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

Lithological Profile of Krishna River Basin

April 2025

Lithological Profile of Krishna River Basin

National River Conservation Directorate (NRCD)

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.

www.nrcd.nic.in

Centres for Krishna River Basin Management and Studies (cKrishna)

The Center for Krishna River Basin Management and 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 center 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.

www.ckrishna.org

Centres 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 NIT Warangal (Lead Institute) and NIT Surathkal (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.

Team Members

N V Umamahesh, cKrishna, NIT Warangal
K Venkata Reddy, cKrishna, NIT Warangal
P V Rao, cKrishna, NIT Warangal
Ajey Patel, cKrishna, NIT Warangal
Shashi Mesapam, cKrishna, NIT Warangal
Hari Prasad Reddy P, cKrishna, NIT Warangal
Manali Pal, cKrishna, NIT Warangal
Sridhar Pilli, cKrishna, NIT Warangal
Vamsi Krishna Vema, cKrishna, NIT Warangal
Jew Das, cKrishna, NIT Warangal
Lita Kumar Ray, cKrishna, NIT Warangal
Sumanth C, cKrishna, NIT Warangal
Kamalini Devi, cKrishna, NIT Warangal
S Shrihari, cKrishna, NITK Surathkal
B. Manu, cKrishna, NITK Surathkal
Arun Kumar Thalla, cKrishna, NITK Surathkal
Devatha C P, cKrishna, NITK Surathkal
Anupama Surenjan, cKrishna, NITK Surathkal
Jacklin Jeke Nilling, cKrishna, NITK Surathkal
Saranya P, cKrishna, NITK Surathkal
Laxman Nandagiri, cKrishna, NITK Surathkal
Dwarakish G S, cKrishna, NITK Surathkal
Varija K, cKrishna, NITK Surathkal
Ramesh H Gowda, cKrishna, NITK Surathkal
Shwetha H R, cKrishna, NITK Surathkal
Chandan Pradhan, cKrishna, NITK Surathkal

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.

Prof. N V Umamahesh
Centres for Krishna River Basin
Management and Studies (cKrishna)
NIT Warangal (Lead Institute), NIT Surathkal (Fellow Institute)

Contents

List of Figures

List of Tables

1. Introduction

The Krishna River Basin, one of the largest in peninsular India, spans an area of approximately 260,579 square kilometres, covering the states of Maharashtra, Karnataka, Telangana, and Andhra Pradesh. This vast basin is distinguished by its complex and diverse geological formations, which play a pivotal role in shaping its hydrological, geomorphological, and ecological systems.

The lithological profile of the Krishna Basin reflects its rich geological history, featuring a variety of rock types, including granites, basalts, gneiss, schists, and sedimentary formations. These lithological characteristics significantly influence the basin's groundwater availability, soil fertility, and mineral resources, while also determining its vulnerability to natural hazards such as landslides, soil erosion, and droughts.

This report explores the lithological characteristics of the Krishna Basin, focusing on its lithological profile, lithologs, aquifer details, soil layers, soil depth information, and historical landslide assessments. The study is specifically centred on seven sub-basins within the Krishna Basin: Lower Bhima, Upper Bhima, Upper Krishna, Middle Krishna, Lower Krishna, Upper Tungabhadra, and Lower Tungabhadra.

2. Geographical and Tectonic evaluation

The Krishna Basin, part of the larger Krishna-Godavari Basin, is a pericratonic passive margin basin located along the eastern coast of India. Its geological and tectonic evolution is characterized by multiple phases of rifting, sedimentation, and subsidence(Mishra et al. 2020). Seismic imaging studies (Fainstein et al. 2015) have provided crucial insights into the basin’s structural evolution, highlighting fault-controlled subsidence and sediment distribution patterns (Figure 1).

2.1 Tectonic and Structural Evolution:

1. Rift-Related Origin and Mesozoic Evolution

G.N. (2001) discusses the basin’s evolution as a passive margin rift basin, originating from the breakup of Gondwana during the Mesozoic. The rift system led to the formation of horst and graben structures, which controlled early sedimentation. Bastia and Nayak (2006) further elaborate on the role of NE-SW and NW-SE trending faults in defining sub-basins and depocenters. Seismic imaging (Figure 1) confirms the presence of these fault systems, indicating their role in sediment accommodation and deposition.

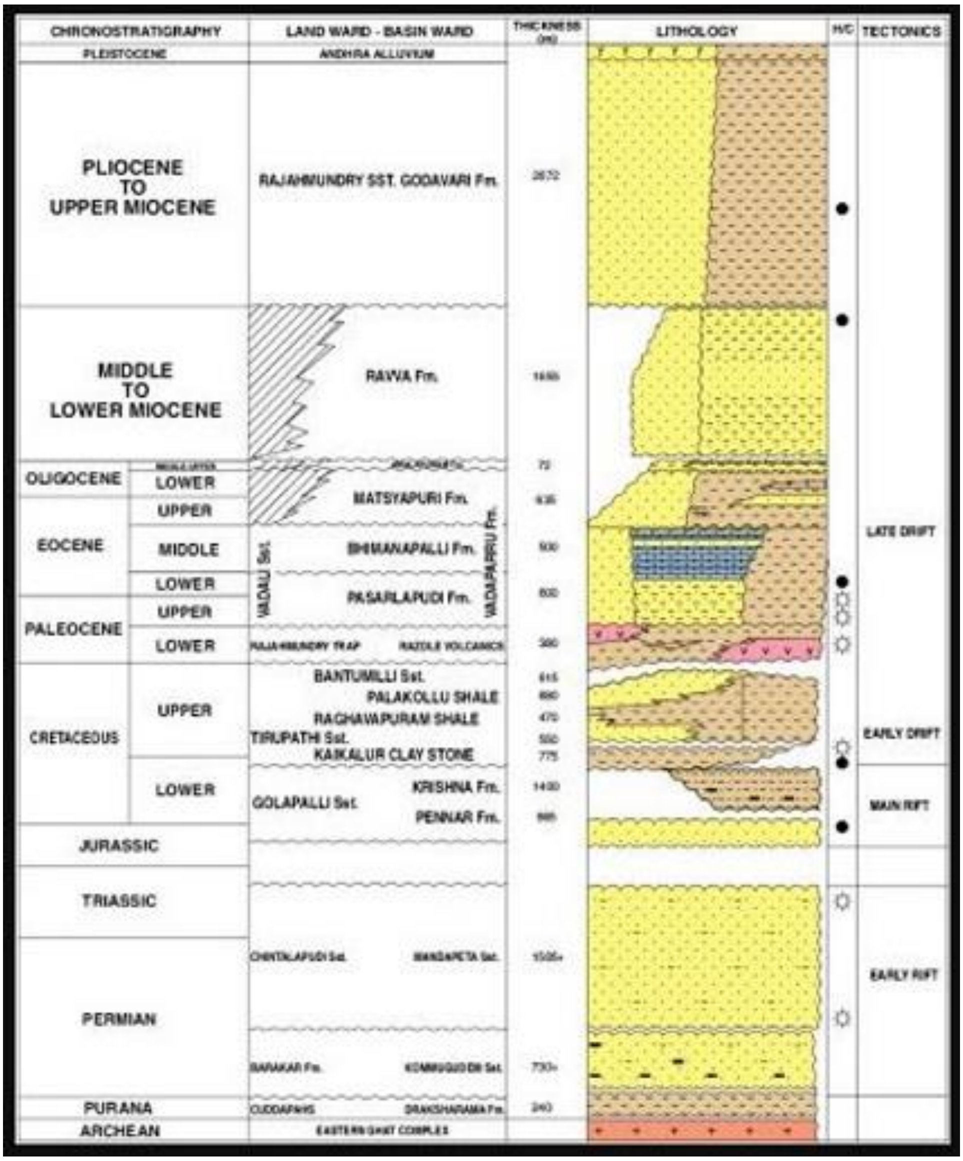

Figure 1 A detailed figure showcasing time/depth seismic imaging

2. Cenozoic Subsidence and Sedimentation

Rabi Bastia (2012) emphasize the post-rift thermal subsidence phase during the Paleogene and Neogene, leading to significant sediment deposition. The Krishna-Godavari Basin underwent multiple episodes of transgression and regression, influenced by eustatic sea-level changes and tectonic movements. Growth fault systems and shale tectonics played a crucial role in shaping deepwater structures. . Seismic profiles (Fainstein et al. 2015) further reveal

subsurface features, including fault-controlled subsidence zones and stratigraphic traps, which are essential for petroleum system analysis.

2.2 Stratigraphy and Depositional Environment

1. Cretaceous to Recent Sedimentation

According to G.N. (2001), the basin's stratigraphy includes late Jurassic to Recent sedimentary sequences, dominated by deltaic and deep marine deposits. The Cretaceous section is characterized by extensive sandstone and shale formations, forming major petroleum reservoirs. Bastia and Nayak (2006) identifies key depositional environments, ranging from shelf deltas to deepwater fan systems.

2. Influence of Himalayan Orogeny

Rabi Bastia (2012) highlight that the Himalayan orogeny significantly influenced sediment supply, leading to thick deltaic sequences in the KG Basin. Sediment transport from the Deccan Plateau further contributed to extensive siliciclastic deposition. Subsurface seismic records provide evidence of prograding deltaic sequences, which correspond to increased sediment influx during tectonically active periods (Fainstein et al. 2015)

3. Geology

The geological layers across these sub-basins include Quaternary, Cenozoic, Triassic, Carboniferous, Neoproterozoic, Mesoproterozoic, Palaeoproterozoic, Proterozoic, and Archaean formations. Table 1 provides a detailed breakdown of the lithological composition for each sub-basin.

1. **Quaternary Deposits**: These are predominantly found in the Lower Krishna sub-basin (3,794.27 units) and are minimal in the Middle Krishna (76.01 units).
2. **Cenozoic Formations**: These are most prominent in the Upper Bhima sub-basin (502.26 units) and least represented in the Middle Krishna (0.01 units).
3. **Carboniferous Formations**: The Upper Bhima sub-basin contains the largest extent (45,621.76 units), while significant deposits are also observed in the Lower Bhima (17,171.34 units).

4. **Neoproterozoic Formations**: These are concentrated in the Lower Krishna (3,141.85 units) and Upper Krishna (2,973.02 units) sub-basins.
5. **Mesoproterozoic Formations**: These are dominant in the Middle Krishna (3,740.36 units) and Upper Krishna (2,746.41 units).
6. **Palaeoproterozoic Formations**: These are sparse, with minor deposits in the Lower Tungabhadra (55.24 units) and Upper Tungabhadra (0.19 units).
7. **Archaean Formations**: These form the largest lithological component across all sub-basins, especially in the Lower Tungabhadra (41,812.57 units) and Lower Krishna (30,554.95 units).

The spatial distribution of these geological layers is visualized in Figure 1, which maps the lithology of the Krishna River Basin. The map highlights the dominance of Archaean formations in most sub-basins, followed by significant contributions from Carboniferous and Neoproterozoic layers in specific regions. The spatial variability in lithological composition reflects the complex geological history of the Krishna River Basin and its sub-basins.

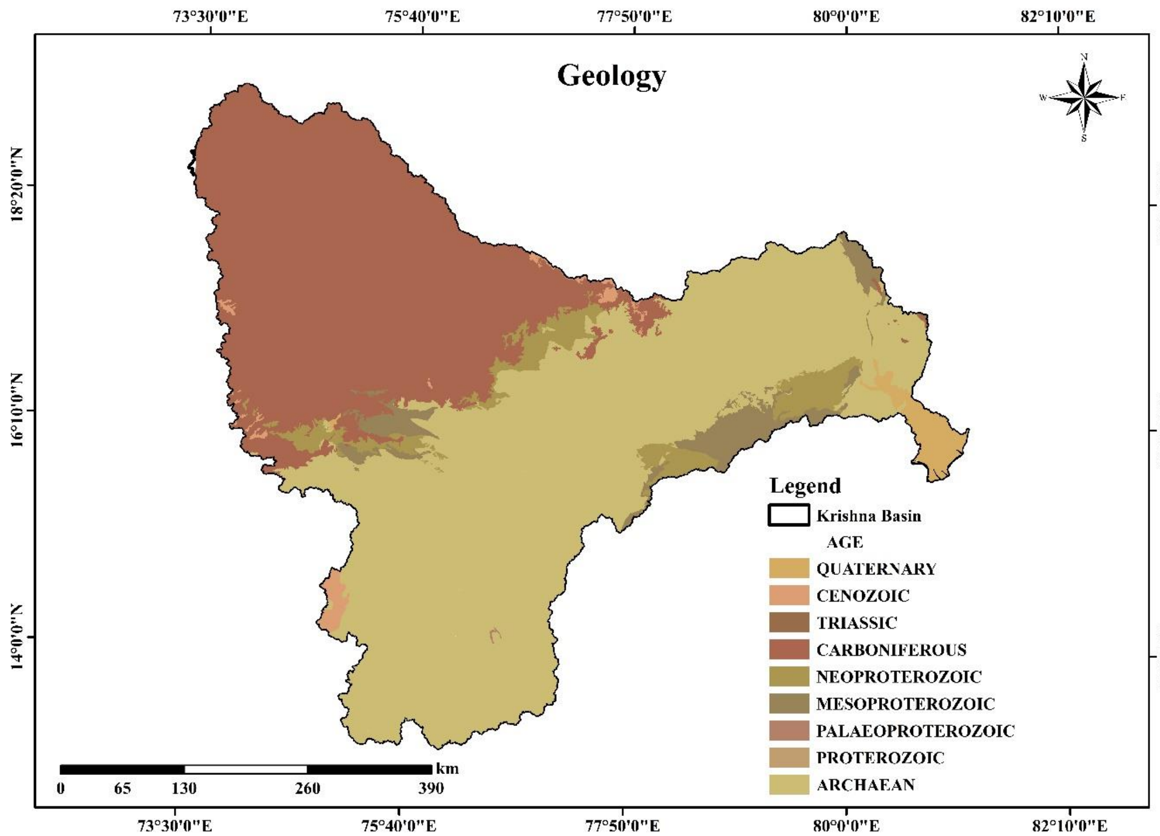

Figure 2 Map showing geological layers in Krishna Basin

Table 1 Area covered by different geological layers across different sub-basins of the Krishna River

Geological layer/Sub-basin	Lower Krishna (Km^2)	Middle Krishna (Km^2)	Upper Krishna (Km^2)	Lower Bhima (Km^2)	Upper Bhima (Km^2)	Lower Tungabhadra (Km^2)	Upper Tungabhadra (Km^2)
Quaternary	3794.27	-	76.01				
Cenozoic	91.15	0.01	380.62	502.26			1119.57
Triassic			2765.23	2882.98			331.56
Carboniferous	916.90	99.93	32958.21	17171.34	45621.76		
Neoproterozoic	3141.85	1527.25	2973.02	3301.61		478.34	
Mesoproterozoic	2168.94	3740.36	2746.41			409.18	
Palaeoproterozoic						55.24	0.19
Proterozoic	1.62						
Archaean	30554.95	17243.26	16271.04	3602.94		41812.57	27046.31

4. Lithological Composition

The lithological composition of the Krishna River sub-basins is shown in **Table 2** and **Figure 2**. The seven sub-basins exhibit a diverse range of lithologies which are detailed below:

1. Lower Krishna Sub-Basin

The lithological profile of the Lower Krishna sub-basin is dominated by the Basement Gneissic Complex (28,654.64 units), followed by Alluvium (3,167.67 units) and Limestone (3,083.67 units). These lithologies are significant for groundwater storage and recharge, with alluvium providing high porosity and permeability, while limestone formations often act as aquifers in karst topography. The dominance of the Basement Gneissic Complex indicates limited soil fertility, making agriculture reliant on irrigation.

2. Middle Krishna Sub-Basin

The Middle Krishna sub-basin's primary lithology is the Basement Gneissic Complex (16,170.54 units), accompanied by Quartzite (2,587.79 units) and Shale (2,129.21 units).

Quartzite and shale formations are less permeable, leading to lower groundwater availability. However, the Basement Gneissic Complex supports localized groundwater storage through fractures, making it vital for rural water supply in this sub-basin.

3. Upper Krishna Sub-Basin

The lithological profile of the Upper Krishna sub-basin is dominated by Basalt (34,587.13 units), a significant contributor to groundwater recharge through vesicular and fractured zones. The presence of Basement Gneissic Complex (12,942.65 units) and minor Alluvium layers enhances surface water retention. The basaltic terrain supports black soil formation, which is crucial for cotton and sugarcane cultivation in the region.

4. Lower Bhima Sub-Basin

The Lower Bhima sub-basin has a diverse lithological composition, with significant coverage of Alluvium (16,932.11 units), Limestone (2,765.23 units), and the Basement Gneissic Complex (3,598.23 units). Alluvium and limestone formations facilitate groundwater storage, making this sub-basin agriculturally productive. The limestone beds may also be exploited for industrial purposes like cement production.

5. Upper Bhima Sub-Basin

The Upper Bhima sub-basin is predominantly covered by Alluvium (45,790.67 units), indicating high groundwater recharge potential and fertile soils for agriculture. The presence of Basement Gneissic Complex (3,598.23 units) and minor Limestone (2,882.98 units) highlights localized groundwater availability. The extensive alluvial plains are significant for sustaining paddy and sugarcane cultivation.

6. Lower Tungabhadra Sub-Basin

The lithological profile of the Lower Tungabhadra sub-basin is dominated by the Basement Gneissic Complex (32,073.16 units), with Schist (3,422.69 units) and minor Alluvium deposits (376.89 units). Schist formations often host metamorphic aquifers with moderate groundwater potential. The gneissic terrain supports small-scale agriculture but requires extensive irrigation due to its low water-holding capacity.

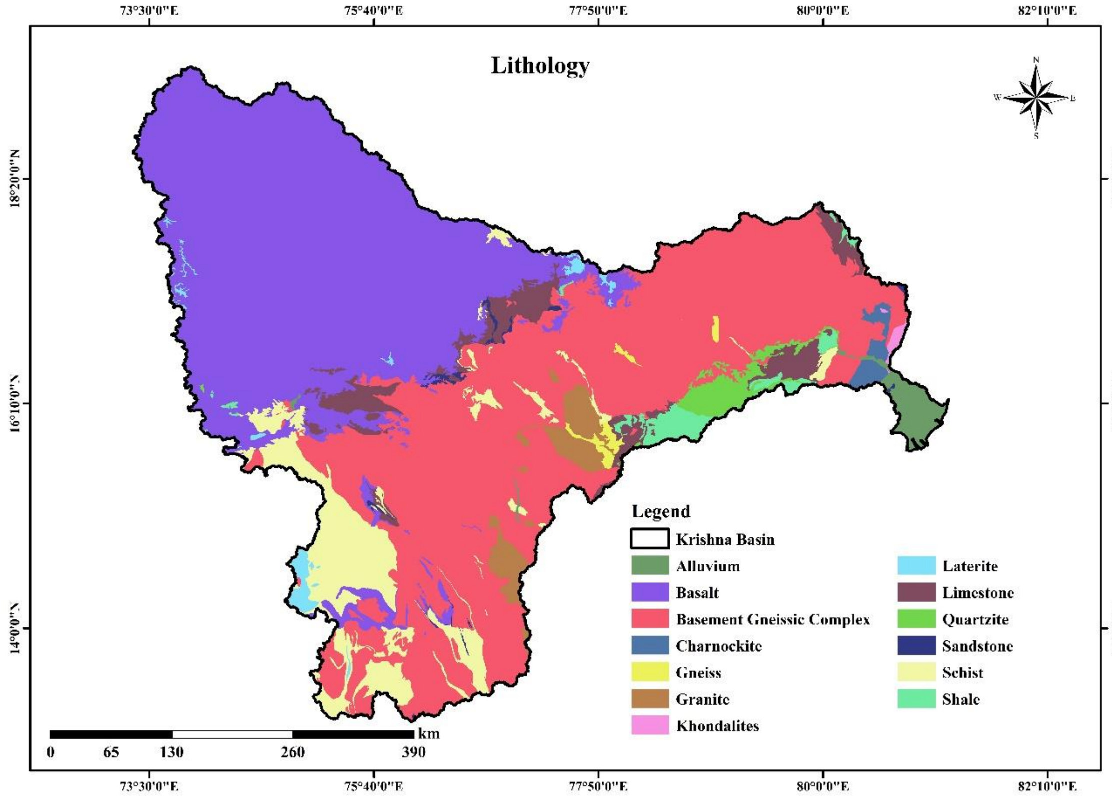

Figure 3 Map showing lithology in Krishna Basin

Table 2 Area covered by different lithological layers across different sub-basins of the Krishna River

Geological layer/Sub-basin	Lower Krishna (Km^2)	Middle Krishna (Km^2)	Upper Krishna (Km^2)	Lower Bhima (Km^2)	Upper Bhima (Km^2)	Lower Tungabhadra (Km^2)	Upper Tungabhadra (Km^2)
Alluvium	3167.67		65.45			83.07	
Basalt	740.83	101.22	34587.13	16932.11	45790.67	376.89	2076.15
Basement Gneissic Complex	28654.64	16170.54	12942.65	3598.24		32073.16	13850.05
Charnockite	1710.05						
Granite		605.98				5099.16	
Gneiss	170.96	147.82				792.74	
Khondalites	447.42						
Laterite	133.67	0.33	430.63	380.22		6.03	1186.53
Limestone	3083.67	550.56	2765.23	2882.98		804.79	331.56
Quartzite	1025.44	2587.79	24.58			32.53	
Sandstone	166.96		261.41	287.82		100.44	78.24

Schist	439.41	321.22	4223.60	474.05		3422.69	10664.51
Shale	1090.17	2129.21	118.99	62.13		50.54	

7. Upper Tungabhadra Sub-Basin

In the Upper Tungabhadra sub-basin, Schist (10,664.51 units) and Basement Gneissic Complex (13,850.05 units) are the dominant lithologies. Schist provides moderate groundwater storage through fissures, while the gneissic complex supports localized water retention. This sub-basin is significant for mixed cropping systems, with groundwater playing a critical role in sustaining agriculture during dry spells.

5. Aquifer Details

The Krishna River Basin comprises diverse aquifer types categorized as semi-confined to confined, unconfined, and transitional (unconfined to confined). These aquifer types, their spatial extent, and significance are crucial for understanding groundwater availability and recharge potential. The spatial distribution of these aquifers is depicted in Figure 3, while their area coverage across the basin is summarized in Table 3.

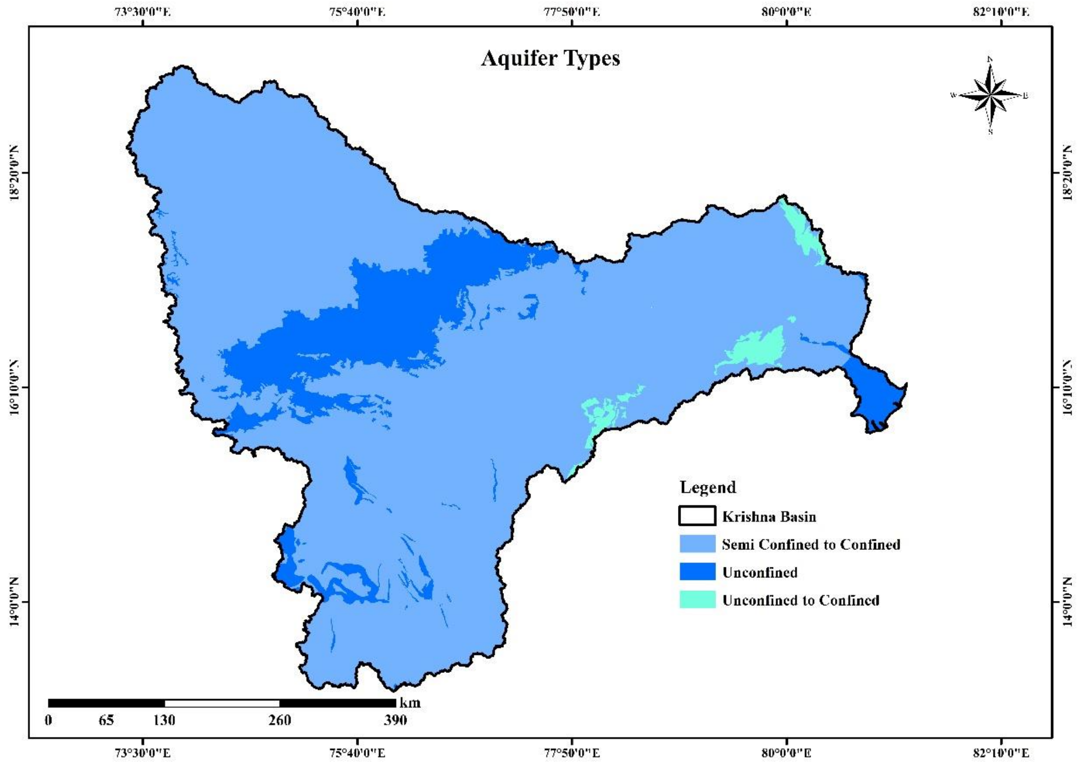

Figure 4 Map showing aquifer types in Krishna Basin

- Semi-confined to Confined Aquifers dominate the basin, with a total area of 223,310.59 km², representing the primary groundwater storage reservoirs. These aquifers play a vital role in sustaining water supply for agricultural and domestic purposes, especially in regions with high water demand.
- Unconfined Aquifers, covering 50,013.80 km², contribute significantly to direct recharge, making them critical for groundwater replenishment in areas with high rainfall or irrigation return flow.
- Transitional Aquifers (Unconfined to Confined), with an area of 6,928.21 km², exhibit mixed characteristics, supporting moderate recharge and groundwater availability.

The dominance of semi-confined aquifers underscores the importance of sustainable groundwater management practices to prevent overexploitation and ensure long-term resource availability.

Table 3 Area covered by different aquifer types in Krishna Sub-Basin

Aquifer Type/Sub-basin	Lower Krishna (Km^2)	Middle Krishna (Km^2)	Upper Krishna (Km^2)	Lower Bhima (Km^2)	Upper Bhima (Km^2)	Lower Tungabhadra (Km^2)	Upper Tungabhadra (Km^2)
Semi confined to Confined	372362.60	22565.31	37000.71	8706.96	44833.25	42267.17	24514.56
Unconfined	3418.631	49.38	15653.73	13027.61	957.42	566.43	3340.92
Unconfined to confined			2765.23	2882.98		8.43	331.56

6. Soil layers

The soil characteristics of the Krishna River Basin, including soil depth, erosion potential, productivity, slope, and texture, are analysed to understand the agricultural potential and land management needs.

5.1 Soil Depth

- Soil depth in the Krishna Basin varies significantly, with **deep soils** (greater than 100 cm) covering the largest area, making them suitable for deep-rooted crops like sugarcane and cotton.

- Shallow soils are found in certain regions, limiting root penetration and water storage capacity, which affects crop productivity.
- Figure 4 provide insights into the spatial distribution of soil depth.

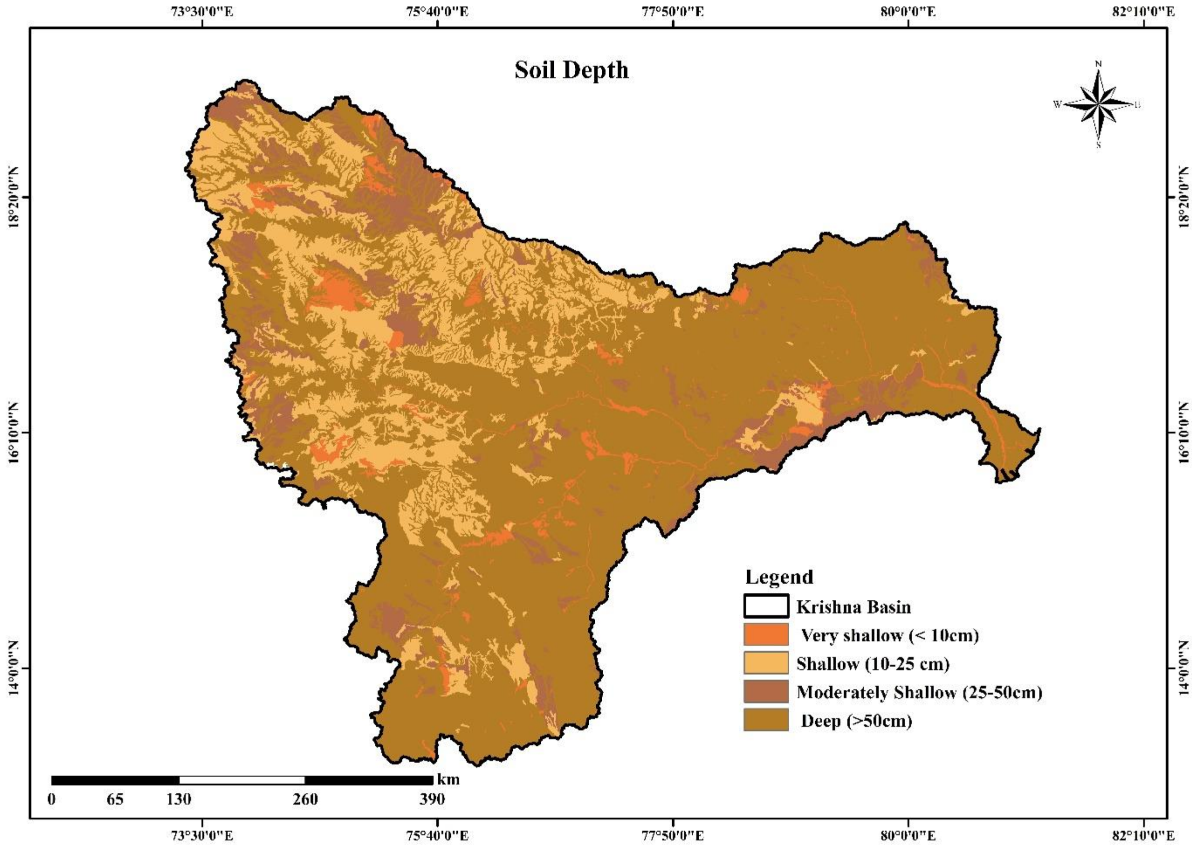

Figure 5 Map showing soil depth in Krishna Basin

5.2 Soil Erosion Potential

- Moderate and slight erosion zones dominate the basin, which can be managed with appropriate soil conservation techniques like contour farming and vegetation cover.
- Areas with severe to very severe erosion need urgent measures, such as reforestation and check dams, to mitigate land degradation.
- Figure 5 shows the spatial distribution of erosion levels and their management priorities.

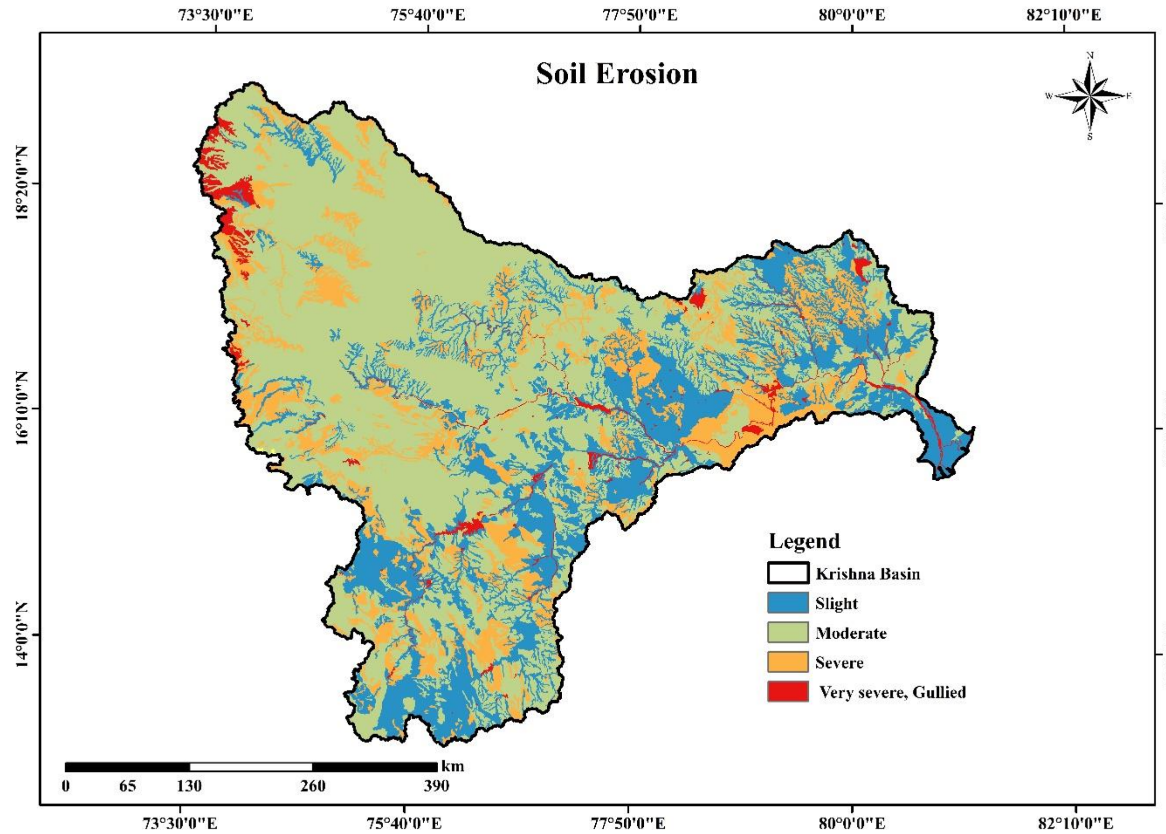

Figure 6 Map showing soil erosion in Krishna Basin

5.3 Soil Productivity

- The basin predominantly features moderate to high productivity zones, indicating good potential for agricultural development.
- Regions with low productivity soils may benefit from interventions such as organic matter addition, irrigation enhancements, and crop diversification.
- Figure 6 showcases the variation in productivity across sub-basins.

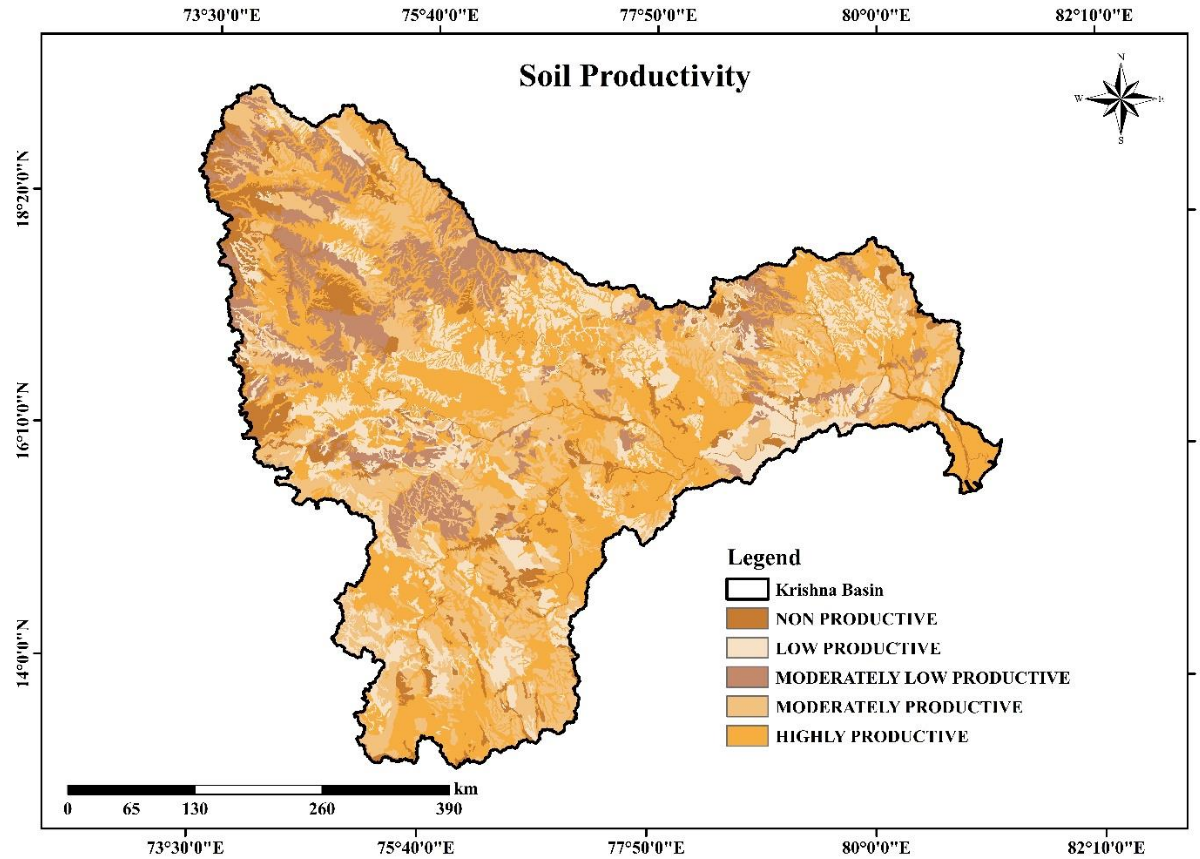

Figure 7 Map showing soil productivity in Krishna Basin

5.4 Soil Slope

- Very gentle to gently sloping terrains are the most prevalent in the basin, making them favourable for farming and irrigation infrastructure development.
- Steep slopes, although covering a smaller area, require careful planning to prevent soil erosion and promote sustainable land use.
- Figure 7 detail the slope characteristics and their distribution.

5.5 Soil Texture

- The basin is dominated by medium-textured soils like sandy loam and loam, providing a balance between water retention and aeration, which is ideal for most crops.
- Areas with fine-textured soils, which retain more water, require proper drainage management to avoid waterlogging and salinity issues.
- Figure 8 illustrate the spatial variation of soil textures within the basin.

These characteristics offer a comprehensive understanding of the basin's soil resources, guiding targeted strategies for agriculture, watershed management, and sustainable land use planning.

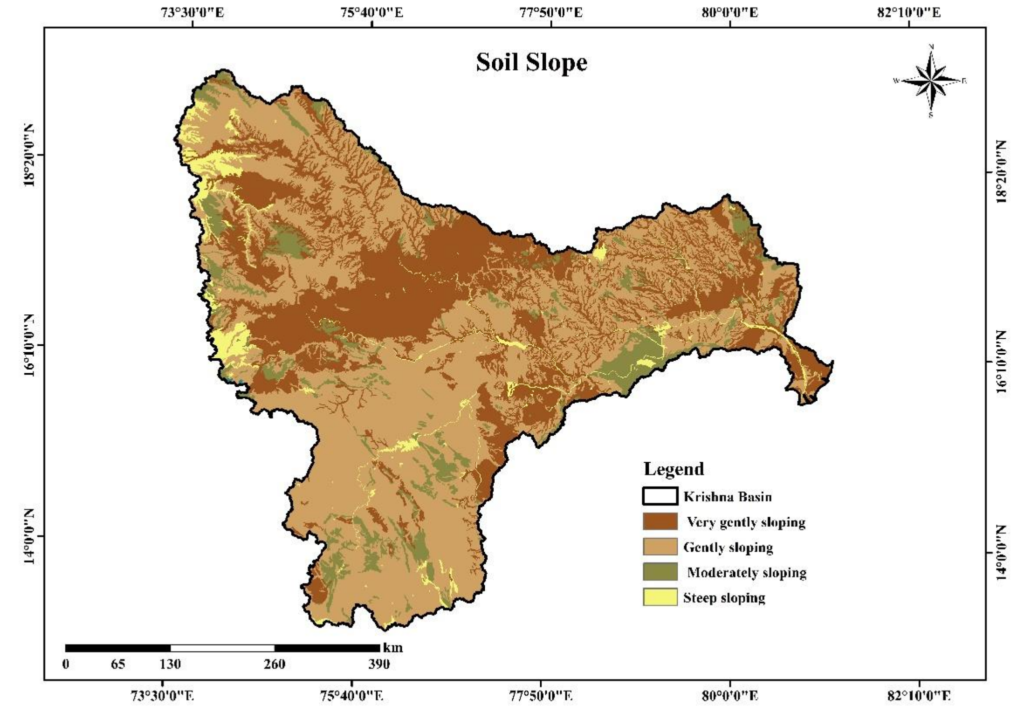

Figure 8 Map showing soil slope in Krishna Basin

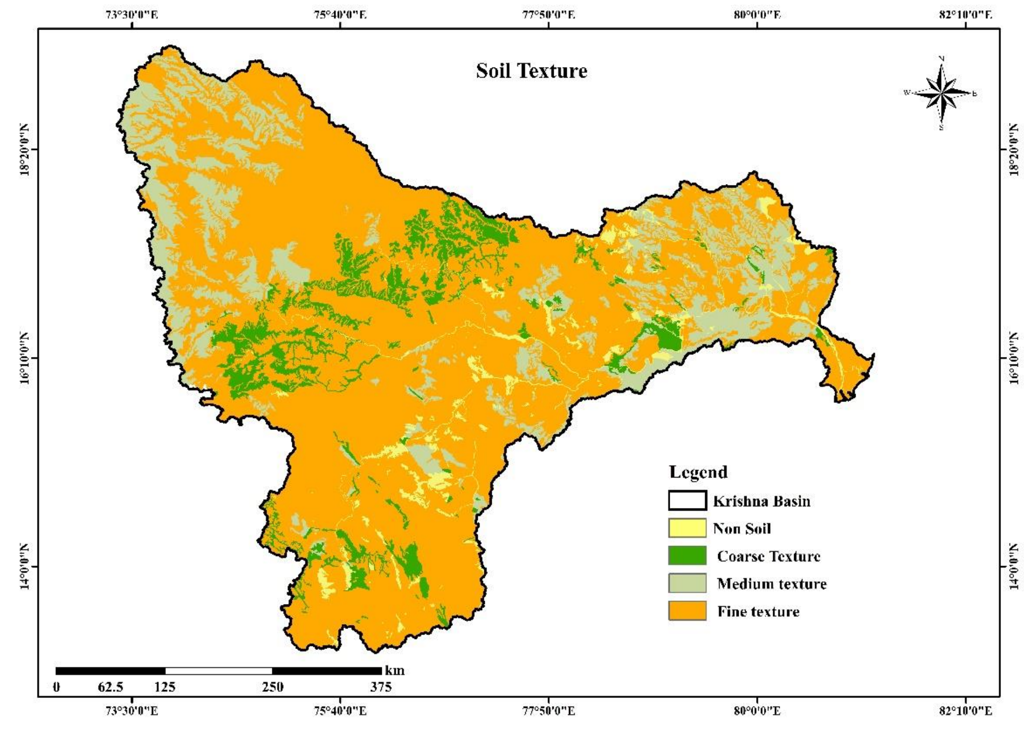

Figure 9 Map showing soil texture in Krishna Basin

7. Historical Landslides

The Historical Landslide Inventory map of the Krishna Basin (Figure 9) reveals a significant concentration of landslide occurrences along the western boundary, particularly in the Western Ghats region. This area is characterized by steep slopes, intense rainfall, and fragile geological formations, which collectively contribute to high susceptibility to landslides. The southern and central parts of the Western Ghats within the basin exhibit a higher density of landslides compared to the northern section, indicating localized influences such as rainfall intensity and slope instability. Conversely, the eastern and central parts of the basin show no recorded landslides, likely due to their flatter terrain, semi-arid climate, or potentially limited inventorying in these regions.

The pronounced clustering of landslides along the escarpments of the Western Ghats underscores the vulnerability of this area to geomorphological hazards. This poses risks to settlements, infrastructure, and agricultural activities in the region. It highlights the critical need for targeted risk mitigation strategies, such as slope stabilization, afforestation, and careful infrastructure planning. Furthermore, adopting sustainable land-use practices and improving monitoring systems can play a crucial role in reducing the risks and safeguarding the lives and livelihoods of communities in these vulnerable areas.

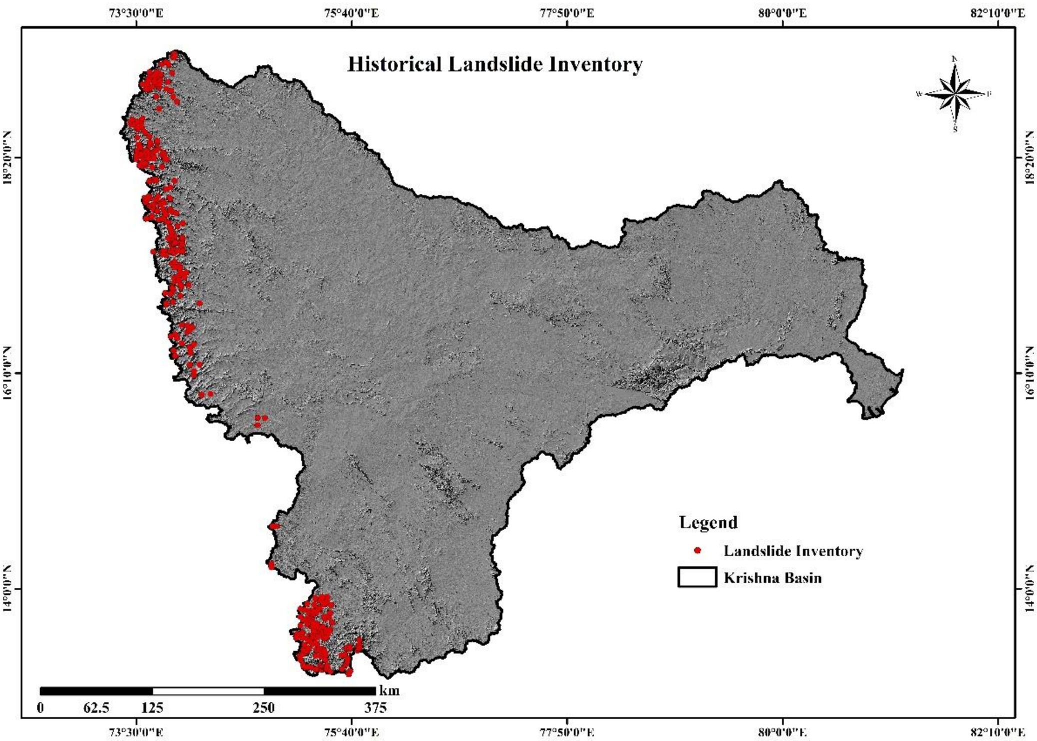

Figure 10 Map showing historical landslide inventories in Krishna Basin

8. Conclusion

- The Krishna River Basin exhibits a highly complex and diverse geological framework that significantly influences its hydrology, agriculture, and vulnerability to natural hazards. Its tectonic history, marked by rifting and sedimentation events, has shaped a unique and varied lithological structure across its sub-basins.
- The dominance of Archaean and Carboniferous formations, along with significant alluvial and basaltic deposits, highlights the region's importance for groundwater recharge and agricultural productivity. However, disparities in lithological characteristics and aquifer types suggest the need for sub-basin-specific management strategies.
- Soil assessments indicate generally favorable conditions for agriculture, particularly in areas with deep, medium-textured soils and moderate to gentle slopes. Nonetheless, zones prone to erosion and landslides require urgent conservation measures and sustainable land-use practices.
- The western region of the basin, particularly the Western Ghats, is highly susceptible to landslides due to steep topography, intense rainfall, and fragile geological structures. This underscores the importance of early warning systems, afforestation, and slope stabilization techniques.
- Despite the critical importance of lithology in understanding and managing river basins, there remains a significant gap in focused studies on the lithological aspects of the Krishna River Basin. This report addresses this gap to some extent, but further detailed and region-specific investigations are urgently needed to inform better policy, planning, and sustainable development practices.
- A comprehensive and interdisciplinary approach combining geology, hydrology, soil science, and hazard mapping is essential for the effective and sustainable management of the Krishna River Basin, especially in the context of increasing anthropogenic pressures and climate variability.

REFERENCES

1. Bastia, Rabi. 2012. “Basin Evolution and Petroleum Prospectivity of the Continental Margins of India.” *Developments in Petroleum Science* 59: vii–x. http://www.sciencedirect.com/science/article/pii/B9780444536044099932.
2. Bastia, Ravi, and Prasanta K. Nayak. 2006. “Tectonostratigraphy and Depositional Patterns in Krishna Offshore Basin, Bay of Bengal.” *Leading Edge (Tulsa, OK)* 25(7): 839–45.
3. Fainstein, Roberto et al. 2015. “Krishna Basin Exploration, India East Coast Offshore - Broadband Time/Depth Seismic Imaging.” *SEG Technical Program Expanded Abstracts* 34(August 2015): 1961–65.
4. G.N., Rao. 2001. “Sedimentation, Stratigraphy, and Petroleum Potential of Krishna-Godavari Basin, East Coast of India.” *AAPG Bulletin* 85(9): 1623–43.
5. Mishra, Ashish Kumar et al. 2020. “Age of the Earliest Transgressive Event in the Krishna-Godavari Basin, India: Evidence from Dinoflagellate Cysts and Planktonic Foraminifera Biostratigraphy.” *Journal of Palaeogeography* 9(1).
6. https://indiawris.gov.in/wris/#/geoSpatialData (Access on 06 January 2025)
7. https://bhukosh.gsi.gov.in/Bhukosh/MapViewer.aspx (Access on 06 January 2025)

Back cover page