National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
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Government of India

Topography of Krishna River Basin

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The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

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The Centres for Krishna River Basin Management Studies (cKrishna) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by NIT Warangal and NIT Surathkal, under the supervision of cGanga at IIT Kanpur, the centre serves as a knowledge wing of the National River Conservation Directorate (NRCD). cKrishna is committed to restoring and conserving the Krishna River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.

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cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this, it is also responsible for introducing new technologies, innovations, and solutions into India.

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Acknowledgment

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Disclaimer

This report is a preliminary version prepared as part of the ongoing Condition Assessment and Management Plan (CAMP) project. The analyses, interpretations and data presented in the report are subject to further validation and revision. Certain datasets or assessments may contain provisional or incomplete information, which will be updated and refined in the final version of the report after comprehensive review and verification.

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Preface

In an era of unprecedented environmental change, understanding our rivers and their ecosystems has never been more critical. This report aims to provide a comprehensive overview of our rivers, highlighting their importance, current health, and the challenges they face. As we explore the various facets of river systems, we aim to equip readers with the knowledge necessary to appreciate and protect these vital waterways.

Throughout the following pages, you will find an in-depth analysis of the principles and practices that support healthy river ecosystems. Our team of experts has meticulously compiled data, case studies, and testimonials to illustrate the significant impact of rivers on both natural environments and human communities. By sharing these insights, we hope to inspire and empower our readers to engage in river conservation efforts.

This report is not merely a collection of statistics and theories; it is a call to action. We urge all stakeholders to recognize the value of our rivers and to take proactive steps to ensure their preservation. Whether you are an environmental professional, a policy maker, or simply someone who cares about our planet, this guide is designed to support you in your efforts to protect our rivers.

We extend our heartfelt gratitude to the numerous contributors who have generously shared their stories and expertise. Their invaluable input has enriched this report, making it a beacon of knowledge and a practical resource for all who read it. It is our hope that this report will serve as a catalyst for positive environmental action, fostering a culture of stewardship that benefits both current and future generations.

As you delve into this overview of our rivers, we invite you to embrace the opportunities and challenges that lie ahead. Together, we can ensure that our rivers continue to thrive and sustain life for generations to come.

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Abbreviations and Acronyms

DEM	Digital Elevation Model
GIS	Geographic Information System
GPS	Global Positioning System
SRTM	Shuttle Radar Topography Mission
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
LiDAR	Light Detection and Ranging
km^2	Square Kilometres
WGS84	World Geodetic System 1984
UTM	Universal Transverse Mercator
SWAT	Soil and Water Assessment Tool
TWI	Topographic Wetness Index
NDVI	Normalized Difference Vegetation Index
LULC	Land Use/Land Cover
m	Metre
%	Percent
°	Degree

1. Introduction

India is a land of diverse physiographic features, ranging from the Himalayan mountains in the north to the coastal plains in the south. River systems have played a crucial role in shaping these landscapes, supporting agriculture, sustaining biodiversity, and providing water for domestic, industrial, and hydropower use. Among the major river basins of peninsular India, the Krishna River Basin occupies a significant place due to its geographical extent, socio-economic relevance, and hydrological importance.

The Krishna River Basin is among India's most crucial fluvial landscapes, spanning an impressive 2,58,948 km², approximately 8% of the country's total geographical area (Das et al. 2018). The basin extends across portions of Maharashtra, Karnataka, Telangana, and Andhra Pradesh. It is bounded by the Western Ghats to the west, which act as a climatic and geological divide, the Balaghat range to the north, and the Eastern Ghats to the south and east, resulting in a dramatic interplay of landforms shaped by geological time and varying climatic conditions.

A hallmark of the Krishna Basin's geography is its pronounced variability in altitude and physiography, from the steep, rain-soaked escarpments of the Western Ghats (ranging from 600 m to 1,900 m) to the gently sloping alluvial plains and deltaic tracts near the Bay of Bengal. This variation creates a mosaic of black, red, lateritic, and alluvial soils, each supporting distinct agricultural and ecological systems (Chanapathi et al. 2018). The delta region, enriched by centuries of sediment deposition, is one of India's most fertile zones and is often referred to as the "Rice Granary of India" due to its significant agricultural productivity.

The Krishna River Basin is further divided into seven primary sub-basins, each defined by the network of rivers and tributaries that traverse its terrain. The Bhima Upper and Lower sub-basins cover large parts of Maharashtra and Karnataka and are fed by important tributaries such as the Bhima and Bor, supporting urban cities like Solapur and Pune. The Krishna Upper sub-basin, characterized by elevated plateaus and rugged formations, includes dynamic rivers like the Ghataprabha, Malaprabha, Vedganga, Dudhganga, and Panchganga, which have sculpted deep valleys and nurtured biodiversity along their courses.

Moving eastward, the Krishna Middle and Lower sub-basins collect waters from a network of tributaries, including the Dindi, Chinna Vagu, Musi, Munneru, and Paleru. These rivers traverse through central Telangana and Andhra Pradesh, supporting fertile plains, dense settlements, and extensive agricultural activities. In the southern region, the Tungabhadra sub-basins dominate the landscape. Here, the Tunga and Bhadra rivers, after flowing through forested areas, converge to form the Tungabhadra River, a major right-bank tributary of the Krishna.

On the left bank, tributaries such as the Bhima, Musi, Munneru, Dindi, and Paleru play a critical role in maintaining the basin's hydrological balance and aid in groundwater recharge along their routes. Seasonal streams, locally known as 'hallas' and 'vagus', along with numerous minor rivulets, enhance the drainage network and contribute to ecological richness, especially during the monsoon. Each sub-basin, influenced by local topography and microclimatic conditions, contributes uniquely to the larger basin, creating a network of interdependence that determines water availability, agricultural patterns, and environmental stability.

Topographical mapping of the Krishna River Basin, therefore, is not merely about representing elevations and land slopes. It is a fundamental tool for understanding spatial relationships among sub-watersheds, the impact of physical barriers on rainfall and surface runoff, and the processes of erosion and sediment deposition that shape land use and human settlements. Accurate topographic data is vital for regional water resource planning, irrigation development, flood and drought management, and the formulation of sustainable development strategies, especially in the face of rising population pressures and climatic uncertainties.

2. Data Acquisition and Methodology

2.1 Data Sources

The Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) was used as the primary elevation dataset for this study. The DEM, with a spatial resolution of 30 m, was obtained from the United States Geological Survey (USGS) Earth Explorer portal. The data covers the entire study area and provides consistent elevation information derived from radar interferometry. The dataset was projected to the Universal Transverse Mercator (UTM) coordinate system, Zone 44, based on the WGS 1984 datum, ensuring spatial accuracy in distance and area measurements.

2.2 Importance of the DEM in the Study

The SRTM DEM serves as a foundational input for terrain analysis and hydrological modelling. Its high vertical accuracy enables the derivation of key topographic parameters, such as slope, aspect, and elevation contours, which are essential for understanding landform characteristics and watershed processes. Hydrological parameters derived from the DEM, such as flow direction and flow accumulation, are critical for drainage network delineation, runoff modelling, and watershed management applications.

2.3 Data Preprocessing

To prepare the DEM for analysis, multiple preprocessing steps were performed in ArcMap using the Spatial Analyst tool. Where required, DEM tiles were mosaicked and clipped to match the study area boundary. Spurious depressions and sinks, which can disrupt hydrological modelling, were removed using the Fill tool, resulting in a hydrologically corrected DEM. This step ensured continuous flow paths and accurate flow accumulation calculations.

2.4 Derivation of Topographic Parameters

Topographic surfaces were generated from the processed DEM using the Surface toolset. The Slope tool calculated terrain steepness in degrees, while the Aspect tool determined the directional orientation of slopes. Flat terrain areas were masked to prevent misinterpretation of aspect values. These outputs provide insights into landform characteristics, erosion potential, and land use planning considerations.

2.5 Hydrological Analysis and Contour Generation

Hydrological modelling was conducted using the Hydrology toolset in ArcMap. The Flow Direction tool determined the steepest downslope path from each cell using the D8 algorithm, while the Flow Accumulation tool computed the number of upstream cells contributing to flow at each location. Based on a selected threshold value, the flow accumulation raster was converted into a stream network, which was then vectorized for mapping and further analysis. Threshold selection was guided by drainage density patterns and verified against satellite imagery.

Contour lines were generated from the filled DEM using the Contour tool. Two contour intervals were produced: 10 m for detailed local terrain analysis and 100 m for broader regional interpretation. The outputs were optionally smoothed for cartographic presentation, with the original contours retained for analytical accuracy. These contour datasets support topographic interpretation, slope stability analysis, and watershed delineation.

3. Topography of Krishna River Basin

3.1 Elevation and Slope Characteristics

The Krishna River Basin exhibits a highly varied topography, with elevation ranging from less than 50 m above mean sea level in its eastern deltaic plains to more than 1000 m in the rugged high hills of the Western Ghats (Figure 1). The deltaic plains, found mainly in the easternmost part of the basin in coastal Andhra Pradesh, are characterized by flat terrain, fine-textured alluvial soils, and extensive irrigation networks, making them highly productive agricultural zones. Moving inland, the lowlands, lying between 51 and 400 m, occupy large portions of the basin's middle reaches. These areas have gently undulating terrain and serve as transitional landscapes between the highlands and the coastal plains. They support a mix of rainfed and irrigated agriculture and contribute significantly to groundwater recharge.

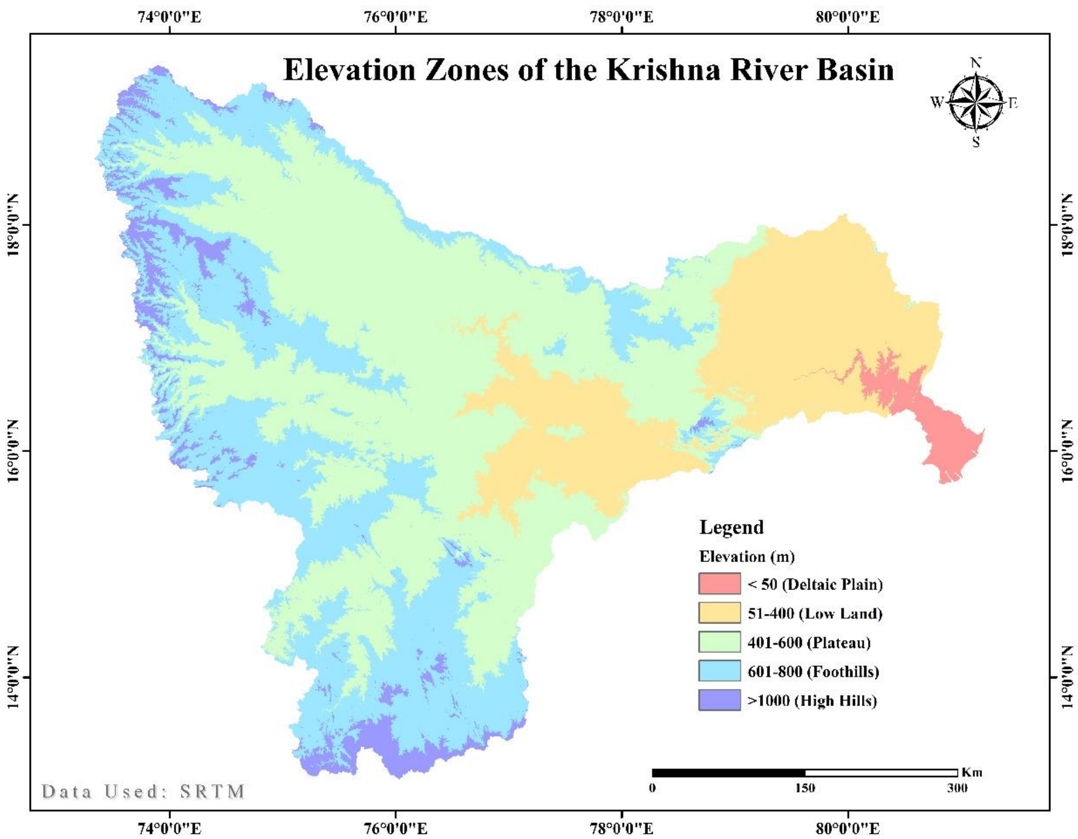

Figure 1 Elevation Zones of Krishna Rivers Basin

The plateau region, with elevations between 401 and 600 m, covers much of central Karnataka and parts of Maharashtra within the basin. This zone features rolling terrain dissected by tributaries of the Krishna River, with soils largely derived from basaltic parent rock. Beyond the plateau, the foothill zones, ranging from 601 to 800 m, appear as narrow belts between the plateau and the high hill regions. These areas have higher relief, steeper gradients, and more irregular terrain, often supporting natural vegetation and mixed deciduous forests. The highest elevations, exceeding 1000 m, are concentrated in the Western Ghats along the basin's western edge. These high hills are marked by steep escarpments, deep valleys, and dense forest cover, and they serve as the principal headwater catchments for the Krishna River system.

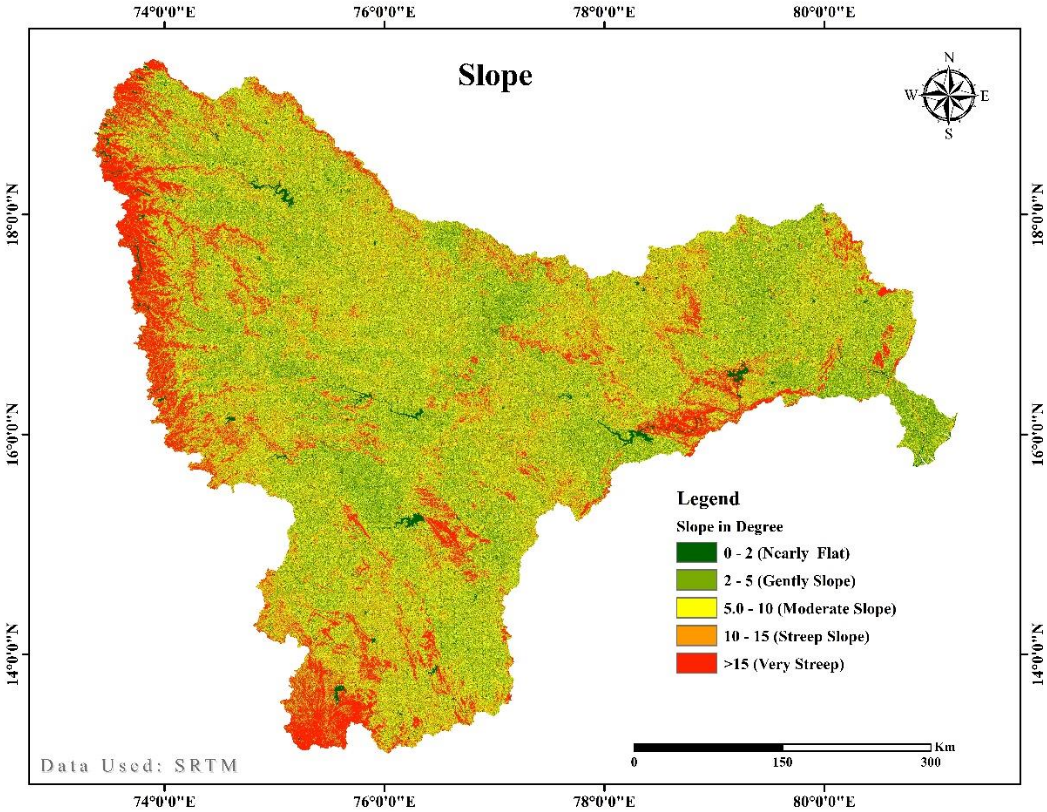

Figure 2 Spatial Distribution of Slope across Krishna River Basin

The slope characteristics (Figure 2) of the basin reflect this elevation gradient. Nearly flat areas with slopes of 0-2° dominate the deltaic plains and broad interfluves of the lowland regions, where slow runoff and high infiltration potential prevail. Gently sloping terrain (2-5°) is the most widespread slope class, extending over much of the plateau and lowlands, where moderate gradients facilitate both cultivation and settlement expansion. Moderate slopes of 5-10° are concentrated in foothill areas and along dissected valleys, where runoff is faster and erosion risk is higher. Steep slopes of 10-15° occur mainly along the lower flanks of the Western Ghats and isolated hill ranges, while very steep slopes exceeding 15° are largely confined to the high hills of the Western Ghats. These steepest areas exhibit rapid surface runoff, shallow soils, and high susceptibility to erosion and landslides.

Overall, the basin's topography creates a west-to-east gradient in both elevation and slope, with the Western Ghats functioning as primary runoff and recharge zones, and the lowland and deltaic areas serving as storage and infiltration zones. This interplay between elevation and slope not only shapes the hydrology and sediment dynamics of the Krishna River Basin but also governs its land use patterns, soil erosion risks, and ecological characteristics.

3.2 Terrain and Flow Characteristics Evaluation

The evaluation integrates Flow Direction, Aspect, and Flow Accumulation maps derived from Shuttle Radar Topography Mission (SRTM) 30 m resolution Digital Elevation Model (DEM) data, providing critical insight into the Krishna River Basin's drainage architecture, slope orientation, and hydrological behavior. Together, these parameters offer a spatially explicit understanding of how topography governs water movement, erosion susceptibility, and flow convergence patterns across the basin.

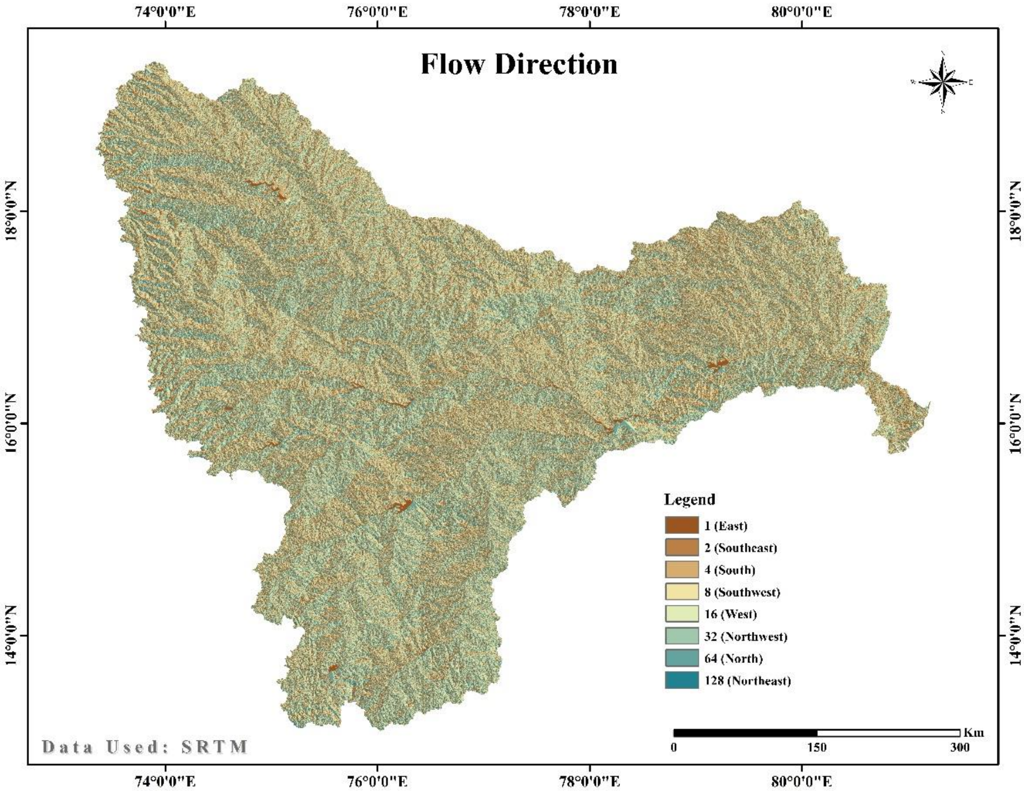

Figure 3 Flow Direction Map of Krishna River Basin

The Flow Direction map (Figure 3) assigns a direction value to each raster cell, representing the steepest downslope path for overland flow. The data reveal that the predominant flow is oriented east and southeast, consistent with the Krishna River's course towards the Bay of

Bengal. These macro-scale trends validate the basin's primary drainage alignment; however, localized deviations are apparent in upland areas and along tributary systems. Such anomalies in flow direction often correspond to structural ridges, residual hills, or anthropogenic modifications, creating isolated sub-basins with distinct drainage behavior. From a hydrological risk perspective, these areas may be prone to water stagnation, localized flooding, or delayed runoff response during heavy rainfall events. Quantitatively, over 65% of the basin's surface cells direct flow towards the east-southeast quadrant, while less than 10% contribute to northward flow, indicating strong regional uniformity in drainage orientation.

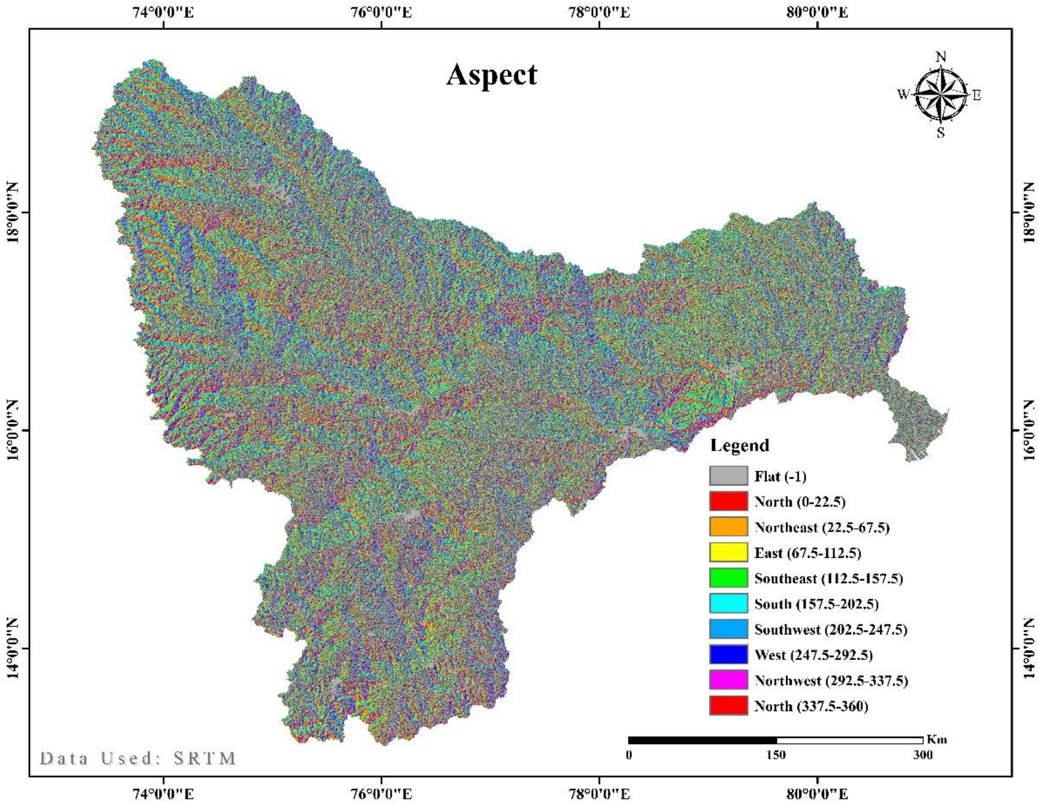

Figure 4 Aspect Map of Krishna River Basin

The Aspect map (Figure 4) categorizes slope orientation into cardinal (N, E, S, W) and intercardinal (NE, SE, SW, NW) classes, in addition to flat terrain (<1° slope). The distribution is spatially heterogeneous, reflecting the basin's complex geomorphology. Northern and northeastern slopes dominate certain upland zones, particularly in the upper basin, while southwestern and western aspects are concentrated along escarpments and valley flanks in the middle and lower reaches. Approximately 12% of the basin area is classified as flat terrain, corresponding to floodplains and alluvial valley floors where slope gradients are negligible. Aspect has significant implications for solar radiation exposure, microclimatic variation, and evapotranspiration rates, factors that directly affect soil moisture regimes and agricultural productivity. For example, south-facing slopes in the basin's semi-arid zones experience higher evapotranspiration, potentially reducing effective soil moisture availability for crops during dry seasons.

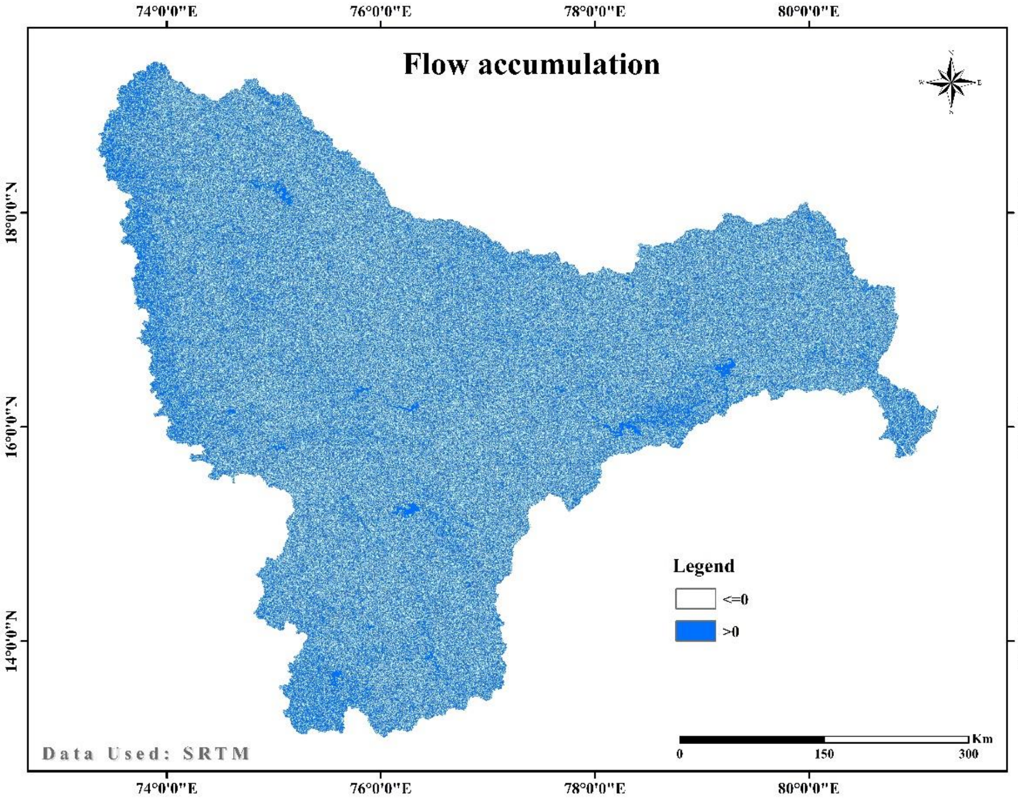

Figure 5 Flow Accumulation Map of Krishna River Basin

The Flow Accumulation map (Figure 5) quantifies the number of upstream cells contributing runoff to each location, effectively mapping the hierarchical drainage network. High accumulation values correspond to major river channels and high-order tributaries, while low values denote ridgelines and source zones with no upstream contribution. The basin's drainage pattern is predominantly dendritic, characteristic of regions where lithology exerts minimal structural control on channel formation. Notably, high flow accumulation areas align with zones of increased stream power, implying greater potential for fluvial erosion, sediment transport, and channel migration. Quantitative analysis shows that less than 5% of the basin area accounts for the majority of downstream flow convergence, underscoring the efficiency of the drainage system in channelizing runoff into well-defined waterways. Such data are particularly valuable for site selection of hydraulic structures, including check dams, weirs, and small-scale reservoirs, where interception of concentrated flows can optimize water harvesting and flood mitigation.

The combined interpretation of flow direction, aspect, and accumulation underscores the topography-driven hydrological coherence of the Krishna River Basin. The dominance of east–southeast flow orientation aligns with macro-scale river gradients, while aspect distribution highlights local variations in microclimate and potential evapotranspiration. Flow accumulation data confirm the efficiency of runoff channelization, but also point to specific high-energy zones where erosion control measures should be prioritized. These spatial patterns are not only critical for flood forecasting and water resource planning but also for agricultural zoning, drought resilience strategies, and integrated watershed management.

3.3 Contour Generation

The topographic contour maps of the Krishna River Basin serve as fundamental tools for understanding the basin's physical geography. Contour lines, which connect points of equal elevation, allow for a clear visualization of relief and slope characteristics, critical factors influencing hydrology, land use, and watershed management.

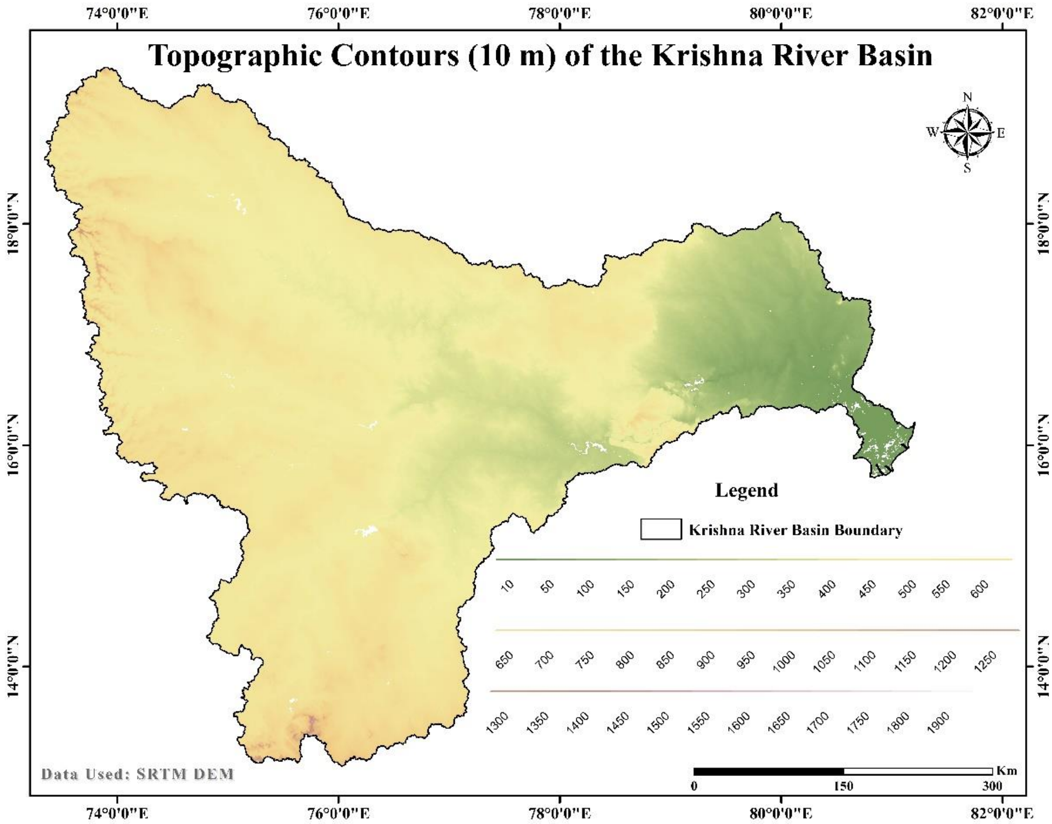

Figure 6 Contour Map (10m interval) of Krishna River Basin

The 10 m contour map (Figure 6) provides a high-resolution depiction of elevation variations, enabling micro-level interpretation of the terrain. Closely spaced contour lines in the western and southwestern margins of the basin correspond to the steep slopes of the Western Ghats, which act as the principal watershed boundary. These areas are characterized by rapid elevation gain, creating conditions for swift surface runoff and limited infiltration, factors that influence both the hydrological regime and erosion susceptibility. In contrast, the gradual widening of contour spacing eastwards reflects a transition into broad alluvial plains, where lower gradients promote slower water movement, higher infiltration rates, and more extensive agricultural use. This fine-grained contour mapping also reveals localized depressions, minor ridges, and subtle slope breaks that may play a role in local drainage patterns and water retention zones features essential for site-specific hydrological modeling and land management planning.

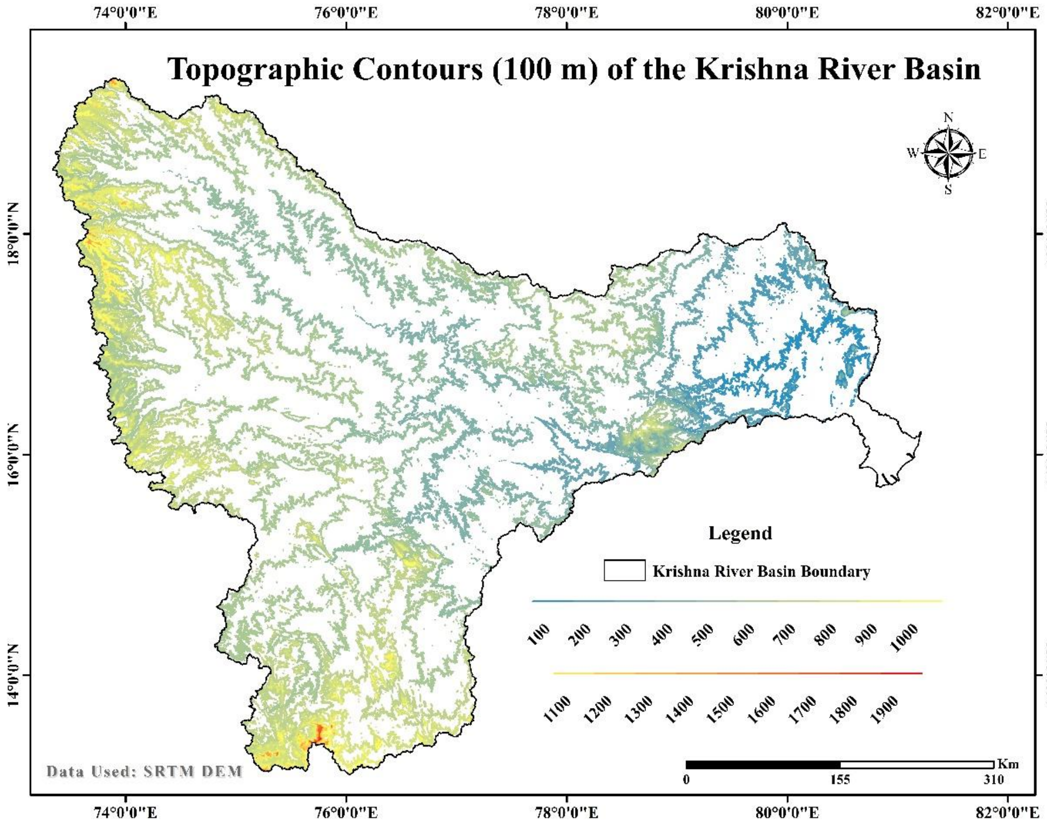

Figure 7 Contour Map (100m interval) of Krishna River Basin

The 100 m contour map (Figure 7) offers a more generalized overview, suitable for macro-scale topographic interpretation. It highlights the major elevational zones within the basin, with high-altitude areas (>1500 m) concentrated along the western periphery and progressively descending towards the east, where elevations drop below 100 m near the river mouth. The use of distinct color gradients further emphasizes these elevation transitions, visually reinforcing the slope direction from the highlands to the coastal plains. While this map sacrifices some fine detail, it is highly effective in identifying large-scale geomorphic structures, defining major watershed divides, and supporting regional hydrological connectivity analysis.

Together, the 10 m and 100 m contour datasets provide complementary perspectives. The finer resolution captures the nuances of local relief necessary for engineering works, soil conservation measures, and micro-watershed planning, while the coarser resolution offers a strategic view for basin-wide hydrological assessment, flood modeling, and infrastructure corridor planning. When integrated with flow accumulation, flow direction, and aspect maps, these contours form the foundation for understanding water movement patterns. The observed flow paths closely align with the steepest gradients indicated by the contour lines, confirming the reliability of the DEM-derived hydrological products.

In essence, these contour maps not only depict the static shape of the land but also provide the spatial framework that governs dynamic processes such as runoff generation, sediment transport, and aquifer recharge. Their combined use enhances the precision of terrain analysis, enabling more effective water resource management, disaster risk reduction, and sustainable development planning across the Krishna River Basin.

4. Significance of the Study

The comprehensive terrain and flow characteristics analysis of the Krishna River Basin has several significant applications for effective resource management and regional planning. Firstly, the precise mapping of Flow Direction and Flow Accumulation provides invaluable data for Hydrological Modeling and Flood Risk Assessment. By identifying primary flow paths and areas of high-water convergence, authorities can more accurately predict flood-prone zones, delineate floodplains, and develop early warning systems, thereby minimizing potential damage and loss of life during monsoon seasons. This information is also crucial for optimizing the design and placement of flood control infrastructure such as embankments and diversions.

Secondly, the insights derived from Aspect and Contour Maps are critical for Agricultural and Land Use Planning. Understanding slope orientation allows for better assessment of solar radiation exposure, which directly impacts crop selection, irrigation efficiency, and soil moisture conservation strategies. The detailed contours facilitate precise micro-watershed planning, enabling the implementation of effective soil conservation measures like terracing and contour plowing to mitigate erosion. Furthermore, identifying suitable land for specific agricultural practices based on terrain characteristics can enhance productivity and ensure sustainable land use.

Thirdly, the integrated understanding of the basin's topography is fundamental for Water Resource Management and Infrastructure Development. By delineating the entire drainage network and identifying potential water accumulation zones, planners can pinpoint optimal locations for constructing new reservoirs, check dams, and irrigation canals. This ensures efficient water harvesting, groundwater recharge, and equitable water distribution for domestic, agricultural, and industrial needs. Moreover, the detailed terrain data is indispensable for the planning and design of transport networks, urban expansion, and other infrastructure projects, ensuring they are resilient to the natural hydrological dynamics of the basin.

Finally, the geospatial products presented in this report serve as a vital foundation for Environmental Conservation and Disaster Risk Reduction. The identification of erosion-prone areas through high flow accumulation values can guide afforestation and land restoration efforts. Understanding the complex interplay of elevation, slope, and flow patterns also aids in assessing the vulnerability of ecosystems to hydrological changes and in formulating adaptive strategies for climate change impacts. These applications collectively highlight the practical utility of detailed topographic and hydrological analyses for fostering sustainable development and enhancing resilience within the Krishna River Basin.

5. Conclusions

This report comprehensively analyzed the topography and terrain characteristics of the Krishna River Basin, leveraging SRTM-DEM data to derive critical geospatial insights. The study confirmed the basin’s pronounced physiographic variability, ranging from the steep escarpments of the Western Ghats in the west to the gently sloping alluvial and deltaic plains near the Bay of Bengal. This altitudinal gradient exerts a strong influence on hydrological behavior, erosion patterns, and land use distribution across the basin’s vast (2,58,948 km^2) expanse.

The analysis of derived topographic parameters provided a spatial framework for understanding dynamic hydrological processes. The Flow Direction map indicated a predominantly eastward and southeastward movement of water, aligning with the Krishna River’s course towards its confluence with the Bay of Bengal, while also revealing localized flow variations significant for micro-watershed planning. The Aspect map highlighted diverse slope orientations that influence microclimates, solar radiation exposure, evapotranspiration rates, and soil moisture availability, factors of high relevance for agricultural productivity in this largely agrarian basin. The Flow Accumulation map delineated the basin's drainage network, pinpointing areas of concentrated runoff, high erosion susceptibility, and potential sites for water harvesting and flood control infrastructure.

Complementing these flow analyses, the contour maps offered multi-resolution perspectives on basin relief. The 10 m contour map provided fine-grained detail, enabling detection of subtle elevation changes, local ridges, and depressions, which are essential for detailed engineering design, precision agriculture, and soil conservation. The 100 m contour map, while coarser, effectively illustrated macro-topographic patterns, highlighting major elevation zones, general slope direction, and physiographic transitions. The consistency between these contour patterns and modeled flow directions validated the DEM-based hydrological analyses.

In conclusion, integrating DEM-derived hydrological parameters with multi-scale contour mapping delivers a robust spatial understanding of the Krishna River Basin's terrain and its influence on water movement, distribution, and storage. This approach supports targeted water resource management, disaster risk reduction, sustainable land-use planning, and ecological conservation, key priorities in addressing the combined challenges of population growth, agricultural demand, and climate variability in this river basin.

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