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

Geological Profile of Godavari River Basin

November 2024

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Geological Profile

of Godavari 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.

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Centres for Godavari River Basin Management Studies (cGodavari)

The Centre for Godavari River Basin Management Studies (cGodavari) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by CSIR-NEERI and IIT Hyderabad, under the supervision of cGanga at IIT Kanpur, the center serves as a knowledge wing of the National River Conservation Directorate (NRCD). cGodavari is committed to restoring and conserving the Godavari River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.
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cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this, it is also responsible for introducing new technologies, innovations, and solutions into India.

www.cganga.org

Acknowledgment

This report is a comprehensive outcome of the project jointly executed by CSIR-NEERI (Lead Institute) and IIT Hyderabad (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It is 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 the Godavari River Basin
Management and Studies (cGodavari)
CSIR-NEERI, IIT Hyderabad

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Abbreviations and Acronyms

USGS	United States Geological Survey
OSM	OpenStreetMap
KG	Krishna–Godavari
DGH	Directorate General of Hydrocarbons
OGIM	Oil and Gas Infrastructure Mapping (OGIM)
GEE	Google Earth Engine
GFC	Global Forest Change
GLC	Global Landslide Catalogue
NASA	National Aeronautics and Space Administration
GDIS	Geocoded Disasters
EM-DAT	Emergency Events Database
SEDAC	Socioeconomic Data and Applications Center
EIA	Environmental Impact Assessment

1. Introduction

1.1. Overview of the Basin

The Godavari Basin, located on the Deccan Plateau between 73°24' to 83°4' east longitudes and 16°19' to 22°34' north latitudes, is one of the country's main river basins, encompassing an area of approximately 312,812 km^2. The Godavari River originates in the Western Ghats and travels through states such as Maharashtra (48.7%), Telangana and Andhra Pradesh (23.7%), Madhya Pradesh (7.8%), Odisha (5.7%), Karnataka (1.4%), Chhattisgarh (12.4%), and Puducherry (0.01%) before reaching the bay of Bengal. This basin has a diverse landscape and climate, allowing for a wide range of species and extensive agriculture.

1.2. Geological significance of the region

The Western Ghats, which form the western edge of the Godavari basin, are made up mostly of old crystalline rocks such as granite, gneiss, and schist that are part of the Indian Shield. The Deccan Traps, which are basaltic rock formations formed by volcanic activity in the late Cretaceous and early Paleogene periods, cover a substantial portion of the basin. The Godavari River and its tributaries contain sedimentary deposits such as alluvial soils, sandstone, shale, and limestone formations (Figure 1).

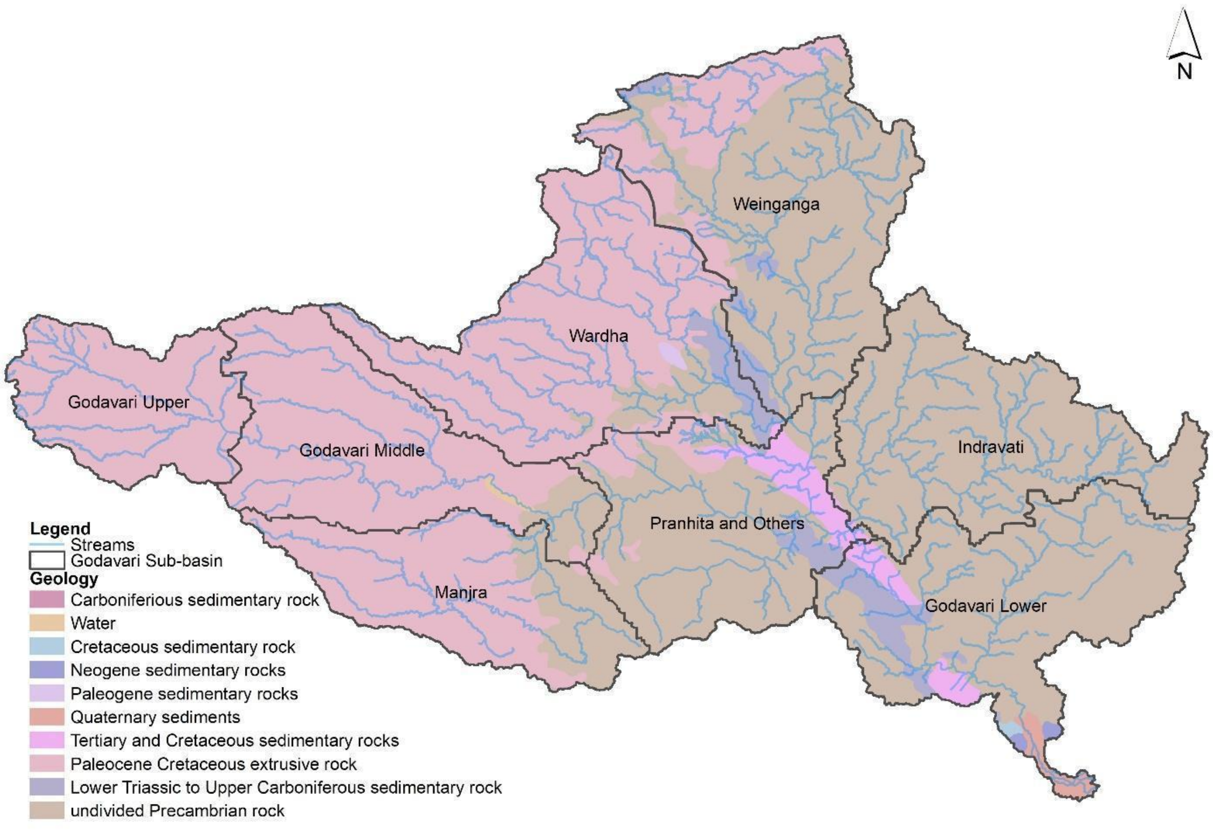

Figure 1: Geology in Godavari basin

The data was collected from the USGS. The basin is located in a seismically active zone where tectonic forces have heavily influenced the landscape. Quaternary deposits, including riverine sands, gravels, and clayey sediments, are found near river channels and floodplains and are constantly changed by erosion and depositional processes. The geology at the river's mouth changes into coastal formations impacted by marine processes, such as estuary deposits, beach sands, and mangrove swamps, which are vulnerable to dynamic changes caused by sea-level fluctuations and coastal erosion.

Table 1: Stratigraphic summary table [1]

Stratigraphic Unit	Age / Type	Main Rock Formations	Basin/Sub-basin Occurrence	Hydrogeological Significance
Archaean Crystalline Basement	Precambrian	Gneiss, schist, granites	Penganga, Wardha, Pranhita, Indravati, Sabari sub-basins	1) Groundwater in weathered/fractured zones, schistose planes. 2) Forms basement.
Dharwar/Vindhyan Groups	Precambrian	Schists, quartzites, limestones	Middle reaches (Maner sub-basin), some parts of shield area	1) Groundwater in joints, fissures, fractures. 2) Confined aquifers.
Purana & Gondwana Formations	Paleozoic–Mesozoic	Sandstones, shales, coal-bearing units	Manjra & Maner sub-basins, parts of shield	1) Unconfined aquifers in sandstones & shales. 2) Confined in Gondwanas. 3) Coal deposits present.
Deccan Traps	Late Cretaceous–Early Paleogene	Basaltic lava flows, vesicular tops, jointed flows	Upper reaches (Pravara, Purna sub-basins), Wardha–Wainganga plains	1) Vesicular/jointed flows act as aquifers. 2) Massive flows are less permeable.
Laterites	Tertiary	Lateritic soils, laterite cappings	Scattered across plateau & uplands	Locally important moderate aquifers.
Alluvium	Quaternary	Sand, silt, clay, gravels	Godavari valley, floodplains, delta	1) Highly porous & permeable aquifers. 2) Major irrigation & drinking water source.

The Deccan volcanic rocks (basalt) cover about half of the Godavari basin's main catchment area. Other important rocks in the basin include Precambrian granites and gneisses from the Dharwar Craton, sandstones, shales and limestones from the Gondwana Supergroup, sediments from the Cuddapah and Vindhyan basins, rocks like charnockites and khondalites from the Proterozoic Eastern Ghats Mobile Belt, and sandstones from the Rajahmundry Formation [2]. The Godavari River carries the most sediments among all peninsular rivers, with most of the sediment movement happening during the monsoon [3]. Mineral magnetic investigations show that much of the river's floodplain sediments come from Deccan basalt, while the heavier bed load materials come from nearby rocks [2]. Therefore, the intense chemical weathering in the Deccan basalts may be connected to the inflow of Deccan source water in the Godavari River up to the delta regions and possibly in the Bay of Bengal off the Godavari [2]. Around 3,200 to 3,100 years ago, sediments in the Bay of Bengal showed signs of reduced plant cover, changes in carbon and sediment sources, and an increase in ferrimagnetic minerals. This suggests that deforestation and soil erosion in the Deccan Plateau increased at that time, likely due to growing agricultural activities during the Deccan Chalcolithic culture [4].

1.3. Objectives of the report

The goal of the report is to evaluate and quantify different natural and human activities that could affect the basin's geological uniqueness. It seeks to identify important elements and assess their impact on the structure and long-term sustainability of the basin, including mining, tunnelling, deforestation, riverbed exploitation, and natural geological processes. The analysis of these activities aims to shed light on potential changes to the basin's geology and provide guidance for sustainable resource planning and conservation.

2. Factors affecting Geology of the basin

2.1. Excavations, explosions and mining activities

The geology of a basin is changed by mining, explosions, and excavations in a number of ways. The removal of overburden and large-scale rock due to open-pit and underground mining causes production of voids and alters the subsurface's stress/strain distribution. It may also result in surface deformation or sinking of the strata above. Its examples are hydraulic heads in aquifers that can form and change as a result of bed separation in mined strata. This can modify groundwater flow and potentially cause sudden drops in water pressure when layers fracture and collapse [5]. Explosive blasting causes new fractures and increased porosity in rock masses. When fresh fracture surfaces react with water, mineral alteration such as clay precipitation is accelerated, changing the strength of the rock and potentially clogging fracture networks [6]. The hydrology of the basin is also influenced by mining. As dewatering mine pits lowers the local groundwater table, modifies flow gradients, decreases seepage to wetlands or surface water bodies, or in certain situations, increases baseflow or discharge to the pits [5][7][8]. Mining and waste rock/tailings can also create chemical changes like acid mine drainage, which mobilises metals and changes the chemistry of the sediments in the basin. It is caused by sulphide minerals being exposed to air and water [9] [10]. These activities together have the potential to drastically alter groundwater storage, sedimentation patterns, water quality, and basin morphology.

2.2. Tunnelling

Tunnelling activities in a river basin have a substantial impact on its geology because they disturb the native rock layers, adjust stress fields, and create paths for groundwater circulation. Tunnel excavation can cause rock fracturing, subsidence, and slope instability, especially in areas with weak or fractured lithology [11]. Material removal and blasting alter the stress distribution in nearby rocks, resulting in micro-seismic activity and long-term structural degradation [12]. Tunnelling also frequently interrupts aquifers, affecting groundwater flow and potentially causing drawdown, seepage, or contaminant migration within the basin [13]. Changes like this can seriously disrupt the hydrological processes and the geological stability of the basin.

2.3. Fracking

Fracking, also known as hydraulic fracturing, is a method of extracting oil and natural gas from deep underground rock formations by pumping high-pressure fluids into the rock and causing fissures. This process enhances the permeability of previously impermeable layers such as shale, allowing hydrocarbons to flow to the surface. While fracking is useful for energy production, it changes the geology of a river basin in various ways. Artificial fractures and the reactivation of natural faults can alter subsurface permeability, disrupting groundwater routes and raising the danger of pollution. Elevated pore pressures from injected fluids can also cause induced seismicity and destabilize rock strata, whereas large-scale fluid withdrawal can contribute to localized subsidence. At the surface, drilling infrastructure and excavation disrupt soil and sediment dynamics, increasing erosion and affecting river channel stability [14][15].

2.4. Deforestation

Deforestation in a river basin can significantly modify its geology through a variety of interrelated processes. Removing vegetation diminishes canopy interception of rainfall, evapotranspiration, and root networks that help bind soil, all of which contribute to increased surface runoff and decreased infiltration [16][17][18]. When more water runs off instead of soaking in, soil becomes more easily dislodged and there is an increase in transported erosion, particularly on slopes. This results in topsoil loss, changes in soil structure and nutrient content, and more sediment entering rivers [16][17][18][19]. River channels may alter when sediment load increases, such as broadening, incising, or increasing bank migration and channel meandering rates [16][20]. Over time, severe erosion and sedimentation might lead to:

1) The composition of sediments deposited downstream changes (more fine-grained particles and less organic matter), affecting soil and riverbed properties.

2) Deforested hillsides provide a higher danger of landslides and mass wasting due to changes in slope stability [17][18].

3) Variations in the speed of erosion and deposition can alter long-term geological features, such as the basin’s terraces, the thickness of the floodplain, and the layering of sediments.

2.5. River bed mining

River-bed mining removes the sand and gravel that naturally preserve bed elevation and channel stability which modifies the geology of a river basin. The cross-section and gradient of the river are altered by ongoing extraction, which also causes bank instability, erosion, and incision of the river bed. It also impacts adjacent riparian zones by decreasing recharge, which lowers the groundwater table. The basin's general geomorphic processes and natural sediment balance are upset by these alterations [21].

2.6. Hill slope change

Changing sediment movement, erosion rates, and landscape shape, changes in the hill slope gradients inside the basin have a substantial impact on the geological features. Steeper slopes tend to boost erosion and sediment transport capacity by increasing surface runoff and sediment delivery to streams. While softer slopes encourage the deposition of sediment, which helps to create landforms like floodplains and alluvial fans. These changes in sediment movements can impact the stratigraphy of the basin by affecting the arrangement and makeup of sedimentary strata. Slope variations can also affect hydrological processes like groundwater recharge and infiltration, which can alter the basin's geological development [22]. Also instability brought on by shifting hill slopes often results in slope collapse and subsequent landslides [26].

2.7. Natural geological disasters

A geological disaster is a calamitous phenomenon originating from natural events within the Earth's crust. It has the potential to seriously harm infrastructure and human lives. Different types of natural geological disasters include earthquakes, landslides, avalanches, sinkholes, tsunamis, volcanic eruptions, etc. As there are no active volcanoes, avalanches and tsunamis. And sinkholes are not common in the Godavari basin region, earthquakes and landslides can be considered relevant for the study. Earthquakes and landslides can cause tremendous loss of life and property, while also changing the geology of the basin extensively.

1) Earthquakes

   Earthquakes are a sudden occurrence that causes the ground and everything on it to shake violently. They happen when the sliding crustal or lithospheric plates release accumulated stress.

2) Landslides

   Landslides are a movement of a pile of rock, earth, or debris down a slope. They can be caused by natural factors like rainfall and also by anthropogenic causes like overdevelopment, cattle grazing, etc.

3. Data Acquisition and Methodology

3.1. Excavations

Data collection regarding excavation activities in the Godavari basin is severely constrained due to lack of standardised and publicly available statistics. Excavations related to resource extraction, urban growth, hydrological projects, and infrastructure development are frequently completed by private contractors or several administrative entities, leading to fragmented records that are rarely methodically assembled at the basin scale. Also a large number of short-term or small-scale excavation projects are still unrecorded, which makes it more difficult to estimate their overall effect. The extent, frequency, and spatial distribution of excavations throughout the Godavari basin are thus not captured by any comprehensive official data.

3.2. Explosions

Scarcity of data similar to excavations is also noted for explosion-related activities in the basin, especially those associated with mining, quarrying, construction, and controlled blasting for infrastructure connected to transportation or water resources. Reporting of such operations is usually restricted to project-specific documentation and regulatory clearances. Also there may be no record of many explosive operations in isolated or rural locations, which significantly under-represents them in the records that are currently accessible. Official geographic information about explosion incidents in the Godavari basin is still mainly unavailable for the analysis because of these limitations.

3.3. Mining

The dataset (Global Mining Areas and Validation Datasets) used for the mining component of this study provides spatially explicit information on land areas directly impacted by surface mining activities worldwide [27]. It includes more than 21,000 polygons, representing regions where mining of coal and metal ores has altered the natural land surface. They correspond to mining sites that were active at any point between 2000 and 2017, offering a contemporary picture of human-induced geological modification during this period. The dataset is compiled by expert analysis of high and very-high-resolution satellite images (including Sentinel-2 and commercial sources) to map the land-use footprint, which includes open-cuts, tailings dams, waste-rock dumps, water ponds, and processing infrastructure. The authors report an overall accuracy of 88.4% based on control points. The mapped areas were filtered for the Godavari basin region.

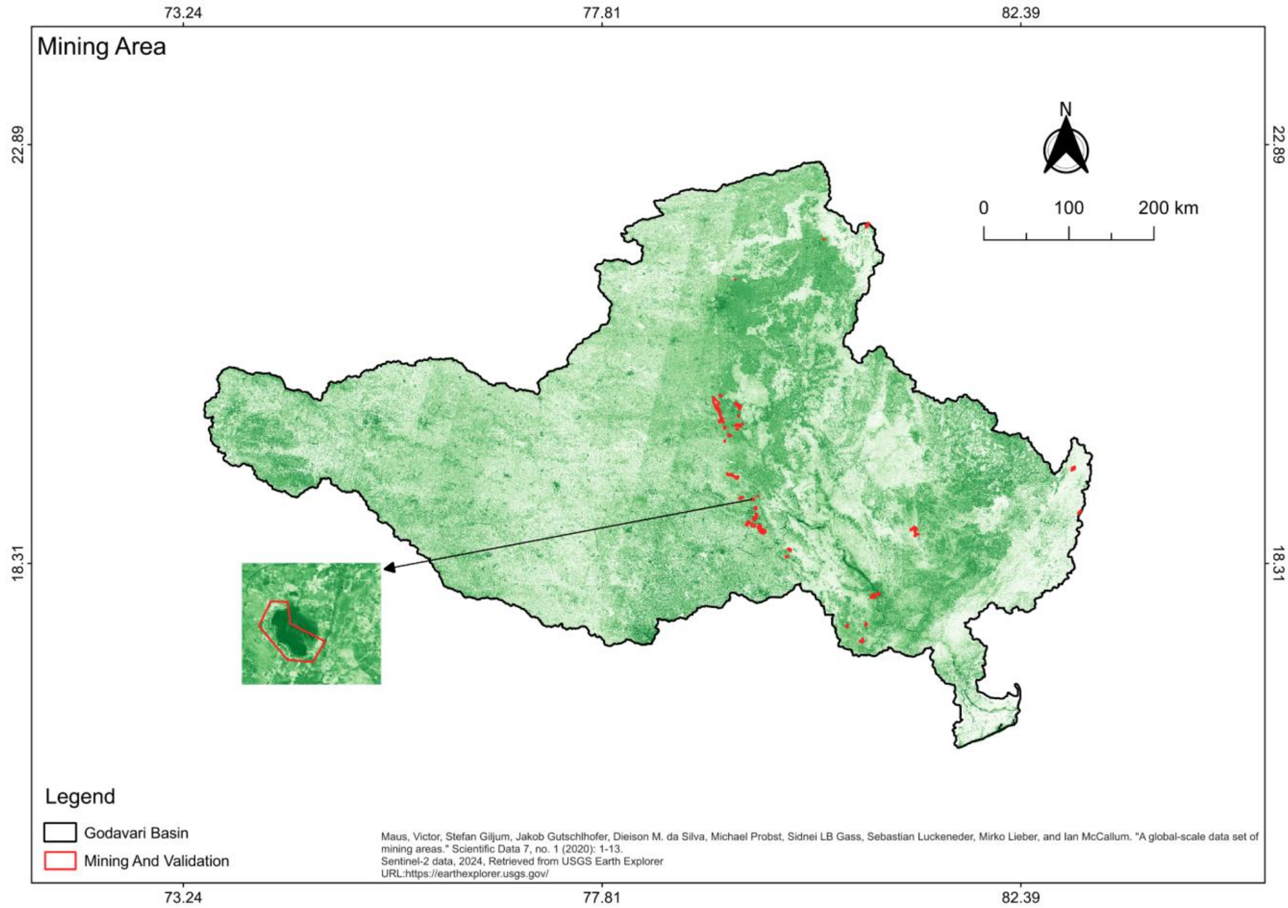

Figure 2: Mining Areas and Validation from 2000 to 2017 in Godavari Basin

Riverbed mining represents another major form of mineral exploitation in the Godavari basin. But due to inconsistent reporting and the lack of a centralised monitoring and documentation framework, data availability for riverbed mining operations in the Godavari basin is still restricted. Instead of a continuous spatial assessment of mining impacts, the information that is currently available is frequently limited to permit-based extraction records and is usually scattered across several government agencies and regulatory organisations. Apart from that a sizable amount of riverbed mining is done illegally, evading environmental laws and leaving no official record in public databases. Therefore, understanding of riverbed mining largely depends on local surveys and isolated case reports, rather than a comprehensive dataset covering the entire basin.

3.4. Tunnelling

Tunnelling data for the Godavari river basin was gathered using the OpenStreetMap (OSM) database [28]. OSM is a freely available map database with methodically tagged data on underground passages such as road tunnels, railway tunnels, and utility tunnels with the attribute 'tunnel=*'. This gives a reliable and current picture of man-made subterranean structures that can be used in regional geological assessments. The procurement procedure included accessing the OSM database using the tool Overpass Turbo, an online tool for specialised data extraction [29]. A bounding box encompassing the Godavari basin was established, and only features with the 'tunnel=yes' attribute were requested. The query results were exported directly from Overpass Turbo and clipped to accurately represent the tunnels in the Godavari basin extent.

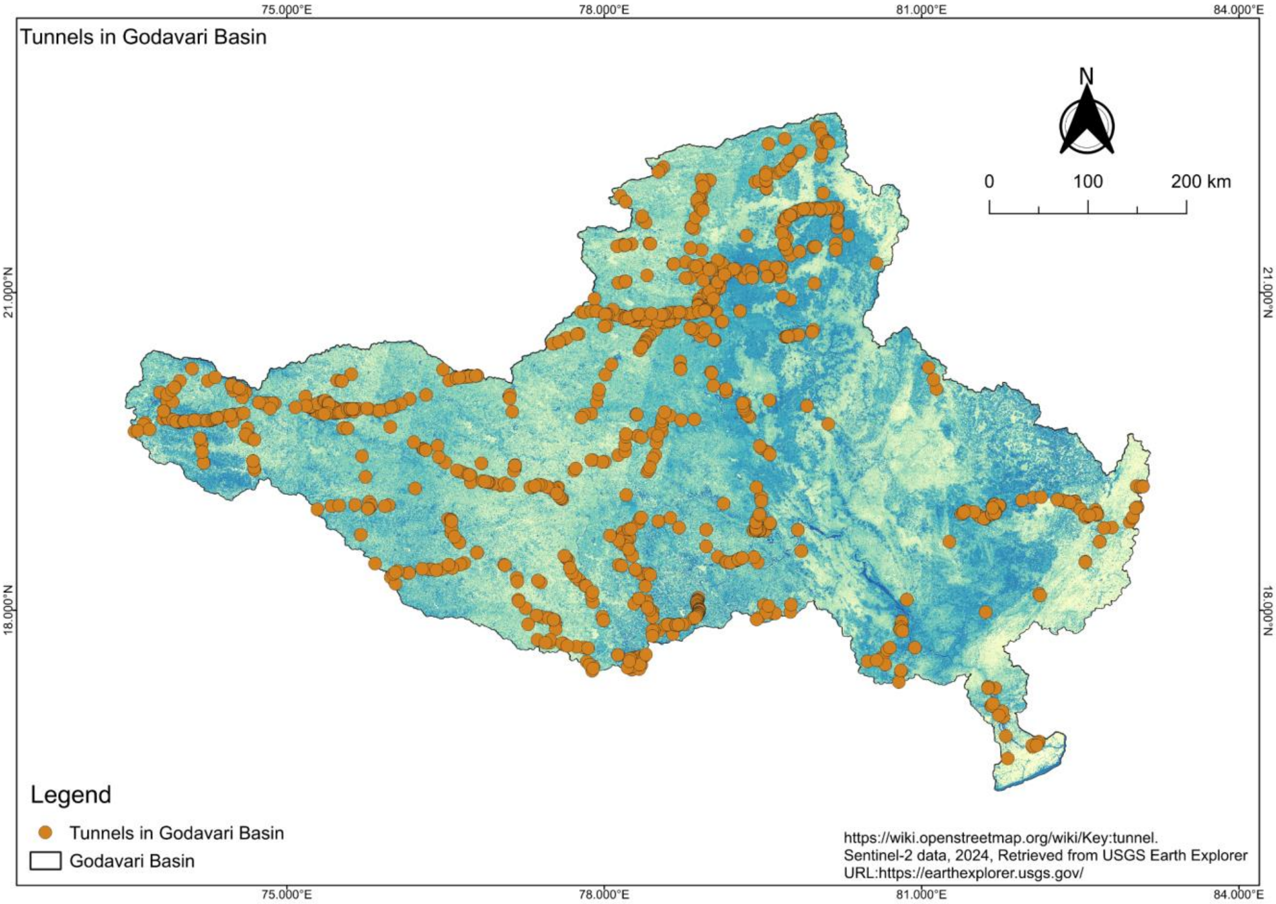

Figure 3: Tunnels in Godavari Basin

3.5. Fracking zones

The Krishna–Godavari (KG) Basin has been formally recognized by the Directorate General of Hydrocarbons (DGH) as one of the nation's potential shale oil and gas basins, emphasizing its potential for unconventional hydrocarbon development [23]. As no official dataset of hydraulic fracturing (fracking) operations in India is publicly available, the delineation of potential fracking zones within the Godavari basin was carried out through secondary data collection and spatial analysis. The Oil and Gas Infrastructure Mapping (OGIM) dataset, accessible on the Google Earth Engine (GEE) platform was used for this purpose [30]. The OGIM database offers feature sets of hydrocarbon-related infrastructure worldwide, such as pipelines, wells, licensing blocks for natural gas and oil, and related facilities. The license block polygons were thought to be the best representative for possible unconventional hydrocarbon development zones. The GEE code editor was used to import the OGIM oil and natural gas licensing block layer. Features of license blocks that overlapped with the boundaries of the Godavari basin were filtered. A geospatial dataset of the basin's oil and gas licensing blocks was created by exporting the filtered subset.

It is crucial to note that rather than real fracking sites, the generated dataset represents estimated fracturing zones. This restriction results from the fact that license blocks, which are administrative units awarded for exploration and production, are not exact well pad sites but rather large polygons encompassing possible regions. Also the distinction between conventional and unconventional hydrocarbon activity is not made clear by OGIM. Rather than being verified, spatially precise fracking sites, the polygons obtained should be viewed as potential fracking zones based on hydrocarbon exploration rights.

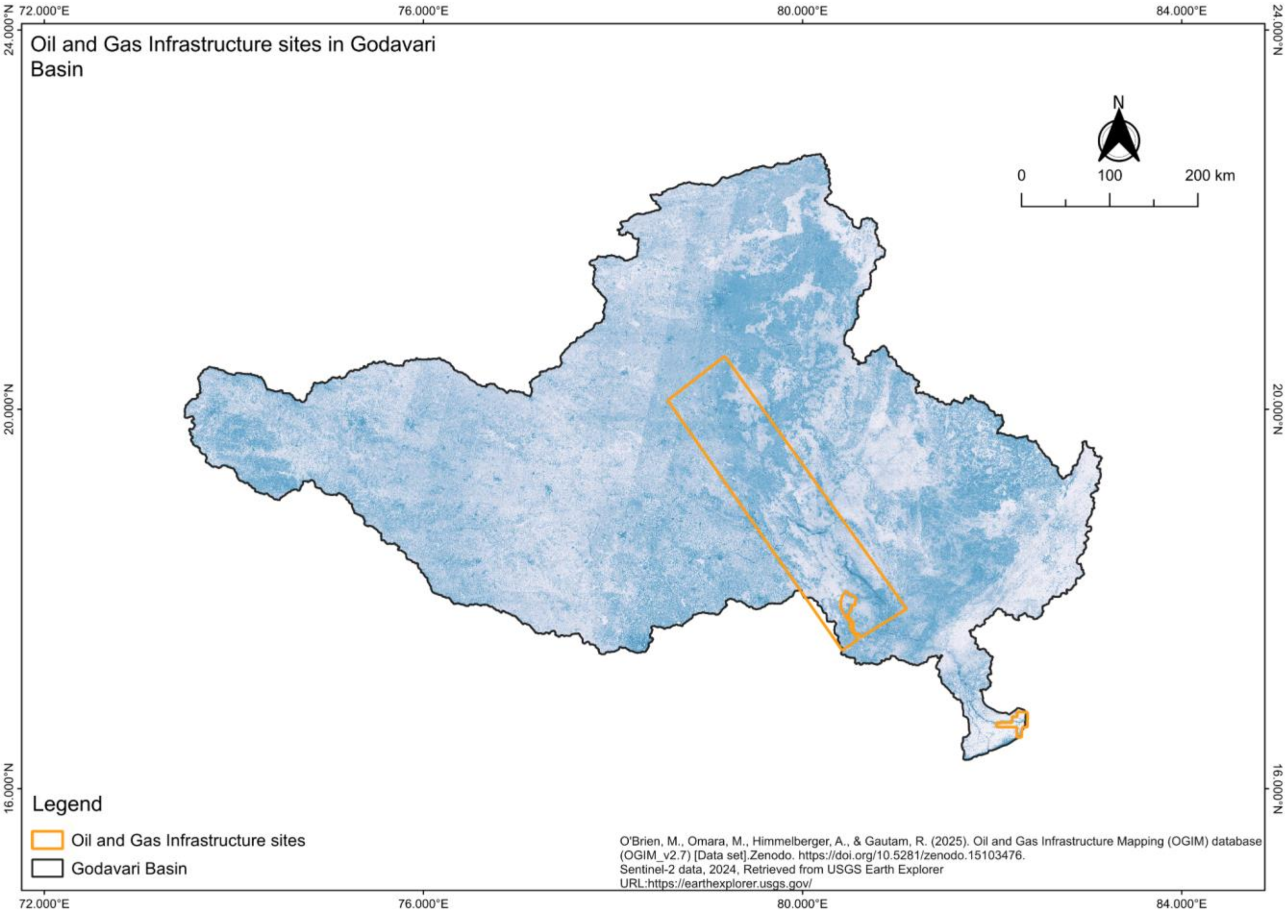

Figure 4: Oil & Gas Infrastructure sites in Godavari Basin

3.6. Deforestation

The deforestation data used for this study was obtained from the Global Forest Change (GFC) dataset developed by Hansen et al. (2013) [32]. This dataset offers annual data on forest cover, forest loss, and forest increase based on time-series analysis of Landsat satellite imagery at a 30-meter spatial resolution from 2000 to 2024. The dataset measures changes in tree cover over time using cloud-free picture composites created from continuous Landsat images. The percentage of tree canopy cover in 2000 is represented by each pixel, and layers show the years of forest gain and loss events from 2000 to 2024 [24]. When imported into GEE the layers treecover2000, loss, lossyear, and gain were used. These layers collectively describe the spatial extent and temporal characteristics of deforestation and forest regrowth. This deforestation dataset was then spatially clipped to the extent of the Godavari basin.

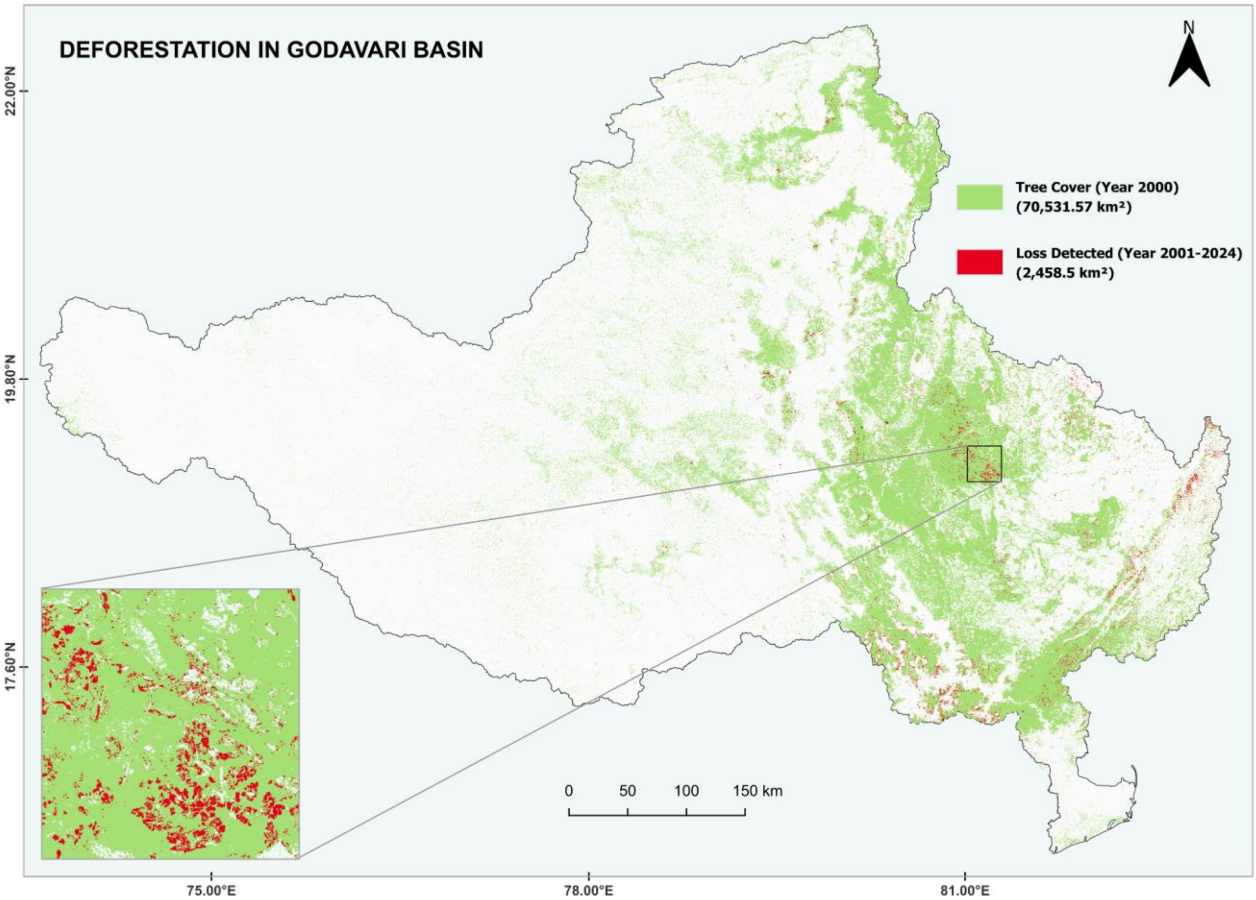

Figure 5: Deforestation in Godavari Basin

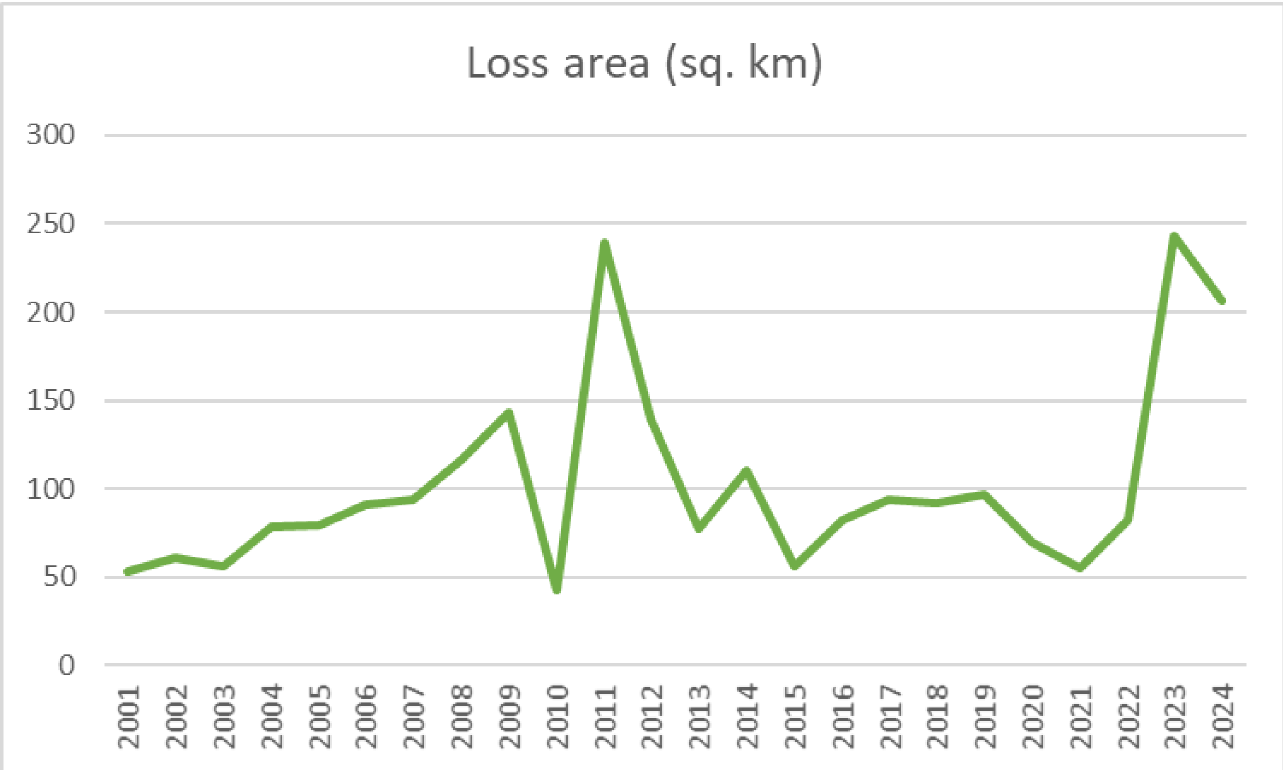

Figure 6: Tree cover loss area in Godavari Basin

Over the past 20 years, there have been significant changes in the forest cover in the Godavari river basin. The basin's total tree cover area according to the dataset was 70,531.57 km² in the year 2000. And the total tree cover loss of almost 2,458.5 km² was noted between 2001 and 2024. This decrease represents a slow but steady loss of forested landscapes that are essential for soil stability and hydrological equilibrium, amounting to around 3.5% of the basin's initial forest cover. An examination of annual loss trends reveals that deforestation did not happen consistently over time, but rather exhibited sporadic spikes which can be associated with both natural and anthropogenic factors. Between 2001 and 2005, there was a comparatively mild annual loss of 53 km² to 80 km², indicating localised clearing activities that were probably related to small-scale development projects and agricultural expansion. Losses increased more sharply between 2006 and 2009, reaching a peak of 143.32 km² in 2009, which may have been related to increased infrastructure development and land conversion in forested areas. The next ten years saw the most notable losses, especially in 2011, 2023, and 2024, when deforestation peaked at 238.94 km², 243.22 km², and 206.16 km². These years show significant increases in the loss of tree cover, which may be linked to extensive development pressures and increased mining. On the other hand, intermittent years like 2010 (42.43 km²) and 2015 (55.71 km²) had lower rates of deforestation, suggesting either temporary recoveries or successful forest conservation efforts.

Cumulative statistics suggest that the Godavari basin still has a significant amount of forest cover, but its ecological resilience is threatened in the long run by the continuous pace of tree cover loss. In order to lessen the effects of deforestation and maintain the environmental integrity of the basin, it is imperative that conservation frameworks, afforestation initiatives, and sustainable land-use planning be strengthened.

Table 2: Tree cover loss area from 2001 to 2024

Year	Loss area (km^2)	Year	Loss area (km^2)	Year	Loss area (km^2)	Year	Loss area (km^2)	Year	Loss area (km^2)
2001	53.217873	**2006**	90.7453	**2011**	238.9448	**2016**	82.63465	**2021**	55.36296
2002	60.9328	**2007**	93.98344	**2012**	139.2917	**2017**	93.94564	**2022**	81.82873
2003	56.434303	**2008**	116.4824	**2013**	77.48305	**2018**	91.54558	**2023**	243.2205
2004	78.503722	**2009**	143.3165	**2014**	110.0575	**2019**	96.813	**2024**	206.1644

2005	79.673187	**2010**	42.42808	**2015**	55.71445	**2020**	69.77617	–	–

3.7. Hill slope change

Modification of the hill slope within the basin increases the terrain's vulnerability to instability and ultimately causes landslides. The equilibrium conditions of hillslopes are disrupted by changes in slope geometry brought about by natural erosion, tectonic activity, deforestation, and development along steep gradients. Slope failures are caused by these alterations, which raise shear stress and lower the resisting forces in the soil and rock mass [26]. The Global Landslide Catalogue (GLC) dataset from NASA Goddard was used to extract landslide events pertinent to the Godavari basin [36][37]. Below is a landslide distribution map showing the sites throughout the basin where documented landslide events have happened.

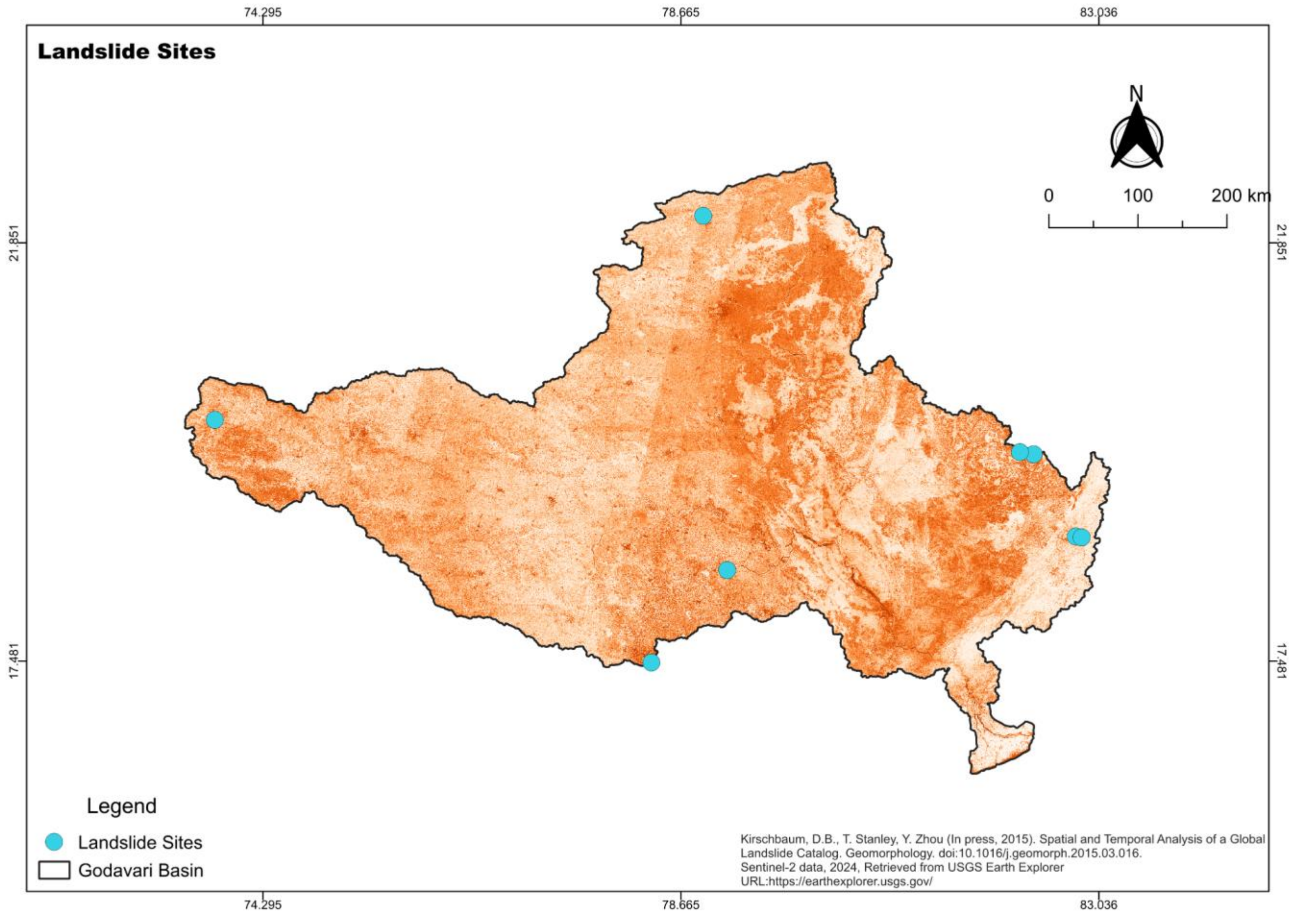

Figure 7: Landslides in Godavari Basin from 1970 to 2019

3.8. Geological disasters

Data of all disasters was obtained through the Geocoded Disasters (GDIS) dataset. Which is developed from the EM-DAT disaster inventory and published through NASA-SEDAC. It provides a spatially referenced catalogue of 9,924 natural disaster events worldwide reported between 1960 and 2018 at district to village level resolution [38]. Floods, storms (including typhoons and monsoons), earthquakes, landslides, droughts, volcanic activity, and extremely high or low temperatures that were recorded in EM-DAT during the time period of these 58 years (1960-2018) and could be geocoded are available in the data set.

Incorporation of the GDIS events layer facilitates the identification of zones with recurrent geological disturbances, which may drive subsidence, sediment delivery, active fault-related deformation, slope instability, and depositional pattern changes. The dataset was filtered to the basin region. Out of the disasters presented below earthquakes and landslides are geological disasters.

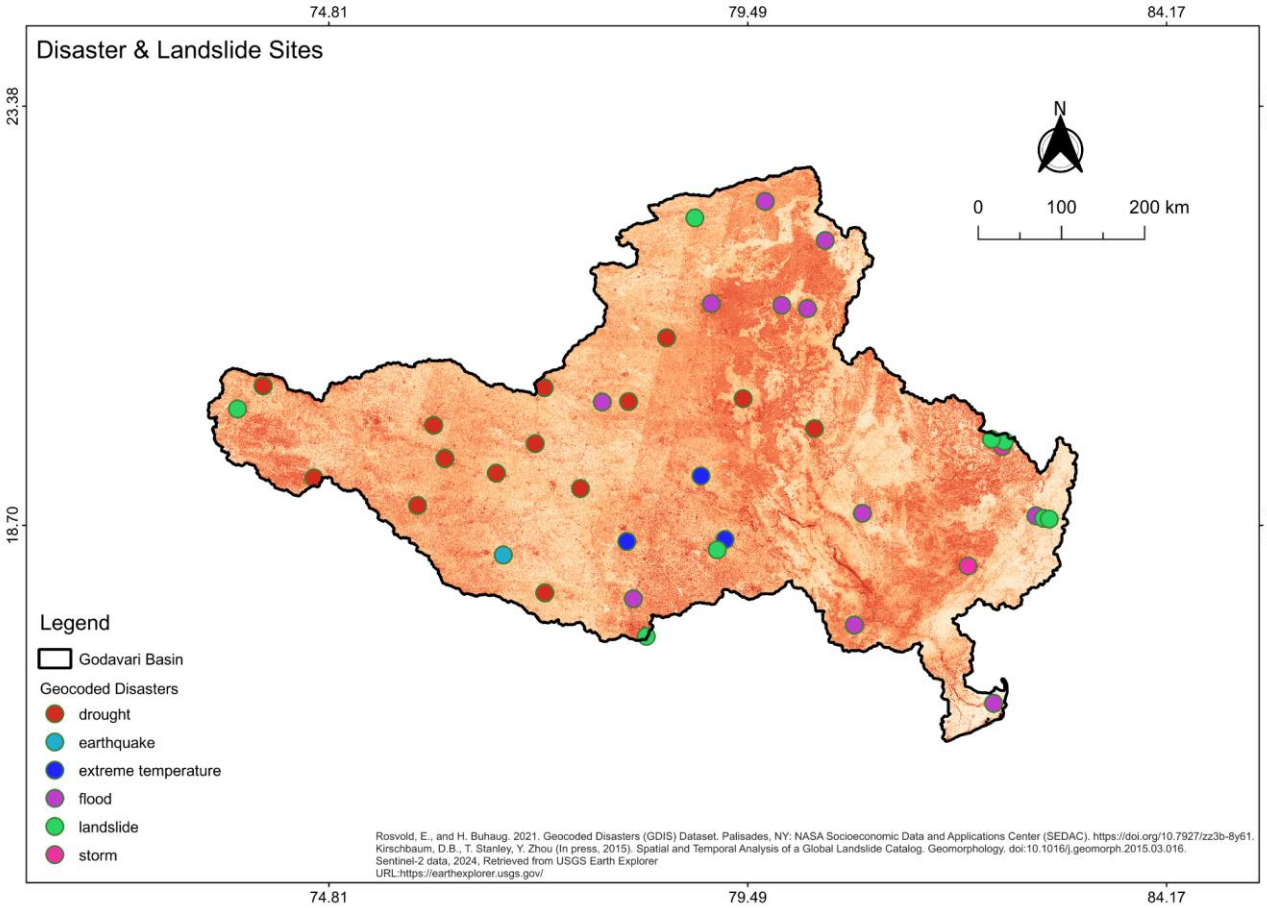

Figure 8: Disasters in Godavari Basin from 1960 to 2018

3.8.1 Earthquakes

Data specifically for earthquakes in the Godavari basin was acquired from USGS earthquake dataset [25]. It covers earthquake events worldwide, with data drawn from multiple sources including seismic stations, ground observations and satellite inputs. It is regularly updated making it particularly suitable for hazard-assessment. The collection was accessed via the GEE interface, leveraging the dataset’s designated identifier within the catalog. Then the data was filtered to the geographic bounds of the Godavari basin.

Table 3: Earthquakes in Godavari Basin from 1923 to 2025

Date	Longitude	Latitude	Magnitude	Magnitude type	Place
13-Apr-1969	80.775	17.747	5.699999809	mw	14 km NW of Bhadrachalam, India
14-Sep-1983	73.76	19.694	4.5	mb	14 km E of Ghoti Budrukh, India
18-Apr-1987	79.259	22.346	4.900000095	mb	10 km ENE of Amarwara, India
18-Oct-1992	76.856	18.069	4.400000095	mb	12 km ESE of Nilanga, India
02-Nov-1992	76.562	18.218	3.900000095	mb	7 km ESE of Ausa, India
29-Sep-1993	76.451	18.066	6.199999809	mwb	20 km SSW of Ausa, India
29-Sep-1993	76.441	18.092	5	mb	18 km SSW of Ausa, India
30-Sep-1993	76.519	18.09	4.599999905	mb	17 km S of Ausa, India
30-Sep-1993	76.658	18.159	4.5	mb	11 km WNW of Nilanga, India
12-Nov-1993	76.533	18.12	4.599999905	mb	14 km SSE of Ausa, India
14-Dec-1995	76.543	18.131	4.300000191	mb	13 km SSE of Ausa, India
10-Nov-1996	76.695	18.301	4.099999905	mb	17 km SE of Latur, India
19-Jun-2000	76.487	18.014	4.400000095	mb	24 km NW of Umarga, India
06-Sep-2007	76.535	18.057	3.599999905	mb	21 km S of Ausa, India
21-Nov-2020	79.6342	22.1407	4.300000191	mb	10 km NE of Seoni, India
21-Mar-2024	77.2545	19.4899	4.599999905	mb	20 km NNE of Basmat, India
10-Jul-2024	77.2915	19.4402	4.400000095	mb	18 km NE of Basmat, India
04-Dec-2024	80.3296	18.4471	5	mb	49 km NE of Mulugu, India

Here, mw refers to Moment Magnitude, mb denotes Body Wave Magnitude, and mwb represents Long-Period Body Wave Magnitude, each indicating different scales used to quantify earthquake size based on seismic wave characteristics.

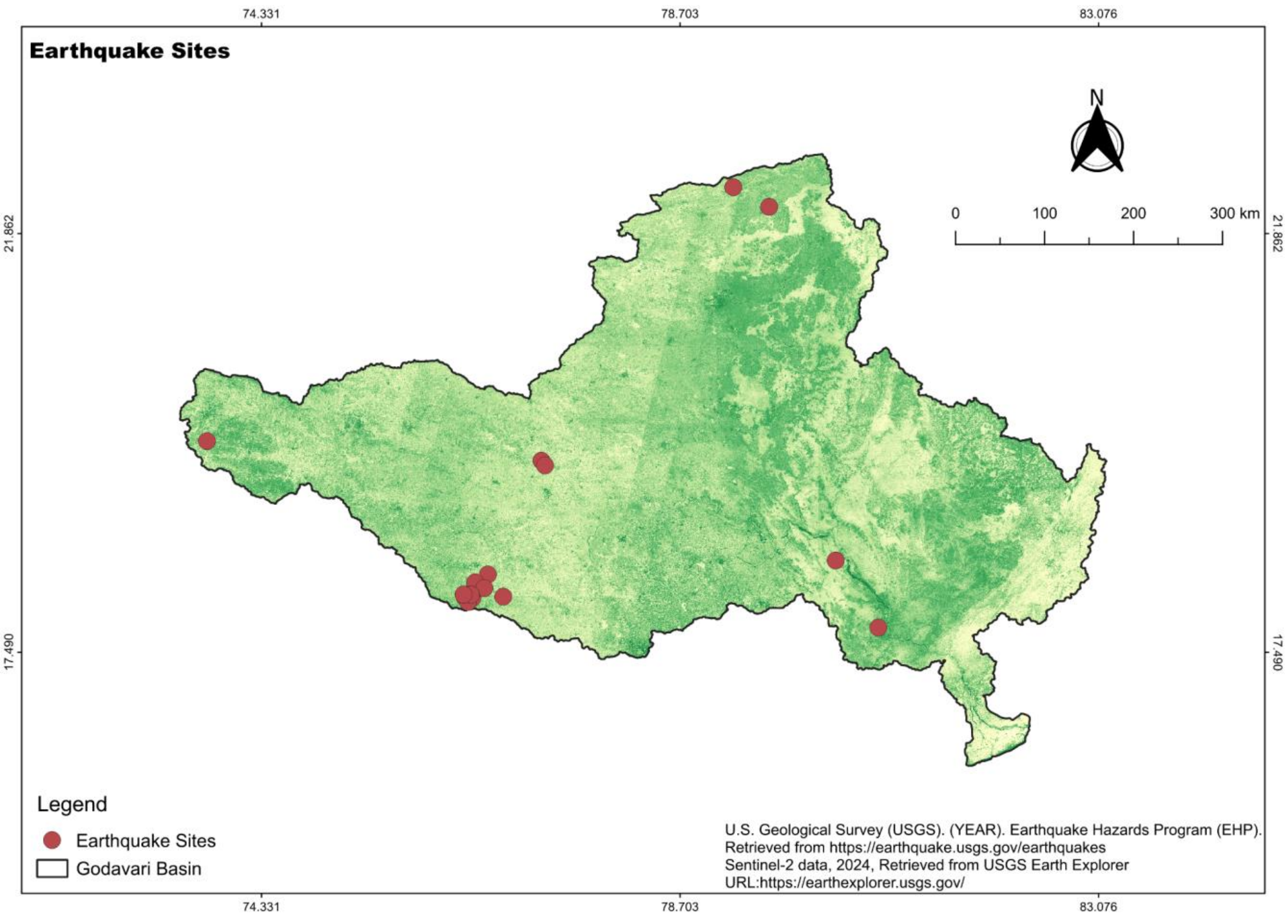

Figure 9: Earthquakes in Godavari Basin from 1923 to 2025

3.8.2 Landslides

Global Landslide Catalog (GLC) dataset developed by NASA Goddard provided landslide-specific data [36][37]. It is an extensive dataset that records landslide incidents caused by rainfall across the globe from 1970 to 2019. The dataset gathers landslide records from a variety of sources, including media stories, scientific publications, and disaster reporting sites. The GLC is accessible as a feature collection in Google Earth Engine that includes geographical point-based recordings of previous landslides together with related variables including the date of occurrence and succinct event descriptions. The recorded landslide occurrences were spatially filtered to extract just those that fell inside the basin's limits after the GLC was imported into Google Earth Engine.

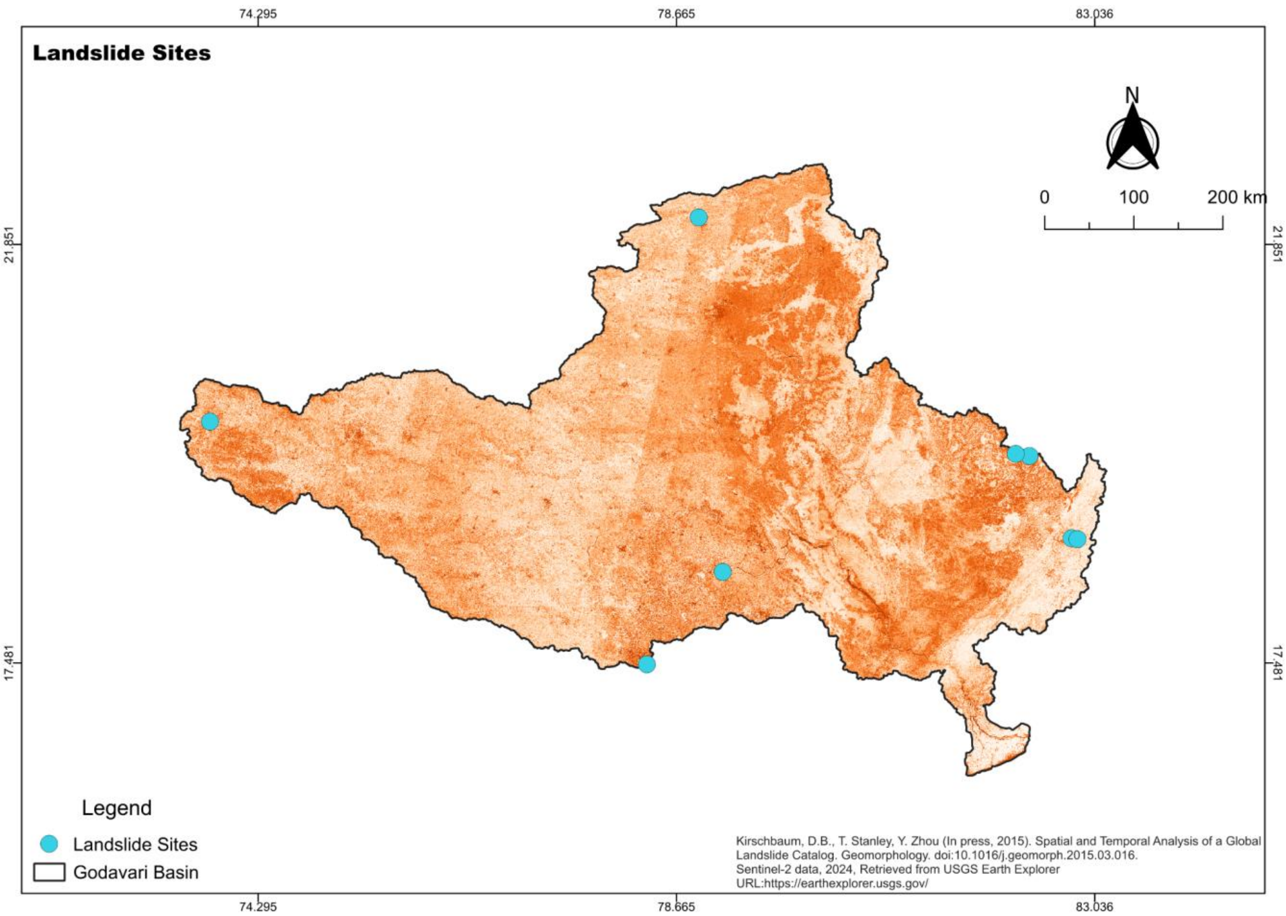

Figure 10: Landslides in Godavari Basin from 1970 to 2019

Table 4: Landslides in Godavari Basin from 1970 to 2019

Date and time	Latitude	Longitude	Place	Location accuracy	Fatality count	Injury count
25-Jun-2007 12:00 AM	18.431	79.1492	Karimnagar	25km	10	_
09-Dec-2016 02:22 PM	19.64199	82.35406	Siunaguda village under Jharigaon block in Odisha's Nabarangpur district	exact	3	3
20-Nov-2013 11:30 PM	20.0014	73.7917	Kazigadi Near Nashik, Maharashtra	50km	0	_
31-Mar-2017 12:57 PM	19.66393	82.21022	Hugulahandi under Umerkote block of Nabarangpur district, Odisha, India	1km	1	0
07-Mar-2016 12:00 AM	22.1337	78.8979	Chhindwara	100km	3	0
16-Sep-2015 12:00 AM	18.7828	82.7935	Dumuriput, Odisha 764021, India	1km	0	0
15-Sep-2015 06:00 PM	18.7734	82.8555	Railway tracks between Dumriput and Damanjodi	5km	0	0
13-Mar-2017 02:32 PM	17.46563	78.35651	Hyderabad, Rangareddy, Telangana	1km	2	0

4. Applications

Understanding the various elements impacting the geology of the Godavari Basin allows for a wide range of scientific, environmental, and policy applications. The compiled datasets and analytical insights lay the groundwork for assessing the cumulative effects of anthropogenic and natural processes on the basin's geology, stability, and long-term viability. This study provides a comprehensive picture of how both human and natural forces shape the basin's landscape by combining data and insights on excavations, explosions, mining activities, tunnelling, fracking, deforestation, hill slope modifications, and natural geological disasters like earthquakes and landslides .

These assessments can directly support environmental monitoring programs by identifying zones of active geological change and indicating areas that may require more regulation or protection. These findings can be used by resource managers and planning authorities to build more informed land-use strategies, ensuring that development activities, particularly mining, extraction, and infrastructure projects, are consistent with geological sensitivity and ecological resilience. The approach also helps risk assessment frameworks by assisting in the prediction of probable landslide-prone areas, regions prone to erosion or seismic effect, and areas where cumulative extraction pressures may compromise geological stability.

The findings of this study are also useful for scientific research. The information and resulting interpretations provide a foundation for geographic modelling, remote sensing research, and long-term monitoring initiatives targeted at detecting changes in geological processes throughout the basin. The data can also be used to guide environmental impact assessments (EIAs), assist disaster management authorities with vulnerability mapping, and help conservation agencies prioritize forested or ecologically sensitive zones.

5. Conclusion

The Godavari Basin represents a dynamic and complex geological system shaped by the interplay of natural processes and human-driven activities. The factors examined in this report show how multiple drivers interact to influence the region's structural integrity, geomorphic evolution, and environmental sustainability. This work highlights the spatial extent, intensity, and implications of each element by acquiring and analyzing multiple information, demonstrating how localized disturbances can scale to basin-wide geological repercussions. Natural and anthropogenic factors continue to affect the basin's geography. The examination of both types of effects provides for a more comprehensive understanding of the basin's geological weaknesses, emphasizing the importance of managing development in the context of environmental and geological sensitivity. This paper underlines the importance of ongoing monitoring, increased data availability, and the use of standardized evaluation frameworks to enable informed decision-making in the Godavari Basin. Recognizing the combined effects of natural and human variables allows stakeholders to better forecast geological risks, build more robust infrastructure, and encourage sustainable land-use practices. The findings reported here provide a platform for future research and policy measures targeted at protecting the Godavari Basin's geological stability and ecological balance.

6. Data sources

Table 5: Data sources table

Factors affecting Geology	Dataset used	Time range	Data format
Excavations	_	_	_
Explosions	_	_	_
Mining	Global Mining Areas and Validation Datasets [27]	2000-2017	GeoJSON
Tunnelling	OpenStreetMap [28] Overpass Turbo [29]	Exported on 26/9/25	GeoJSON
Fracking	Oil and Gas Infrastructure Mapping (OGIM) database [30][31]	Exported on 25/9/25	GeoJSON
Deforestation	Global Forest Change 2000-2024 [32][33][34][35]	2000-2024	GeoJSON
Hill slope change	Global Landslide Catalog :NASA Goddard (1970-2019) [36][37]	1970-2019	GeoJSON
Disasters	Geocoded Disasters (GDIS) Dataset (1960–2018) [38]	1960-2018	GeoJSON
Earthquakes	USGS Global Earthquake dataset [25]	1923-2025	GeoJSON

Landslides	Global Landslide Catalog :NASA Goddard (1970-2019) [36][37]	1970-2019	GeoJSON

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