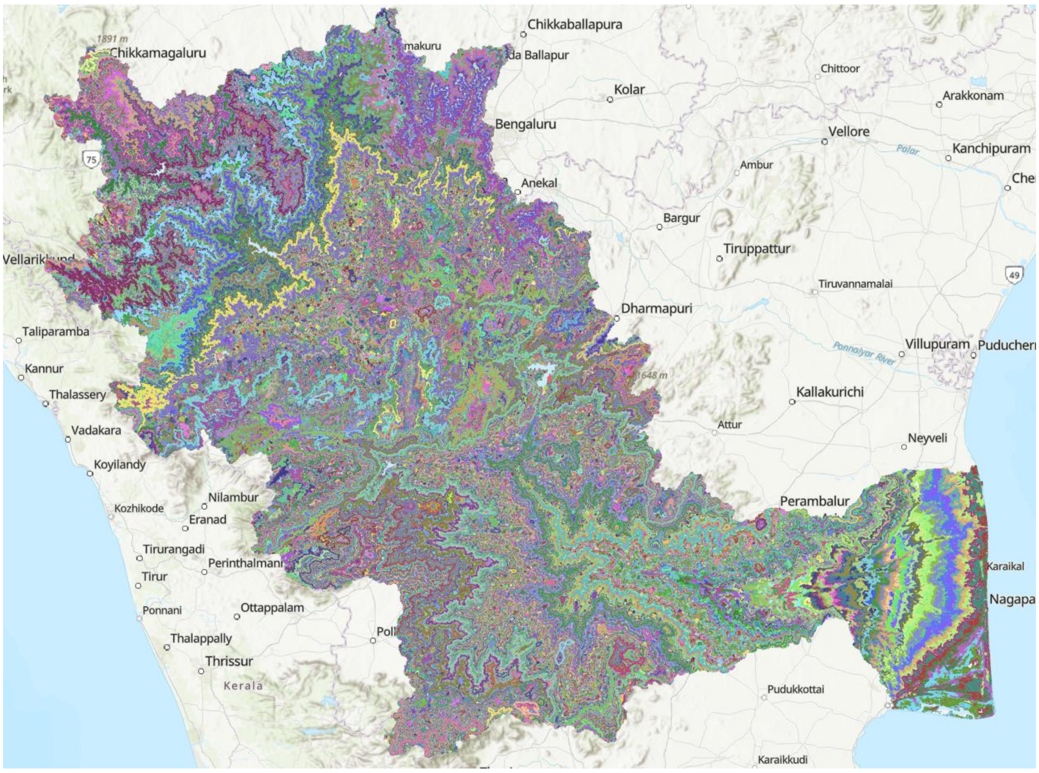
National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development and Ganga Rejuvenation
Government of India

Topographic Maps of Cauvery River Basin



March 2025

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Topographic Maps

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National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development and 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.

www.nrcd.nic.in

Centres for Cauvery River Basin Management Studies (cCauvery)

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

www.ccauvery.org

Centre for Ganga River Basin Management and Studies (cGanga)

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.

www.cganga.org

Acknowledgment

This report is a comprehensive outcome of the project jointly executed by IISc Bengaluru (Lead Institute) and NIT Tiruchirappalli (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It was submitted to the National River Conservation Directorate (NRCD) in 2024. We gratefully acknowledge the individuals who provided information and photographs for this report.

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.

Centres for Cauvery River Basin
Management and Studies (cCauvery)
IISc Bengaluru (Lead Institute), NIT Tiruchirappalli (Fellow Institute)

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Abbreviations and Acronyms

CRB	Cauvery River Basin
CWC	Central Water Commission
DEM	Digital Elevation Model
GSI	Geological Survey of India
KRS	Krishna Raja Sagara
SoI	Survey of India
ALOS	Advanced Land Observing Satellite
PALSAR	Phased Array type L-band Synthetic Aperture Radar
JAXA	Japan Aerospace Exploration Agency
ASF	Alaska Satellite Facility

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1. Introduction

The Cauvery River Bain (CRB) is one of the most significant and complex river systems in Peninsular India, spanning a total area of approximately 85,220 sq. km. Originating from Talakaveri in the Western Ghats of Karnataka at an elevation of about 1,341 m above mean sea level, the Cauvery River flows southeast for nearly 800 km before emptying into the Bay of Bengal in Tamil Nadu. The basin lies between latitudes 10°9′N to 13°30′N and longitudes 75°27′E to 79°54′E, covering major parts of the states of Karnataka and Tamil Nadu, along with portions of Kerala and the Union Territory of Puducherry (CWC, 2017). Understanding the topography of the basin is essential for interpreting the river's flow characteristics, drainage behaviour, sediment transport, and flood vulnerability.

Topographically, the basin is divided into three broad physiographic regions, i.e., the Western Ghats, the Deccan Plateau, and the Delta (CWC, 2017). The upper catchment in the Western Ghats is marked by steep slopes, dense vegetation, and high rainfall, which contribute significantly to the river's base flow and runoff. As the river descends onto the Deccan Plateau, the terrain becomes moderately undulating, interspersed with residual hills and agricultural plains. This middle region serves as an important agricultural zone supported by irrigation from reservoirs and an intricate canal network. Finally, in the lower basin, the river enters the low-lying Cauvery Delta, which features flat topography, rich alluvial soils, and high flood susceptibility due to its gentle slope and proximity to the coast.

The CRB is fed by numerous tributaries. On the left bank, important tributaries include the Harangi, Hemavathi, and Shimsha rivers, while on the right bank, key tributaries are the Lakshmana Tirtha, Kabini, Bhavani, and Amaravathi rivers. These tributaries originate from varying terrain types, which influence the local topographic and hydrological patterns within their respective sub-basins.

Climatically, the CRB experiences both the Southwest and Northeast monsoons. The basin has a basin-average annual rainfall of approximately 1,075-1,130 mm, with the wettest zones in the Western Ghats receiving ~1,700-5,000 mm annually (locally >3,000-3,500 mm in some high-rain spots) and the driest eastern/northern interior plains receiving around 600 mm or less. This uneven distribution of precipitation, coupled with significant topographic variation, results in spatially diverse flow regimes and water availability across the basin. These differences are further amplified by seasonal variations, making the region prone to both droughts and floods.

Administratively, the basin traverses four political regions. In Karnataka, the upper catchment is home to key reservoirs like Hemavati, Harangi, and Kabini. Tamil Nadu encompasses the middle and lower stretches, including the agriculturally vital Cauvery Delta. Parts of Kerala contribute to the basin's flow through the Kabini and Bhavani rivers, while a small portion of Puducherry, particularly around Karaikal, lies within the deltaic tract of the basin.

This report aims to systematically analyse the topographic features of the CRB using high-resolution datasets, including contour maps, to interpret the terrain's influence on hydrological processes. Through the integration of elevation, slope, flow direction and accumulation, this study supports efforts to enhance climate resilience, infrastructure planning, and ecological conservation within the basin.

2. Data Sources and Methodology

The topographic analysis of the CRB presented in this report is primarily based on two key datasets, i.e., Survey of India (SoI) topographic sheets and the Advanced Land Observing Satellite (ALOS) Phased Array type L-band Synthetic Aperture Radar (PALSAR) Digital Elevation Model (DEM). The SoI topographic sheets, available at a scale of 1:50,000, serve as authoritative sources for terrain features, drainage networks, contour lines, elevation benchmarks, and other geomorphological details. These sheets provide a consistent and verified topographic framework, which is particularly valuable for delineating watershed boundaries, identifying slope breaks, and validating terrain features derived from remote sensing data.

Complementing the topographic sheets, ALOS PALSAR DEM data at 12.5 m spatial resolution were used for digital terrain assessment. The ALOS PALSAR dataset, developed by the Japan Aerospace Exploration Agency (JAXA), provides continuous elevation coverage with enhanced vertical accuracy and is particularly suitable for generating derived topographic products such as slope, aspect, and contour lines. The DEM was downloaded from the Alaska Satellite Facility (ASF) Data Portal and processed using open-source GIS tools to ensure spatial alignment with the coordinate system and elevation benchmarks indicated in the SoI maps.

Geospatial processing was carried out using GIS platforms, which facilitated data handling, visualization, and spatial analysis. Standard digital terrain analysis procedures were applied to generate elevation, slope, aspect, and contour maps from the DEM. Hydrological parameters were derived using the Flow Direction and Flow Accumulation tools available within the ArcGIS Spatial Analyst extension, while the geomorphometric map was sourced from the Bhukosh platform (GSI). Aspect maps were created to interpret slope orientation and potential solar exposure, factors that strongly influence vegetation patterns, soil moisture retention, and microclimatic variations. Contour lines derived from the DEM were produced at 100 m, 50 m, and 1 m intervals to support both regional-scale assessments and site-specific planning requirements. Overall, this methodological framework enabled the development of a robust set of topographic datasets, providing reliable spatial inputs for hydrological modelling, environmental analysis, and developmental planning across the CRB.

3. Topographic Characterization of the CRB

The topography of the CRB plays a critical role in determining the direction and speed of water flow, shaping the river's drainage network, and influencing flood dynamics, sediment transport, and watershed behaviour. This section presents a detailed analysis of elevation, slope, and contours based on high-resolution topographic datasets.

3.1. Elevation Profile

The elevation map illustrates how the CRB transitions from rugged mountain terrain to flat coastal plains as the river moves from west to east (Fig. 1). Elevation data was extracted from the ALOS PALSAR DEM, known for its high vertical accuracy and strong performance in hydrological terrain delineation (DAAC, A., 2021). The elevation values were organized into five classes, i.e., <50 m, 50 – 200 m, 200 – 500 m, 500 – 1000 m, and >1000 m.

The >1000 m elevation class occupies the western fringe of the basin, coinciding with the Western Ghats. This area is characterized by steep slopes, deep valleys, dense vegetation, and intense orographic rainfall. High elevations here function as the basin’s primary water-generating zone, with rapid runoff feeding the Cauvery River and its tributaries. Because of the steep gradients, infiltration opportunity is low, and hill streams converge quickly, giving these tributaries a flashy hydrological response.

Between 500 – 1000 m, the terrain becomes more dissected and transitions into plateau conditions. This region includes upland agricultural areas and reservoir catchments. The relatively moderate slopes here allow for a balance between runoff and infiltration, which supports tank irrigation systems historically developed across southern.

The central basin, dominated by 200 – 500 m elevations, marks the Mysuru plateau. The landscape opens into wider valleys with gentler relief. The river stabilizes as a single defined channel, supporting agriculture and settlements along its course. This is the stretch where the river's hydraulic gradient decreases, enabling the development of key irrigation projects.

Downstream, the basin transitions into the 50 – 200 m and <50 m elevation zones, forming extensive plains across Tamil Nadu. The slope becomes nearly flat, the river meanders with reduced velocity, and distributaries emerge. These lowlands form the Cauvery Delta, known as the "Rice Bowl of South India" for its high agricultural productivity supported by fertile alluvial soils and canal irrigation.

The elevation gradient, therefore, not only shapes the terrain but directly influences the hydrology, land use, sediment transport, and agricultural suitability of the region. Steep uplands produce water, mid-elevation plateaus regulate flow, and the low-lying plains distribute and utilize water.

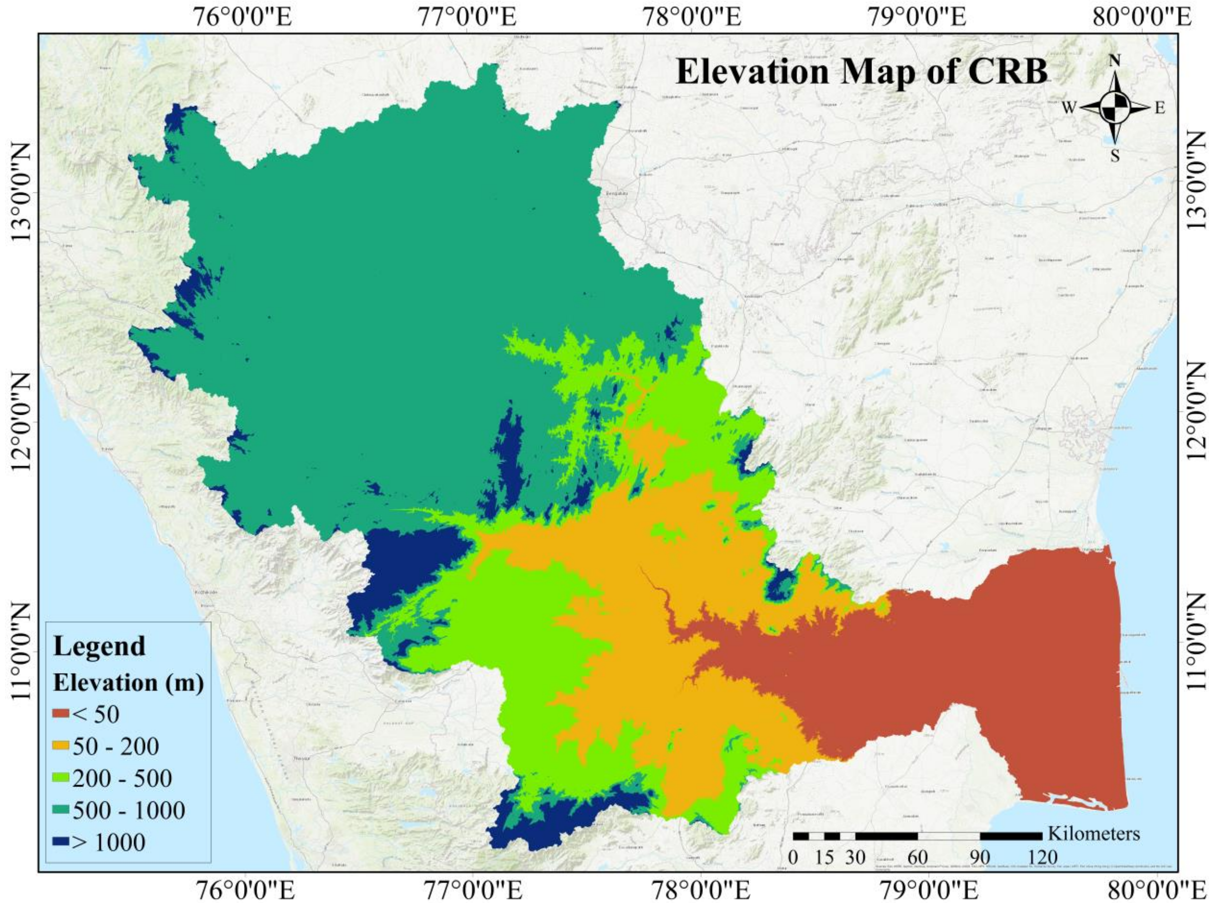

Fig. 1. Elevation map of the CRB

3.2. Slope Map

The slope map of the CRB was generated from the ALOS PALSAR DEM using a 3 by 3 cell neighbourhood algorithm in GIS to calculate slope in degrees (Fig. 2). The resulting map shows clear spatial variation in terrain steepness across the basin. Most of the basin exhibits very gentle slopes, represented in light and dark green shades. These flat to mildly sloping areas dominate the central and eastern parts of the basin in Karnataka and Tamil Nadu, including the Cauvery Delta. This terrain supports agriculture, groundwater recharge, and surface water spreading, which explains the extensive irrigated command areas in these regions.

The steepest slopes, shown in yellow, orange, and red, are concentrated along the western and south-western boundary of the basin where the river originates in the Western Ghats. These high-relief headwater zones generate rapid runoff and contribute significantly to sediment supply. Due to these steep gradients, rainfall events produce quick hydrological responses, higher flow velocity, and increased erosion potential within the upper sub-basins.

As the river progresses eastward from the plateau toward the plains, the slope gradually decreases. The terrain transitions from moderate slopes to nearly flat areas, which slows down the flow and allows water to disperse laterally. In the Cauvery delta region, the slope becomes almost zero, creating a wide floodplain. This characteristic explains the high flood susceptibility, seasonal waterlogging, meandering of distributary channels, and deposition of fertile alluvium across the delta.

Overall, the slope map highlights the strong topographic control on hydrological processes within the CRB. The steep Western Ghats act as an erosion and runoff source zone, while the downstream plains and delta function as deposition and flood-prone zones, strongly influencing water movement, sediment transport, and land use across the basin.

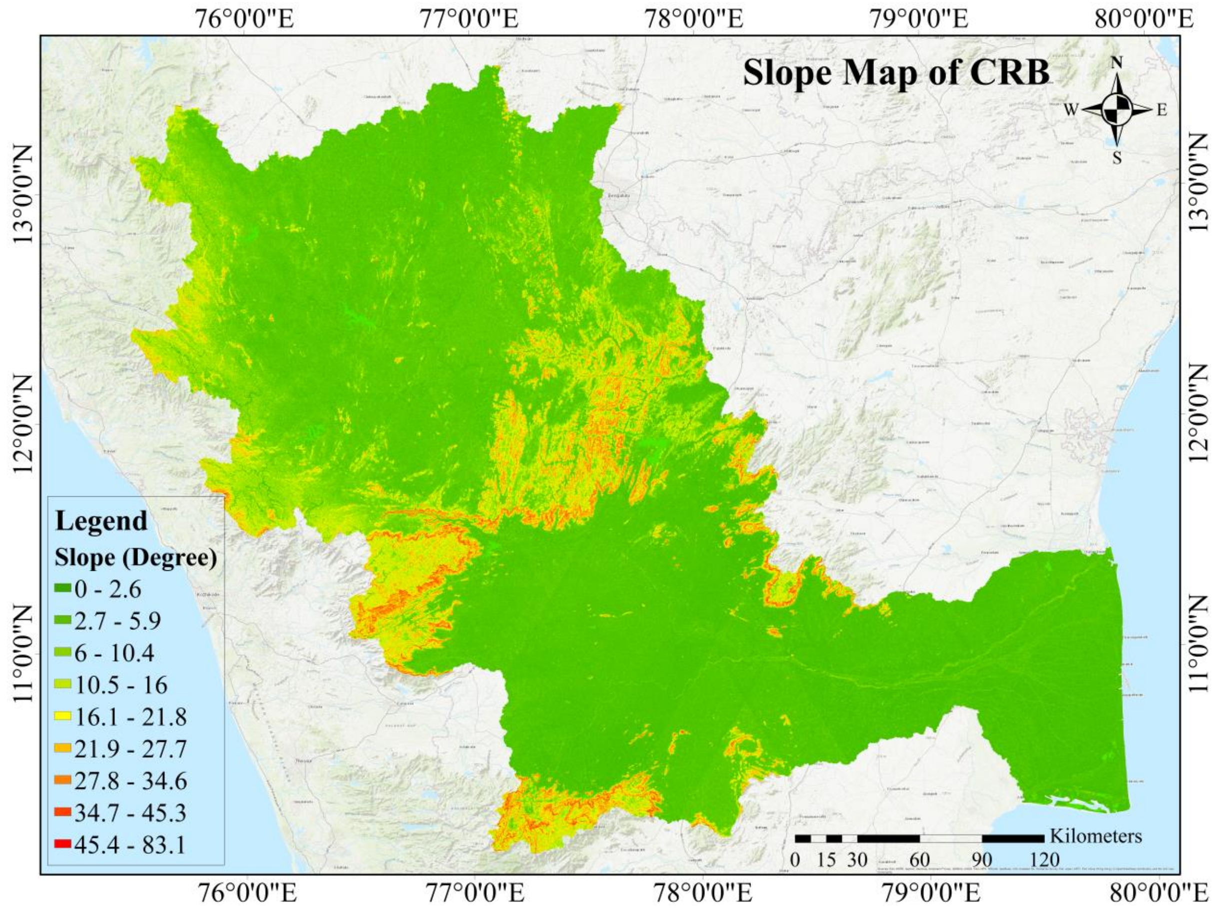

Fig. 2. Slope map of the CRB

3.3. Aspect Map

The aspect map of the CRB illustrates the directional orientation of slopes across the basin, derived from DEM analysis (Fig. 3). Aspect denotes the compass direction that each terrain surface faces, classified into eight principal directions along with flat areas that lack slope-related orientation. This spatial distribution of slope direction helps interpret how terrain controls hydrology, erosion, vegetation, and drainage behaviour within the CRB. In the Western Ghats and upper catchments, such as the Kabini, Hemavati, and Harangi sub-basins, steep and rugged terrain produces strongly defined aspects, predominantly facing east and southeast, which align with the natural eastward descent of the basin. These orientations enhance rapid runoff during the southwest monsoon, accelerate sediment transport, and guide the development of headwater drainage networks.

In the central part of the basin, comprising the Mysuru-Mandya plateau and adjoining dissected uplands, aspect becomes more variable due to the influence of underlying geological structures and moderately undulating terrain. This mixed pattern creates localised differences in soil moisture, microclimate, and vegetation, with south-facing slopes warming and drying faster, while north-facing slopes retain moisture for longer durations. In the drier interior regions of Karnataka and northern Tamil Nadu, these aspect-driven moisture contrasts influence dryland agriculture, irrigation needs, and vegetation type. As the river approaches the lower basin and deltaic plains around Tiruchirappalli, Thanjavur, and Nagapattinam, the topography becomes extremely flat, resulting in large areas classified as "flat" with negligible aspect influence.

However, even small slope variations in the delta control micro-drainage, canal alignment, and field-level water movement. Overall, the aspect distribution across the CRB governs runoff pathways, monsoon-driven erosional patterns, vegetation zonation, soil moisture retention, and landscape stability, making it a critical topographic parameter for understanding the physiographic and hydrological dynamics of the basin.

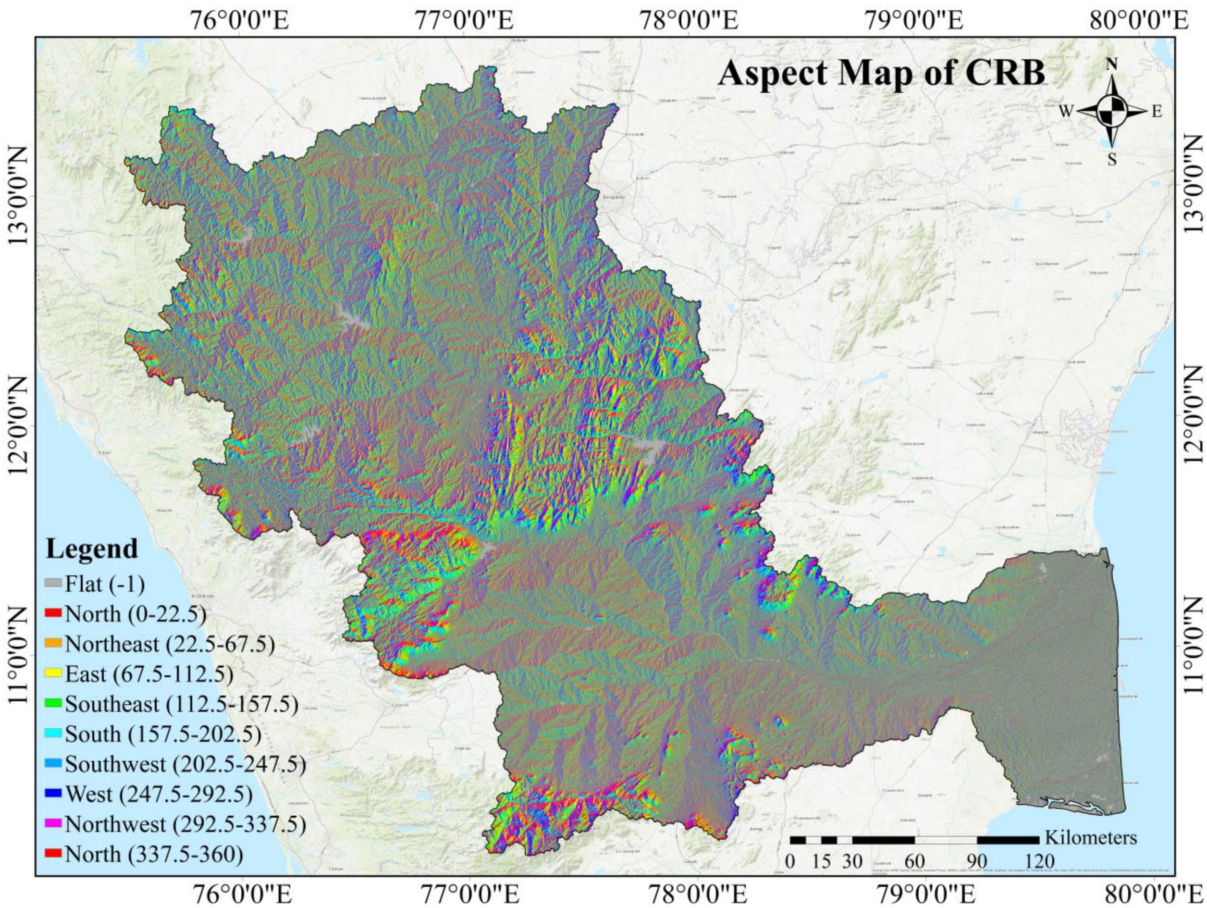

Fig. 3. Aspect map of the CRB

3.4. Contour Analysis

Contour datasets for the CRB were generated from the ALOS PALSAR DEM, which provides a native resolution of approximately 12.5 m and is well suited for basin-scale terrain quantification (JAXA, 2017; JAXA, 2023). Three vertical contour intervals, i.e., 1 m, 50 m, and 100 m, were extracted to support multi-scale interpretation of elevation gradients and terrain discontinuities across the basin.

The 1 m contours were generated across the entire basin to retain micro-topographic detail that coarser intervals tend to generalize (Fig. 4). This level of precision reveals elevation features such as minor embankments, field bunds, canal edges, settlement mounds, and small channel offsets that strongly influence local hydrological behaviour. In the delta and lower floodplain, where slopes commonly drop below 0.5%, these subtle terrain controls determine how floodwater is routed, where water stagnates, and how irrigation return flows propagate toward distributary channels. In the steeper upper basin, the same 1 m interval helps trace minor ridge breaks and perched drainage pockets that guide initial runoff pathways.

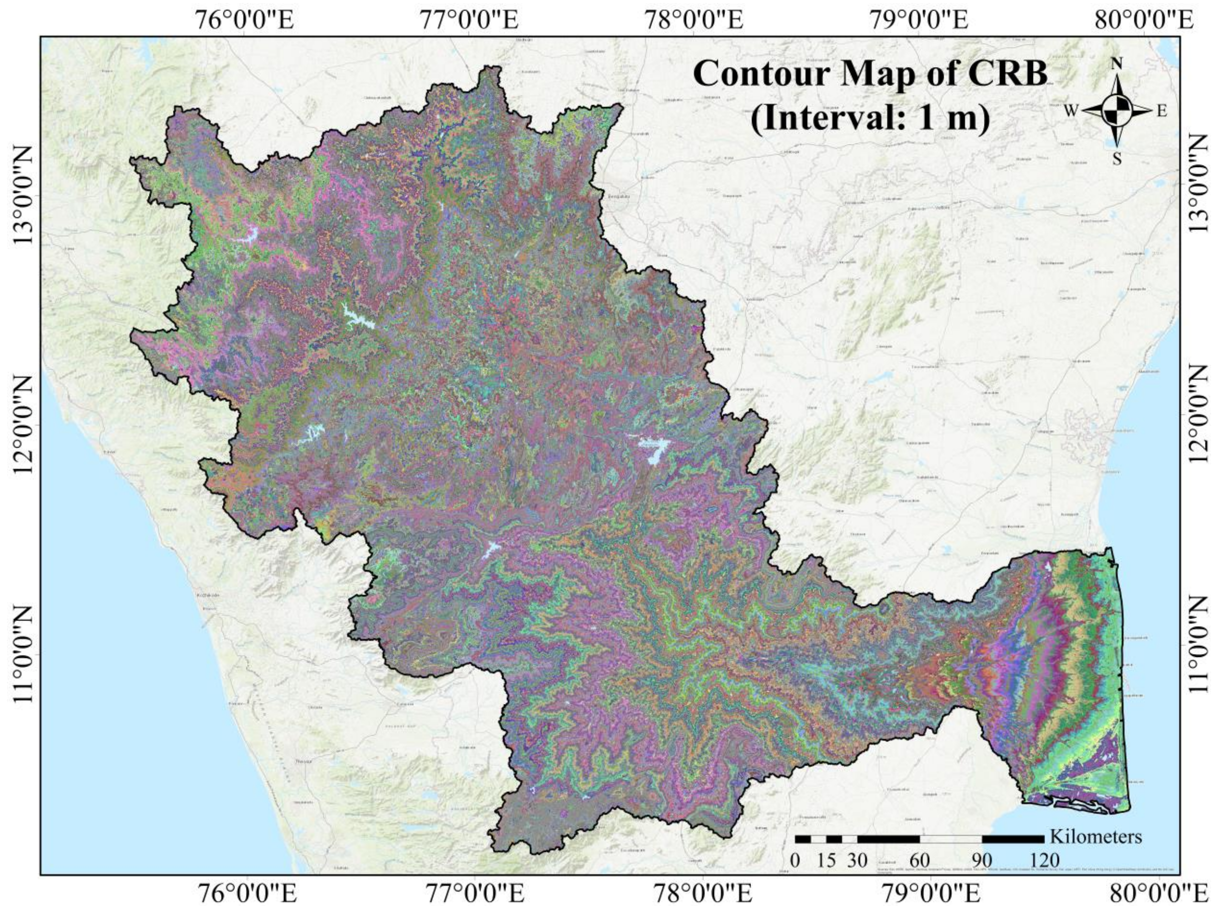

Fig. 4. Contour map (1 m interval) of the CRB

The 50 m contours serve as an intermediate representation for the transitional zone between the Eastern Ghats foothills and the Mysuru plateau (Fig. 5). This vertical spacing reduces noise without suppressing mesoscale relief variations, which are characteristic of dissected uplands and reservoir command areas. The 50 m interval clearly delineates elevation discontinuities associated with structural ridges, deep valleys formed by tributaries (Kabini, Bhavani, and Hemavathi), and plateau edge escarpments that govern runoff concentration patterns within the upper and middle basin.

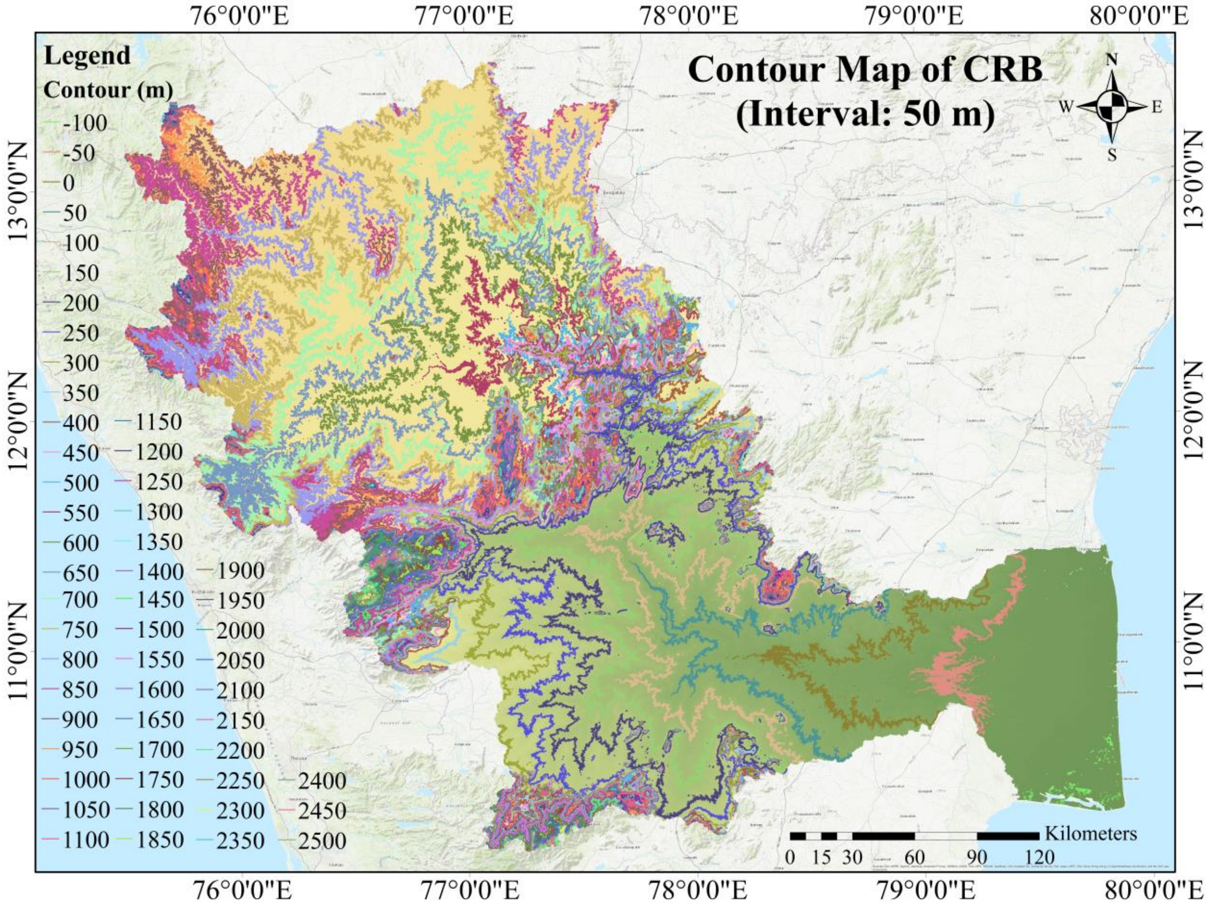

Fig. 5. Contour map (50 m interval) of the CRB

The 100 m contours generalize the terrain sufficiently to highlight the macro-physiographic organization of the CRB, a steep western boundary dominated by the Western Ghats (>2000 m elevation) transitioning to a low-gradient alluvial plain in the east (Fig. 6). At this interval, elevation domains relevant for hydrological modelling become visually distinguishable, enabling rapid identification of orographic controls affecting rainfall interception and discharge patterns into the downstream reaches. Due to ALOS PALSAR's reliable elevation consistency with ground-validated DEMs (Ferreira & Cabral, 2021), the resulting contours provide a dependable topographic foundation for subsequent slope, flow direction, and watershed delineation analyses.

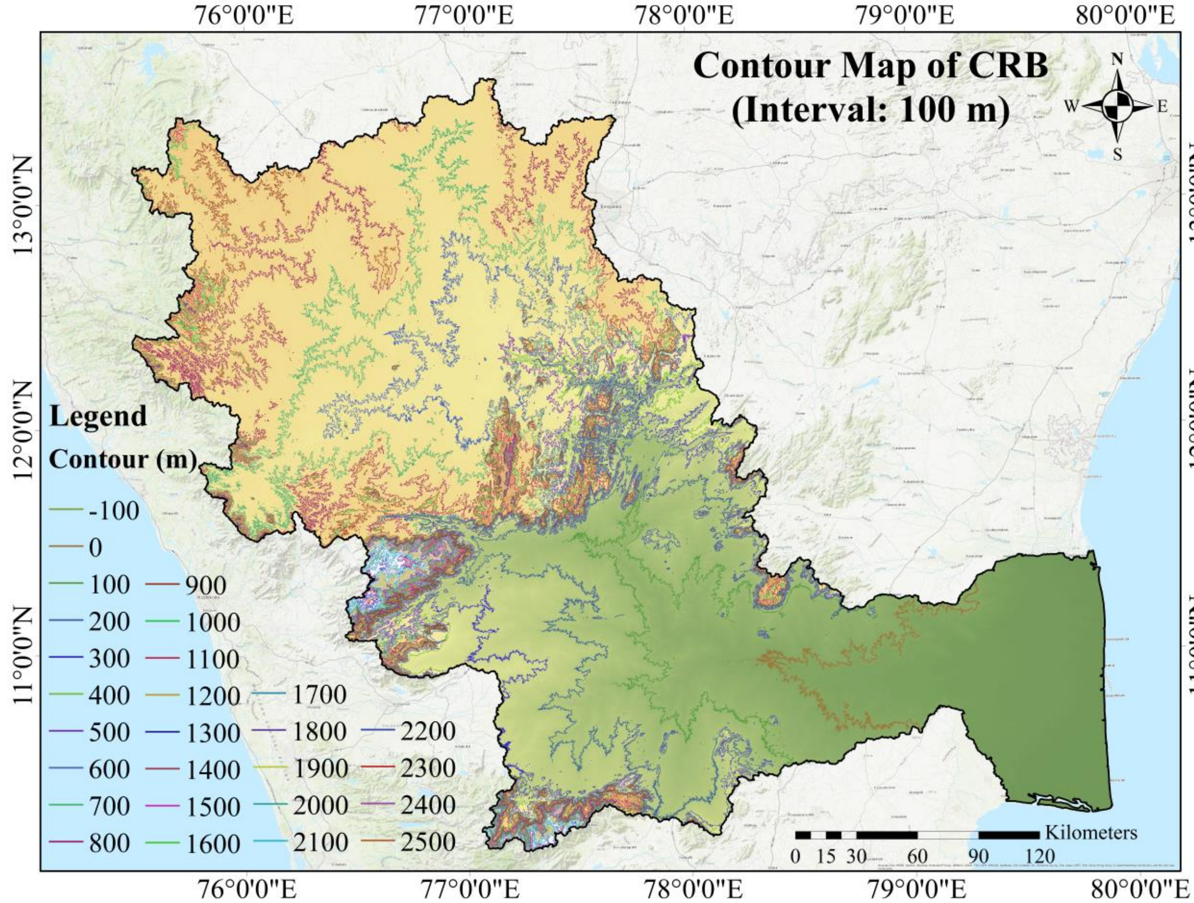

Fig. 6. Contour map (100 m interval) of the CRB

The key observations from the contour analysis are described in Table 1.

Table 1. Key observations from the contour analysis

Observation from Contour Maps	Geomorphic Interpretation	Hydrological Implication
Dense clustering of contours in the Western Ghats region (>2000 m elevation)	Extremely steep slopes and strong terrain discontinuity controlled by structural uplift	Rapid runoff generation, shorter concentration time, high erosion potential at headwaters
Irregular contour spacing across the central plateau (Mysuru-Shivamogga region)	Dissected plateau with moderate relief and valley incision by Kabini, Bhavani, Hemavathi tributaries	Enhanced storage and infiltration; reservoirs and tanks benefit from natural topographic depressions
Gradual widening and parallel alignment of contours in the lower Cauvery floodplain and delta	Very low relief (<50 m), mature alluvial plain dominated by sediment deposition and lateral channel migration	High susceptibility to flooding; small elevation differences influence inundation extent and drainage efficiency
1 m contours reveal micro-topographic features such as paleo-levees, abandoned channels, and backwater depressions	Active and historical fluvial reworking; anthropogenic canal systems visible due to elevation contrast	Supports micro-level flood modelling, drainage planning, and flood hazard zoning
Contour bending and sharp deflection near ridge barriers in Kabini and Bhavani sub-basins	Structural controls influence drainage alignment and valley orientation	Flow path confinement increases stream power and potential for sediment entrainment
Convergence of contours near tributary confluences in the upper basin	Rapid gradient transition zones where streams merge and lose energy	Possible sediment deposition and bar formation at confluence zones
Smooth, gentle contour transitions approaching the river mouth	Channel gradient reduces significantly, indicating near-neutral slope	Increased sedimentation and risk of avulsion in distributary networks

The contour analysis clearly shows how topography governs the hydrological behaviour of the CRB. Steep gradients in the Western Ghats accelerate runoff and sediment transport, while the dissected plateau in the middle basin slows and redistributes flow through storage structures and tributary networks. As the river enters the low-relief delta, the terrain flattens almost completely, making the system far more sensitive to minor elevation differences, especially during floods or backwater conditions. The multi-interval contour mapping (1 m, 50 m, and 100 m) makes this transition unambiguous, revealing a direct link between terrain structure, drainage efficiency, and flood susceptibility across the basin.

3.5. Flow Direction Dynamics

Flow direction for the CRB was derived from the ALOS PALSAR DEM using the D8 flow routing algorithm, which assigns flow from each raster cell to the steepest downslope neighbour (Fig. 7). This allows the DEM to be transformed from a static elevation surface into a hydrologically meaningful drainage network representation.

In the upstream Western Ghats section, flow direction cells show strong alignment and convergence toward steep valley corridors. The dominance of uniform flow vectors here indicates that runoff rapidly concentrates into narrow drainage paths, consistent with the steep relief and high stream power of the headwaters. This is also the part of the basin where the longest uninterrupted flow sequences occur, feeding major tributaries such as Kabini and Bhavani.

Across the central plateau, the flow direction pattern becomes more fragmented and spatially variable. The vector field reveals frequent directional changes associated with dissected uplands, reservoir backwaters, and local depressions. These patterns reflect the role of storability in this part of the basin, water temporarily spreads, reorients, and then reconverges into engineered and natural drainage networks.

In the lower basin and deltaic zone, flow direction vectors gradually become parallel and diffuse. The near absence of strong directional gradients shows that water movement is governed more by micro-topography than by slope. This explains why the delta is extremely sensitive to monsoon floods, tidal interference, and sediment aggradation, small changes in elevation influence the routing and stagnation of water.

Overall, the flow direction map confirms a consistent upstream-downstream transition, from steep, energy-dominated runoff generation zones to low-relief depositional plains where flow deceleration and sediment accumulation dominate. This spatial organization directly influences routing efficiency, flood wave propagation, and sediment delivery to the delta.

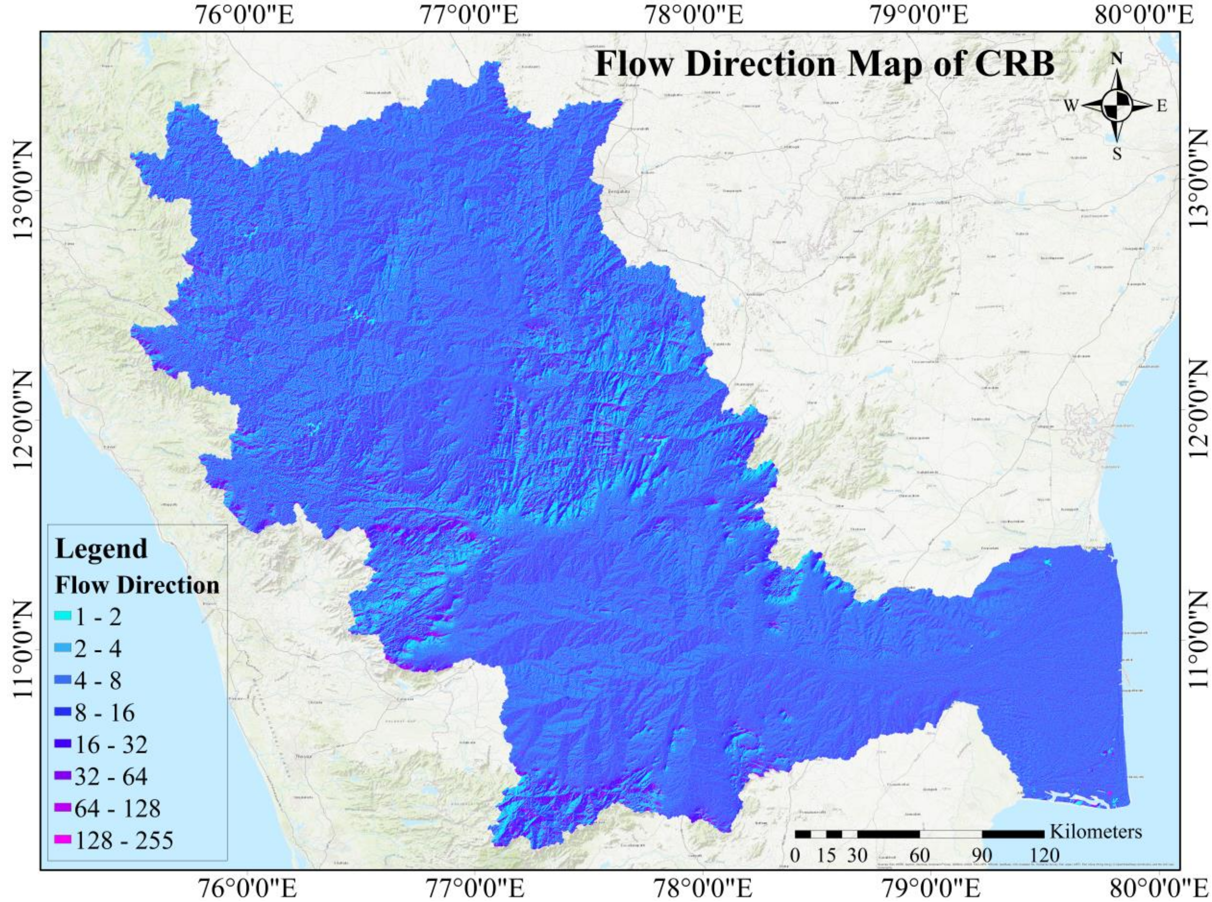

Fig. 7. Flow direction map of the CRB

The key observations from the flow direction dynamics are described in Table 2.

Table 2. Key observations from the flow direction dynamics

Flow Direction Observation	Interpretation (Terrain / Drainage Behaviour)	Hydrological Implication
Flow direction vectors radiate outward from elevated Western Ghats headwater zones	Steep slopes force runoff into narrow, well-defined first-order streams	Quick concentration of flow, higher peak discharge response to intense rainfall
Dominant flow orientation is west-to-east across the basin	Elevation decreases progressively towards the Bay of Bengal	Predictable basin-scale flow routing; supports macro-level flood routing models
Local flow divergence and convergence are visible around plateau and undulating mid-basin terrain	Micro-topography affects how flow paths form and merge	Influences sub-basin hydrograph timing and routing efficiency
Flow direction shifts near major reservoirs (e.g., Kabini, Krishnaraja Sagar, Mettur)	Water infrastructure interrupts natural drainage pathways	Controlled discharge alters downstream flood peaks and seasonal water availability
In the eastern plains and deltaic zone, flow direction becomes uniform and parallel	Minimal elevation gradient results in low-energy flow	Increased waterlogging risk during monsoon and reduced drainage capacity
Multiple internal drainage lines reveal clear sub-basin demarcation (Kabini, Hemavathi, Amaravathi, Bhavani)	Flow direction matrix successfully captures watershed divides	Supports accurate runoff modelling and sub-basin management strategies
Flow vectors align consistently with major river courses and tributary confluences	High coherence between DEM-derived flow and natural channel network	Confirms DEM precision and reliability for hydrological simulation and modelling inputs
Minimal flow ambiguity or flat-area conflicts in headwater and plateau zones	Good quality ALOS PALSAR DEM ensures clear slope-driven routing	Reduces error propagation in downstream hydrologic analysis (accumulation, stream order, watershed delineation)

3.6. Flow Accumulation Pattern

Flow accumulation was computed from the flow direction grid to quantify how surface runoff converges and forms the drainage network across the CRB (Fig. 8). Each raster cell stores the number of upstream cells contributing flow to it, allowing identification of drainage hierarchy from first-order streams to the main channel. Areas with high accumulation values represent locations where runoff concentrates, while low-value cells indicate ridgelines or local divides.

In the Western Ghats headwaters, flow accumulation increases sharply within short distances due to steep slopes and densely converging drainage lines. Small contributing areas here rapidly evolve into well-defined channels, confirming that the upper basin behaves as a high-energy runoff production zone. This aligns with steep gradient terrain and orographic rainfall concentration, leading to flashier hydrological response at tributary origins.

Across the Mysuru plateau and transitional middle basin, accumulation patterns spread laterally before reconverging. This dispersion reflects the influence of geomorphology and anthropogenic interventions, reservoirs, tanks, and command areas temporarily interrupt surface flow and redirect runoff through engineered channels. The accumulation map distinctly traces these flow interruptions, indicating zones of water storage and delayed hydrological routing.

Toward the eastern plains and Cauvery delta, flow accumulation becomes increasingly elongated and parallel, highlighting subdued gradients and diffused drainage patterns. The high-accumulation corridors flatten and widen, showing slower routing and higher potential for sediment deposition. The accumulation surface confirms a progressive hydrological shift from steep, energy-dominated drainage in the upper basin to broad hydraulic attenuation and water stagnation zones near the delta. This transition explains the contrasting flood behaviour between upstream flash discharge zones and the downstream regions where waterlogging and slow recession dominate.

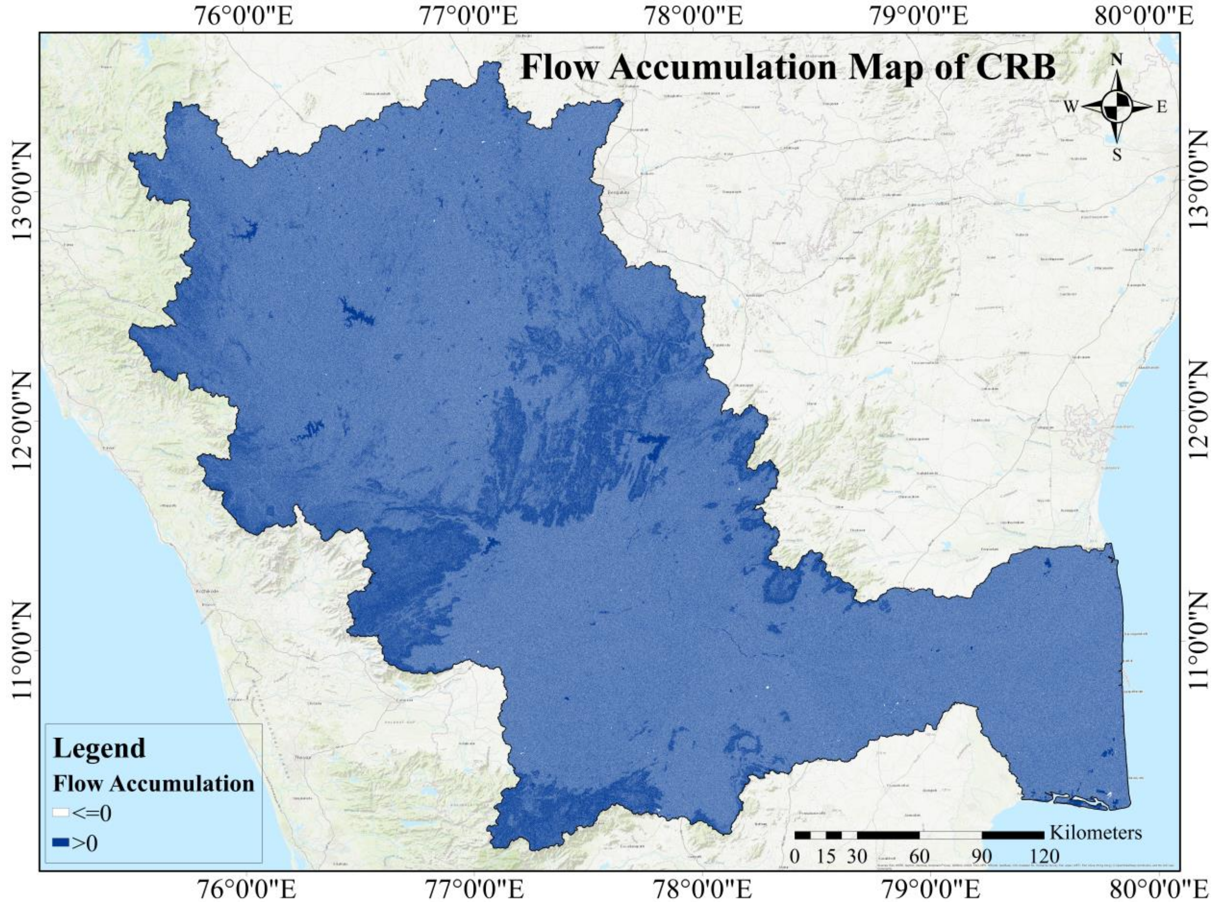

Fig. 8. Flow accumulation map of the CRB

The key observations from the flow accumulation pattern are described in Table 3.

Table 3. Key observations from the flow accumulation pattern

Flow Accumulation Observation	**Interpretation (Terrain / Drainage Behaviour)**	**Hydrological Implication**
Rapid increase in flow accumulation within short distances in the Western Ghats headwaters.	Steep terrain causes immediate channel initiation and strong drainage convergence.	Fast runoff concentration; flash flood potential in upper sub-basins (Kabini, Bhavani).
Small contributing areas evolve into continuous, elongated drainage lines.	Well-defined natural stream hierarchy; low interception by surface depressions.	Efficient routing of rainfall to streams; minimal delay in peak discharge.
Accumulation disperses laterally before reconverging in the Mysuru plateau and mid-basin.	Flow pathways are interrupted by undulating terrain, storage structures (reservoirs/tanks), and agricultural command areas.	Increased detention time; moderation of flood peaks downstream.
Flow accumulation corridors coincide with artificial canal networks around irrigation structures.	Anthropogenic intervention visibly alters natural drainage routing.	Modified flow paths; engineered control over spatial distribution of runoff.
Accumulation patterns flatten and broaden toward the eastern plains and delta.	Very low relief; diffuse drainage leading to sheet flow and ponding.	High floodwater storage, prolonged recession, increased waterlogging risk.
Multiple low-accumulation ridgelines visible across the basin boundary.	Clear watershed boundaries and internal sub-basin divisions.	Supports accurate watershed delineation for hydrological modelling.
Micro-accumulation paths detected even at fine resolution (5–10 m cell scale).	Presence of shallow depressions, abandoned channels, and micro-drainage networks in the delta.	Critical for local flood vulnerability assessment, especially during monsoon and backwater effects.

4. Geomorphological Characteristics

The geomorphological characteristics of the CRB reflect the complex interaction of tectonics, lithology, climate, and long-term fluvial processes that have shaped the basin from its origin in the Western Ghats to its extensive delta along the Bay of Bengal (Fig. 9). The western and upper reaches of the basin are dominated by steep denudational hills, structural ridges, and deeply incised valleys formed over the crystalline rocks of the Ghats. These rugged headwater regions include the upper catchments of the Kabini, Hemavati, Harangi, and Bhavani rivers, where intense weathering, heavy monsoonal rainfall, and high relief energy produce rapid drainage development, strong erosional forces, and significant sediment transport. Structural hills and plateaus are prominent in these zones, where foliation trends, fractures, and lithological contrasts control slope orientation, valley alignment, and watershed boundaries. This high-relief terrain plays a crucial role in the basin's hydrology by generating high runoff, triggering slope instability, and acting as the primary sediment source for the middle and lower reaches of the Cauvery River.

As the river moves eastward into the central part of the basin, the terrain transitions into moderately dissected denudational plateaus, rolling uplands, and broad pediplains. These landscapes display gentler slopes, wider interfluves, and a more subdued topographic pattern influenced by prolonged erosion under semi-arid climatic conditions. The geomorphology here is marked by pediments, pediplains, and inselbergs, which reflect the gradual lowering of the land surface and the retreat of hill slopes through weathering and sheet wash processes. These central plateau regions form the major agricultural belt of Karnataka and Tamil Nadu due to their moderate slopes, fertile soils, and better accessibility to irrigation infrastructure. Groundwater occurs in weathered zones and fracture networks, and geomorphic features such as pediplains and valley fills enhance recharge potential. The dissected uplands and plateaus also serve as important ecological transition zones, with vegetation varying from dry deciduous forests on ridges to cultivated lands and scrub vegetation in valley regions.

Further downstream, the geomorphology becomes increasingly dominated by fluvial and alluvial processes. The Cauvery River, along with its distributaries such as the Kollidam, forms extensive younger and older alluvial plains characterized by point bars, levees, backswamps, meander scars, and abandoned channels. These alluvial landscapes represent the dynamic history of channel migration, sediment deposition, and periodic flooding that continue to shape the river corridors. The alluvial plains downstream of Tiruchirappalli and Thanjavur are particularly well-developed and are among the most fertile tracts in South India, supporting intensive agriculture, especially paddy cultivation. These landscapes exhibit high groundwater potential due to thick alluvial sediments and interconnected floodplain aquifers. Seasonal inundation and channel avulsions in these stretches highlight the active nature of fluvial geomorphology in the lower basin.

In the easternmost part of the basin lies the Cauvery Delta, a classic example of a mature fluvio-marine depositional system influenced by river discharge, tidal action, and coastal processes. The delta consists of older and younger coastal plains, beach ridges, tidal flats, mudflats, and estuarine deposits. Landforms such as natural levees, distributary channels, sand spits, and lagoonal environments reflect the geomorphic evolution of the delta under changing sea levels and sediment supply conditions. However, extensive dam construction in the upper and middle basin has led to sediment starvation in recent decades, contributing to delta shrinkage, coastal erosion, and salinity intrusion in groundwater. The geomorphology of the delta therefore exhibits both natural depositional features and significant anthropogenic impacts that alter sediment flow, channel stability, and coastal resilience.

Across the basin, man-made geomorphic features such as reservoirs, tanks, canals, quarry pits, and mine dumps also contribute to the modified landscape. Large reservoirs like Krishna Raja Sagara, Mettur, Kabini, and Harangi interrupt sediment transport, modify flow seasonality, and influence downstream channel form and floodplain processes. Tank irrigation systems, especially in Tamil Nadu, create localized depositional basins and alter natural drainage pathways. Quarrying and mining activities in parts of Karnataka and Tamil Nadu have generated excavated depressions and spoil heaps that affect slope stability and sediment yield. Collectively, these human-induced modifications overlay the natural geomorphic framework and influence hydrological connectivity, water storage patterns, and sediment dynamics.

Overall, the geomorphological character of the CRB is a composite of rugged high-relief Western Ghats terrain, transitional plateaus and pediplains in the central basin, extensive alluvial floodplains in the lower reaches, and a complex, evolving deltaic system at the mouth of the river. These geomorphic zones govern fundamental basin processes, including runoff generation, sediment transport, groundwater recharge, floodplain dynamics, ecological distribution, and land-use suitability. A clear understanding of these geomorphic units is essential for effective river basin management, flood forecasting, water resource planning, ecological restoration, and climate resilience strategies across the Cauvery Basin.

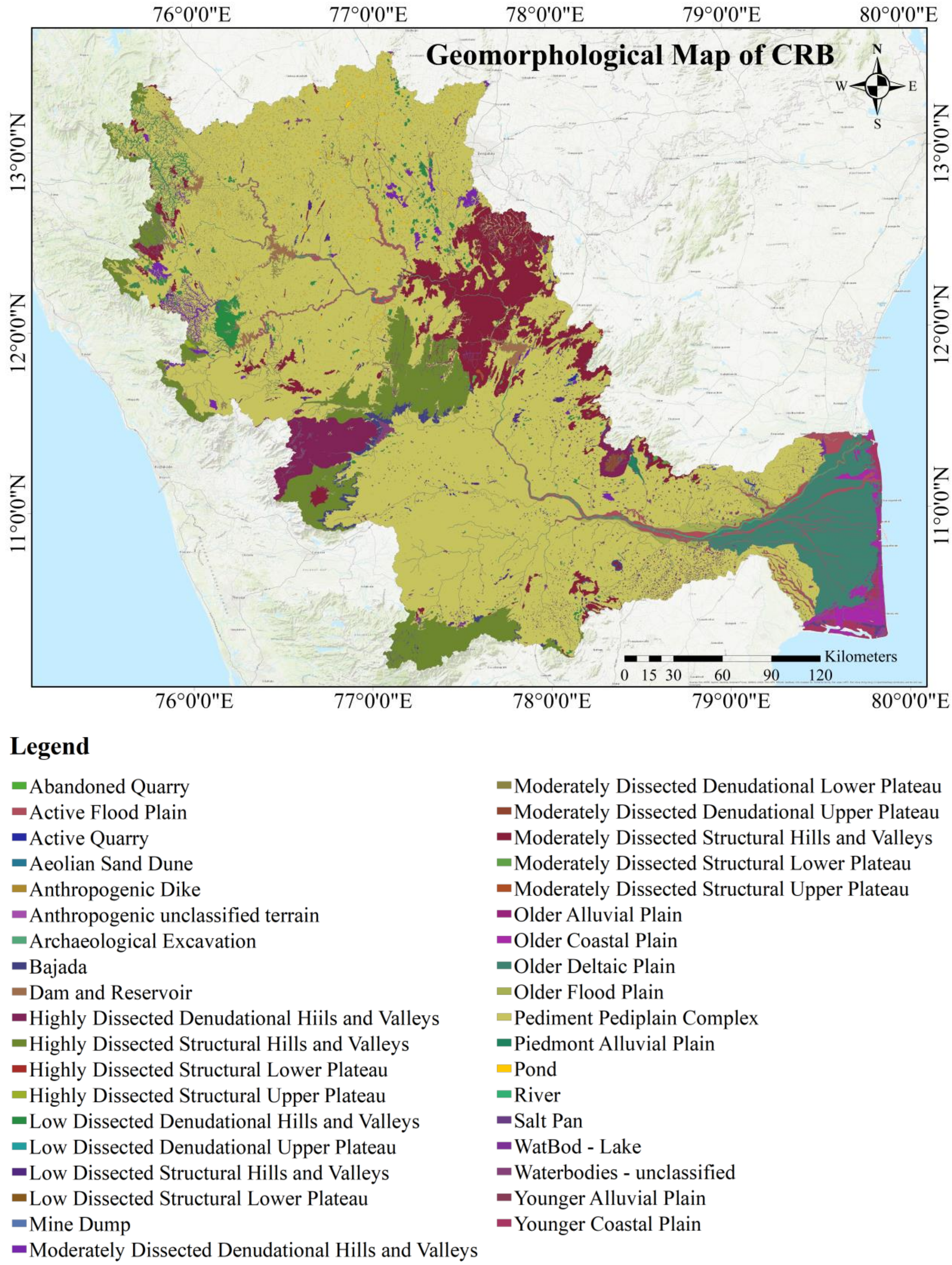

Fig. 9. Geomorphological map of the CRB

(Source: Bhukosh, GSI)

5. Applications and Planning Implications

High-resolution topographic maps are powerful tools for river basin management, infrastructure planning, and climate resilience strategies. In the context of the CRB, which spans diverse terrain from steep highlands to flat coastal deltas, the topographic data directly supports multidisciplinary planning applications. This section outlines the practical use-cases of the topographic analysis and its implications for sustainable basin management.

5.1. Flood Risk Management and Disaster Planning

- Zonation of flood-prone areas using detailed elevation and slope data helps local and state authorities plan flood-resilient infrastructure (embankments, detention basins, elevated roads).
- Contour-based water flow simulations assist in demarcating evacuation routes, positioning of relief shelters, and identifying flood-safe zones in low-lying villages.

5.2. Irrigation and Water Resource Planning

- Command area mapping for major irrigation projects (e.g., KRS, Mettur, Kabini reservoirs) can be refined using topographic contours to design gravity-fed canal alignments and optimise field-level water distribution.
- The identification of natural micro-watersheds and ridges supports the siting of check dams and farm ponds in the rainfed and semi-arid zones of Karnataka and Tamil Nadu.

5.3. Infrastructure Siting

- Contour maps enable cut-fill analysis for construction of roads, embankments, and pipelines, reducing cost and environmental impact.
- Planning of green infrastructure like urban wetlands, retention basins, and stormwater networks in rapidly urbanizing areas (e.g., Mysuru, Erode) depends on terrain mapping.

5.4. Watershed Development and Soil Conservation

- Delineation of micro-watersheds and slope zones supports soil erosion modelling, check dam planning, and contour bunding in vulnerable rural landscapes.
- Restoration of degraded uplands through topography-based afforestation and water conservation strategies.

5.5. Urban and Regional Planning

- Urban topographic mapping in cities such as Bengaluru (Arkavathi basin) and Tiruchirappalli (Coleroon reach) helps identify flood-risk zones and suitable drainage alignments.

- Terrain analysis informs zoning and building regulations, especially in areas with high slope instability or floodplain encroachment.

5.6. Groundwater and Aquifer Management

- Identification of topographic depressions and paleo-channels aids in locating shallow aquifers and groundwater recharge hotspots.
- Slope analysis supports artificial recharge structure design and check dam alignment along natural flow paths.

5.7. Climate Change Adaptation and Resilience

- Terrain-driven hydrological modelling is essential for simulating future flood scenarios under changing rainfall patterns.
- Integration with climate projections allows for long-term infrastructure design that accounts for changing hydrodynamics.

5.8. Policy and Governance Support

- Topographic insights provide scientific backing for river regulation zone policies, inundation buffer planning, and catchment area treatment plans.
- Supports compliance with national guidelines on floodplain management, watershed development, and inter-basin water transfers.
- Facilitates stakeholder engagement by offering visual tools (maps, profiles) for community planning and participatory decision-making.

6. Challenges and Limitations

Despite the advantages of using high-resolution topographic data in analysing the CRB, several challenges and limitations persist in data availability, accuracy, integration, and applicability. This section outlines the key constraints encountered during the study and their implications for future work and decision-making. By acknowledging these challenges, future work can prioritize ground-truthing, improved DEM acquisition, and enhanced integration of topographic data with hydrology, climate, and land use datasets. Addressing these limitations is essential for developing robust, scalable, and context-sensitive solutions for the CRB.

7. Summary and Recommendations

High-resolution topographic mapping should be one of the essential approaches to ensure proper management of the CRB. The basin's topography range, from steep highlands down to flat deltaic plains, directly influences river flow, its flood vulnerability, and land suitability for agriculture and infrastructure. This report can help identify flood-prone areas, optimise the planning of irrigation and drainage infrastructure, and help in targeting watershed-level interventions for soil and water conservation. These informed landscape-based plans are also crucial for enhancing climate resilience in both rural and urban areas. Full-scale application remains constrained, however, by the unavailability of high-resolution data coverage, a lack of ground validation, and fragmented access at the institutional level. In this regard, recommended future effort investments include full-basin LiDAR or UAV-based mapping, establishment of protocols for regular inter-agency data sharing, and building technical capacity at the local planning level. Topographic mapping should be a key component of basin-scale planning, which will dramatically enhance sustainable water governance and climate adaptation strategies across the entire CRB.

8. Significance of the Topographic Maps Report

The topography report of the CRB carries comprehensive information on elevation, slope, contour, and drainage patterns across the basin. These topographic analyses provide important input for flood risk zoning, watershed development, irrigation planning, and infrastructure design. The integration of terrain data with hydrological modelling in this report supports science-based decision-making for sustainable water resource management, disaster preparedness, and climate resilience across the states sharing the CRB.

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