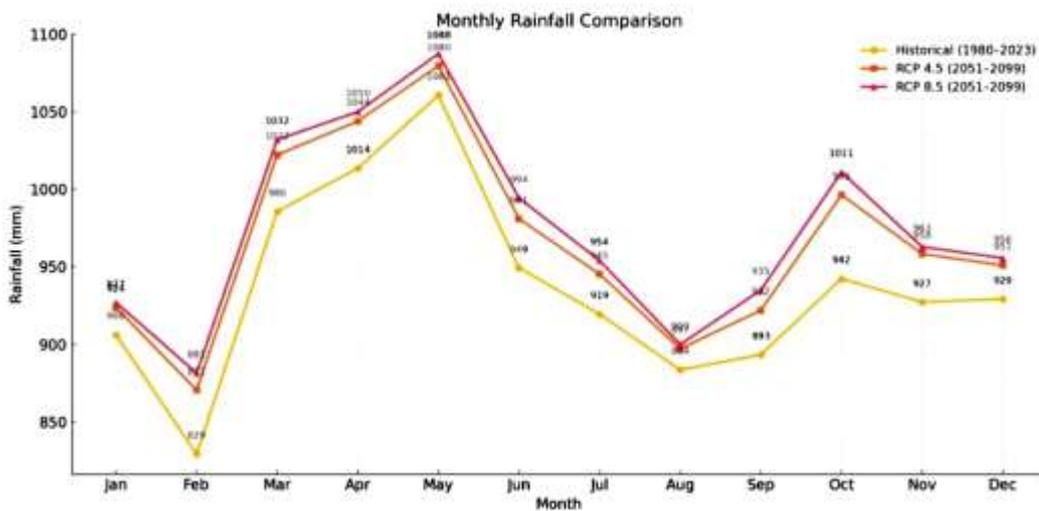
These negative values don't mean that RCP8.5 has weaker impact as compared to RCP4.5. Here, the values are for shorter term and RCP8.5 is a longer-term trajectory, where more severe effects of high emissions are projected to emerge after 2050, becomes more dominant by the end of the century (2100 and beyond).

**b. Results of comparing modelled historical data (1980-2023) Vs Future projection for year (2051-2099) under two climate scenarios RCP4.5 (stabilization scenario) and RCP8.5 (high emission and worst-case scenario):**

**Table 3:** Shows Rainfall Analysis Summary for year periods 1980-2023 Vs 2051-2099 with RCP4.5 Vs RCP8.5

Months	Rainfall 1980-2023	Rainfall RCP 4.5 2051-2099	Rainfall RCP 8.5 2051-2099	Difference of Rainfall RCP 4.5 2051-2099 and 1980-2023 in mm	Difference of Rainfall RCP 8.5 2051-2099 and 1980-2023 in mm	Difference of Rainfall RCP 8.5 and RCP 4.5
Jan	906.16	923.72	926.98	17.56	20.82	3.26
Feb	829.13	870.50	881.37	41.38	52.24	10.87
Mar	985.72	1022.25	1032.17	36.53	46.45	9.92
Apr	1013.69	1044.04	1050.06	30.35	36.37	6.02
May	1060.76	1079.67	1087.58	18.91	26.82	7.91
Jun	949.27	981.07	994.39	31.80	45.12	13.32
Jul	919.39	945.29	954.02	25.90	34.63	8.73
Aug	883.51	897.09	899.83	13.58	16.31	2.74
Sep	893.38	922.02	934.99	28.64	41.61	12.97
Oct	942.31	996.48	1011.18	54.17	68.88	14.70
Nov	927.29	958.32	962.90	31.03	35.61	4.57
Dec	929.18	951.00	955.62	21.82	26.44	4.62

**Graph 2:** Shows Monthly Rainfall Comparison (2051-2099)



Under the RCP 4.5 scenario, rainfall is projected to show a moderate increase in the near future (2024-2050), with the highest increase observed in October. The RCP 8.5 scenario also indicates an overall increase in rainfall, though slightly lower than RCP 4.5 in some monsoon months (June-September). In the far future (2051-2099), both RCP 4.5 and RCP 8.5 show significant increases in rainfall, with RCP 8.5 projecting higher rainfall, particularly during the post-monsoon months.

**3. Temperature (Tmax and Tmin) Projections:**

Tmax and Tmin are projected to rise consistently under both RCP 4.5 and RCP 8.5 scenarios, with more pronounced increases in the far future (2051-2099) and under the higher emission RCP 8.5 pathway. The analysis reveals a strong correlation between the increases in Tmax and Tmin with the projected changes in rainfall patterns, suggesting a trend towards hotter and wetter conditions in Nashik.

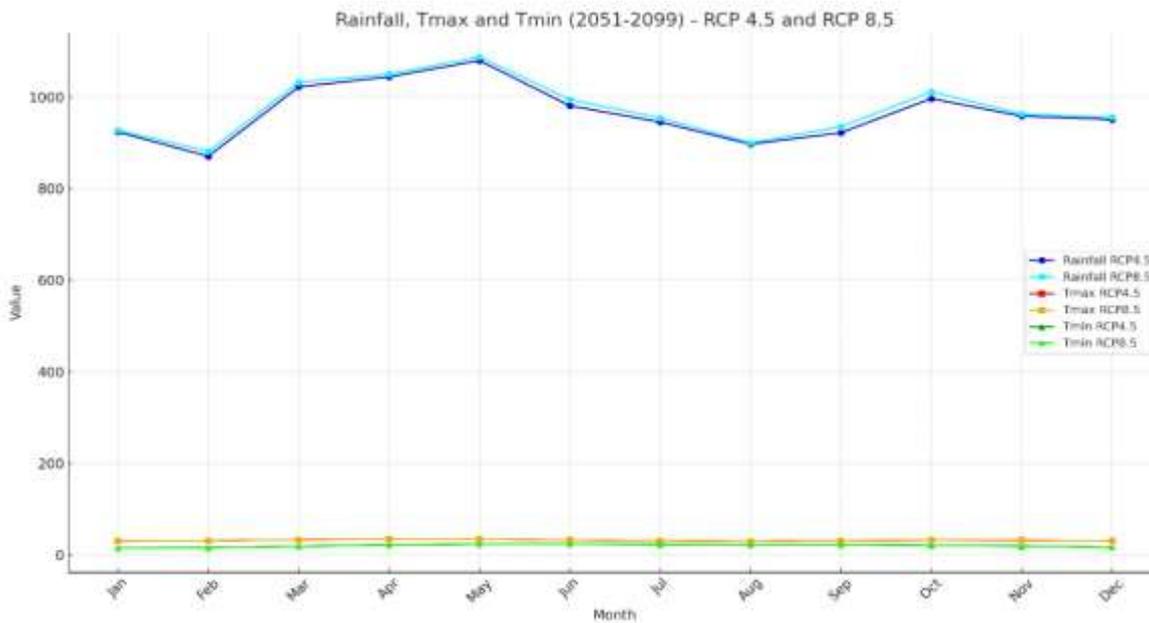
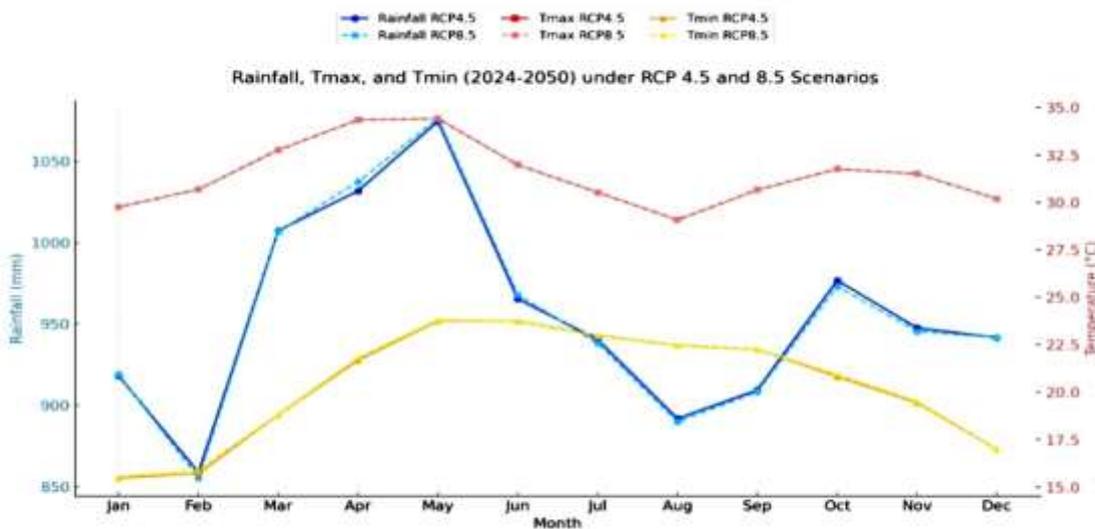
**Table 4:** Shows Comparison of Near-Future vs Far-Future

**4. Relationship between Rainfall, Tmax and Tmin:**

The study examines the seasonal interactions between rainfall, Tmax, and Tmin, highlighting how temperature patterns influence the onset and intensity of the monsoon season.

Parameter	2024–2050	2051–2099	Key Observation
Tmax	Moderate rise	Higher rise	More warming in 2051–2099
Tmin	Moderate rise	Higher rise	Nights will get significantly warmer in far future
Rainfall	Small to moderate increase	Moderate increase	Far future sees more intense rainfall events

The findings indicate that the projected increases in both Tmax and Tmin, particularly under the RCP 8.5 scenario, may contribute to more intense rainfall events and heighten the risk of urban flooding in Nashik.

**Graph 3:** Shows Combined results for Rainfall, Tmax and Tmin under RCP 4.5 and 8.5 (2024-2050) scenarios:**Graph 4:** Shows Combined Graph for Rainfall, Tmax and Tmin under RCP 4.5 and 8.5 (2051-2099) scenarios:

## VI. FLOOD RISK ASSESSMENT:

The climate projection analysis conducted in this study for Nashik provides valuable insights into the potential flood risks facing the city in the future.

### 1. Increased Rainfall Intensity and Frequency:

The projections indicate a consistent increase in rainfall, particularly under the RCP 8.5 scenario and in the far future (2051-2099) period.

The higher rainfall volumes, especially during the monsoon and post-monsoon seasons, suggest a heightened risk of intense rainfall events and urban flooding.

### 2. Rising Temperatures and Warmer Nights:

The study shows a steady rise in both maximum (Tmax) and minimum (Tmin) temperatures under both RCP 4.5 and RCP 8.5 scenarios.

The increase in Tmin, particularly under the RCP 8.5 pathway, indicates warmer nights, which can contribute to higher atmospheric moisture content and further intensify rainfall events.

### 3. Compound Effects of Hotter and Wetter Conditions:

The analysis reveals a strong correlation between the projected increases in temperature and rainfall, suggesting a trend towards hotter and wetter conditions in Nashik.

This combination of higher temperatures and increased rainfall intensity can lead to more severe and frequent flooding events, posing significant challenges for the city's infrastructure and water resource management.

#### 4. Implications for Urban Planning and Flood Mitigation:

The findings from this study underscore the urgent need for Nashik's local authorities to incorporate climate projections into their urban planning and flood management strategies.

Measures such as upgrading drainage systems, implementing nature-based solutions, and developing early warning systems can help enhance the city's resilience to future flood risks.

Overall, the climate projection analysis highlights the heightened flood risks facing Nashik in the coming decades, particularly under the high-emission RCP 8.5 scenario. Proactive and evidence-based adaptation strategies will be crucial to safeguarding the city's population, infrastructure, and economic well-being.

#### VII CONCLUSION:

1. The SDSM model has been validated and found reliable for projecting Nashik's future climate under different emission scenarios.
2. Both RCP 4.5 and RCP 8.5 scenarios indicate an increase in monsoon rainfall for Nashik during 2024-2050, with RCP 4.5 showing slightly higher rainfall during monsoon months.
3. Long-term projections (2051-2099) reveal a significant increase in rainfall volume, particularly under RCP 8.5, suggesting a higher flood risk.
4. The analysis shows a concurrent rise in both maximum temperature (Tmax) and rainfall, with more pronounced changes under RCP 8.5 during 2051-2099.
5. The projections indicate hotter and wetter conditions for Nashik in the future, with RCP 8.5 posing greater risks than RCP 4.5.
6. The study emphasizes the urgent need for climate-resilient planning, particularly in flood risk mitigation and urban infrastructure adaptation, to safeguard Nashik's future.

**The findings from this climate projection study for Nashik can be translated into the following actionable policy recommendations for local authorities:**

##### 1. Integrate Climate Projections into Urban Planning and Infrastructure Development:

Ensure that future infrastructure projects, such as drainage systems, floodplain zoning, and water storage facilities, are designed to withstand the projected increase in rainfall intensity and frequency.

##### 2. Enhance Flood Management Strategies:

Develop early warning systems and real-time flood forecasting capabilities to improve preparedness and response.

Invest in nature-based solutions, such as rainwater harvesting structures and wetland restoration, to enhance water retention and mitigate flood risks.

##### 3. Adopt Adaptive Water Resource Management:

Implement Integrated Water Resources Management (IWRM) approaches to ensure sustainable and equitable water use under changing precipitation and temperature patterns.

Promote efficient irrigation techniques and water conservation measures to adapt to potential water scarcity issues.

##### 4. Mainstream Climate Risk into Policy Frameworks:

Incorporate climate change projections and flood risk assessments into local development plans, disaster management strategies, and environmental policies.

##### 5. Increase Community Awareness and Engagement:

Conduct public awareness campaigns to educate citizens about climate risks and foster a culture of preparedness.

Encourage stakeholder participation in the planning and implementation of adaptation measures.

##### 6. Regularly Update Projections and Adapt Strategies:

Establish a mechanism to periodically review and update climate projections using the latest data and models, ensuring the relevance and effectiveness of adaptation strategies.

#### How it overcomes lacunas:

The research on climate projections and flood risk assessment for Nashik city presented in this report appears to build upon and address some of the key limitations or lacunas observed in the referenced prior studies.

##### 1. Comprehensive Modelling Approach:

Unlike some of the earlier studies that focused on specific aspects like trend analysis or hydrological modelling, this research employs a more holistic approach by integrating multiple modelling techniques.

The use of the Statistical Downscaling Model (SDSM) allows for the generation of localized climate projections, addressing the limitations of coarse-resolution global climate models.

## 2. Detailed Analysis of Climate Variables:

While some previous studies examined either rainfall or temperature individually, this report provides a comprehensive analysis of the interplay between rainfall, maximum temperature (Tmax), and minimum temperature (Tmin).

This approach enables a deeper understanding of the complex relationships between these climate variables and their potential impacts on flood risk.

## 3. Consideration of Future Scenarios:

Unlike studies that focused solely on historical trends, this research explores the implications of different future climate scenarios (RCP 4.5 and RCP 8.5) for both the near-term (2024-2050) and long-term (2051-2099) periods.

This forward-looking perspective allows for a more comprehensive assessment of the potential challenges and risks that Nashik may face in the coming decades.

## 4. Emphasis on Adaptation and Resilience:

The report not only presents the climate projections and flood risk analysis but also provides a detailed set of recommendations for urban planning, infrastructure development, and flood management strategies.

This focus on actionable solutions and adaptation measures sets this research apart from studies that primarily focused on the assessment of climate impacts.

## 5. Potential for Knowledge Sharing:

The methodological approach and findings of this research can serve as a reference for other flood-prone cities in India and beyond, fostering knowledge exchange and collaborative efforts to address climate-related challenges.

This broader applicability and potential for knowledge sharing enhance the significance and impact of this study beyond the local context of Nashik.

Overall, the comprehensive and forward-looking nature of this research, coupled with its emphasis on adaptation strategies and knowledge sharing, represents a valuable contribution to the existing body of work on climate change impacts and flood risk management.

## VIII. FUTURE SCOPE:

The current study on climate projections and flood risk assessment for Nashik provides a strong foundation for understanding future climate trends and their potential impacts. However, the research also identifies several areas for future scope and further exploration to enhance the precision and applicability of the findings.

### 1. Integration with Hydrological Models:

Coupling the projected climate data with hydrological and hydraulic models, such as HEC-HMS and SWAT, can help in quantifying flood extents, flow patterns, and water resource availability more accurately.

### 2. High-Resolution Downscaling:

Employing regional climate models (RCMs) and finer-scale downscaling techniques can improve the spatial resolution of the climate projections, particularly for urban planning and infrastructure development.

### 3. Socioeconomic Impact Assessment:

Future studies can incorporate socioeconomic vulnerability mapping to assess the differential impacts of projected floods on various population segments and infrastructure within Nashik.

### 4. Multi-Scenario Comparisons:

Expanding the analysis to include other RCP scenarios (e.g., RCP2.6 or RCP6.0) and future Shared Socioeconomic Pathways (SSPs) can provide a more comprehensive understanding of the uncertainties and planning options.

### 5. Real-Time Monitoring and Early Warning Systems:

Leveraging the climate projection data to develop adaptive early warning systems and decision-support tools can significantly enhance disaster preparedness and response capabilities.

### 6. Policy-Oriented Research:

Translating the scientific findings into actionable urban and environmental policy recommendations can help bridge the gap between research and real-world resilience strategies.

By addressing these future research directions, the study can further strengthen the evidence base for climate-informed decision-making, leading to more effective and sustainable flood management practices in Nashik and potentially other flood-prone regions.

## IX. RECOMMENDATIONS:

**Based on the climate projection analysis and flood risk assessment for Nashik city, the following key recommendations are proposed:**

### 1. Urban Planning and Infrastructure Resilience:

Future infrastructure developments, such as drainage systems, floodplain zoning, and water storage facilities, should be designed to withstand the projected increase in rainfall intensity and frequency. Climate change projections should be integrated into the city's urban planning and development frameworks to ensure long-term resilience.

### 2. Flood Management Strategies:

Early warning systems and real-time flood forecasting capabilities should be developed to enhance preparedness and response to extreme weather events. Nature-based solutions, such as rainwater harvesting structures and wetland restoration, should be implemented to improve water retention and mitigate flood risks.

### 3. Water Resource Management:

Adaptive water resource management strategies, including Integrated Water Resources Management (IWRM) approaches, should be adopted to ensure sustainable and equitable water use under changing precipitation and temperature patterns. Water conservation measures and efficient irrigation techniques should be promoted to adapt to potential water scarcity issues.

### 4. Climate-Informed Policy Making:

Local governments should mainstream climate risk assessments into their planning and policy frameworks, ensuring that long-term adaptation strategies are guided by the latest climate projections.

### 5. Community Awareness and Engagement:

Public awareness campaigns should be conducted to educate citizens about climate risks and foster a culture of preparedness, especially in vulnerable and low-lying areas. Stakeholder participation should be encouraged in the planning and implementation of adaptation measures to ensure community ownership and effective implementation.

### 6. Periodic Re-Evaluation Using Updated Data:

As climate models and emissions pathways evolve, the city should regularly update its climate projections and adaptation strategies using the latest available data and research. By implementing these recommendations, Nashik can enhance its resilience to the anticipated impacts of climate change, particularly the increased flood risks, and ensure the long-term sustainability and well-being of its population and infrastructure.

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