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

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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 Studies (cKrishna)

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.

www.ckrishna.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

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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.

Prof. N V Umamahesh
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Abbreviations and Acronyms

NW	North West
SW	South West
NW	North East
SE	South East
Indian WRIS	Indian Water Resource Information System
KG Basin	Krishna Godavari Basin
CGWB	Central Groundwater Board
NGDR	National Geoscience Data Repository

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-Relakted 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.

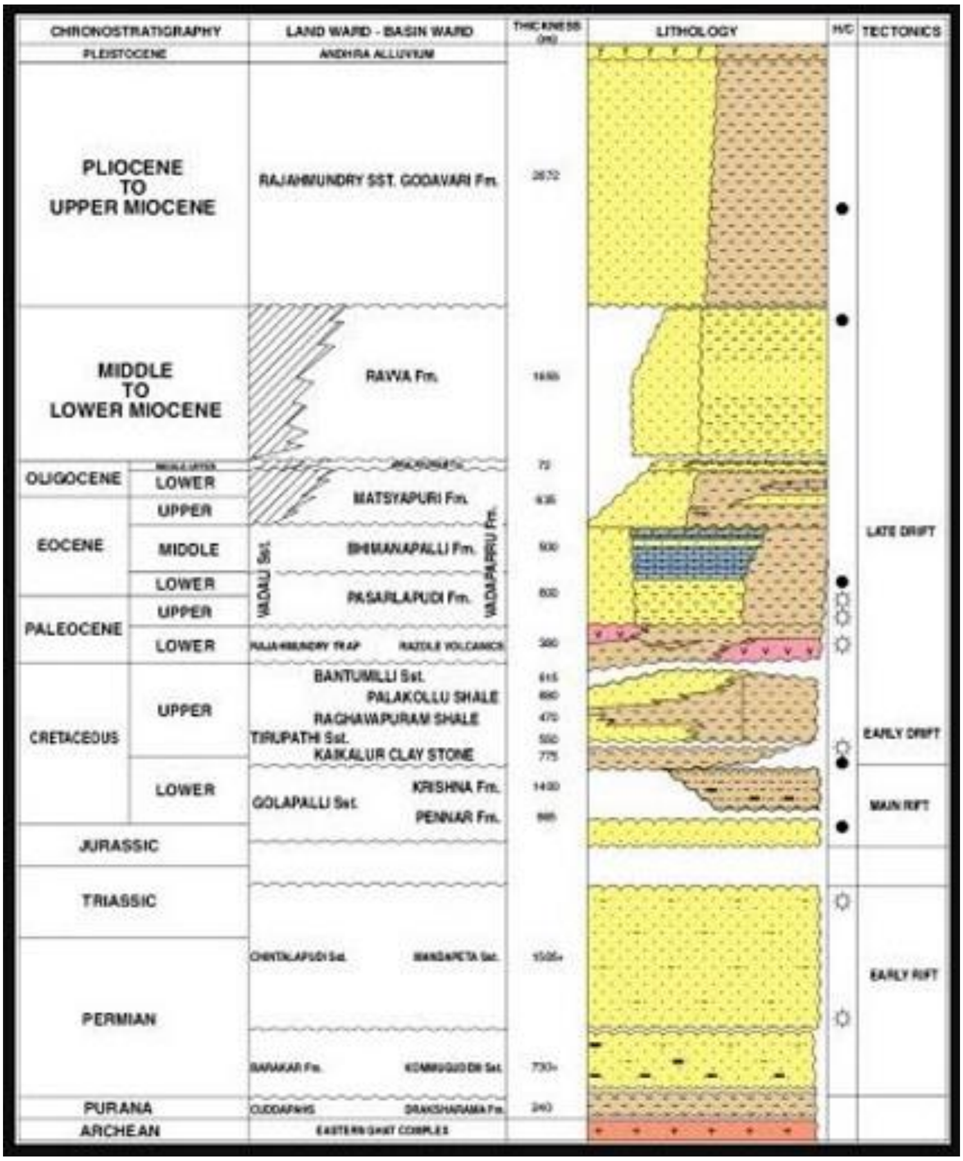


Figure 1 A detailed figure showcasing time/depth seismic imaging

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) identify 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.

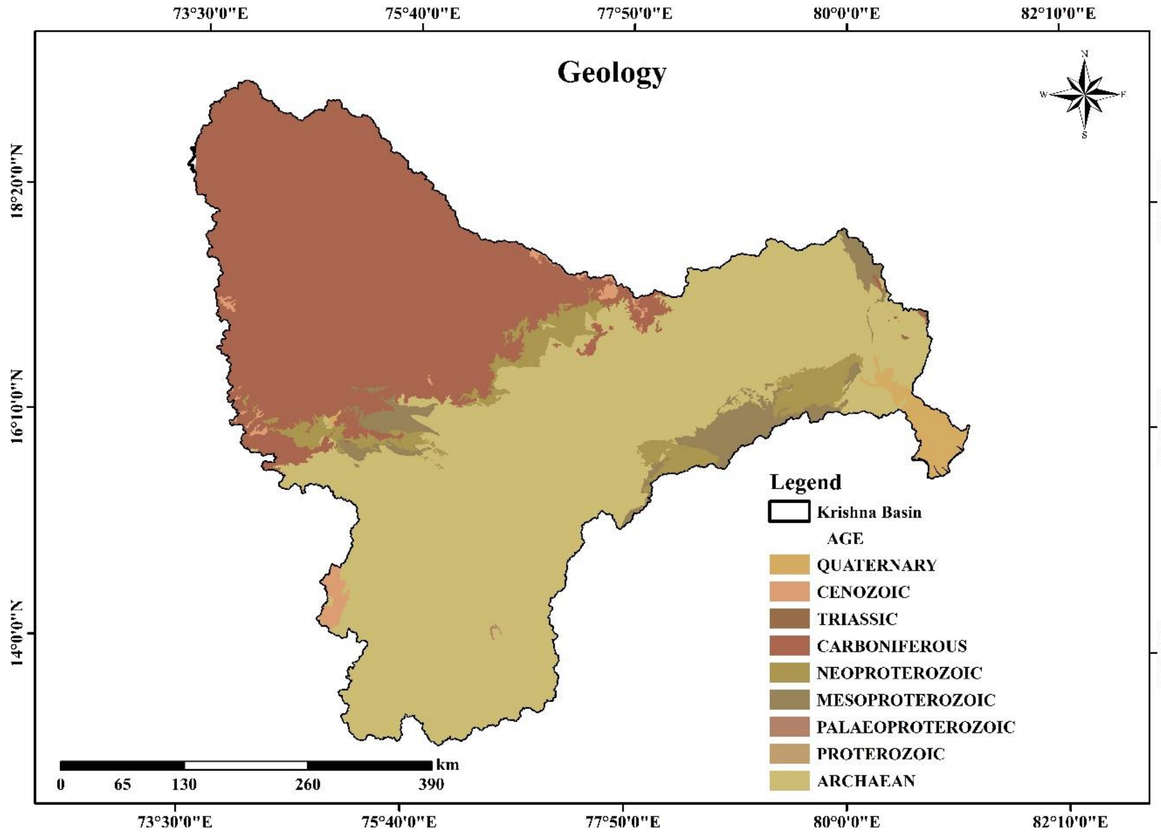


Figure 2 Map showing geological layers in Krishna Basin

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 3**. 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.

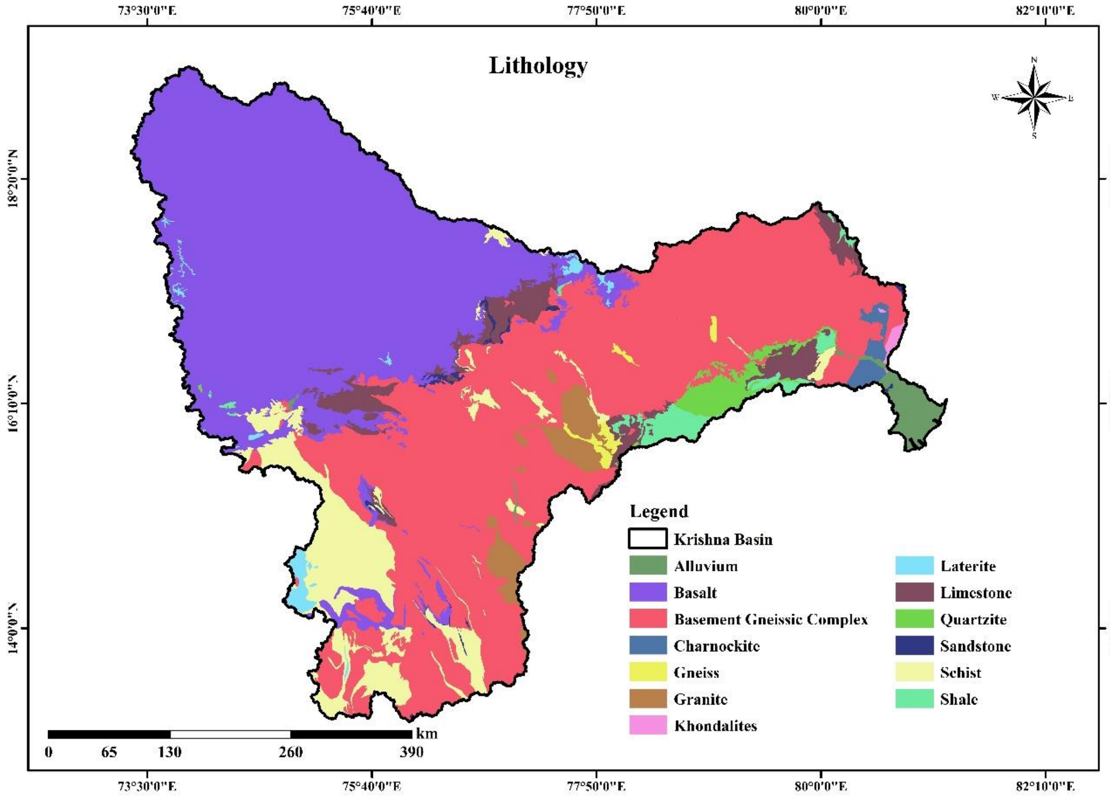


Figure 3 Map showing lithology in Krishna Basin

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.

4.1 Dominant Rock Types

The Krishna River Basin exhibits a wide range of dominant rock types that reflect its complex geological history. The following rock types are the most prevalent and have a significant influence on groundwater recharge, soil formation, and agricultural potential:

- Basalt: Found mainly in the Upper Krishna and Upper Bhima sub-basins. These volcanic rocks contribute significantly to groundwater recharge through vesicular and fractured zones and support fertile black soils.
- Basement Gneissic Complex: Widespread across Lower Krishna, Middle Krishna, and Tungabhadra sub-basins. These rocks have moderate groundwater potential, primarily through fractures.
- Schist and Quartzite: Prominent in the Upper Tungabhadra and Middle Krishna sub-basins. These metamorphic rocks support limited aquifer potential and influence slope stability.
- Alluvium: Dominant in floodplain areas like Upper and Lower Bhima. These loose sediments offer excellent groundwater storage and support productive agriculture.
- Limestone: Common in Lower Bhima and Lower Krishna. These formations are known for their karstic aquifers and industrial use (e.g., cement production).
- Granite and Laterite: Found in localized pockets; granite is important for construction and laterite influences red soil formation.

These dominant rock types govern the hydrological and geotechnical behaviour of the basin and are crucial inputs for resource planning and hazard mitigation.

5. Lithologs

The lithologs in the Krishna River **Basin** provide detailed records of the subsurface geological formations encountered during borehole drilling across the basin. These logs are essential for interpreting the vertical sequence of rock types, understanding aquifer properties, and assessing the geotechnical characteristics of different zones. The litholog data reveals a wide variation in rock types including igneous (both plutonic and volcanic), metamorphic, clastic sedimentary, and mixed lithologies, each with distinct implications for groundwater movement, storage, and surface hydrology. These logs help delineate the geological framework that supports watershed development, groundwater recharge potential, and the stability of riverbanks and infrastructure.

Figure 4 illustrates the spatial distribution of these major lithological units across the Krishna River Basin, highlighting the diversity and geographical spread of different rock formations. A detailed classification of these lithological units, their rock types, and broader geological categories is presented in Table 3

Table 3: Lithology Description and Classification of Borehole Lithologs in the Krishna River Basin

Lithology Description	Major Litho-log Category	Rock Type
Schist, Gneiss	Hornblende-Bearing Metamorphic Rocks	Metamorphic (Schist + Gneiss)
Schist, Gneiss, Granite	Igneous & Metamorphic Rocks	Mixed (Metamorphic + Igneous)
Schist, Granite, Or-Clase Granite	Igneous & Metamorphic Rocks	Mixed (Feldspar-bearing Granite)
Shale	Clastic Sedimentary Rocks	Sedimentary (Shale)
Shale, Sandstone	Clastic Sedimentary Rocks	Sedimentary (Shale + Sandstone)
Vesicular Basalt	Igneous & Metamorphic Rocks	Igneous (Volcanic, Vesicular Basalt)
Vesicular Basalt, Fractured Massive Basalt	Igneous & Metamorphic Rocks	Igneous (Volcanic Complex)
Weathered Amphibole Basalt	Igneous & Metamorphic Rocks	Igneous (Altered Basalt)

Weathered Fractured Basalt	Igneous & Metamorphic Rocks	Igneous (Altered & Fractured Basalt)
Weathered Vesicular Basalt	Igneous & Metamorphic Rocks	Igneous (Altered Vesicular Basalt)
Weathered Vesicular Basalt, Fractured Basalt	Igneous & Metamorphic Rocks	Igneous (Complex Altered Basalt)
Weathered Vesicular Basalt, Fractured Massive Basalt	Igneous & Metamorphic Rocks	Igneous (Volcanic Complex, Weathered)
Wheathered Fractured Basalt, Fractured Massive Basalt	Igneous & Metamorphic Rocks	Igneous (Volcanic Complex, Weathered)
Wheathered Granite, Gneiss	Hornblende-Bearing Metamorphic Rocks	Metamorphic (Weathered)
Wheathered Granite, Gneiss Quartz	Hornblende-Bearing Metamorphic Rocks	Metamorphic (Weathered Quartz Gneiss)
Pegmatite, Schist	Igneous & Metamorphic Rocks	Igneous + Metamorphic
Pink Granite	Igneous & Metamorphic Rocks	Igneous (Granite)
Quartz Rich Granite, Biotite Granite, Granite Gneiss, Doleritic Dyke, Loose Sand	Igneous & Metamorphic Rocks	Igneous + Metamorphic + Sedimentary
Sandstone	Clastic Sedimentary Rocks	Sedimentary (Sandstone)
Sandstone, Granite Gneiss	Mixed: Clastic & Metamorphic	Sedimentary + Metamorphic
Sandstone, Schist	Mixed: Clastic & Metamorphic	Sedimentary + Metamorphic
Schist	Hornblende-Bearing Metamorphic Rocks	Metamorphic (Schist)
Granite, Quartz Rich Granite Gneiss, Granite	Igneous & Metamorphic Rocks	Igneous + Metamorphic
Granitic	Igneous & Metamorphic Rocks	Igneous (Granite)
Kaladgi Formation (Sandstone)	Clastic Sedimentary Rocks	Sedimentary (Sandstone)
Limestone	Fossiliferous & Carbonate Rocks	Sedimentary (Carbonate)
Granite, Hornblende Amphibole (Fractured)	Igneous & Metamorphic Rocks	Igneous (Plutonic, Fractured)

Granite Gneiss	Hornblende-Bearing Metamorphic Rocks	Metamorphic
Biotite Granite, Hornblende Granite, Granite	Igneous & Metamorphic Rocks	Igneous (Plutonic)
Biotite Orthoclase Granite, Granite Gneiss	Igneous & Metamorphic Rocks	Igneous + Metamorphic
Esicular Basalt	Igneous & Metamorphic Rocks	Volcanic (Igneous)
Fractured Basalt	Igneous & Metamorphic Rocks	Volcanic (Igneous)
Fractured Basalt, Vesicular Basalt	Igneous & Metamorphic Rocks	Volcanic (Igneous)
Fractured Basalt, Weathered Basalt	Igneous & Metamorphic Rocks	Volcanic (Altered)
Fractured Massive Basalt	Igneous & Metamorphic Rocks	Volcanic (Massive)
Fractured Massive Basalt, Vesicular Basalt-Fractured	Igneous & Metamorphic Rocks	Volcanic
Fractured Vesicular Basalt	Igneous & Metamorphic Rocks	Volcanic
Fractured Vesicular Basalt, Amygdaloidal Basalt	Igneous & Metamorphic Rocks	Volcanic
Fractured Vesicular Basalt, Fractured Massive Basalt	Igneous & Metamorphic Rocks	Volcanic
Fractured Vesicular Basalt, Weathered Amygdaloidal Basalt	Igneous & Metamorphic Rocks	Volcanic (Altered)
Fractured Weathered Basalt	Igneous & Metamorphic Rocks	Volcanic (Weathered)
Gneiss	Hornblende-Bearing Metamorphic Rocks	Metamorphic
Basalt	Igneous & Metamorphic Rocks	Igneous (Volcanic)
Basalt & Kaladgi Sandstone	Mixed (Igneous + Sedimentary)	Igneous + Sedimentary
Basalt, Granite Gneiss	Igneous & Metamorphic Rocks	Igneous + Metamorphic
Basalt, Granite Gneiss, Red Bole	Igneous & Metamorphic Rocks	Igneous + Metamorphic
Basalt, Red Bole	Igneous (Weathered Volcanic)	Igneous
Basalt, Schist	Igneous & Metamorphic Rocks	Igneous + Metamorphic

Basalt, Shale, Limestone	Mixed (Igneous + Sedimentary Rocks)	Igneous + Sedimentary

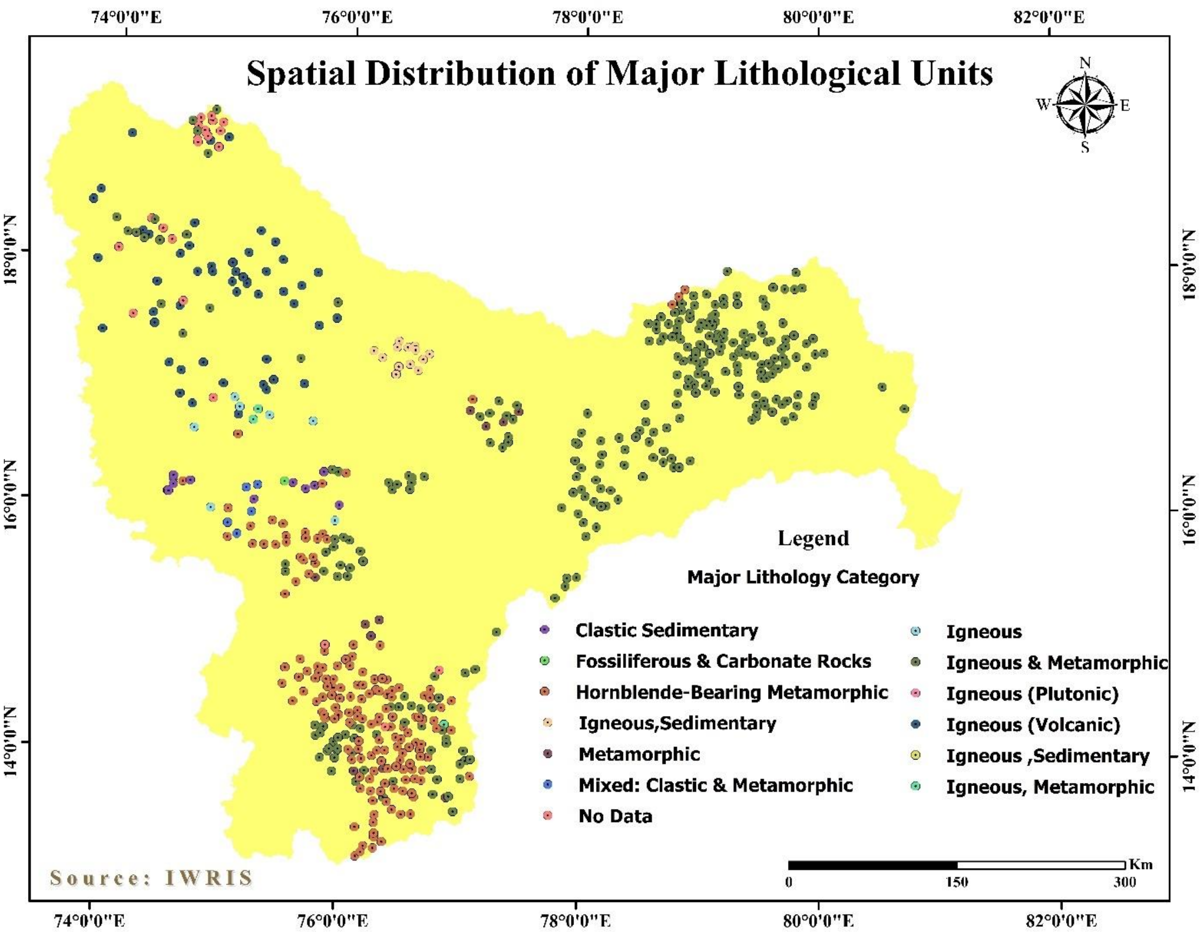


Figure 4 Spatial Distribution of Major Lithological Units in the Krishna River Basin (Source: IWRIS)

6. 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.

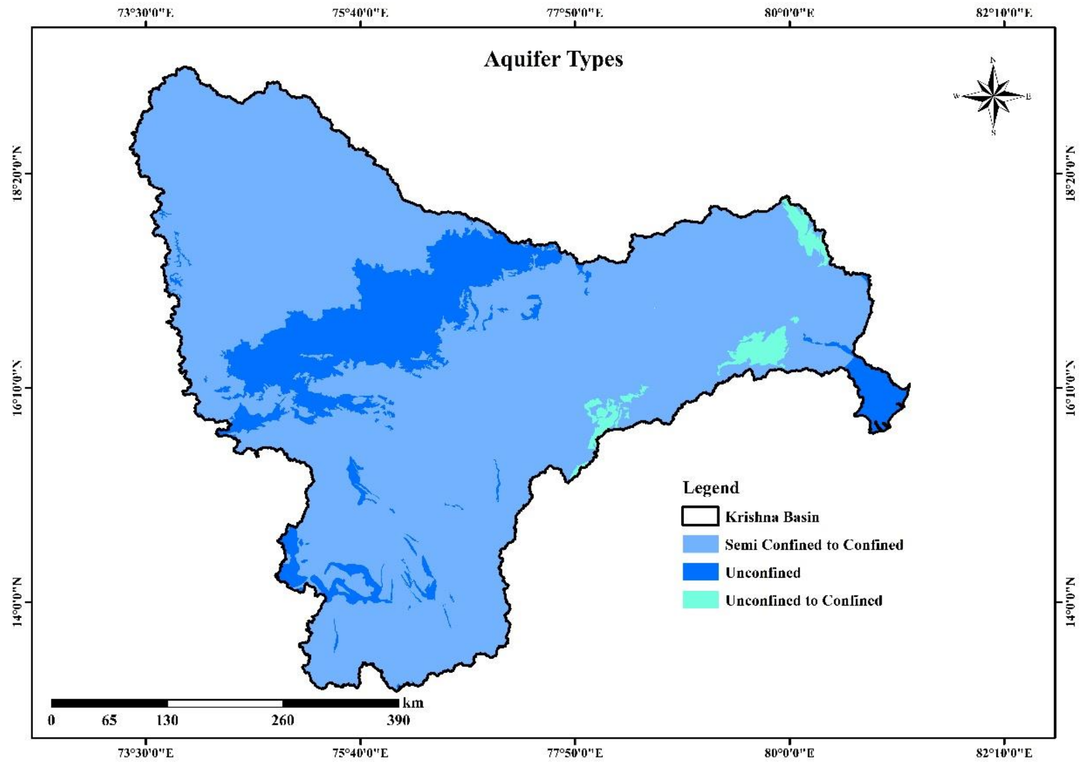


Figure 5 Map showing aquifer types in Krishna Basin

- 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

6.1 Groundwater Scenario

A total of 2,148 groundwater observation wells has been established across the Krishna River Basin by the Central Ground Water Board (CGWB). Among the sub-basins, the Krishna Lower Sub-basin has the highest number of observation wells, with 559 wells, while the Krishna Middle Sub-basin has the fewest, with 197 wells.

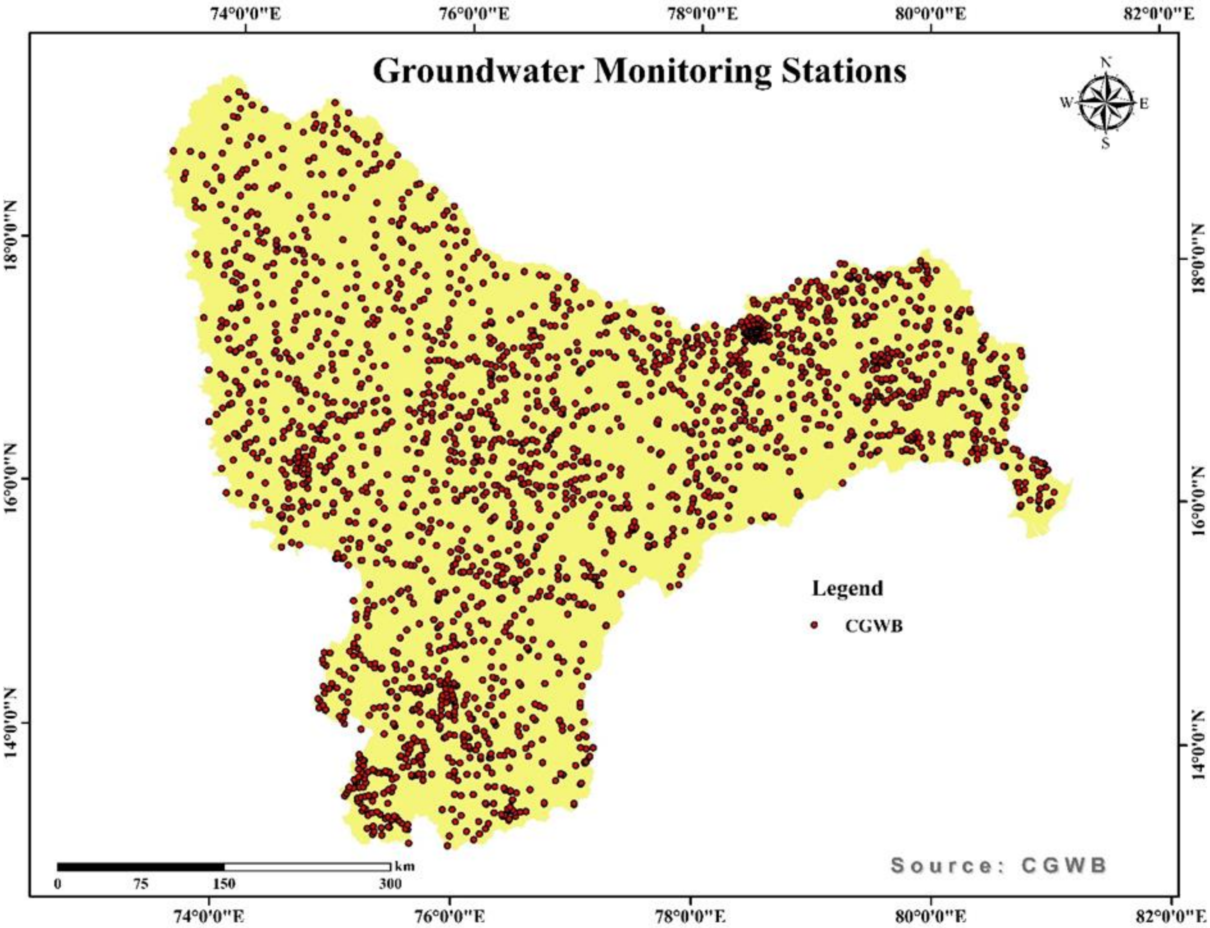


Figure 6 Groundwater Observation wells in Krishna River Basin

Figure 6 illustrates the spatial distribution of these groundwater monitoring wells across the basin. Table 4 provides detailed information on the distribution of observation wells within each sub-basin, along with the corresponding groundwater level ranges recorded from 2020 to 2024.

Table 4 Groundwater Observation Wells and Water Levels in Krishna River Basin

Sub Basin	Total Number of Monitored Stations (Observation Wells)	Observed Range of Water Level (m bgl)
Bhima Lower	184	0-67.41
Bhima Upper	206	0-86.28
Krishna Lower	559	0-67.78
Krishna Middle	197	0-69.35
Krishna Upper	401	0-75.56
Tungabhadra Lower	291	0-111.12
Tungabhadra Upper	310	0-57.75

Table 5 presents district-wise groundwater resource data for the states of Telangana, Andhra Pradesh, Maharashtra, and Karnataka. The dataset includes information on annual groundwater draft for domestic, industrial, and irrigation purposes, as well as net groundwater availability across the region. Out of the 61 districts covered, the majority (approximately 46 districts) are classified as safe based on the stage of groundwater development. Eleven districts fall under the semi-critical category, while two districts are classified as critical and another two as over-exploited. Notably, over 75% of the region is categorized as safe, indicating a relatively balanced and sustainable status of groundwater availability across most of the study area.

Table 5 District Wise Ground Water Resources Data of Krisna River Basin (In ham) of 2020

State	District	Annaul Domestic and Industry Draft	Annual Irrigation Draft	Annual Groundwater Draft	Annual Replenishable Groundwater Resources	Natural Discharge During Non-Monsoon Season	Net Groundwater Availability
Andhra Pradeh	Ananthapuramu	17549	130283	185489	9275	23268	78547
	Guntur	11249	53003	177950	8898	15899	119483
	Krishna	10216	72684	270552	13528	7913	186400
	Kurnool	1107	35205	182984	9149	933	141044
	Prakasam	2146	41186	133252	6663	10307	85908
Karnataka	Dharwad	1518	14185	28650	2555	1623	11816
	Bagalkot	3640	48186	57782	5723	3952	10148
	Belagavi	10642	71196	105589	9828	11510	31998
	Bellary	4348	43422	80170	7924	4745	32328
	Bidar	1021	13106	28706	2823	1104	12743
	Chikmagalur	2434	31439	73815	7014	2537	37269
	Chitradurga	4358	52173	53465	5347	4721	6321

	Dakshina Kannada	3077	21083	62512	6251	3263	34992
	Davanagere	2681	46181	61794	5346	2854	18363
	Gadag	1997	23112	29552	2955	2127	5145
	Hassan	3741	47694	85618	8290	4019	35182
	Haveri	2948	37390	75183	6528	3169	31809
	Kalburagi	4377	22341	55743	5574	4803	28606
	Koppal	2256	36246	70332	6945	2494	28370
	Raichur	3728	29833	68603	6596	4520	31529
	Shimoga	3828	34117	113824	11339	3979	68679
	Tumkur	5532	69147	84634	8182	6012	18160
	Udupi	3758	14393	67138	6714	3955	45835
	Uttar Kannada	3398	22434	101934	10093	3603	69202
	Yadgir	2111	14772	44975	4497	2276	25540
	Bijapur	3734	29727	49999	4627	4053	16926
Maharashtra	Kolhapur	2058	54174	120879	7224	2058	59617
	Latur	2142	35723	68256	3422	2142	29800
	Osmanabad	2316	50589	85803	4327	2316	31058
	Pune	8174	120241	184454	9999	8174	61717
	Raigad	2015	6367	38180	1933	2015	29880
	Ratnagiri	1292	6589	40990	2292	1292	32109
	Sangli	3270	72565	139306	8846	3270	58786
	Satara	4850	63142	101634	5794	4850	32698
	Sindhudurg	2215	9303	22985	1155	2215	12527
	Solapur	4866	107790	145205	7294	4866	37138
	Thane	714	3111	17355	952	714	13292
	Ahmednagar	6197	120785	159326	8457	6197	41700
	Beed	4213	72025	128491	6425	4213	50041
Telangana	Jogulamba Gadwal	580	13319	35740	3574	481	18847
	Khammam	3808	41589	116736	11650	3769	64095
	Mahabubabad	2556	27659	51872	5187	1503	19034
	Mahabubnagar	883	18626	25636	2410	851	4683
	Medak	967	26582	44060	4343	826	13135
	Medchal-Malkajgiri	2573	6012	9893	989	1067	2892
	Mulug	236	16043	39976	3998	198	19935
	Nagarkurnool	5130	29862	48131	4813	5003	13475
	Nalgonda	8139	55684	122686	12184	5543	55204
	Narayanpet	437	12635	29522	2952	58	13934
	Rangareddy	6638	30768	42339	4234	4936	7460
	Sangareddy	2472	22883	36492	3576	2171	10344
	Siddipet	1217	37867	53660	5366	969	10448
	Suryapet	2601	33932	134207	13421	2563	86913
	Hyderabad	1751	1751	1732	173	2018	0

	Jangaon	2589	21258	26905	2691	2222	3547
	Bhadradri Kothagudem	8428	30151	88947	8211	5763	51397
	Vikarabad	2802	19383	32157	3044	2768	9729
	Wanaparthy	1306	13260	31504	3095	1306	15150
	Warangal Rural	1726	21451	56627	5540	506	29482
	Warangal Urban	1173	17016	21240	2097	1173	4406
	Yadadri Bhuvanagiri	3820	29497	50770	4991	2796	16351

7. 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.

7.1 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.

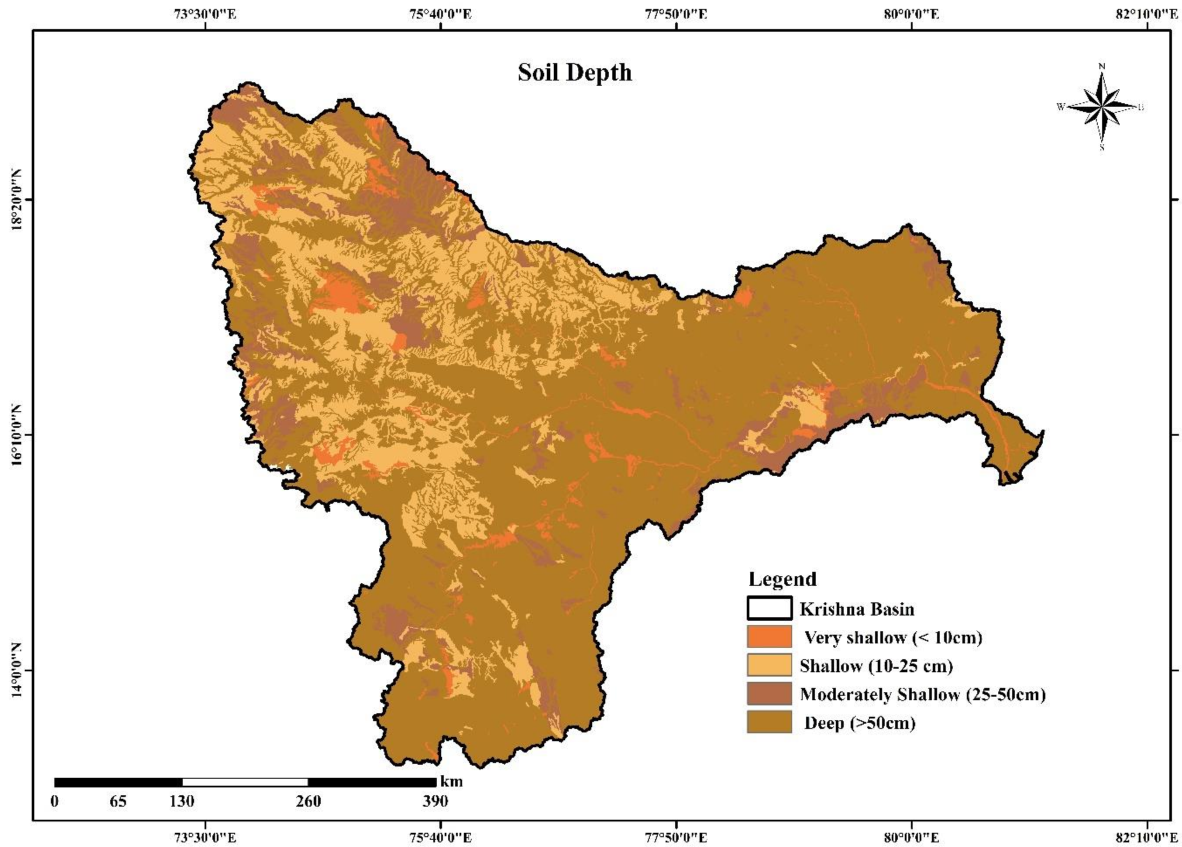


Figure 7 Map showing soil depth in Krishna Basin

7.2 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.

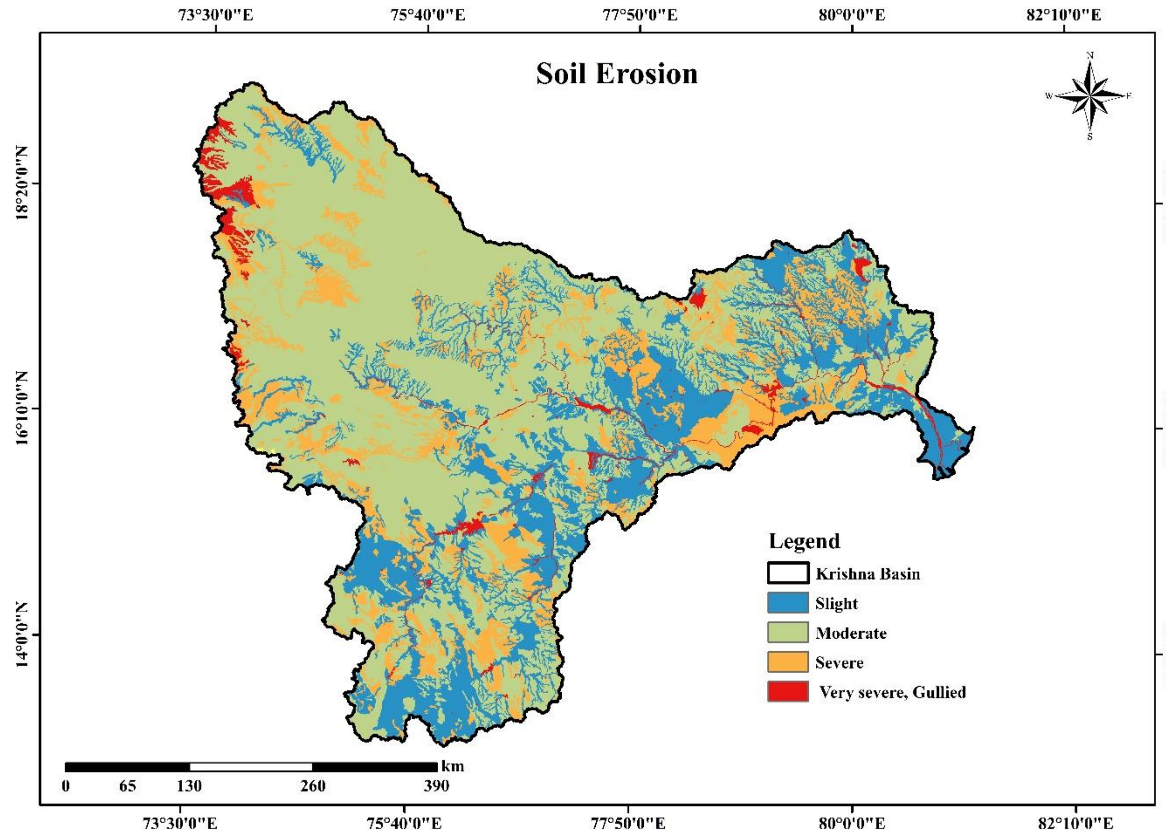


Figure 8 Map showing soil erosion in Krishna Basin

7.3 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.

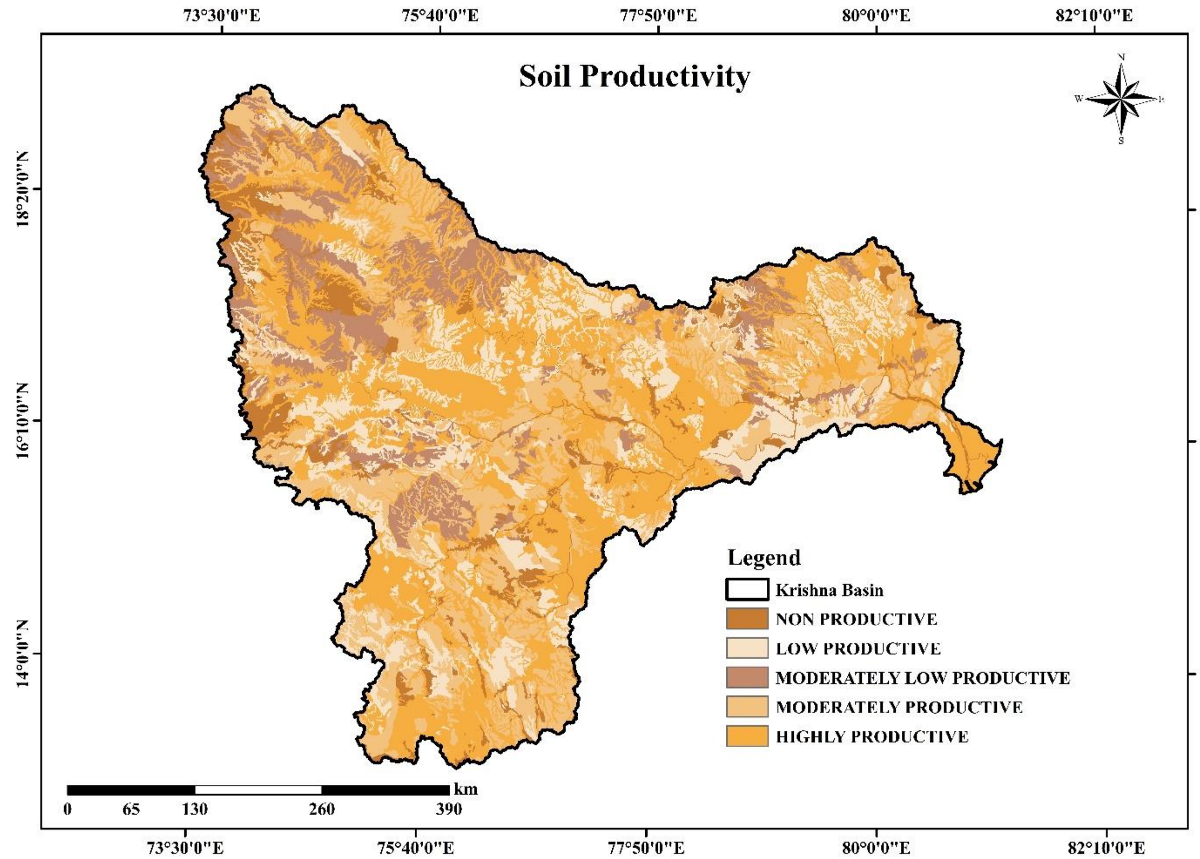


Figure 9 Map showing soil productivity in Krishna Basin

7.4 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.

7.5 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.

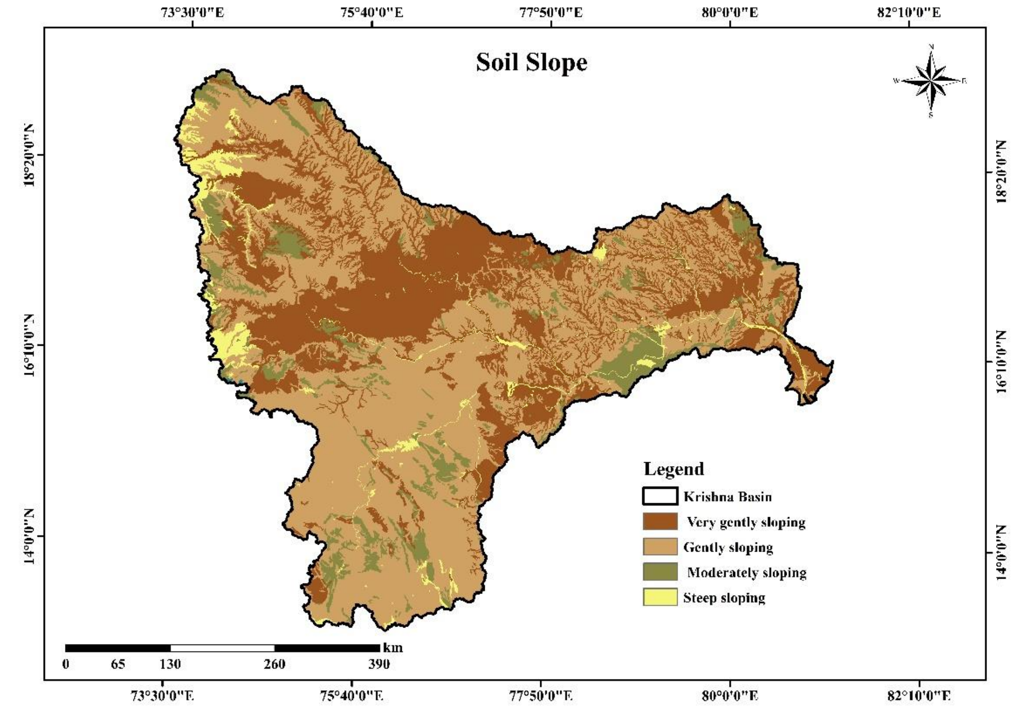


Figure 10 Map showing soil slope in Krishna Basin

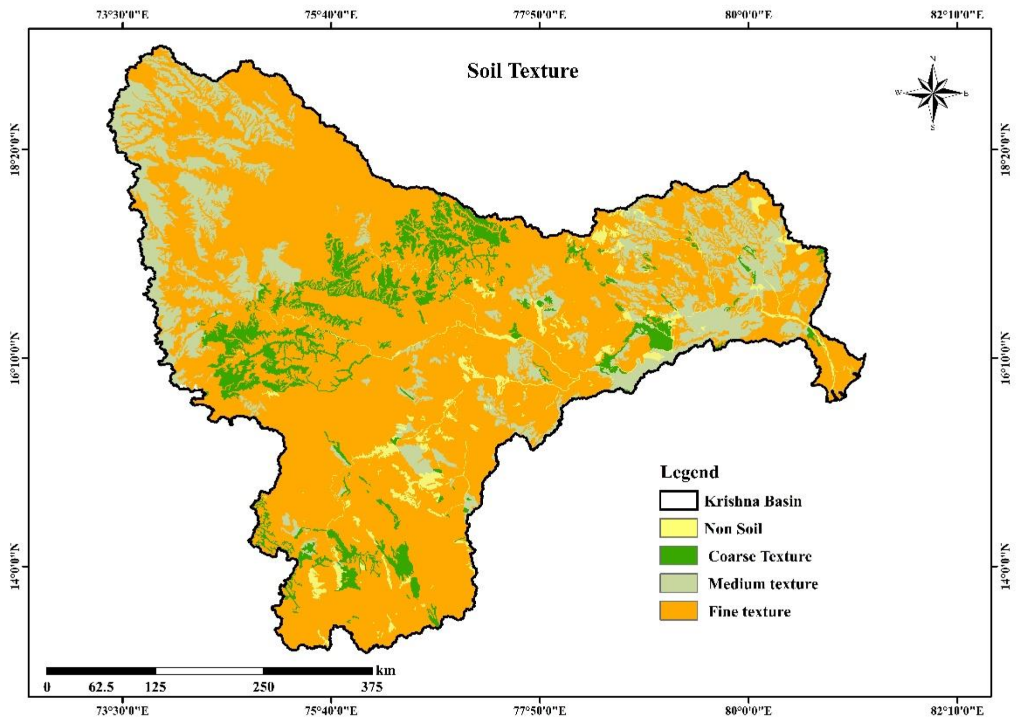


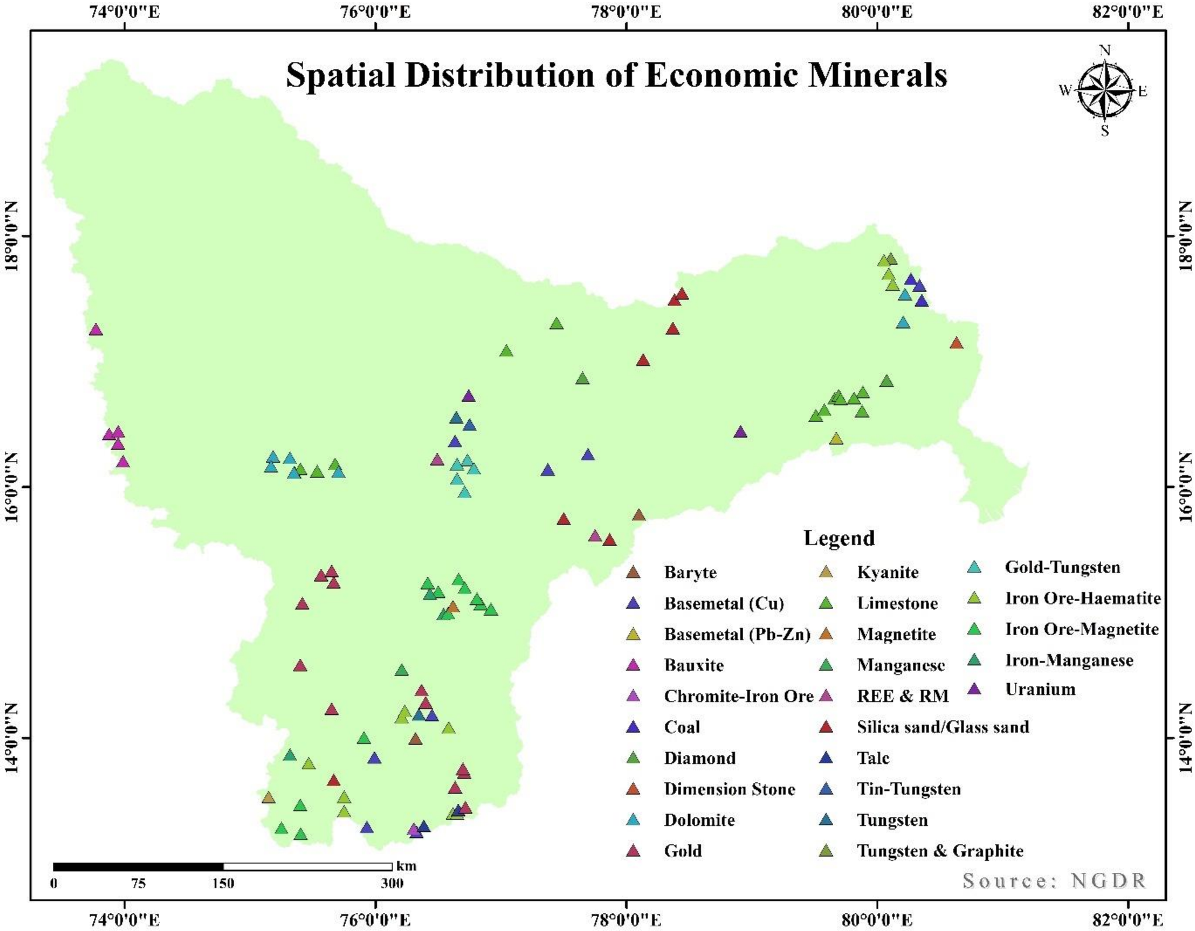
Figure 11 Map showing soil texture in Krishna Basin

8. Mineral resources

The Krishna River Basin is a geologically diverse region rich in economic minerals that play a vital role in supporting the industrial economy, infrastructure development, and employment generation across the basin states of Maharashtra, Karnataka, and Andhra Pradesh. Among the most economically valuable minerals is limestone, extensively found in the eastern and southern regions, which fuels the cement and construction industry—a cornerstone of infrastructure and urban growth. The basin's bauxite deposits are strategically important for the aluminum industry, supplying raw material for refineries and smelters in Karnataka and beyond. Iron ore, in the form of hematite, magnetite, and mixed iron-manganese ores, supports steel production and alloy manufacturing, making the region a key contributor to India's metallurgical sector.

The presence of manganese and chromite is crucial for ferroalloy production, which feeds into the automobile, defense, and heavy machinery industries. Basemetals, such as copper and lead-zinc, though found in smaller pockets, are vital for electrical components, batteries, and chemical industries, offering potential for small and medium mining enterprises. Gold and gold-tungsten occurrences, although limited, indicate possible zones for strategic mineral exploration and localized mining initiatives. Similarly, uranium deposits, if proven viable, may support nuclear energy programs, underlining the region's future strategic relevance.

In addition, minerals like dimension stone, dolomite, and silica sand have a robust domestic and export market, serving construction, glass, and ceramic industries, while talc, graphite, and clay minerals are utilized in pharmaceuticals, paints, and lubricants. The diversity of these mineral resources contributes not only to regional GDP and export revenue but also supports employment, particularly in rural and tribal areas, where mining-related activities generate livelihood opportunities. Figure 6 provides a visual representation of the spatial spread of these economic minerals, reflecting the geological richness and industrial potential of the Krishna River Basin (Source: NGDR).



9. 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.

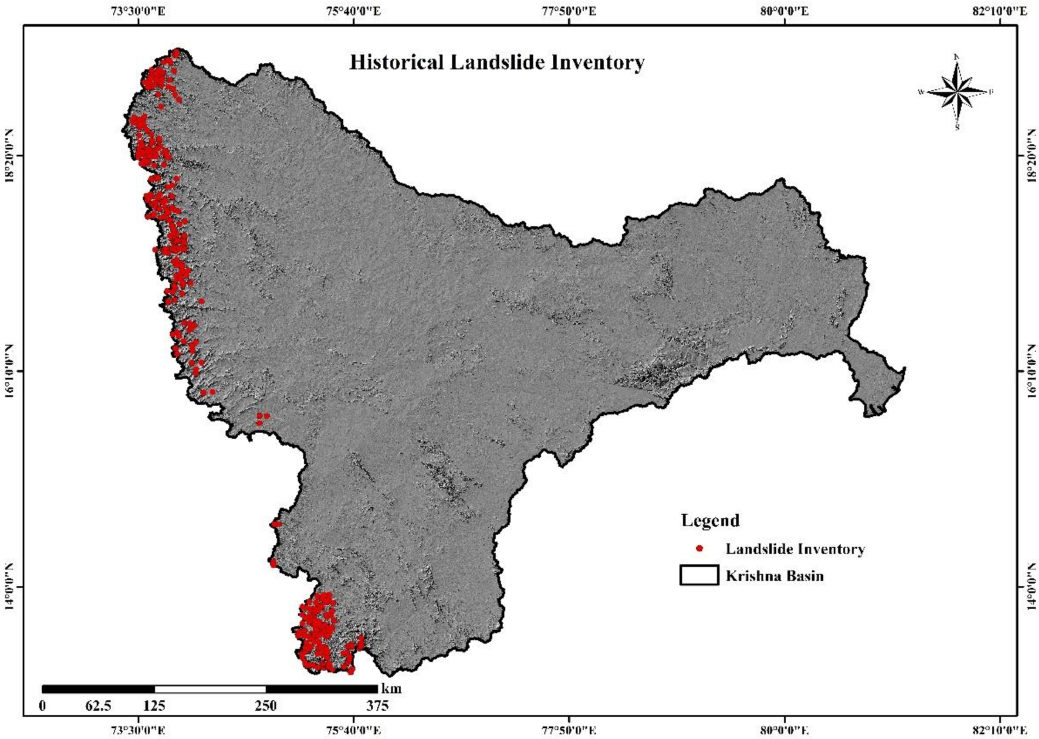


Figure 12 Map showing historical landslide inventories in Krishna Basin

9.1 Landslide Susceptibility Map

The landslide susceptibility analysis of the Krishna River Basin reveals that a vast majority of the area falls under the low susceptibility zone, accounting for approximately 93% of the basin's geographical extent. Medium susceptibility zones cover around 3% of the basin, while high susceptibility zones occupy about 4%, indicating relatively localized but critical areas of concern. Spatially, the high susceptibility zones are predominantly concentrated along the Western Ghats and adjoining steep terrain, particularly in districts such as Chikkamagaluru, Shivamogga, Uttara Kannada, Kolhapur, Satara, Pune, and Sindhudurg, where rugged topography, high rainfall, and fragile geological formations combine to elevate landslide risks. Medium susceptibility zones are also clustered in these regions, extending into parts of Belagavi, Ahmednagar, Sangli, and Nagarkurnool. On the other hand, central and eastern districts of the basin such as Solapur, Kalaburagi, Raichur, and Nalgonda exhibit predominantly low susceptibility, attributed to their relatively flat terrain and lower precipitation levels. The spatial distribution map (Figure 13) clearly illustrates this gradient, with high-risk areas concentrated along the western periphery and diminishing eastward. The pie chart (Figure 14) further emphasizes the dominance of low susceptibility zones. This assessment underscores the need for targeted landslide risk management strategies in the high and medium susceptibility districts, integrating slope stabilization, vegetation restoration, and early warning systems to safeguard vulnerable communities and infrastructure.

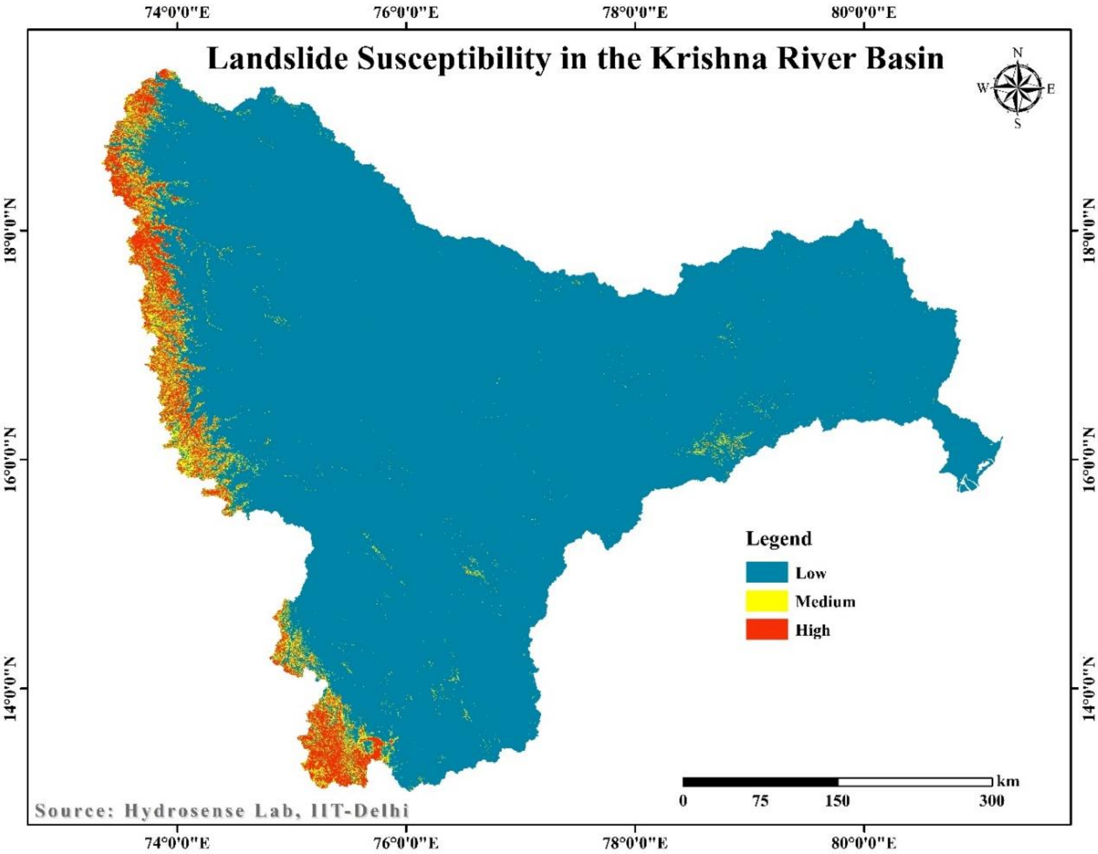


Figure 13 Landslide Susceptibility Map of Krishna River Basin

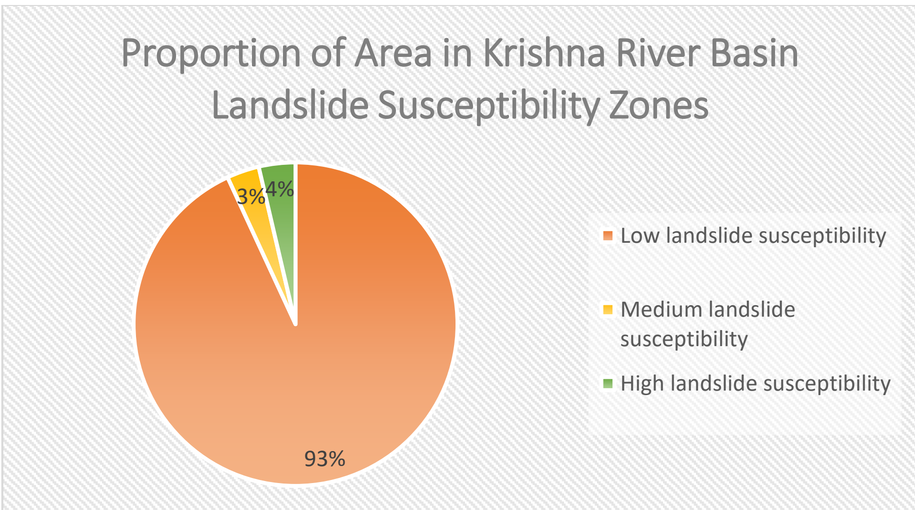


Figure 14 Pie chart Showing the Proportion of Area in Krishna River Basin Landslide Susceptibility Zones

10. Importance of Lithological Study in River Basin Management

The lithological structure of a river basin is fundamental to understanding its hydrological behavior, natural resource potential, and environmental vulnerabilities. In the Krishna River Basin, the diverse rock types—from ancient Archaean complexes to younger alluvial and basaltic formations—determine not only the physical landscape but also the ecological and socio-economic dynamics of the region.

Key reasons highlighting the importance of lithological study include:

- **Groundwater Occurrence & Storage**: Aquifer types such as vesicular basalt, fractured gneiss, and limestone are directly influenced by lithology. These govern the recharge, yield, and sustainability of groundwater—critical for agriculture, drinking water, and industry.
- **Soil Formation & Agricultural Suitability**: Lithology controls soil texture, depth, and fertility. For instance, basaltic regions support black soils suitable for cotton and sugarcane, whereas gneissic zones need irrigation support due to limited water retention.
- **Mineral Resource Distribution**: Economically valuable minerals such as limestone, laterite, bauxite, and granite are associated with specific lithologies. Mapping these helps in guiding industrial growth and sustainable mining.
- **Hazard Assessment**: Fragile metamorphic and sedimentary formations in steep regions, especially along the Western Ghats, are prone to landslides. Understanding lithological composition aids in geohazard mapping and mitigation planning.
- **River Morphology and Infrastructure Planning**: Lithology influences erosion patterns, sediment transport, and riverbed characteristics—essential for flood control, dam siting, and infrastructure safety.

By integrating lithological insights with hydrological, agricultural, and socio-economic planning, this study supports a holistic and sustainable approach to basin management.

11. 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.

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