BEFORE THE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE, CHENNAI

ORIGINAL APPLICATION NO. 235 OF 2024 (SZ)

IN THE MATTER OF:

Tribunal on its own motion SUO MOTU based on the news items published in 'The New Indian Express', Chennai Edition, dated 01.08.2024, under the caption "***Karnataka hit by 46 landslides this year, 12 die experts warn of more in the future***" and in 'The Indian Express' dated 02.08.2024, under the caption "***Landslides hamper Bengaluru-Mangaluru road Connectivity: flood threat looms over part of Karnataka***".

…APPLICANT

AND

The Chief Secretary to Govt. of Karnataka
Bengaluru and Ors

...RESPONDENT(S)

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Filed by

Darpan KM
Standing Counsel
State of Karnataka
Lower Ground Floor, K-6
Lajpat Nagar – III, New Delhi 110 024

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REPORT ON BEHALF OF THE DEPARTMENT OF REVENUE AND DISASTER MANAGEMENT, STATE OF KARNATAKA

MOST RESPECTFULLY SHOWETH:

A. Karnataka experienced two major and some minor incidents of varying intensities of landslides, debris flows and mudflows/mudslips during July of 2024. There were human casualties in one landslide in Shiruru village in Ankola Taluk in Uttara Kannada district which was primarily linked to the unscientific cutting of slope and stabilization in the road development works undertaken by the NHAI along the National Highway 66. In total, 09 fatalities were reported; 9 in Shiruru (with 2 people still missing) in Ankola taluk of the Uttara Kannada district.

Brief note on Shiruru landslide incident in Ankola Taluk of Uttara Kannada district

1. **Background:** From 1st July to 23rd July, 2024 Uttara Kannada district recorded 1,389 mm of rainfall, significantly higher than the normal of 751 mm, which is departure of +85%. It is pertinent to note that Uttara Kannada district typically experiences high rainfall, so an 85% departure translates into a substantial amount of continuous rain over 20 days. Ankola taluk recorded extremely heavy rainfall of 275 mm on 16th July 2024. The heavy rainfall (accompanied by strong winds) triggered a landslide incident on National Highway-66 at Shiruru village, Ankola Taluk, Uttara Kannada district on 16th July 2024 at approximately 08:30 hrs.The precise location of the event is at the left-hand side of Chainage number 148.000 (14.603554°N / 74.371219°E) of NH-66. The landslide was characterized as a deep rotational debris flow with approximate dimensions: Length - 110m, Width - 130m, and Height - 50m. The landslide event obstructed communication through the National Highway-66, with a runout distance exceeding 150m, depositing debris material into the Gangavalli river channel.
2. The heavy influx of debris swept away one fully loaded LPG gas HP tanker and fully loaded Benz truck into the adjoining Gangavalli river. A total of 11 persons were affected by the landslide in Shirur Village. Of these, 9 bodies have been recovered, while 2 bodies are missing.
3. **Expert report on the incident:** The Geological Survey of India, which is the nodal Government agency for landslide studies, investigated the landslide slide on the 17th and 18th July, with the primary aims of understanding the geogenic causes of the landslide. As per the preliminary report submitted by the GSI. "***The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of toe support are the primary causative factors of the debris flow***." In

essence, the heavy rainfall resulted in a landslide due to the unscientific slope modification by the National Highways Authority of India(NHAI).

A brief summary of the GSI report is as follows:

General Observations about the site:

- The site has a very thick weathered rock and in-situ clay-rich lateritic soil (having thickness ranging from 5-15m) exposed by slope cutting.
- The pyroxenite rock in the area is highly weathered, topped by a thick soil cover. The fresh pyroxenite rock exposed at the toe tapers, providing minimal natural toe buttress or support for the slid zone.
- Natural drainage flows have been **disturbed due to slope modifications**. The slide area and the left flank are structurally deformed, presenting friable and gouge-like material.
- The landslide movement is extremely rapid and currently active, with the potential for enlargement.
- The adjoining slope on the right of the landslide has a gradient of approximately 40° without benches. Fresh tension cracks present in this area may lead to failure in case of continuous rainfall. The debris thickness here is also considerable. Tension cracks of 2 feet depth were observed in the left flank also.
- Multi-temporal satellite imagery indicates anthropogenic interference on the slopes from Chainage number 147.400 to 148.200 since 2017, with some landslide scars above the cut slopes.
- The 3-day antecedent rainfall in the area was 503 mm, causing saturation of the thick debris material and lithomarge, thereby increasing pore water pressure.
- The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of toe support are the

primary causative factors of the debris flow. Intense rainfall acted as the trigger for the landslide.

- The high relief and overburden material in the hill slope suggest that retrogression of the slide is probable during prolonged rainfall.

Geo-technical cause for the landslide:

- The site has a very thick weathered rock and in-situ clay-rich lateritic soil exposed by slope cutting.
- The pyroxenite rock in the area is highly weathered, topped by a thick soil cover. The fresh pyroxenite rock exposed at the toe tapers, providing minimal natural toe buttress or support for the slid zone.
- Natural drainage flows have been disturbed due to slope modifications.
- The slide area and the left flank are structurally deformed, presenting friable and gouge-like material.
- The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of toe support are the primary causative factors of the debris flow.

Long term remedial measures suggested by GSI:

- The gradient at the slope sector from 147.400 to 148.200 should adhere strictly to BIS codes for slope gradient with benching, based on the geotechnical properties of the soil. The bench width should enable the slope segments to act independently, as prescribed in IS code 14680:1999.
- Benches should be provided with lined ditches or drainage to reduce erosion and infiltration along with slope reinforcement measures.
- The natural drainage path is modified due to extensive slope cutting at the site. A culvert with sufficient diameter pre-cast pipes should be

provided to accommodate water and debris discharge at the toe of the landslide at Ch. No. 148.000.

- Monitor for tension cracks and possible displacement of slope material at the crown area.
- Given the excess subsurface water flow, engineered slopes should include provisions to drain subsurface water, such as perforated horizontal pipes of appropriate diameter, depending on site conditions.
- A comprehensive geotechnical investigation is recommended to determine appropriate slope stabilization strategies for the Shiruru site.

Based on the preliminary report by the Geological Survey of India (GSI), the Deputy Commissioner of Uttara Kannada has issued a notice under Sections 33 and 34 of the Disaster Management Act, 2005 to the NHAI. The notice directs the Regional Officer of the National Highways Authority of India (NHAI) and the Project Director, NHAI, to ensure compliance with the remedial measures suggested by the GSI in its report.

Debris removal operations were carried out in accordance with the precautions outlined in the GSI preliminary report, with work proceeding from both the Ankola and Kumta sides using the specified machinery and adhering to the GSI's recommendations.

Short-term, medium-term, and long-term slope stabilization measures, as suggested by the GSI, will be implemented by the NHAI. However, persistent rains during the Southwest Monsoon and the current Northeast Monsoon have hampered the implementation. On the basis of reports that in a meeting held on 13.08.2024, Hon’ble Minister(RTH) has decided to form a Steering Committee under the Chairpersonship of Principal Secretary, Public Works Department, GoK involving NHAI and State Govt. Departments (Forest/ Geology/ Remote Sensing) to undertake a study of landslide-prone locations, identify reasons &

remedial measures and for speedy implementation of slope protection works within ROW by NHAI.In this context a letter has been addressed to Principal secretary,Public Works department,Government of Karnataka enclosing the GSI reports on the Shiruru landslide with a copy marked to the Regional Officer,NHAI for speedy implementation of work. Monthly reports will be obtained from them on the action taken to prevent such incidents of landslide.

As an immediate measure the District Disaster Management Authority, Uttara Kannada, along with GSI conducted two workshops to train selected Village Administrative Officers, other cutting edge Government officers including Grama Panchayat staff and employees of the NHAI Concessionaire IRB as **landslide spotters**. In total, 228 spotters have been trained and mapped to 439 locations across the district. The spotters are assigned to landslide vulnerable areas to identify signs of landslides, such as soil movement, unusual noises, or changes in vegetation patterns. The spotters monitor slopes, soil conditions, and any signs of instability such as cracks or unusual water flow. When a potential landslide sign is detected, spotters immediately communicate to the local disaster management teams. Spotters are also trained to raise awareness with the local communities about the risk and signs of landslides and response plan.

CHIEF SYNOPTIC FEATURES AND ASSOCIATED WEATHER DURING JULY 2024:

- A trough at mean sea level ran along Maharashtra-Kerala coast on 01st and 02nd July; ran along south Gujarat-Kerala coast on 03rd & 04th; ran along south Gujarat-Kerala coast on 05th; persisted over the same region on 06th; ran along south Gujarat-north Kerala coast on 07th; persisted over the same region on 08th; ran along Maharashtra-north Kerala on 09th; and ran along north Maharashtra – north Kerala coast on 10th; persisted over the same region on 11th& 12th; ran along Maharashtra-north Kerala Coast on 13th;

ran along south Gujarat-north Kerala coast on 14th; persisted over the same region on 15th to 21st July. Under the influence of aforementioned conditions, active monsoon conditions prevailed all along the Karnataka Coast and adjoining Malnad district during 1st to 16th July 2024 resulting in excess to large excess rainfall in Coastal and adjoining Malnad (Western Ghat area) districts.

- Rainfall warning by India Meteorological Department (IMD) are as follows:

DISTRICT	1st July	2nd July	3rd July	4th July	5th July	6th July	7th July	8th July	9th July	10th July	11th July	12th July	13th July	14th July	15th July	16th July
Dakshina Kannada	YELLOW	YELLOW	YELLOW	ORANGE	ORANGE	ORANGE	ORANGE	RED	YELLOW	YELLOW	YELLOW	YELLOW	ORANGE	RED	RED	RED
Udupi	YELLOW	YELLOW	YELLOW	ORANGE	ORANGE	ORANGE	ORANGE	RED	YELLOW	YELLOW	YELLOW	YELLOW	ORANGE	RED	RED	RED
Uttara Kannada	YELLOW	YELLOW	YELLOW	ORANGE	ORANGE	ORANGE	ORANGE	RED	ORANGE	YELLOW	YELLOW	YELLOW	ORANGE	RED	RED	RED
Chikkamagaluru	YELLOW	YELLOW	YELLOW	ORANGE	YELLOW	ORANGE	ORANGE	ORANGE	YELLOW		YELLOW	YELLOW	ORANGE	RED	RED	RED
Kodagu	YELLOW			YELLOW								YELLOW	ORANGE	YELLOW	ORANGE	RED
Shivamogga	YELLOW	YELLOW	YELLOW	ORANGE	YELLOW	ORANGE	ORANGE	ORANGE			YELLOW	YELLOW	ORANGE	RED	RED	RED
Hassan						ORANGE		YELLOW	YELLOW				YELLOW	YELLOW	ORANGE	ORANGE

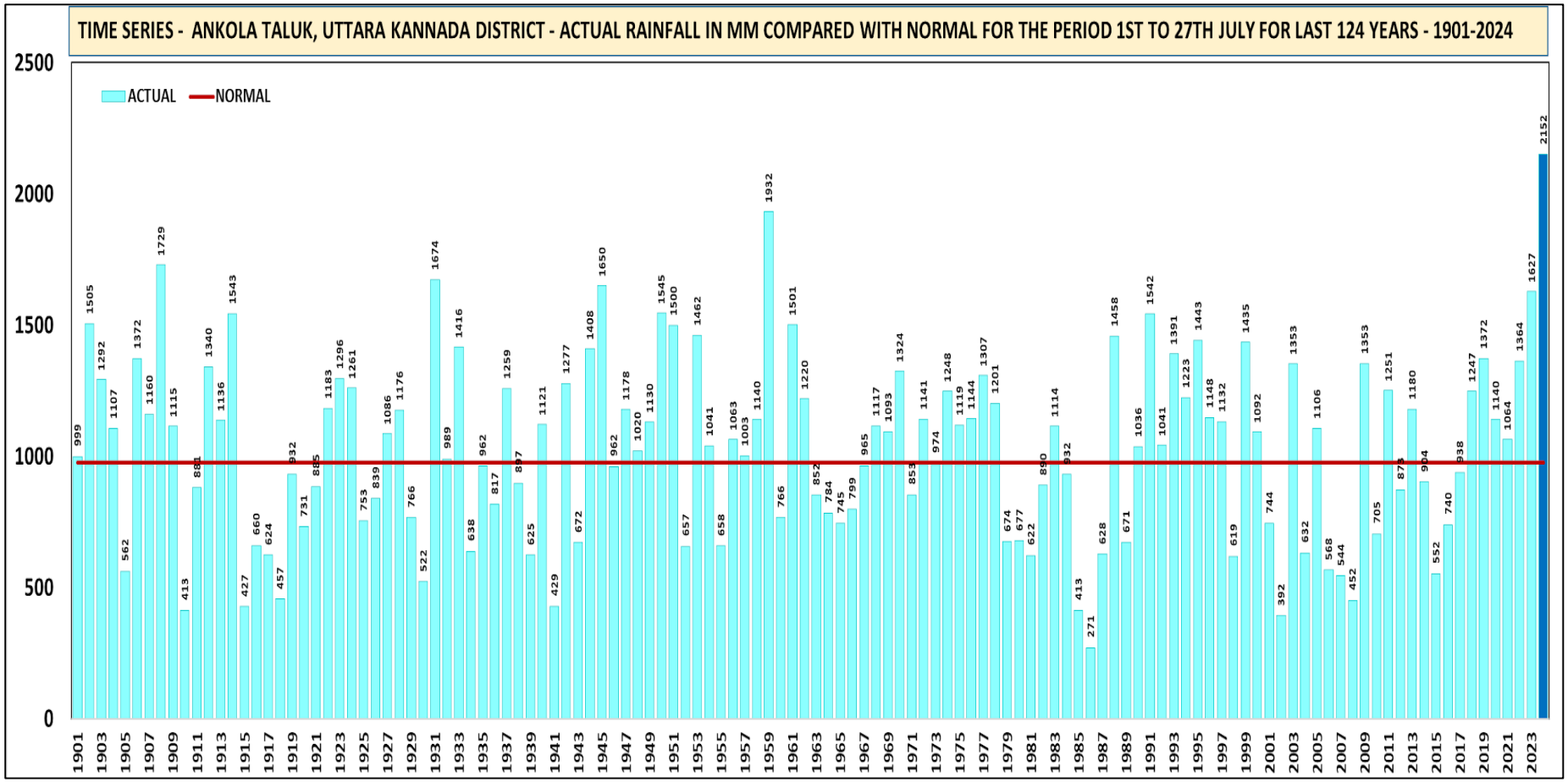
The rainfall warnings issued by IMD for Uttara Kannada district is as follows:

DISTRICT	DATE	IMD WARNING
UTTARA KANNADA	01st July	YELLOW
	02nd July	YELLOW
	3rd July	YELLOW
	4th July	ORANGE
	5th July	ORANGE
	6th July	ORANGE
	7th July	ORANGE
	8th July	RED
	9th July	ORANGE
	10th July	YELLOW
	11th July	YELLOW
	12th July	YELLOW
	13th July	ORANGE
	14th July	RED
	15th July	RED
	16th July	RED

Especially, due to the active phase of SW Monsoon, Uttara Kannada district experienced incessant rains during July 2024. The Telemetric Rain Gauge Station in Belase GP recorded rainfall of 100 mm and above every day from 13th July, 2024 to 16th July, 2024 accompanied with heavy winds reaching the maximum wind speed 30-40 kmph and at times 45-55 kmph. On the day of Landslide incidence, dated 16.07.2024, the Belase GP TRG Station has reported Extremely Heavy Rainfall of 267.0 mm (Extreme Heavy Rainfall > 204.5 mm).

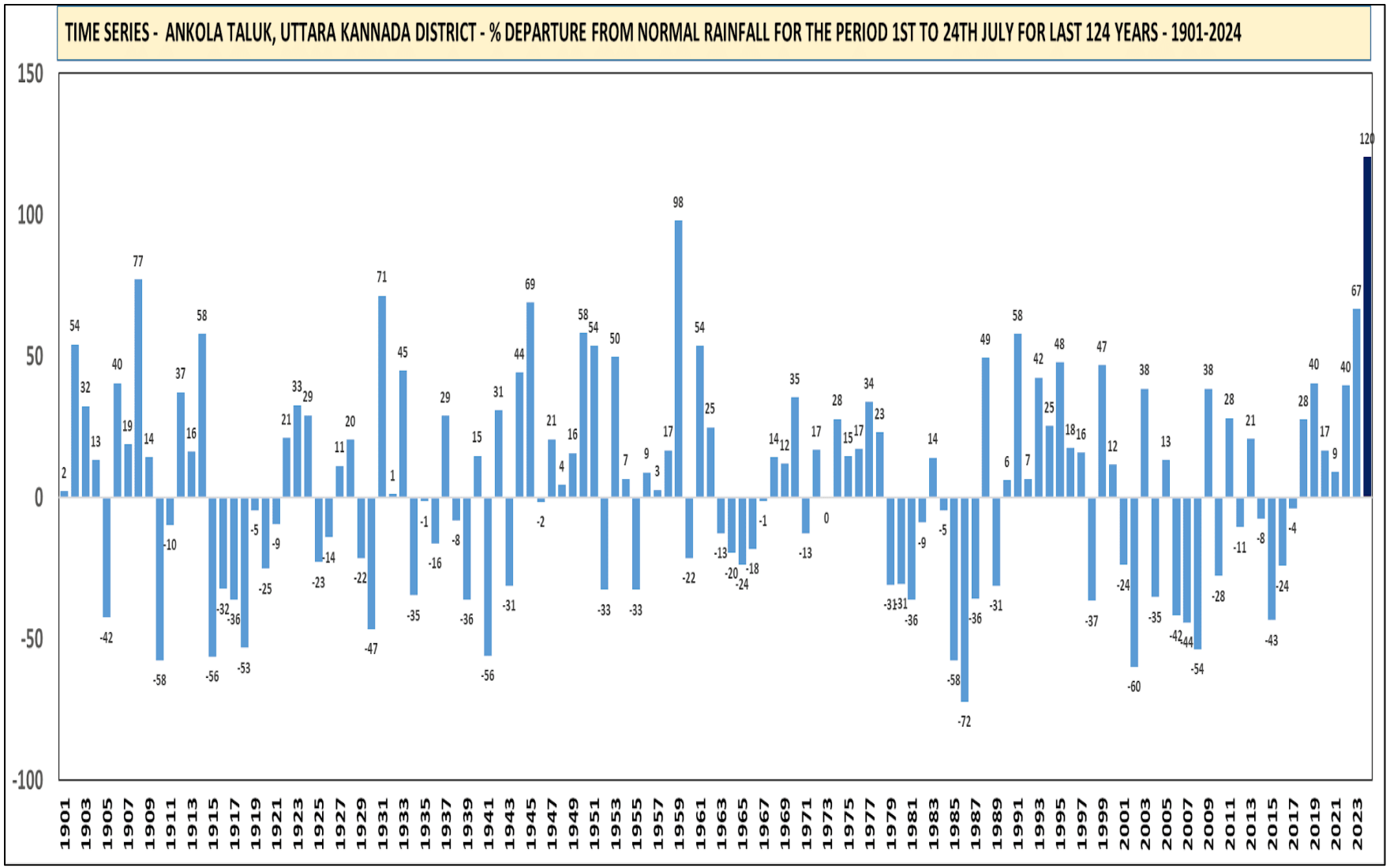
Landslide incidence 7 Days Prior (9th till 15th July, 2024) and during (16th till 22nd July, 2024): During 9th till 15th July, 2024, Balale Hobli as a whole recorded an actual rainfall of 382.2 mm as against a normal rainfall of 230.8 mm with a percentage departure from normal being (+) 65.6%, getting classified under the “Large Excess Category”. Similarly, during 16th till 22nd July, 2024, Balale Hobli as a whole recorded an actual rainfall of 882.7 mm of rainfall as against the normal rainfall of 236.1 mm with a percentage departure from normal being (+) 274.0%, getting classified under the “Large Excess Category”, indicating incessant rainfall occurrence during the incidence period.**July 2024:** During **1st to 28th July 2024**, Balale Hobli as a whole recorded an **actual amount of 2246.5 mm** of rainfall as against the **normal rainfall of 943.9 mm** with a percentage departure from normal being **(+) 138%, getting classified** under the **“Large Excess Category”** during July, 2024.

Rainfall Record: Ankola taluk received 2152 mm rainfall during 1st to 27th July 2024, which is the highest recorded rainfall since 1901 in the last 124 years. Time series graph in Figure 1 and 2



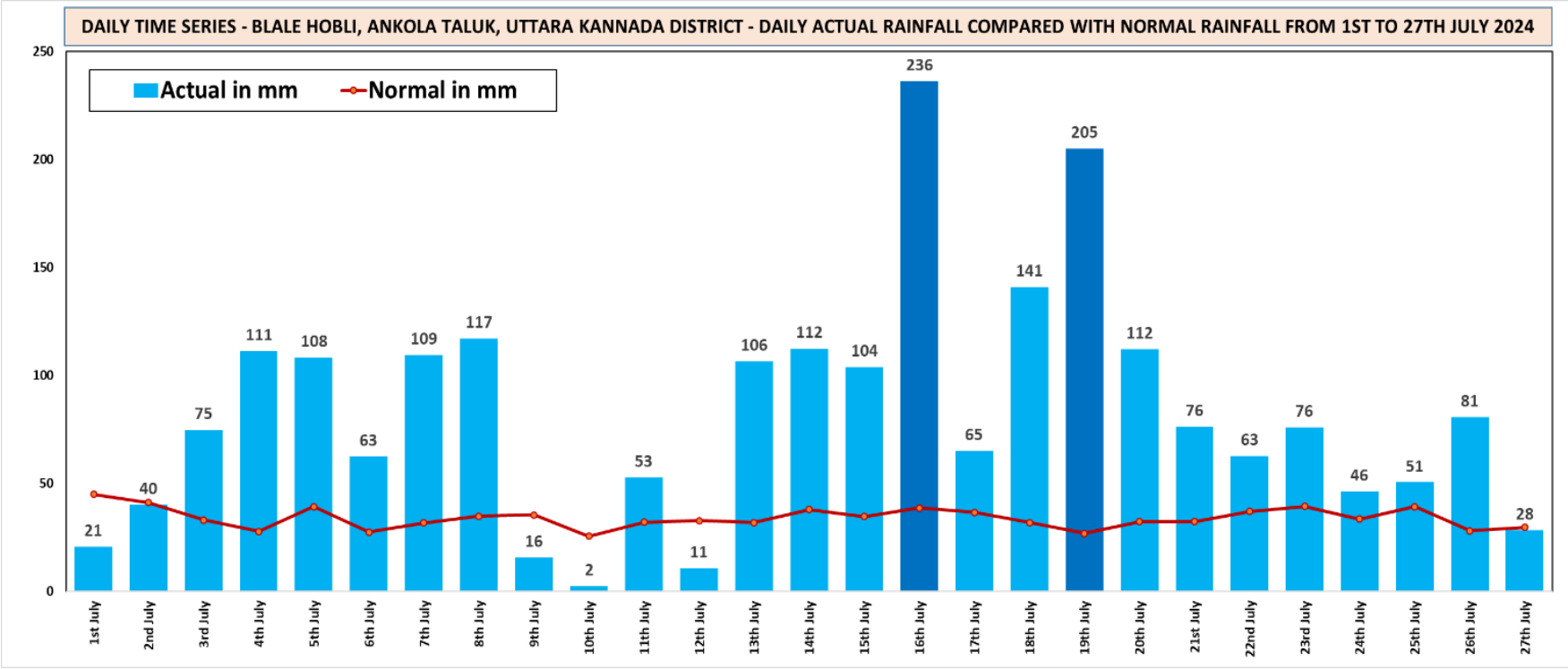
Rainfall Time series for Ankola Taluk, Uttara Kannada District – Actual Vs Normal Rainfall for the period 1st to 27th July -1901-2024 (last 124 years) Highest Record Rain since 1901

Rainfall Time series for Ankola Taluk, Uttara Kannada District – % departure from Normal Rainfall for the period 1st to 27th July -1901-2024 – Highest since 1901



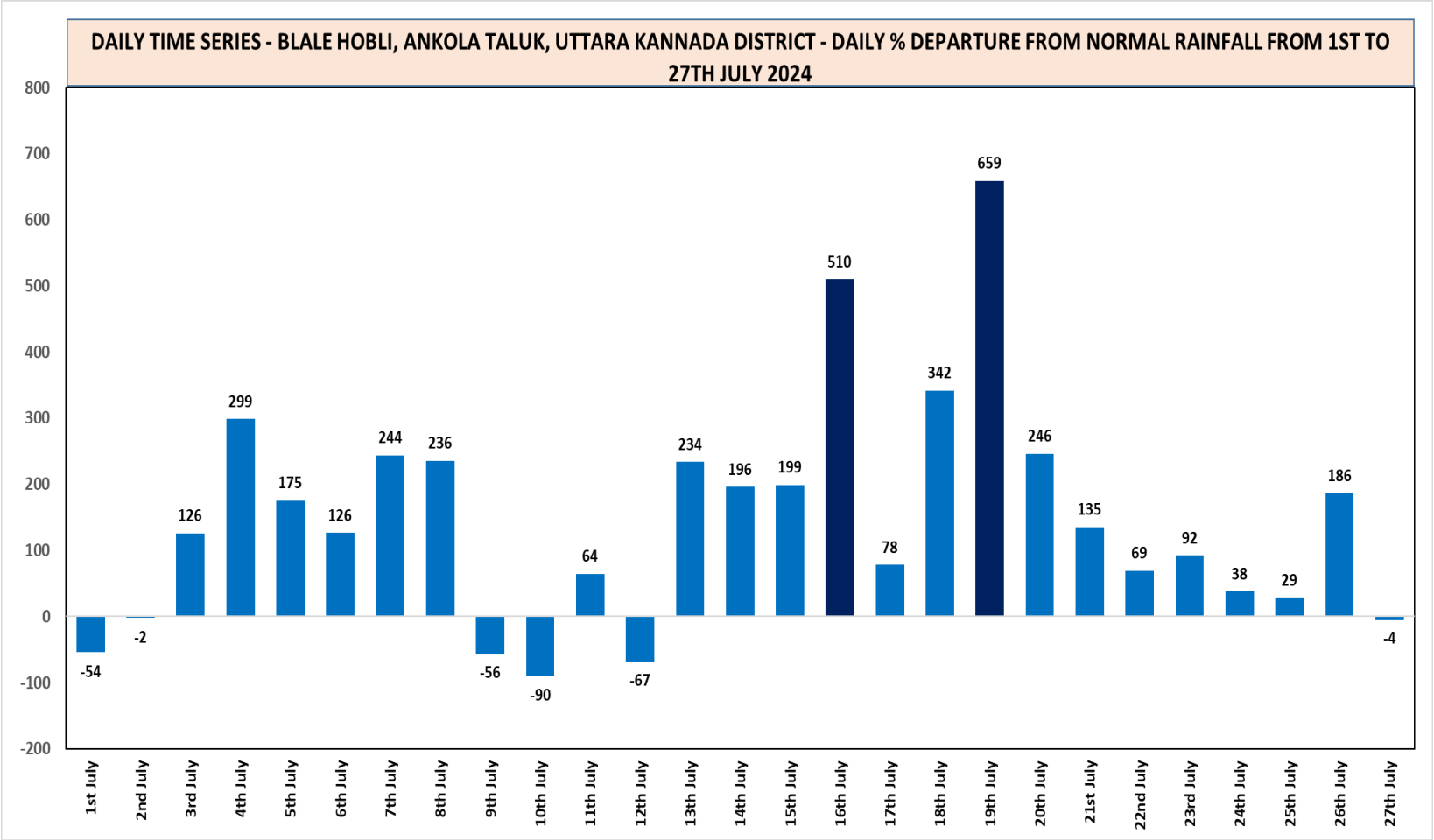
Balale Hobli - Daily Rainfall Time Series for the Period 1st July To 27th July 2024

Daywise Actual Rainfall Compared with Normal Rainfall for Balale Hobli, From 1stTo 27th July 2024



The above graph depicts, during 1st to 27th July 2024, the Balale hobli received >200 mm of rainfall on 16th July and 19th July, out of 27 days, 22 days Balale hobli received heavy to very heavy rainfall. During 16th to 20th July, Balale hobli received 759 mm of rainfall in short duration.

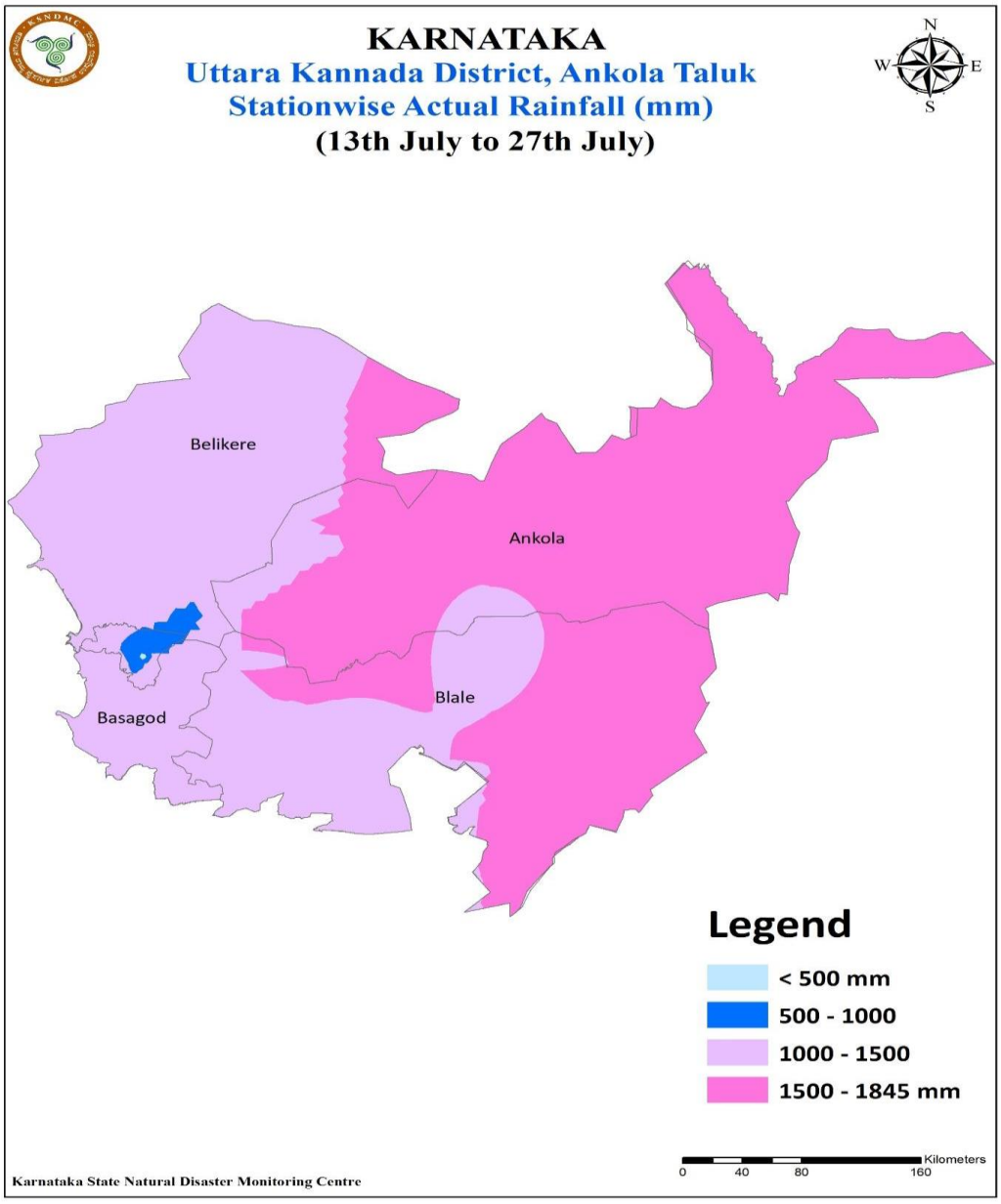
Balale Hobli - Daily Rainfall Departure from Normal rainfall - Time Series for the Period 1st July To 27th July 2024



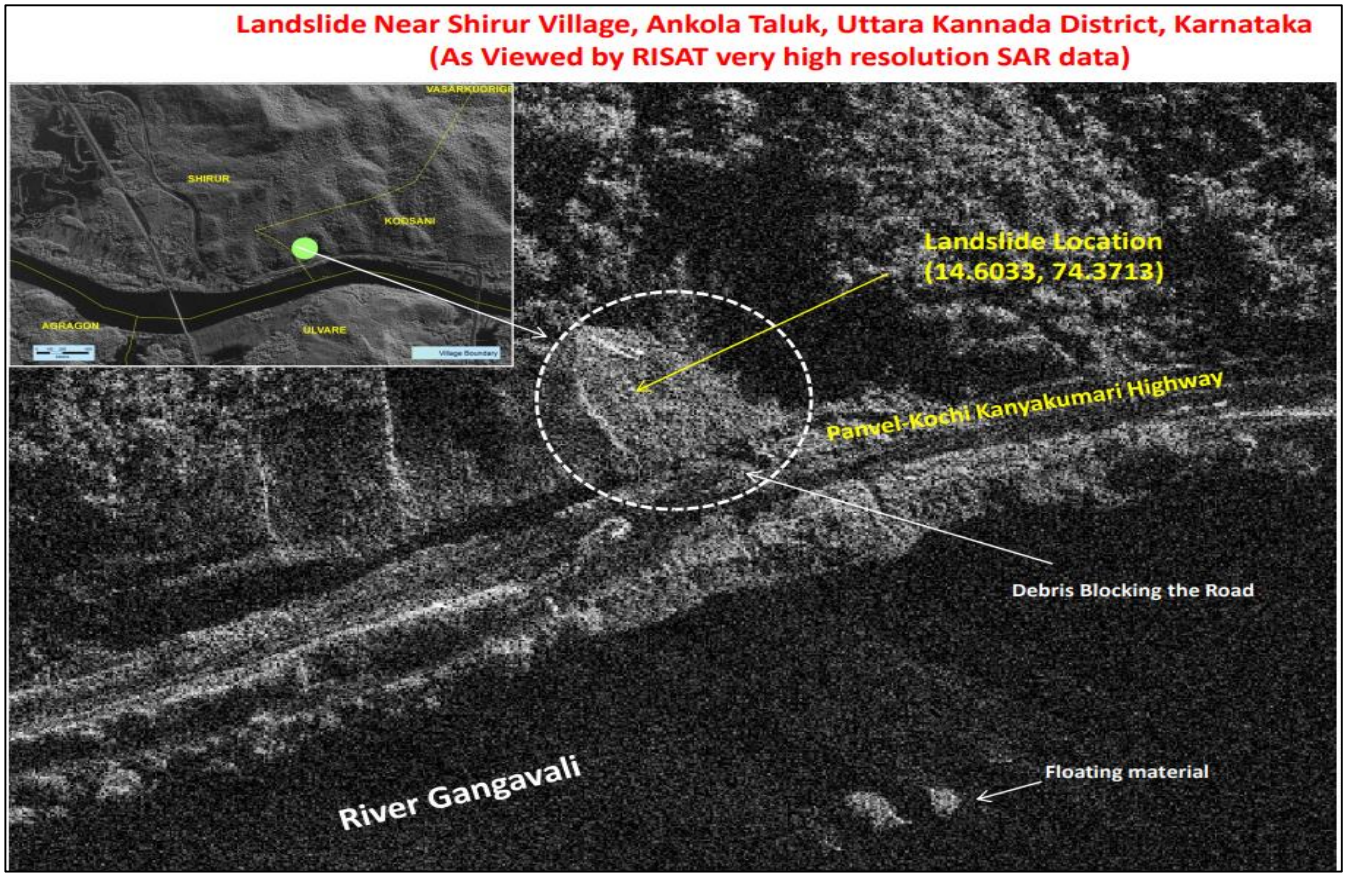
During 1st July to 27th July 2024, Balale hobli, Ankola Taluk, Uttara Kannada District
Recorded >500% Rainfall deviation in 2 days ie. 16th and 19th July
200% to 500% in 8 days and>100 to 200% in 6 days
During the period 1st to 27th July 224, Balale hobli recorded Large Excess in 19 days

The above data indicate an increase in trend in the daily rainfall reported at Balale Hobli, Ankola Taluk, Uttara Kannada district leading to a major Landslide.

ANKOLA TALUK, UTTARA KANNADA DISTRICT - ACTUAL RAINFALL MAP FOR THE PERIOD 13TH TO 18TH JULY 2024



a. LANDSLIDE NEAR SHIRUR VILLAGE, ANKOLA TALUK, UTTARA KANNADA DISTRICT, KARNATAKA(AS VIEWED BY RISAT VERY HIGH RESOLUTION SAR DATA)



Further the said newspaper report states on 2nd Aug 2024 titled "Landslides hamper Bengaluru - Mangaluru road connectivity; flood threat looms over part of Karnataka" during the peak monsoon heavy rainfall episodes were observed over landslides vulnerable areas, however there were no floods during the July-August 2024.

Repeated mudslides and landslides occurred at Shiradi Ghat, Doddathappale village in Heggade, along NH-75 in Hassan district, between 16th July and 31st July 2024. The specific location of the event was at Chainage 234.700 (12.897142°N, 75.732455°E) on National Highway-75. As per preliminary GSI report, the landslides are primarily triggered by prolonged monsoon rains, the region's geological composition, including highly weathered granite gneiss and

thick, cohesionless soil layers. These factors,were exacerbated by the unscientific NHAI road widening,slope cutting which have increased the susceptibility of the slopes to failure.

Notably, the major landslides during the 2024 Southwest Monsoon were on the national highways, with the primary cause attributed to unscientific slope cutting and slope stabilization by NHAI.

Mudslide/landslides of varied intensity have occurred in the following locations of Dakshina Kannada:

1. Kettikall, Tiruvylu, Vamanjur MCC Limit-NH 169
2. Bellibettu , Mulur village, Magaluru taluk NH 169
3. Suji kallu , Kavoor village, MCC limit
4. Putturu bypass road, Mani Mysuru road NH 275 Tenkila area
5. Uppinangadi Puttur road , Kodimbady village
6. Murra Kadambu Major district road , Berike area, Puttur taluk
7. Bellipadi village , Andrigeru area, Puttur taluk
8. Badanadaka area, Melenthbettu village , MDR road, Belthangady
9. Savanal village , Hanyadi area , rural road , Belthangady
10. Gudinbali area, Bantwal Muda village, Bantwal taluk

Kettikal Landslide: As per the preliminary report of GSI, the Kethikal landslide in NH 169 is stemming from a combination of human activities, geological characteristics, and meteorological conditions. **Human-induced alterations, such as slope modifications and inadequate retaining structures,** have exacerbated the slope's instability. Geologically, thick layers of lateritic soil and a clay horizon in the cut slope significantly contribute to the slope’s vulnerability. Additionally, intense and prolonged rainfall has led to soil saturation, further compromising stability.

Action taken by Dakshina Kannada District Administration and NHAI:

Diversion and regulation of traffic. Diversion safety barricade with sign board and crash barrier has been installed. Night flood lightning provided all along the affected section.Workforce and machineries like grader, excavator, roller deployed 24x7 at this location to swiftly respond to emergency. Earthen drains are made to channelize the rain water and to avoid stagnation.**However, no human fatalities were reported** due to these landslides, and debris was promptly cleared. Traffic was diverted until the debris was removed and the affected stretches were deemed safe for the resumption of traffic.

Short-term, medium-term, and long-term slope stabilization measures, as suggested by GSI reports, will be implemented by the NHAI. However, persistent rains during the Southwest Monsoon and the current Northeast Monsoon have hampered the implementation. On the basis of reports that in a meeting held on 13.08.2024, Hon'ble Minister(RTH) has decided to form a Steering Committee under the Chairpersonship of Principal Secretary, Public Works Department, GoK involving NHAI and State Govt. Departments (Forest/ Geology/ Remote Sensing) to undertake a study of landslide-prone locations, identify reasons & remedial measures and for speedy implementation of slope protection works within ROW by NHAI.In this context a letter has been addressed to Principal Secretary,Public Works department,Government of Karnataka enclosing the GSI reports on the Kettikal and other places in Dakshina Kannada along the NH with a copy marked to the Regional Officer,NHAI for speedy implementation of work. Monthly reports will be obtained from them on the action taken to prevent such incidents of landslide.

For interior roads the respective state level agencies are asked to undertake mitigation works with funding from the State Disaster Mitigation Fund.

Geological Survey of India, Government of India is the nodal agency for landslide studies in the country. Since FS 2014-15, GSI has launched and undertook a national programme on landslide susceptibility mapping – Macro-

scale (1:50,000) National Landslide Susceptibility Mapping (NLSM) with an aim to cover the 0.42 million sq. km landslide prone areas of the country. GSI prepared GIS-based seamless Landslide Susceptibility Maps of India on 1:50,000 scale and submitted the following reports to Government of Karnataka during May 2024.

Based on National Landslide Susceptibility Mapping (NLSM) by GSI, list of landslide susceptible Gramapanchayats in Coastal (Dakshina Kannada, Udupi and Uttara Kannada) and Malnad (Kodagu, Hassan, Chikkamagalur and Shivamogga) Districts were identified over the last one and a half decades.

1. **Macro-Scale (1:50,000) Reports (26 Reports)**

https://www.ksndmc.org/Default.aspx/Downloads/GeoSurveyMacroscale

2. **Meso-Scale (1:10,000) Reports (14 Reports)**

https://www.ksndmc.org/Default.aspx/Downloads/GeoSurveyMesoscale

3. **Post Disaster Landslide Studies Reports (13 Reports)**

https://www.ksndmc.org/Default.aspx/Downloads/GSIPDLS

4. **Site Specific Studies (4 Reports)**

https://www.ksndmc.org/Default.aspx/Downloads/GSISitespecific

Based on the above, Landslide Susceptible zones for Karnataka is classified as follows:

Table 1: Details of Total Landslide Prone area in Karnataka

Sl. No	Landslide Susceptibility	Area in sq.km*
1	High Susceptibility	1163.8
2	Moderate Susceptibility	5385.0
3	Low Susceptibility	24682.2
	Total	**31,231.0**

*** Source:** Geological Survey of India, GoI

Link: https://bhukosh.gsi.gov.in/Bhukosh/Public

Western Ghats, north–south-running range of mountains or hills in western India that forms the crest of the western edge of the Deccan plateau parallel

to the Malabar Coast of the Arabian Sea. The Western Ghats are a biodiversity hot spot, a biologically rich and a UNESCO World Heritage site. They play a huge role in India's monsoon weather pattern. The eastern edge of the Deccan plateau is formed by another of the Ghats, the Eastern Ghats.

The steep seaward slopes of the Western Ghats rise abruptly from the coastal plain of the Arabian Sea as an escarpment of variable height and are deeply dissected by streams and canyon like valleys. The slopes on the range's landward side are gentle and transition to wide valleys. The chain, which contains a series of residual plateaus and peaks separated by saddles and passes, extends northward to the Tapti River and southward almost to Cape Comorin at India's southern tip.

Older than the great Himalayan mountain chain, the Western Ghats of India are a geomorphic feature of immense global importance. It is sometimes called the Great Escarpment of India. The central part of Western Ghat which is better known as Sahyadri hill range, occur almost fringing the circular chain of hills forming a loop of mountain chain in Karnataka state.

The Western Ghats constitute peninsular India's principal watershed. The range traps the moisture of winds from the Arabian Sea, creating a tropical monsoon climate along the narrow western littoral and depriving the Deccan of significant precipitation. The early monsoonal airstream piles up against the mountains' steep slopes and then recede before piling up again to greater heights. Increasingly thicker clouds are pushed upward until wind and clouds roll over the barrier and, after a few brief spells of absorption by the dry inland air, cascade toward the interior. The Western Ghats are one of the best examples of the monsoon system on the planet.

The Western Ghats constitutes a very prominent physiographic feature on the western margin of the peninsular India. The Western Ghats, which forms a gorgeous mountain chain separating the Arabian Sea in the west and the eastern plain of the peninsular Indian shield, has been witnessing frequent landslides. The topography of Malnad and coastal region is sensitive and any changes in the land use causes landslide or slope failure affecting the population.

GEOLOGY OF WESTERN GHATS

The Western Ghats are the mountainous faulted, and eroded edge of the Deccan Plateau. Geologic evidence indicates that they were formed during the break-up of the super-continent of Gondwana. After the break-up, the Deccan plateau was formed by basalt rocks, which caused the western side to rise at an elevation.

The mountains came along the west coast of India somewhere in the late Jurassic and early Cretaceous periods when India separated from the African continent. The mountains can be roughly divided into three parts: the northern section with an elevation ranging from 900–1,500 m (3,000–4,900 ft), the middle section starting from the south of Goa with a lower elevation of less than 900 m (3,000 ft), and the southern section where the altitude rises again.

Geophysical evidence indicates that the mountains came along the west coast of India somewhere in the late Jurassic and early Cretaceous periods when India separated from the African continent. Several faults triggered the formation of Western Ghats, then interspersed with valleys and river gorges. Because of the elevation of the Deccan plateau on the west, most rivers flow from west to east, resulting in chiseled eastern slopes and steeper western slopes facing the sea.

TYPES OF LANDSLIDES:

Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief. In low-relief areas, landslides occur as cut-and fill failures (roadway and building excavations), river bluff failures, lateral spreading landslides, collapse of mine-waste piles (especially coal), and a wide variety of slope failures associated with quarries and open-pit mines. The most common types of landslides are described as follows.

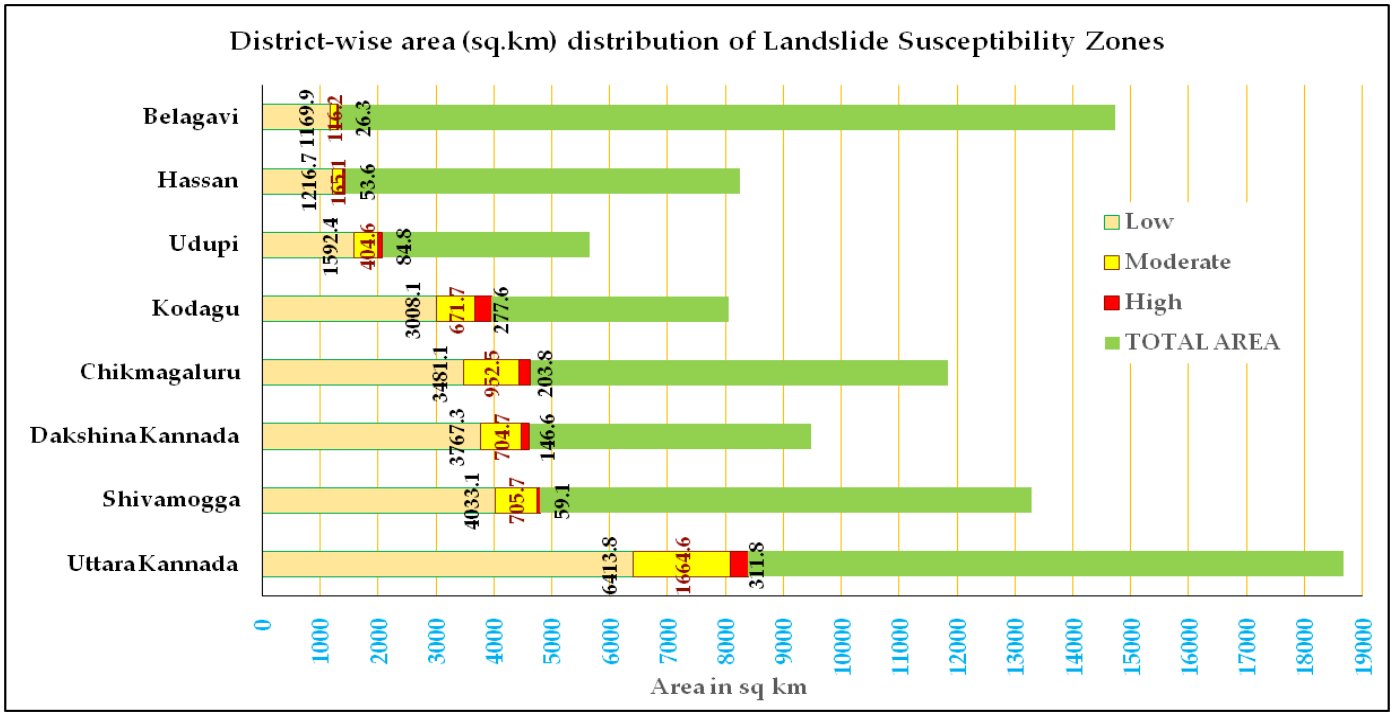
Table 2: Types of landslides(Varnes,1978)

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">TYPE OF MATERIAL</td></tr>
<tr><td colspan="2">ENGINEERING SOILS</td></tr>
<tr><td colspan="2" rowspan="2">TYPE OF MOVEMENT</td><td rowspan="2">BEDROCK</td><td>Predominantly coarse</td><td>Predominantly fine</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">FALLS</td><td>Rock fall</td><td>Debris fall</td><td>Earth fall</td></tr>
<tr><td colspan="2">TOPPLES</td><td>Rock topple</td><td>Debris topple</td><td>Earth topple</td></tr>
<tr><td rowspan="2">SLIDES</td><td>ROTATIONAL</td><td rowspan="2">Rock slide</td><td rowspan="2">Debris slide</td><td rowspan="2">Earth slide</td></tr>
<tr><td>TRANSLATIONAL</td></tr>
<tr><td colspan="2">LATERAL SPREADS</td><td>Rock spread</td><td>Debris spread</td><td>Earth spread</td></tr>
<tr><td colspan="2">FLOWS</td><td>Rock flow (deep creep)</td><td>Debris flow</td><td>Earth flow (soil creep)</td></tr>
<tr><td colspan="5">COMPLEX Combination of two or more principal types of movement</td></tr>
</table>

Table 3: District-wise distribution of landslide Susceptible Zonation

Sl No	District	District total Area in sq. km*	Landslide Susceptible Zone			(A+B+C) Area in sq. km*	Percentage
			Low (A)	Moderate (B)	High (C)		
1	Uttara Kannada	10,291	6413.8	1664.6	311.8	8390.3	81.53
2	Shivamogga	8,495	4033.1	705.7	59.1	4797.9	56.48
3	Dakshina Kannada	4,866	3767.3	704.7	146.6	4618.6	94.9
4	Chikkamagaluru	7,201	3481.1	952.5	203.8	4637.4	64.40
5	Kodagu	4,102	3008.1	671.7	277.6	3957.4	96.47
6	Udupi	3,582	1592.4	404.6	84.8	2081.7	58.11
7	Hassan	6,814	1216.7	165.1	53.6	1435.4	21.0
8	Belagavi	13,415	1169.9	116.2	26.3	1312.4	9.78
Total Area in sq.km		**58,766.0**	**24,682.2**	**5,385.0**	**1,163.8**	**31,231.0**	**482.67**

*** Source:** Geological Survey of India, Government of India

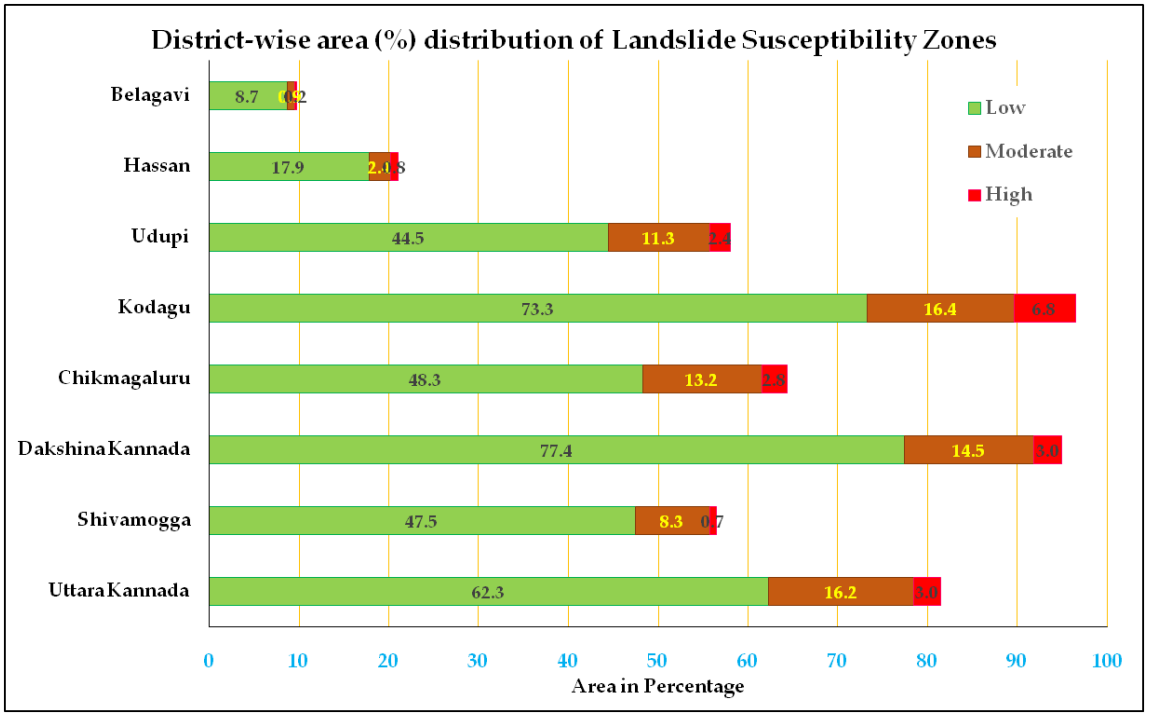


*** Source:** Geological Survey of India, Government of India

Table 4: District-wise area in % distribution of landslide Susceptible Zonation

S. No	Susceptibility	Landslide Susceptibility in %		
		Low	Moderate	High
1	Uttara Kannada	62.3	16.2	3.0
2	Shivamogga	47.5	8.3	0.7
3	Dakshina Kannada	77.4	14.5	3.0
4	Chikkamagaluru	48.3	13.2	2.8
5	Kodagu	73.3	16.4	6.8
6	Udupi	44.5	11.3	2.4
7	Hassan	17.9	2.4	0.8
8	Belagavi	8.7	0.9	0.2
Total %		**379.9**	**83.2**	**19.7**

*** Source:** Geological Survey of India, GoI



*** Source:** Geological Survey of India, GoI

CAUSES OF LANDSLIDES IN KARNATAKA

There are three primary causes of landslides: geological, morphological and human-caused. Sometimes, landslides are caused by a combination of three factors, or worse. According to a detailed study conducted in

Karnataka by Geological Survey of India (GSI), Government of India, geo-scientific causes for most of the landslides are known to be some of the most common causes that act as trigger factors for landslides in Karnataka.

i. High intensity/prolonged rainfall
ii. Modification/Cut of natural slopes
iii. Anthropogenic Activity
iv. Toe erosion by stream and removal of toe support
v. Dump on the head part
vi. The rise in hydraulic head due to increase in sub-surface water flow saturated the slope forming material.
vii. Increase in pore water pressure, due to rain
viii. Reduction of strength on normal/super saturation
ix. Presence of weak slope forming material saturated during the incessant rainfall.
x. Weathered jointed rock; slope disturbance
xi. Flash flood due to construction of temporary dam in Nala
xii. Blockage of natural rivers
xiii. Geographical causes (geographical ridges/structures)

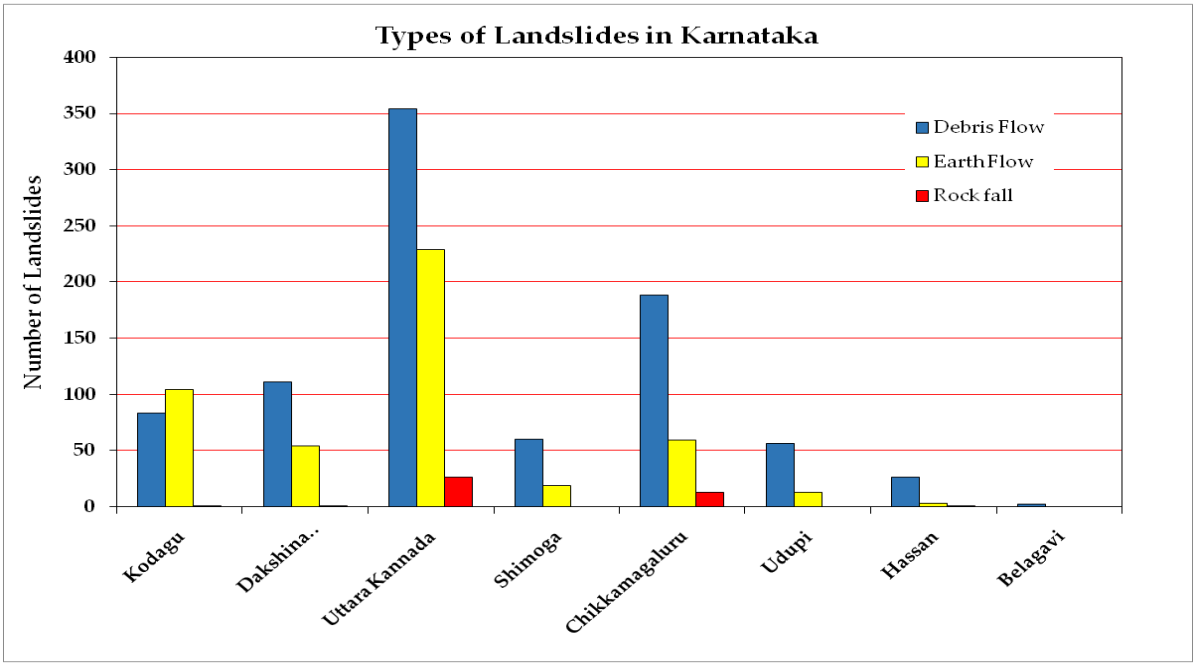
The above said geo-scientific causes may differ from location to location due to its slope, aspect, soil, geology, geomorphology, geological structures, river/drainage system network, lulc and rainfall.

CLASSIFICATION OF LANDSLIDES IN KARNATAKA

Karnataka had experienced three types of landslides viz., Debris flow, Earth flow and Rock fall. District wise classification of landslides are shown table.

Table 5: Types of Landslides occurred in Karnataka from 2006 to 2023

Sl. No	District	Debris Flow	Earth/Mud Flow	Rock fall
1	Kodagu	83	104	1
2	Dakshina Kannada	111	55	1
3	Uttara Kannada	354	229	27
4	Shimoga	60	19	0
5	Chikkamagaluru	188	59	13
6	Udupi	56	13	0
7	Hassan	26	3	1
8	Belagavi	2	0	0
Total		**880**	**482**	**43**



District wise Types of landslides

Majority of the landslide types are debris flow followed by earth/mud flow and rock fall. Uttara Kannada, Chikkamagalur and Dakshina Kannada districts recorded highest number of debris flow type of landslides.

Earth/Mud Flow type of landslides are second highest numbers occurred in Uttara Kannada, Kodagu, Chikkamagalur and Dakshina Kannada districts.

Rock falls type of landslides are lowest numbers occurred in Uttara

Kannada and Chikkamagalur districts. Remaining districts are recorded least number of rock falls.

LANDSLIDE ON NATIONAL HIGHWAYS

Unscientific slope cutting,lack of disaster resilient planning,widening of National Highways in Karnataka is an important developmental project. The highway passes through Coastal (Dakshina Kannada, Uttara Kannada and Udupi) and Malnad (Kodagu, Hassan, Chikkamagalur and Shivamogga) districts are frequently affected by landslides at various places. The landslide occurred information on different National Highways from 2006 to 2024 are shown below.

Sl No	National Highway	Stretch	Landslide Numbers
1	NH- 66	Mangalore to Goa	61
2	NH-75	Mangalore to Hassan	23
3	NH-73	Mangalore to Mudigere	98
4	NH-169	Mangalore to Shivamogga	30
5	NH-69	Honnavara to Shivamogga	56
6	NH-52	Ankola to Yellapur	19
7	NH-275	Mangalore to Madikeri	82

The landslide incidence at Shiradi Ghat, Doddathappale village in Heggade, NH-75 Hassan district occurred on 16th July 2024 and had subsequent reactivations till 31st July 2024. The location of the event is at the Chainage number 234.700 (12.897142°N and 75.732455°E) of National Highway-75. The landslide is characterized as a debris flow having an approximate length of 80m, Width of 90m, and Height of 40m.

This event obstructed the arterial communication corridor National Highway 75 connecting Bangalore and Mangalore route. District

administration taken immediate action to clear entire debris occurred by mudslide within two days.

RAINFALL - A TRIGGERING FACTOR FOR LANDSLIDES IN KARNATAKA

- The landslides which are occurring in the State are being triggered by a sporadic high intensity rainfall as captured by the high density Telemetric Rain Gauge stations established by KSNDMC in Karnataka. The comparatively higher rainfall is the factor which is saturating the soil column and becoming sufficient enough to trigger landslides
- This is mainly due to the fact that groundwater conditions are responsible for slope failures and are related to rainfall through infiltration, evapotranspiration, soil characteristics, antecedent moisture content and rainfall history. The rapid increase in rainfall intensity results in a sharp break in the slope of the rainfall cumulative curve
- A rainfall threshold value is the minimum or maximum level of some quantity of rainfall needed for a process to take place or a state to change. A minimum threshold defines the lowest level below which a process does not occur, while a maximum threshold represents the level, above which a 100% process always occurs, whenever the threshold is exceeded
- For rainfall-induced slope failures, a threshold may represent the minimum intensity or duration of rain, the minimum level of pore water pressure, the slope angle, the reduction of shear strength or the displacement required for a landslide to take place. The most commonly investigated rainfall parameters are: (i) Total (cumulative) rainfall; (ii) Antecedent rainfall; (iii) Rainfall intensity, and (iv)

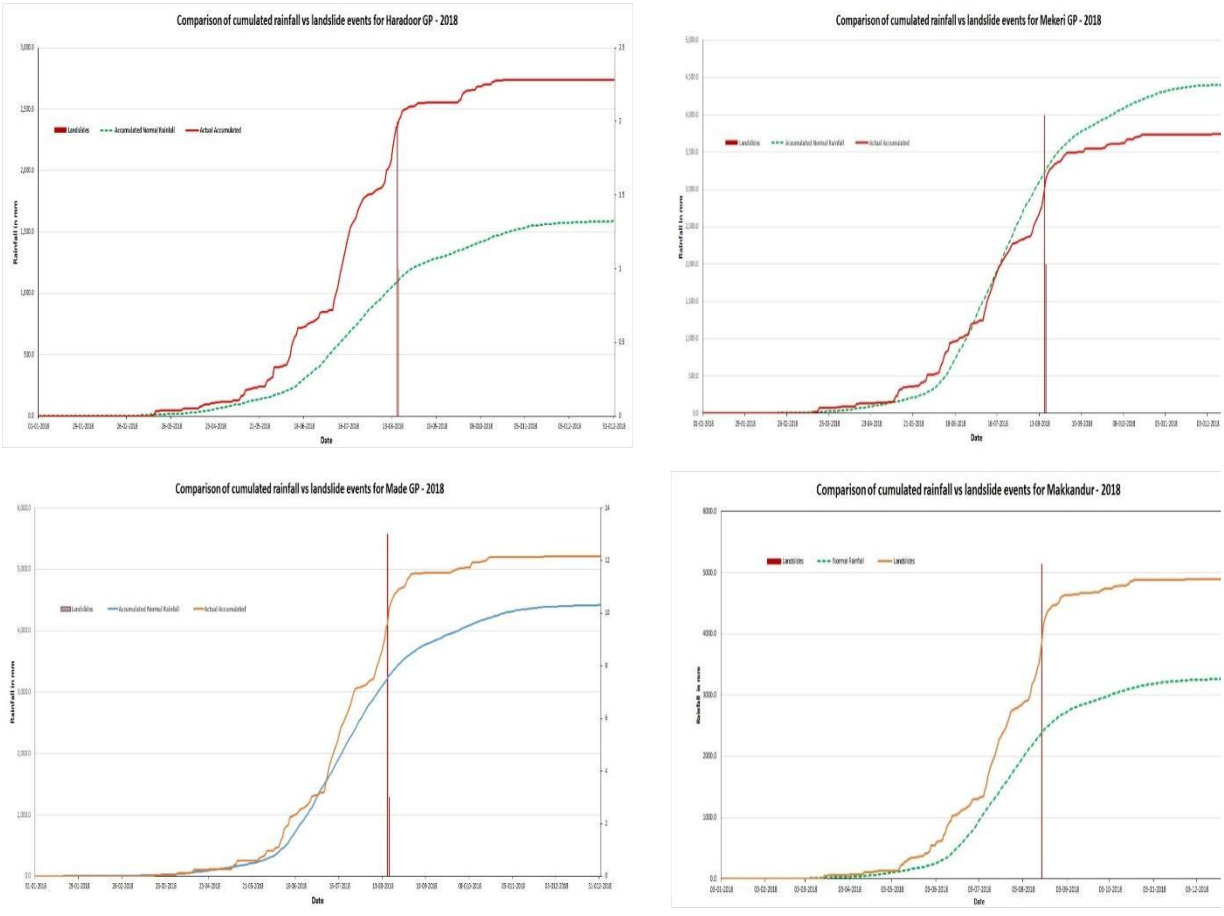
Rainfall duration

- Higher rainfall will lead to landslides, however, there exists a lot of variability in terms of exact amount of rainfall, time of the rainfall-at the beginning of rainy season or later part of rainy season, size of the slide and underlying geological and geotechnical factors. In simplistic term, the critical rainfall is the rainfall measured from the beginning of the event, i.e., from the time when rainfall intensity increases sharply, to the time of the occurrence of the landslide.

Table 6: Year-wise Rainfall threshold for landslides in Karnataka

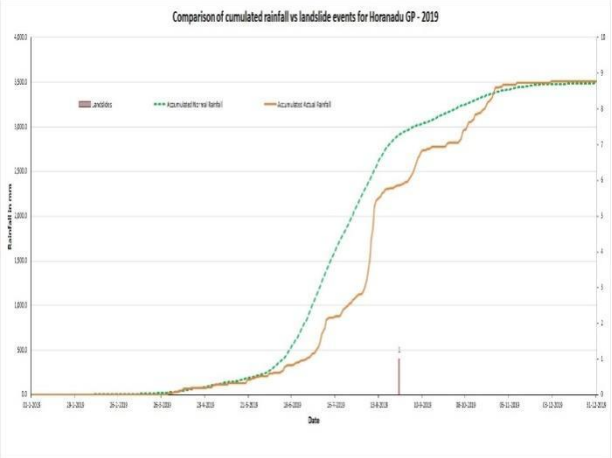
Sl. No.	Year	Duration of Rainy Days	Rainfall limit (mm)			% Dep
			Min	Max	Avg.	
1	2018	08-08-2018 to 17-08-2018 ***(10 Days)***	534	1234	884	(+) 289 %
2	2019	01-08-2019 to 13-08-2019 ***(13 days)***	630	1794	1212	(+) 316 %
3	2020	04-08-2020 to 08-08-2020 ***(6 days)***	258	821	539.5	(+) 201 %
4	2021	21-07-2021 to 26-07-2021 ***(6 days)***	72	824	448	(+) 83.5 %
5	2022	26-08-2022 to 31-08-2022 ***(6 days)***	12	326	169	(+) 19 %
6	2023	01-07-2023 to 16-07-2024 (***16 days***)	14	174	92	(+) 68 %
7	2024	**July and August**	12	319	172	(+) 112 %

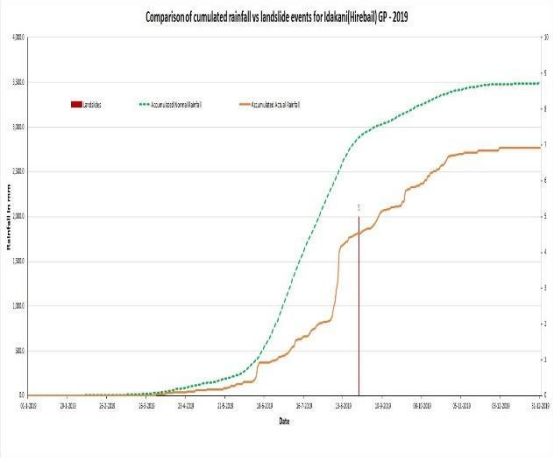
During the years 2018 to 2022, sustained rainfall of 6 to 13 days duration was received, wherein soil saturation levels were crossed in certain gram panchayats before landslide events. The observed variability of rainfall in specific gram panchayats, correlation with rainfall and number of landslide events indicates that landslides are influenced by incessant rainfall, land use pattern, soil stability, management of drainage network system, scientific slope modifications etc.

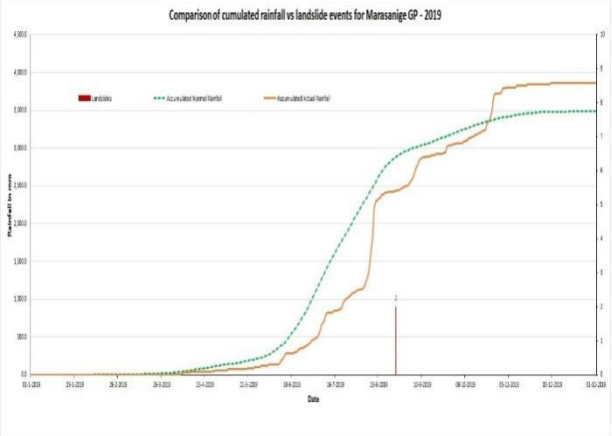


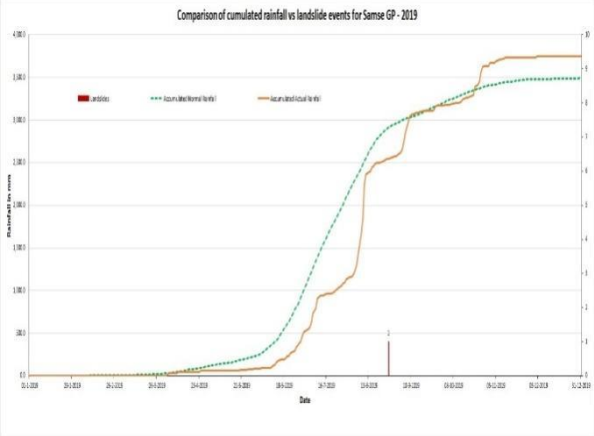
Comparison of Normal vs Actual rainfall with landslide events in Kodagu for 2018

Based on the above graphs, the incessant rain received for the duration 08-08-2018 to 17-08-2018 (10 Days) in landslide occurred Gramapanchayts received 534 mm to 1234 mm.



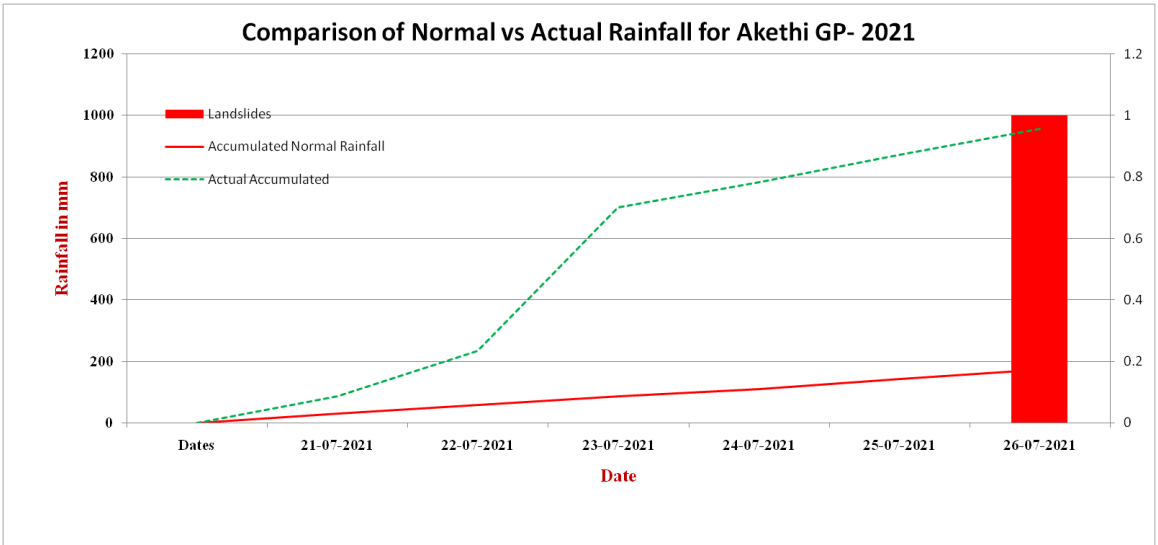






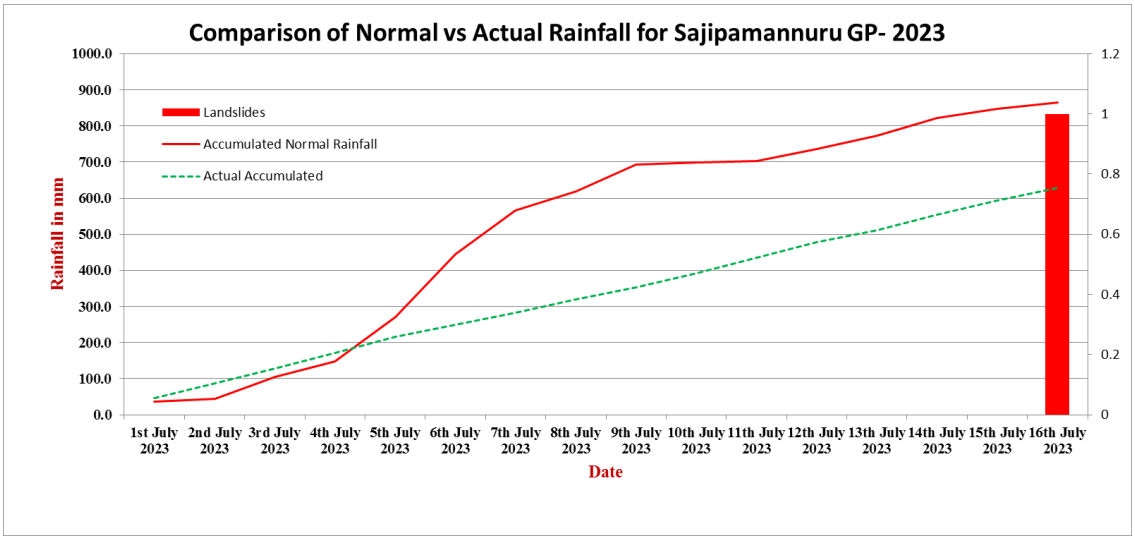
Comparison of Normal vs Actual rainfall with landslide events in Chikkamagalur for 2019

Based on the above graphs, the incessant rain received for the duration in 2019 is 01-08-19 to 13-08-2019 (13 days) received 630 mm to 1794 mm.



Comparison of Normal vs Actual rainfall with landslide events in Uttara Kannada for 2021

Based on the above graphs, the incessant rain received for the duration 21-07-2021 to 26-08-2021 (6 days) received 72 mm to 823.7 mm.



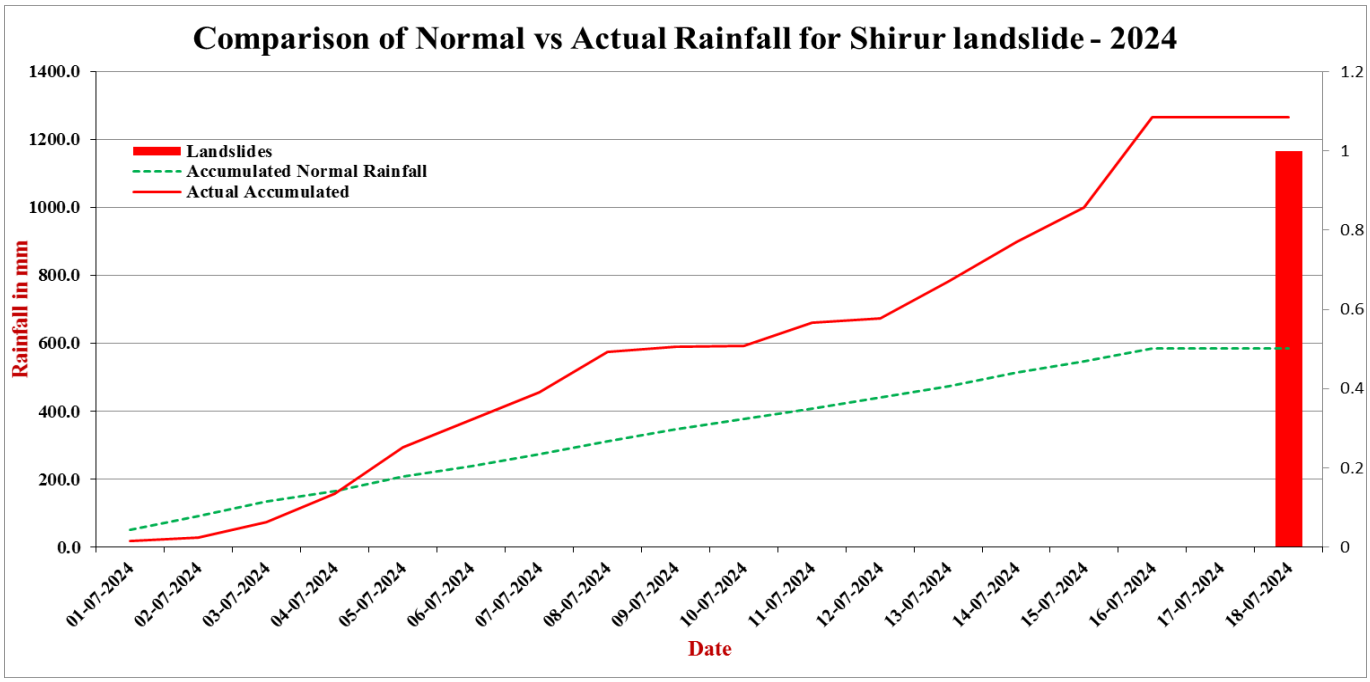
Comparison of Normal vs Actual rainfall with landslide event in Dakshina Kannada for 2023

Based on the above graphs, the incessant rain received for the duration 01-07-2023 to 16-07-2023 (16 Days) in landslide occurred Gramapanchayths received 7 mm to 174 mm.

During July 2024, Coastal Karnataka as a whole recorded an **actual**

amount of 1817 mm of rainfall as against the **normal rainfall of 1142 mm** with a percentage departure from normal being **(+) 59 % (Excess Category).** During **July 2024 Coastal Karnataka Region Rainfall is the 3rd Highest Recorded Rainfall since 1901 (last 124 years). 1st highest in 1908 –1977mmand2ndHighestin1961–1818 mm.**

During July 2024, Malnad Karnataka as a whole recorded an **actual amount of 985 mm** of rainfall as against the **normal rainfall of 591mm** with a percentage departure from normal being **(+) 67% (Large Excess Category).** During **July 2024 Malnad Karnataka Region Rainfall is the 4th Highest Recorded Rainfall since 1901** (last124 years). 1st highest in 1924–1195 mm, 2nd Highest in 1923–1157mm, 3rd Highest in 1961– 1124 mm.



Comparison of Normal vs Actual rainfall with landslide event in Shirur, Ankola for 2024

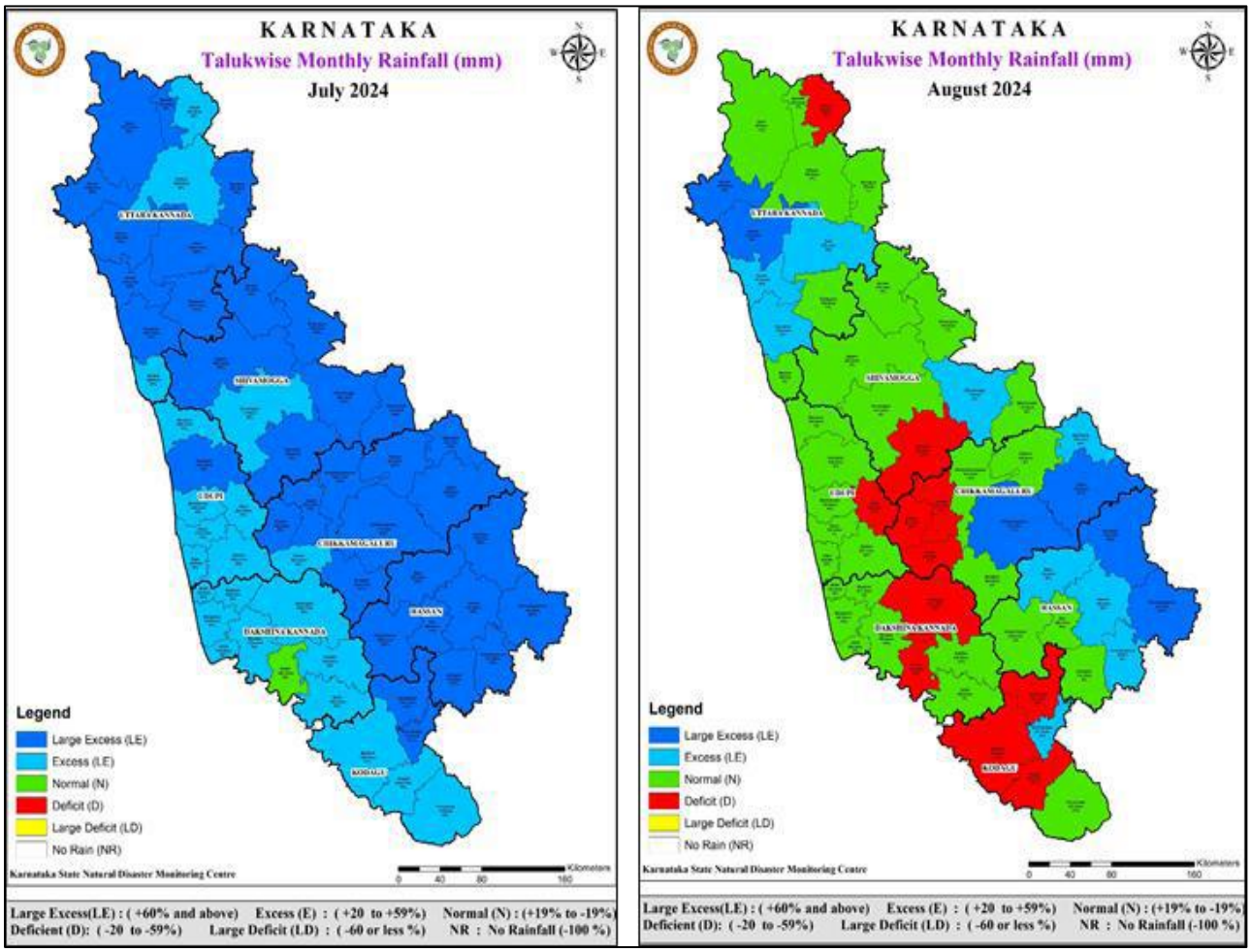
Based on the above graphs, the incessant rain received for the duration 01-07-2024 to 16-07-2024 (16 Days) in Shirur leads to landslide occurred received 10 mm to 267 mm.

From 2018 to 2024, the incessant rain received from 6 to 13 days of duration, whereas the saturation level is crossed in the particular Grama panchayaths before the landslide events.

Table 7: District-wise Rainfall Pattern during July and August 2024

Sl. No.	District	July 2024			August 2024		
		Normal (mm)	**Actual (mm)**	**%DEP**	**Normal (mm)**	**Actual (mm)**	**%DEP**
Malnad Region		**591**	**985**	**67**	**423**	**332**	**-21**
1	Shivamogga	765	1241	**62**	555	405	**-27**
2	Hassan	257	536	**109**	195	199	**2**
3	Chikkamagaluru	551	937	**70**	399	319	**-20**
4	Kodagu	859	1284	**49**	572	427	**-25**
Coastal Region		**1142**	**1817**	**59**	**823**	**794**	**-4**
1	Dakshina Kannada	1232	1685	**37**	892	785	**-12**
2	Udupi	1448	2049	**41**	1064	910	**-14**
3	Uttara Kannada	993	1798	**81**	707	758	**7**
During July 2024 all the 7 districts in coastal and Malnad districts received excess and large Excess Rainfall							

Taluk wise Rainfall Pattern map for July and August 2024 given below:



MAJOR LANDSLIDES IN KARNATAKA STATE

The first noted landslide occurred in Karnataka on 04 July 2006 at midnight in Madikeri town (12° 24' 46.60" N, 75°44'38.01" E), resulting in a massive debris slide along with two houses, killing six people. In this incident, one house was washed away and another house was partially damaged. The incident took place on the 120 m high hill slope on Moornadu road, 3 km from Madikeri town.

The second noted landslide occurred in Karnataka on 2ndOctober 2009 at Jariwada village in Kadawada village, northeast of Karwar in Uttara Kannada district, where 8 to 9 houses were washed away by mudslides, killing 19 people.

During 2018, parts of hilly and coastal Karnataka experienced flash floods and landslides/mud flows due to heavy rainfall causing damage to agriculture/horticulture/high value garden crops, damage to public infrastructure and multiple houses and rendering many families homeless.

On 13 August 2019, a landslide occurred in Thora village of Kodagu district, where 9 houses were damaged by mud flow and 10 people were killed.

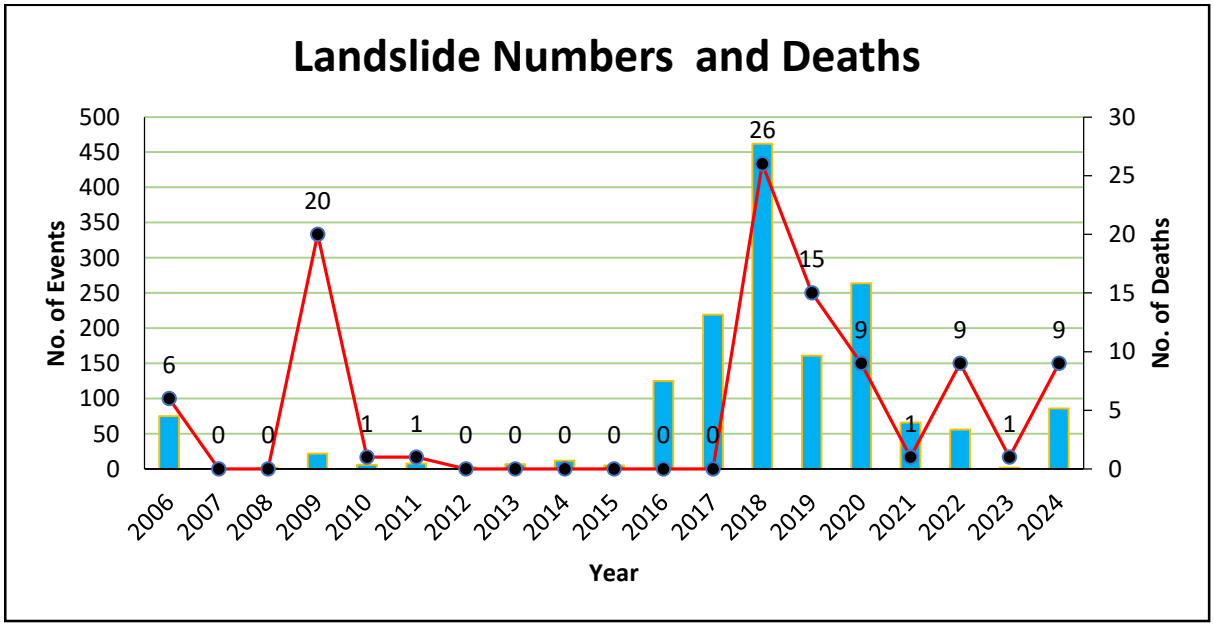
During the first fortnight of August, 2020, some parts of the coast, highlands and northern hinterland recorded very high and exceptionally heavy rainfall. High rainfall areas in the hill districts of Kodagu, Chikkamagaluru, Shimoga and Hassan recorded more than 500% of normal rainfall. Landslides occurred in ghat areas of Kodagu, Chikkamagaluru, Hassan and Dakshina Kannada districts due to heavy rains caused deaths.

Parts of Coastal, Malnad and North Interior Karnataka of the State received incessant torrential rainfall during 21st to 26th July 2021 triggering landslides in Uttara Kannada, Chikkamagaluru, Kodagu and Shivamogga districts. Certain places in Uttara Kannada received 400 mm to 500 mm extremely heavy rainfall in a span of 24 hours, such extreme rainfall events are comparable to the typical rainfall dumped by tropical cyclones during landfall. Subsequently, rainfall, though with less intensity compared to the July 22nd rainfall, continued for 23rd and 24th July 2021.

The first spell of incessant high-intensity rainfall was during the first and second week of July 2022. The State, particularly the Coastal and Malnad districts, recorded incessant high intensity rainfall. The rainfall activity was so vigorous that in a span of 8 days, the deficit rainfall during June was

compensated, and State as a whole recorded + 8% more than the normal. From 4th to 18th July 2022, State received 107 % of Excess rainfall than normal, and districts received Large Excess rainfall. Few stations in Coastal and Malnad have recorded more than 2000 mm of rainfall, and some even recorded more than 400 mm of rainfall in 24hrs.

During the month of July 2024, Coastal and Malnad districts received incessant and high intensity rainfall which leads to record heavy to very heavy rainfall. During 2024, National Highway–69 of Sagara to Honnavara stretch is occurred 01 number of landslide, National Highway–75 of Bangalore to Mangalore stretch is occurred 9 numbers of landslides and National Highway – 66 of Mangalore to Karwar stretch is occurred 25 numbers of landslides. Out of which National Highway–66 in Shiruru village (14°36'12.44"N, 74°22'34.31"E) Ankola Taluk, Uttara Kannada district occurred major extremely rapid, deep rotational debris flow event caused 9 deaths (2 still missing) on 08:00 am of 16.07.2024.



Comparison of Number of landslides and Deaths

Uttara Kannada, Chikkamagaluru, Kodagu and Dakshina Kannada districts have recorded highest numbers of landslides. Wherein, Kodagu, Uttara Kannada and Dakshina Kannada districts are recorded highest numbers of deaths. District-wise number of landslides and deaths are provided in the following table 8:

Table 8: District wise landslide events and deaths -2006 onwards

Sl No	District	No. of Landslides	No. of Deaths	Year of human loss
1	Belagavi	2	0	
2	Chikmagalur	260	0	
3	Dakshina Kannada	166	11	2009, 2020, 2022
4	Hassan	30	0	
5	Kodagu	188	53	2006, 2011, 2018, 2019, 2020
6	Shimoga	79	0	
7	Udupi	69	0	
8	Uttara Kannada	609	34	2009, 2010, 2021, 2022, 2024
Total		**1403**	**98**	

Table 9: Deaths by Landslides in Karnataka

Sl No	District	Taluk	Location	Year	Death
1	Kodagu	Madikeri	Kalakeri Nidugane	2006	6
2	Uttara Kannada	Karwar	Kadwad	2009	19
3	Dakshina Kannada	Belthangady	Ujire	2009	1
4	Uttara Kannada	Karwar	Near Karwar	2010	1
5	Kodagu	Madikeri	Kalakeri Nidugane	2011	1
6	Kodagu	Madikeri	Madikeri & Somvarpet	2018	26
7	Kodagu	Virajpete	Thora	2019	10
8	Kodagu	Madikeri	Korangala	2019	5
9	Dakshina Kannada	Mangalore	Gurpur	2020	2
10	Kodagu	Madikeri	Bhramagiri	2020	5
11	Dakshin Kannada	Mudubidare	Kallamundkuru	2020	2
12	Uttara Kannada	Yellapura	Kalache	2021	1
13	Uttara Kannada	Bhatkal	Muttalli	2022	4
14	Dakshina Kannada	Kadaba	Subramanya	2022	2
15	Dakshina Kannada	Bantwal	Near Panjikallu Village (Mukkuda)	2022	3
16	Dakshina Kannada	Bantwal	Sajipamunnur	2023	1
17	Uttara Kannada	Ankola	Shirur	2024	9 (2 missing)
18	Udupi	Byndoor	Kollur	2024	1

WEATHER FORECAST SYSTEM IN KARNATAKA

Karnataka State Natural Disaster Monitoring Centre (KSNDMC), an Autonomous body affiliated to Revenue Department (Disaster Management) is the nodal agency to monitor Natural Disasters in Karnataka. In view of this KSNDMC is installed the following network of sensors across the state to monitor Natural Disasters.

Weather Forecast at high Spatial & Temporal Resolution is a pre-requisite for planning and executing Risk reduction program with respect to Hydro-Meteorological Disasters. KSNDMC has been collaborating with Space Application Centre, Ahmadabad and providing Grama Panchayath level Rainfall & Weather forecast at 12, 24, 36, 48, 60 and 72 hrs formats for Karnataka.

Table 10: Sensors installed to monitor natural disasters in Karnataka

Sl No	Type of Sensors	Numbers
1	Telemetric Rain Gauges (TRG's)Network	6500
2	Telemetric Weather Station (TWS)	926
3	Lightning & Thunderstorm Sensors	11
4	Seismic Monitoring Observatories	14
5	Water Level Sensors	182
6	Reservoir Water level & Stream Gauge water level Sensors	9 &12

The observational 15 minutes data collected through KSNDMC's Weather Stations Network is ingested in to the SAC model. The Initiative, first of its kind in the Country, is appreciated by the farmers. Equal Spatial Resolution of Weather Forecast & Monitoring Network is a unique feature and advantageous for validating the Weather Forecast. The Observational data is used to validate the Weather Forecast and the result is incorporated in the Model to improve the output dynamically. This forecasted information will

be effectively used for evacuate community during severe weather instances in terms of intensity, time, and geographical span.

EARLY WARNING

Early warning thresholds for well-studied seasonal (repetitive) rain-induced landslides on discrete boundaries hears with known pore pressure variations on the landslide boundaries are the most reliable. Since the inter-relationship between rainfall intensity, slope surface and sub-slope movements, and pore pressures provide a powerful means for reliable landslide forecasting, studies regarding this will be encouraged. Rainfall and the associated slope behavioral information will be utilized for developing indicators for landslide alerts, especially for high landslide hazard areas known to succumb to cloud bursts and high intensity short duration rainfall. In cases where no such information is available, a warning of a general nature and low reliability may still be possible through the study of rainfall records in the backdrop of the previous landslide history.

Landslide Early Warning System (LEWS) vary based on the geographical areas they cover. Systems addressing a single landslide on a specific slope are referred to as local or slope-scale LEWS, whereas systems dealing with the possible occurrence of multiple landslides over a wider geographical area are referred to as territorial or regional LEWS.

INFORMATION DISSEMINATION MECHANISM AT KSNDMC

Information Dissemination plays an important role in disaster risk reduction. KSNDMC has employed various Dissemination systems to send Disaster-related information through Alerts, Advisories and Early Warnings to all the Government Executives & Communities at Real time.

High Spatial and Temporal resolution data thus collected from the ground on various parameters are being converted into information. Subsequently,

in conjunction with the weather forecast, the meteorological information is used to generate customized weather Advisories and disseminated to the users. This has enabled the stakeholders at all levels to take appropriate decisions at right time. Providing early warnings about possible extreme weather condition, Weather forecast at high spatial and temporal resolution helps the end-users to plan and implement appropriate measures to minimize the adverse impact of extreme weather condition.

The Information Dissemination activities undertaken through: 24X7 Varuna Mitra, DEWS, CAP, SMS, E-mail, WhatsApp, Real time weather dashboards, Dynamic websites, Social Media, Media etc;

Information Dissemination through Help-Desk –VarunaMitra

To disseminate the Agro-Met information, forecast and advisories directly to the farmers, a 24x7 Interactive Help Desk "Varuna Mitra" has been functioning in Karnataka at KSNDMC. It is a common experience that required precise information about the weather is not available, on real/near real time, to the community and response players. It takes longtime to obtain the data and lot more time to integrate and generate information/reports/advisories.

Disaster Early Warning System (DEWS)

KSNDMC has developed a unique integrated public alert and warning system called Disaster Early Warning System (DEWS) to disseminate early warnings to the potentially vulnerable panchayaths effectively.

Common Alerting Protocol (CAP)

National Disaster Management Authority (NDMA) has envisaged a Common Alerting Protocol (CAP) Integrated Alert System for Disaster Management to warnthe Indian public of emergencies and disasters and to address the measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with threatening disaster

situations or disasters.

Through CAP, Alert Generating Agencies (AGAs) such as CWC, IMD, INCOIS, FSI & DGRE along with State Disaster Management Authorities (SDMAs) will issue weather–related alerts in the form of SMS, Web browser, Mobile App, and recently added GAGAN and NAVIC medias to the general public in both English and regional languages.

NDMA has collaborated with Union Ministry of Telecommunication and the Centre for Development of Telematics(C-DoT). SMS alerts are geo-tagged and sent only to defined area.

In Karnataka State; whenever there is any warning/alert drafted by IMD–Bengaluru or any Alert Generating Agency(AGA), that particular warning will be pushed to SDMA to disseminate to the define area.

LANDSLIDE EARLYWARNING BULLETINS BY KSNDMC & GSI

Landslide Bulletin by KSNDMC

Rainfall-induced landslide forecasts/bulletins consist of the spatial and/or temporal prediction of the likelihood or probability of slope failure occurrence. Forecasting is a key part of LEWS, falling under the monitoring and warning component. KSNDMC is initiated issuing Rainfall Induced Landslide Forecast Bulletin for the Vulnerable Areas which are falling mainly over Coastal and Malnad Districts, Karnataka from August 2024 onwards on daily basis.

The ongoing active monsoon conditions have led to widespread heavy rains accompanied by high winds over the Coastal and Malnad districts. The rainfall has been very intense in the ghat areas, resulting in high levels of soil saturation, which increases the risk of slope failures and landslides.

Based on the historical landslide inventory and landslide susceptibility zones published by the Geological Survey of India(GSI), the combination of intense rainfall episodes is creating more susceptible conditions for landslide events. Areas experiencing continuous heavy to extremely heavy rainfall have been identified through the KSNDMC Telemetric Rain Gauge (TRG) network during July 2024, specifically in the Coastal (Uttara Kannada, Udupi, Dakshina Kannada) and Malnad districts (Shivamogga, Chikkamagaluru, Hassan, and Kodagu).

Using rainfall statistics, landslide-vulnerable Grama Panchayaths were identified and classified on a risk scale of high, moderate, and low for the month of July. Considering the prevailing conditions and the heavy rainfall forecast at the Grama Panchayath, the level of risk has been identified. The impact of landslide can be mitigated through preparedness. Based on the forecast risk of landslide vulnerability Grama Panchayaths are prepared and precautionary measures for landslides, including dos and don'ts, are provided to take immediate action.

LANDSLIDE BULLETIN BY GEOLOGICAL SURVEY OF INDIA

Geological Survey of India initiated issuing Experimental Regional Scale Rainfall Based Landslide bulletin internally on testing mode for Kodagu district. GSI has reported that landslide bulletins will be issued to all the stakeholders by 2025 monsoon. GSI has also been asked to issue bulletins for all landslide vulnerable districts in Karnataka.

KARNATAKA STATE LANDSLIDE RISK MANAGEMENT ACTION PLAN

By using the landslide database from 2006 to 2024, Karnataka State Disaster Management Authority and Karnataka State Natural Disaster Monitoring Centre jointly prepared the Karnataka State Landslide Risk Management

Action Plan and updating annually for the same.

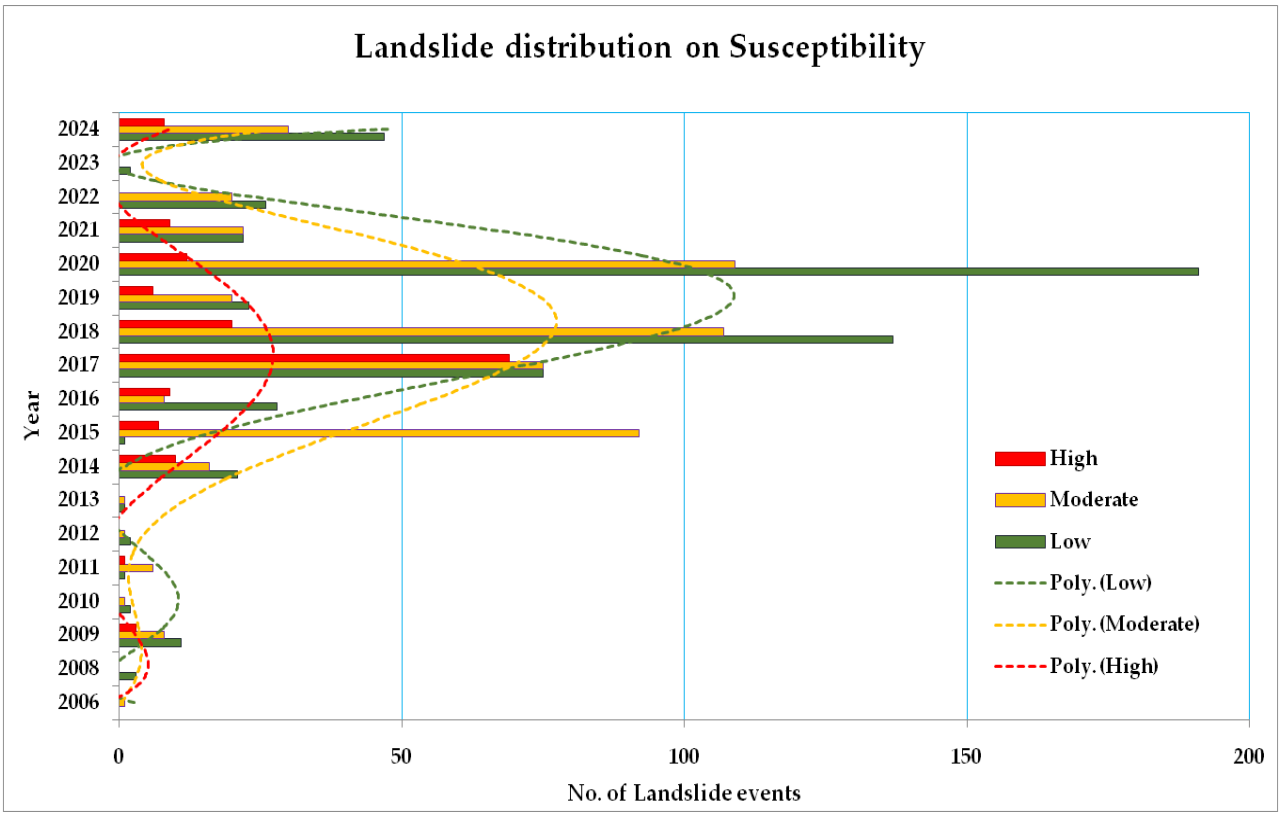
The action plan contains the following contents:

- Introduction
- Landslide Vulnerability in Karnataka
- Landslide Monitoring & Early Warning System (EWS)
- Need for Landslide Action Plan
- Prevention, Mitigation Strategies and Preparedness Measures
- Roles and Responsibility
- Financial Arrangements
- Plan Maintenance& Updation

Based on Geological survey of India, Indian Institute of Science, Karnataka State Natural Disaster Monitoring Centre, Department of Mines and Geology and District Administration data base is generated from 2006 to 2024 and this database is updated annually and used for effective implementation to mitigate the landslides over the State.

Table 11: Landslide distribution on landslide susceptibility

Sl. No.	Year	Landslide Susceptibility		
		Low	Moderate	High
1	2006	0	1	0
2	2008	3	0	0
3	2009	11	8	3
4	2010	2	1	0
5	2011	1	6	1
6	2012	2	1	0
7	2013	1	1	0
8	2014	21	16	10
9	2015	1	92	7
10	2016	28	8	9
11	2017	75	75	69
12	2018	137	107	20
13	2019	23	20	6
14	2020	191	109	12
15	2021	22	22	9
16	2022	26	20	0
17	2023	2	0	0
18	2024	48	30	8
Total		**732**	**517**	**154**



COLLABORATIVE STUDIES

Karnataka State Natural Disaster Monitoring Center (KSNDMC) is carrying out collaborative studies on landslide in Karnataka with the Geological Survey of India (GSI), National Institute of Rock Mechanics (NIRM) and Amritha Vishwa Vidapeetham. Broad scope of work on landslide studies with GSI, NIRM and Amritha Vishwa Vidapeetham organisations. The above said collaborative studies will be carried out under the World Bank funded of Karnataka Multi-sector Disaster & Climate Resilience Project (KMDCRP).

The Roles and Responsibilities for Disaster Management is delineated in the Disaster Management Act 2005.

A Cabinet Sub -Committee has been constituted under the Chairpersonship of the Honourable Revenue Minister,Government of Karnataka with four other Ministers to over see the responses of the State to disaster risk,relief and mitigation.

State Executive Committee (SEC): It is the primary responsibility of the State Government to respond to natural disasters and provide relief to the affected people. Section 22(2) (g) and (h) and Section 24 of the DM Act, 2005 stipulates that the SEC under the Chairmanship of State Chief Secretary coordinate response in the event of any threatening disaster situation or disaster.

Department of Revenue (Disaster Management) is the nodal department for disaster management and Principal Secretary, Revenue Department (Disaster Management) who is also the Relief Commissioner is the focal point in the command and control for disaster response at the State level and also to implement the decisions of the State level Response to natural disasters. Disaster response being a multi-agency function, other Departments of the State Governments provide emergency support in their relevant domains at the State/District levels.

District Level

District Disaster Management Authority (DDMA): Section 30(2) (xvi) of the DM Act, 2005 stipulates that the DDMA under the Chairmanship of Deputy Commissioner, shall coordinate response to any threatening disaster situation or disaster.

The lower administrative units of Districts viz; Sub-divisions under the administrative control of an Assistant Commissioner and Taluks under the administrative control of the Tahsildars will coordinate the functioning of the various departments in their respective jurisdiction.In Karnataka all DDMAs have been constituted and they meet atleast once a month and more frequently during disasters.

STATE EMERGENCY OPERATION CENTER (SEOC)

SEOC at MS Building, Bengaluru, are being maintained and runon 24x7 by Revenue department(DM).

The following tasks are being performed by the Control Room:

a. Receive disaster related information by Telephone, SMS, E-mails, whatsapp, and other means including websites of IMD, CWC, INCOIS, and other early warning agencies.
b. Dissemination of alerts and warning in coordination with KSNDMC to districts and concerned stakeholders and community.
c. Activation of SEOC during disaster and emergency situation.
d. Monitor on 24x7 basis disaster related situation at National, State and District level through Media, internet and reports received from various Government agencies. Control Room also monitors national and international news channels.
e. Prepare and share daily Situation Report with the concerned Authorities
f. Prepare special updates on occurrence of disaster like earthquake, cyclone, tsunami etc.
g. Dissemination of alerts and warning through CAP, various social media platforms, emails, etc in coordination with Karnataka State Natural Disaster Monitoring Center (KSNDMC).

DEOC

District Emergency Operation Center (DEOC) are the nodal centers in the district for disaster response and alert and warning dissemination. 28 DEOC operate 24/7.

Karnataka State Natural Disaster Monitoring Centre (KSNDMC)

Karnataka State Natural Disaster Monitoring Centre (KSNDMC), An

Autonomous body affiliated to Department of Revenue (Disaster Management) is the nodal agency for forecasting and dissemination of alerts and warning pertaining to natural disasters. KSNDMC provides high resolution forecast up to GP level.

Other proactive measures taken by the Government of Karnataka:

- As part of pre-monsoon preparedness, the State Government pre-deployed five well-equipped NDRF teams to vulnerable districts, namely Uttara Kannada, Dakshina Kannada, Kodagu, Belagavi, and Raichur. In addition, five State Disaster Response teams were stationed in each division, along with Fire and Emergency teams already positioned in districts and taluks. This pre-deployment was to ensure a swift response to any contingencies arising during the Southwest Monsoon.
- A detailed circular outlining preemptive measures to be taken before the onset of the monsoon, preventive actions during the Southwest Monsoon, and the roles and responsibilities of each department was issued on 04-05-2024.
- Furthermore, on 19-08-2024, a comprehensive circular was issued detailing proactive and preventive measures for District, Taluk, and Gram Panchayat (GP) administrations in the event of floods and landslides. This circular assigns responsibility for proactive evacuation at the local level. KSNDMC has developed a customized rainfall threshold warning system for landslide-prone areas.
- Gram Panchayat Task Forces are constituted in GPs vulnerable to landslide. Funds have been earmarked for each landslide-vulnerable GP to undertake preparedness measures.

Landslide Mitigation Projects in the Pipeline:

- Under the World Bank-funded Karnataka Water Security and Resilience Project (KWSRP), the Department of Economic Affairs, Government of India, approved the project on 28th February 2024. The primary goal of KWSRP is to enhance services and strengthen institutional and financial capacities to address water and climate stress across Karnataka. The program, set to be implemented over six years starting in 2025-26, will cover the entire state, with a special focus on Bengaluru. As part of this project, **a Landslide Early Warning System** is proposed in collaboration with Amrita Vishwa Vidyapeetham University, which has successfully deployed similar systems in the Northeast region and landslide-prone areas of Kerala. Under the Karnataka Water Security and Resilience Project (KWSRP), it is proposed to strengthen disaster risk governance by building the capacity of the Karnataka State Disaster Management Authority (KSDMA), District Disaster Management Authorities (DDMAs), and officials up to the Gram Panchayat (GP) level including the Ward Committees and the Grama Panchayat Task Forces. Additionally, the establishment of a State Institute of Disaster Management is proposed to enhance capacity building and research activities.
- MoU has also been signed with GSI on developing landslide early warning system in certain Coastal and Maland districts and as already state EWS bulletin will be implemented from Monsoon 2025.
- The Karnataka State Natural Disaster Monitoring Centre (KSNDMC) has shared Landslide Vulnerable Location data with district authorities. The broad abstract of landslide mitigation measures proposed by the districts are as below:

Sl No	District	Mitigation measures taken details
1	Kodagu	38 locations in Madikeri taluk, slope stabilization mitigations works are undertaken
2	Udupi	2 locations from Byndoor town and Kapu taluk slope stabilization mitigations works are undertaken
3	Hassan	Proposals under preparation
4	Dakshina Kannada	Proposals under preparation
5	Uttara Kannada	Proposals under preparation
6	Chikkamagalur	Proposals under preparation
7	Shivamogga	Proposals under preparation

District-wise proposals on mitigation measures to be taken up as suggested by Geological Survey of India (GSI) are shown in below:

The following landslide mitigation measures have been proposed by the District Commissioners of Coastal and Malnad districts are submitted the proposals with line estimates to Government of Karnataka on mitigation measures to be taken up as shown below.They are proposed to be taken up in a phased manner prioritizing such critical locations on the basis of density of population and usage through the State Disaster Mitigation Funds(SDMF),WB funds and the resources of the line departments.

Sl No	District	Proposed No. of locations to take Mitigation measures	Proposed amount in Lakhs.	Type of structural mitigation measures
1	Kodagu	115	4585.45	● Slope stabilization by construction of Retaining wall with weep holes ● Construction of Bridge ● Construction of Drain ● Culvert work ● Ditches ● Pitching ● Lined Drainage, ● Crash Barrier ● Shoulders ● Bench cuttings ● Debris removal
2	Udupi	15	1802.00	
3	Hassan	NHAI and Yettinahole Project will undertake the mitigation measures	Water Resources Department is working on mitigation measures	
4	Dakshina Kannada	261	7931.77	
5	Uttara Kannada	98	10198.918	
6	Chikkamagalur	223	9828.75	
7	Shivamogga	110	8125.08	
Total		**822**	**42, 471.968**	

Summary of department specific SOPs issued pertaining to landslide prevention and mitigation:

- **Rural Development and Panchayat Raj Department**:

  i. Gram Panchayat task force to identify landslide signs of cracks appearing on the surface, sliding, tilting and slumping downwards.

  ii. Removal of silt and obstacles accumulated in waterways/Channels/Drainage/bridges/culverts for easy flow of rainwater during monsoon season.

  iii. Create awareness on safety measures to be taken during heavy rain/floods and landslide.

  iv. Dissemination of weather alerts and warning to the last mile

  v. Proactive evacuation of vulnerable population to designated relief centre based on alerts issued by KSNDMC and IMD.

vi. Checking stability of schools, anganwadis, PHCs and other critical infrastructure.

vii. Regulating vehicular and people movement in landslide vulnerable areas.

- **Public Works Department (PWD)**:

i. Ensuring structural stability of bridges, roads, schools, PHCs and critical government buildings. Retrofitting of vulnerable structures.

ii. Prompt clearance of landslides, mud, rocks, and other debris caused by landslides during the monsoon season and taking all necessary precautionary measures to prevent loss of life and damages due to landslides and mud slips.

iii. Deploying concerned engineers and technical staff for public safety in landslide/flood-prone areas. Road safety and restoration measures are to be undertaken by Public Works Department.

iv. Coordinate with NHAI to closely monitor any signs of mudslips/landslide in National Highways. Take up short-term measures to prevent landslides in vulnerable stretches.

- **Urban Development Department:**

i. Checking stability of roads, bridges, schools, PHCs and other critical infrastructure.

ii. Create awareness on safety measures to be taken during heavy rain/floods and landslide.

iii. Dissemination of weather alerts and warning to the last mile

iv. Proactive evacuation of vulnerable population to designated relief centre based on alerts issued by KSNDMC and IMD.

v. Pre-deployment of disaster response teams to vulnerable locations.

vi. Regulating vehicular movement and people movement in vulnerable areas during high alert period.

vii. Removal of silt and obstacles accumulated in waterways/Channels/Drainage/bridges/culverts for easy flow of rainwater during monsoon season.

- **School Education and Literacy Department**:

i. Taking necessary action to repair school buildings and water leaking during heavy rain/flooding conditions. Identify schools in landslide vulnerable areas and constantly monitor for any signs of cracks appearing on the surface, sliding, tilting and slumping downwards. Proactively evacuate schools children and relocate schools based on forecast.

ii. Demolition of dilapidated and old unused school rooms/buildings.

iii. Declare holiday for schools as per the direction of the Deputy Commissioners during the heavy rainfall (Red & Orange) alerts were issued.

iv. Precautionary measures are taken in flood/landslide-affected areas.

- **Women and Child Welfare Department**

i. Demolition of dilapidated and old unused school Anganwadi buildings and relocation if necessary. Repair of dilapidated Anganwadi buildings if necessary.

ii. Declare holiday for Anganwadi as per the direction of the Deputy Commissioner during the heavy rainfall (Red & Orange) alerts were issued as a precautionary measure in flood/landslide-prone areas.

iii. Evacuation of Anganwadi center and children to safer places during landslide/flood conditions

iv. Ensure the safety of pregnancy and age-old women and children during the monsoon season flood/landslide conditions

v. Dissemination of early warning received from IMD and KSNDMC.

- **Water Resources Department**:

i. Ensuring sufficient buffer in reservoirs as per rule curve for flood moderation.

ii. Real time exchange of inflows and outflows with concerned authorities. Alerting downstream areas of releases.

iii. Compliance to the Dam Safety Act 2021.

Landslide vulnerability of the State when compared to country: As per the prevailing guidelines on the constitution and administration of the National Disaster Mitigation Fund (NDMF) issued by the Ministry of Home Affairs on 28th February 2022, funds have been allocated under the National Disaster Response Fund for four priority areas. One of these areas is managing seismic and landslide risks in 10 hill states based on their vulnerability to landslides, with Rs. 750 crore earmarked for this purpose. The State wise allocation is as follows:

Allocation for Managing Seismic and Landslide risks in Hill States

(Rs. in crore)

Sl No	State	Annual Allocation	Total Allocation (2021-26)
1.	Himachal Pradesh	50	250
2.	Uttarakhand	50	250
3.	All North-Eastern State		250
	Total		**750**

The allocations are for high risk landslide vulnerable States. There is no allocation made to Karnataka. The above information is hence placed on record for this Hon'ble Tribunal's consideration. The Respondent will be duty bound to implement any orders passed by this Hon'ble Tribunal in the instant matter.

Principal Secretary
Department of Revenue (Disaster Management)

V RASHMI MAHESH, I.A.S.
Principal Secretary to the Government
Revenue Department
(DM, S&R and Social Security)

Filed by

Darpan KM
Standing Counsel
State of Karnataka

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