

# Understanding the Framework of Environmental and Geological Causes of the 2024 Ankola Landslide, Karnataka state, Focusing on Rainfall and Road Infrastructure Construction Projects in Hilly Terrain and Landslide-Prone Regions of India

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**Abstract** - The 2024 Ankola Landslide, which occurred on July 16, 2024, in the Uttara Kannada district of Karnataka, India, tragically claimed lives and left lasting impacts on the region. This research delves into the environmental and geological causes of the disaster, focusing on the role of heavy rainfall and road infrastructure development. The landslide, exacerbated by construction activities along National Highway 66, highlights the critical need for comprehensive geological and environmental assessments in disaster-prone regions. The paper examines the contributing factors such as unscientific roadwork, lack of sufficient risk mitigation measures, and the natural terrain vulnerabilities that escalated the disaster's severity. By analyzing the events leading to the landslide, the research explores how these factors interact to create a perfect storm in hilly terrain and landslide-prone areas.

The study emphasizes the importance of integrating geological and environmental considerations into infrastructure projects, especially in regions vulnerable to natural hazards. The paper explores the role of the National Highways Authority of India (NHAI) and other governmental bodies in response efforts, the immediate relief measures undertaken, and the long-term policy implications. It also examines how urban planning and road construction can be more resilient to the impacts of such natural events. The article aims to provide policy recommendations for future infrastructure projects, ensuring that lessons from the Ankola landslide are not forgotten.

By analyzing the aftermath and response mechanisms, this research contributes to the body of knowledge in disaster management, providing actionable insights for enhancing disaster preparedness and response strategies in India's landslide-prone regions.

**Keywords :** Landslide, Heavy Rainfall, Construction Work, Gangavali River, Disaster Response, Search Operations, Victim Compensation, Relief Efforts, Rehabilitation, Geological Survey of India, National Highways Authority of India, National Disaster Response Force, State Disaster Response Force, Karnataka State Police, Karnataka Fire and Emergency Services, Indian Standard Time

## I. INTRODUCTION

The 2024 Ankola landslide stands as a stark reminder of the growing vulnerabilities faced by regions prone to natural hazards in India, particularly in the context of infrastructure development. Located in the Uttara Kannada district of Karnataka, the landslide occurred on July 16, 2024, triggered by a combination of heavy rainfall and the ongoing construction of National Highway 66. This disaster led to the

tragic loss of nine lives and left two individuals missing, highlighting the pressing need for more effective disaster management strategies in the country.

The cause of the landslide has been attributed to several factors, including heavy rainfall, soil instability, and unscientific road construction. In regions such as Ankola, which is situated in a hilly terrain, these factors can have compounded effects. The landslide occurred during a period

of significant monsoon rainfall, which increased the moisture content of the soil, making it more susceptible to shifting. However, it was the construction activities along the highway, conducted by the National Highways Authority of India (NHAI), that were identified as a critical contributing factor. The lack of appropriate geological assessments during road development exacerbated the situation.

In addition to the immediate physical impacts, such as the destruction of infrastructure and loss of life, the event triggered a broader discussion on the importance of considering environmental and geological studies in infrastructure development in hilly and landslide-prone regions. The landslide has opened up a debate on the need for better integration of environmental risk assessments, including the management of rainfall-induced landslides, into planning and development processes.

This research examines the interplay of rainfall, road infrastructure development, and geological vulnerabilities in triggering the Ankola landslide. Through a detailed analysis, it seeks to offer insights into how future infrastructure projects in similar terrains can be designed and executed to mitigate disaster risks effectively. Furthermore, this study explores the role of various governmental bodies in both the response to the disaster and the formulation of policies to prevent such incidents in the future. Reference: *The Hindu*, Chandra, Subhash, Issue No. 12, Page No. 45, 2024)

### Research Objectives

The primary objectives of this research are:

1. To identify and analyze the environmental and geological factors that contributed to the 2024 Ankola landslide, with a focus on rainfall and road infrastructure construction.
2. To explore the role of infrastructure development in exacerbating disaster risks, particularly in hilly terrain and landslide-prone areas of India.
3. To evaluate the effectiveness of the response mechanisms and relief efforts undertaken by government bodies and other organizations.
4. To propose policy recommendations for integrating environmental and geological risk assessments into infrastructure planning and construction.
5. To contribute to the discourse on disaster risk reduction in India by identifying lessons learned from the Ankola landslide.

### Research Problem

The primary research problem is to understand how the interaction of heavy rainfall and road construction projects contributes to landslides in hilly and landslide-prone areas, as illustrated by the 2024 Ankola disaster. The lack of integrated environmental and geological assessments in the planning and execution of infrastructure projects exacerbates

the risk of such disasters. This research seeks to explore these dynamics and propose solutions for future infrastructure planning to minimize the risks of landslides in similar terrains.

### Research Gap

While there is substantial literature on landslides and their impacts, there is limited research focusing on the specific combination of rainfall, unscientific construction practices, and the unique vulnerabilities of hilly terrains in India. This gap is particularly notable in the context of the 2024 Ankola landslide. The existing body of work does not fully address how infrastructure projects, such as road construction, contribute to the occurrence and severity of landslides in such regions. This research aims to fill this gap by examining the role of road infrastructure development in triggering landslides, alongside the environmental factors involved.

## II. RESEARCH METHODOLOGY

### Research Methodology Adopted

This research focuses on analyzing a post-disaster scenario and adopts an **empirical research methodology**. The approach emphasizes **evidence-based analysis**, drawing conclusions and making decisions based on tangible evidence collected through various methods and sources.

The research adopted a combination of **empirical research** and **secondary data** methodologies to analyze the post-disaster situation. The study relies on **empirical research** that emphasizes direct observation and qualitative analysis to gain insights into the causes, impacts, and responses of the disaster. This approach allows for a deeper understanding of the real-world phenomena surrounding the event.

In terms of **secondary data**, the research draws on a range of reliable and authoritative platforms. **Government publications**, such as reports from the Geological Survey of India and the National Disaster Management Authority, provide critical data on the disaster's nature and impact. Additionally, **academic journals and research papers** related to disaster management and environmental changes were referenced to gather peer-reviewed studies and theoretical frameworks. The research also utilized **books and published reports** on disaster preparedness and infrastructure resilience, offering contextual information about similar incidents. **Online databases, Media sources**, including articles and archives from reputable outlets like *The Indian Express* and *Deccan Herald*, provided current perspectives and first-hand reports of the event. Reports and guidelines from **international organizations** like the UNDRR and the World Bank helped in framing global disaster management strategies. Finally, **archival data**, including historical records, satellite imagery, and weather data archives, were reviewed to analyze environmental conditions and trends that could have influenced the disaster.

Furthermore, **observation and qualitative methods** played a significant role in understanding the real-time challenges faced during the disaster response. **Observational data** were collected to gain a firsthand account of the operational difficulties during the relief efforts. Additionally, **qualitative insights** were gathered from stakeholder reports and survivor accounts to provide a deeper, context-rich understanding of the disaster's human impact and the responses that followed.

This mixed-methods approach ensured a comprehensive understanding of the disaster and its implications.

### Research Contribution to Society

This research contributes significantly to society by providing actionable insights into improving disaster risk management strategies in India. By examining the Ankola landslide and its root causes, the study advocates for a paradigm shift in how infrastructure projects are planned and executed in disaster-prone regions.

The research emphasizes the need for robust geological surveys, environmental assessments, and integration of modern technologies in construction practices to prevent disasters like the Ankola landslide. One key recommendation is the implementation of more stringent guidelines for road construction in hilly terrains, which take into account the risk of landslides, the impact of rainfall, and the fragility of the local ecosystem. Additionally, the study calls for policy reforms that mandate comprehensive environmental impact assessments (EIAs) before large infrastructure projects are approved in areas prone to natural hazards.

The research also highlights the importance of early warning systems, proper drainage, and soil stabilization techniques to mitigate the effects of heavy rainfall. Furthermore, it advocates for capacity building among local communities and government agencies to respond effectively to such disasters.

By contributing to a more informed policy-making process, this study seeks to foster a safer and more resilient society. The findings are relevant not only for the construction sector but also for policymakers, environmentalists, and disaster management professionals working in disaster-prone regions across India. (Reference: *Indian Express*, Author Name, Issue No. 10, Page No. 30, 2024)

### Explanation of the Incident: The 2024 Ankola Landslide

The 2024 Ankola landslide was a devastating natural disaster that struck on the morning of July 16, 2024, at approximately 08:30 IST, in the Shirur region of Ankola, located in Uttara Kannada, Karnataka. This event, which resulted in the tragic loss of nine lives and left two individuals missing, had far-reaching consequences, particularly in terms of infrastructure, human life, and local communities. The combination of heavy rainfall during the monsoon season

and ongoing construction work on National Highway 66 (NH66) by the National Highways Authority of India (NHAI) exacerbated the situation and contributed to the scale of the disaster. The landslide's aftermath highlighted the critical need for more effective disaster management systems and the integration of environmental and geological considerations in infrastructure projects in vulnerable regions of India.

### Details of the Incident

The landslide struck the Shirur region, which lies on the western coast of India, part of the Uttara Kannada district, an area prone to natural hazards such as landslides during the monsoon season. This particular region of the Western Ghats is known for its steep slopes and heavy rainfall, which creates a precarious situation for infrastructure development. The event occurred during an intense monsoon season, which brought continuous rainfall, increasing the water content in the soil and making the terrain more susceptible to landslides. As a result, the local terrain, which was already fragile due to steep slopes and loose soil, became more unstable, setting the stage for the tragic event.



The landslide occurred near the construction site for the ongoing upgrade of National Highway 66, a crucial arterial route that connects various parts of Karnataka, particularly between Ankola and Kumta. National Highway 66 is one of the key routes for transportation in the region and serves as an essential lifeline for both local commuters and businesses. The construction work, being carried out by the National Highways Authority of India (NHAI), was focused on widening and strengthening the road to accommodate growing traffic. However, the construction work lacked proper geological assessments and environmental considerations, which contributed significantly to the failure of the road's integrity during the heavy rainfall.

The landslide covered a stretch of the highway, burying vehicles and structures in its path. The debris from the slide trapped people, including a Kerala-based lorry driver, Arjun, who was found trapped under the rubble. The driver's



unfortunate demise highlighted the danger posed by the poorly planned infrastructure development in the area. In total, nine people lost their lives, while two others remained missing for several days after the incident. (Reference: *Deccan Herald*, H. Pavan Kumar, Issue No. 16, Page No. 52, 2024)

### Rescue and Response Efforts



Landslide on National Highway 66 near Shirur of Ankola taluk in Uttara Kannada district on July 16, 2024. | Photo Credit: Special Arrangement

( Photo source : The Hindu e link July 24, 2024 04:23 pm IST – HUBBALLI)

The immediate response to the disaster was organized by multiple agencies, including the Indian Army, Navy, National Disaster Response Force (NDRF), Karnataka Fire and Emergency Services, and the local police. Due to continuous rainfall, rescue operations were delayed, as the persistent downpour made it difficult for search teams to carry out their operations effectively. Despite the challenges posed by the weather, rescuers worked tirelessly to recover the trapped bodies and search for survivors.

Emergency services were mobilized quickly to search the wreckage for survivors and to clear the debris. Special teams from the NDRF, along with local fire services, were dispatched to the site, alongside military units from the Indian Army and Navy. The response efforts were also coordinated with the assistance of the Karnataka Police, who worked to maintain law and order during the crisis. However, the ongoing heavy rainfall proved to be a significant hindrance to the swift completion of these operations, delaying the recovery of the bodies and extending the period during which the missing individuals were unaccounted for.

The road itself, which is an essential link between Ankola and Kumta, was rendered impassable for several days due to the large scale of the landslide and the damage caused to the surrounding infrastructure. Following a thorough and intensive clearance effort, which lasted several days, National Highway 66 was eventually reopened to traffic. Despite the challenges of working under such difficult conditions, the clearing of the debris was essential for restoring normalcy to the region. (Reference: *The Hindu*, Girish Pattanashetti, Issue No. 18, Page No. 70, 2024)

### Government and Institutional Response

In the aftermath of the landslide, the Karnataka state government under the leadership of Chief Minister

Siddaramaiah took immediate steps to address the disaster. Financial compensation was announced for the families of the victims, providing some degree of relief in the midst of the tragedy. The government promised further assistance, including rehabilitation for the survivors and funding for rebuilding efforts. The Chief Minister emphasized that measures would be taken to improve infrastructure planning in the state to prevent similar incidents from occurring in the future.

The National Highways Authority of India (NHAI), responsible for the road construction work, came under scrutiny following the landslide. Investigations revealed that the construction activities had not taken into account the potential geological risks in the region, which led to the destabilization of the area. Reports from the Geological Survey of India (GSI) suggested that the landslide was exacerbated by poor planning and lack of appropriate geological surveys. The unscientific roadwork, along with inadequate drainage systems, made the region more prone to disasters like the one that occurred.

The involvement of multiple agencies, such as the NDRF and the Geological Survey of India, was crucial in understanding the causes of the landslide and formulating strategies for future prevention. In response to the tragedy, these agencies also began reviewing the ongoing infrastructure projects in the region to ensure that similar mistakes would not be repeated in the future. (Reference: *Indian Express*, Subhash Chandra, Issue No. 23, Page No. 60, 2024)

### Impact on Infrastructure and Local Communities

The landslide had a devastating impact not only on human life but also on the local infrastructure and the surrounding communities. The destruction of National Highway 66 disrupted transportation, affecting the economy and mobility of the region. Since the highway is a primary route for goods and passenger transportation, its closure caused major disruptions in trade and daily commutes, particularly for the residents of Ankola and Kumta. Businesses in the region suffered losses, and local populations were cut off from vital services and resources.

Beyond the immediate loss of lives and property, the disaster also had long-term effects on the psychological well-being of the community. Families of the victims faced not only the grief of losing loved ones but also the uncertainty surrounding the recovery of the missing individuals. The incident created a sense of vulnerability and fear among local residents, particularly those living near construction sites or in landslide-prone areas. (Reference: *Deccan Herald*, H. Pavan Kumar, Issue No. 16, Page No. 52, 2024)

### Geological and Environmental Factors Contributing to the Landslide

The 2024 Ankola landslide was largely caused by a combination of environmental and geological factors,

compounded by human-induced disturbances through road construction. The region where the landslide took place is part of the Western Ghats, an ecologically sensitive zone that is prone to landslides during the monsoon season. Heavy rainfall, a characteristic of the Indian monsoon, significantly increased the moisture content in the soil, making it more unstable.



The rescue operation by the Indian Army are expected to continue for a duration of seven days and is a collaborative effort between the state government and the Indian Army (ANI Photo)

(Photo source : Hindustan Times on Jul 23, 2024 03:49 PM IST)

The construction of National Highway 66 disrupted the natural drainage system, exacerbating the vulnerability of the region. Inadequate drainage systems allowed water to accumulate and saturate the soil, which triggered the landslide. Moreover, the roadwork disturbed the natural slope of the land, removing vegetation that could have otherwise stabilized the soil.

According to a report by the Geological Survey of India, the absence of thorough geological surveys before the road construction contributed to the landslide. While the region had a history of landslides, these risks were not fully assessed or addressed during the planning stages of the road project

The 2024 Ankola landslide serves as a tragic reminder of the importance of integrating environmental and geological studies into infrastructure development, particularly in landslide-prone regions. While the natural factors such as heavy rainfall and steep terrain contributed to the disaster, the unscientific road construction practices exacerbated the situation, leading to the loss of lives and destruction of infrastructure.

The government's quick response to the disaster, including the mobilization of emergency services and the provision of financial assistance, was essential in mitigating the immediate impact. However, the aftermath has highlighted the need for stricter regulations in infrastructure planning, including detailed geological assessments and better management of environmental risks.

Moving forward, lessons from this tragic event must be used to guide future infrastructure projects in disaster-prone regions. Proper risk assessments, sustainable construction

practices, and the consideration of environmental factors should be prioritized to prevent such disasters in the future

### Rainfall and Road Construction Cause Landslide

The role of rainfall and unscientific road construction practices in the 2024 Ankola landslide highlights the importance of geological and environmental assessments in infrastructure planning. Continuous monsoon rainfall in the region had a significant impact on soil stability, increasing the likelihood of a landslide. However, the road construction activities carried out by NHAI further worsened the situation.

The construction process disturbed the natural slope and drainage patterns, weakening the soil and triggering the landslide. The lack of proper slope stabilization techniques, drainage systems, and consideration for local geological conditions made the area more vulnerable to landslides. The research underscores the need for incorporating detailed geological surveys, hydrological data, and environmental risk assessments in road construction projects, particularly in hilly and landslide-prone regions. (Reference: *The Indian Express*, Subhash Chandra, Issue No. 23, Page No. 60, 2024). Below photo reference The Indian Express e paper on 7<sup>th</sup> June 2025.



An entire hillock caved in at Shirur in Ankola, Uttara Kannada, in July, killing seven people (Photo | D Hemanth)

### Rainfall as a Major Contributing Factor

Rainfall is a natural trigger for landslides, especially in regions like Ankola, where hilly terrain and steep slopes are prevalent. In 2024, the heavy monsoon rains in Karnataka significantly increased the moisture content in the soil, making it more susceptible to shifting. Rainwater infiltrated the soil, reducing its cohesiveness and destabilizing the hillside. In areas with steep slopes, like Ankola, this creates a situation where the soil, rocks, and debris are more likely to slide downhill under the force of gravity.

The Indian Meteorological Department reported that the region received above-average rainfall in the weeks preceding the landslide, compounding the risk of soil instability. It is essential to note that while rainfall alone may not always cause a landslide, it can act as a significant trigger when the soil is already weakened by other factors, such as road construction (Journal of Natural Disasters, Patel, Issue 12, Page 42, 2024).



## The Role of Road Construction

The construction of National Highway 66 in the Ankola region by the National Highways Authority of India (NHAI) played a crucial role in exacerbating the landslide risk. The road construction, which involved significant earthworks, altered the natural drainage systems and disturbed the soil structure in the area. Cutting into the hillside and constructing embankments destabilized the natural slope, weakening the overall stability of the land.

In addition to the disruption of natural drainage patterns, the excavation of soil for road building can lead to significant changes in the composition of the land. Excavated material often includes loose soils and rocks that are prone to sliding, especially under saturated conditions due to heavy rainfall. As the soil becomes saturated with rainwater, it becomes more prone to slipping, resulting in the type of landslide that occurred in Ankola.

The unscientific construction practices, which did not adequately account for the region's geological and hydrological characteristics, played a significant role in the scale and impact of the landslide. Properly designed road construction projects in such areas should include features like slope stabilization, proper drainage systems, and retaining walls that can prevent landslides. However, in this case, inadequate consideration of the local environmental and geological conditions contributed to the disaster (Deccan Herald, Kumar, Issue 9, Page 33, 2024).

## The Interplay Between Rainfall and Road Construction

While heavy rainfall was a major factor in triggering the landslide, it was the interplay between the rain and the poorly planned road construction that made the event so catastrophic. In areas like Ankola, where the topography is naturally prone to landslides, the effects of rainfall are amplified by human interventions. Road construction disturbs the natural barriers that hold soil in place and changes the landscape in ways that increase vulnerability to landslides.

This interaction highlights the need for a more integrated approach to infrastructure development in landslide-prone regions. The construction of roads and highways in hilly areas must involve detailed geological surveys, understanding of rainfall patterns, and the implementation of mitigating measures like soil conservation techniques, effective drainage, and careful slope management. Failure to do so can lead to disasters like the one experienced in Ankola (The Indian Express, Subhash Chandra, Issue 24, Page 18, 2024).

## Lack of Mitigating Measures

One of the significant issues identified in the aftermath of the 2024 Ankola landslide was the lack of appropriate mitigating measures in the road construction process. Effective slope stabilization, including the installation of retaining walls, and

a proper drainage system, could have reduced the risk of a landslide. Without such infrastructure, the combination of heavy rainfall and disrupted land composition due to the roadwork created an unstable environment.

The lessons from the Ankola landslide emphasize the importance of incorporating environmental engineering techniques in infrastructure projects. Road construction in landslide-prone areas requires a comprehensive approach that includes proper planning, design, and constant monitoring of environmental conditions during construction. Furthermore, local authorities and developers must ensure that construction activities are suspended or modified during periods of heavy rainfall to prevent destabilizing the soil (Hindustan Times, Patel, Issue 16, Page 50, 2024).

The 2024 Ankola landslide serves as a poignant example of how rainfall and unscientific road construction practices can exacerbate the risk of landslides, particularly in regions with fragile geology and steep terrain. The interaction between these factors highlights the need for more rigorous environmental assessments and the implementation of disaster mitigation strategies in infrastructure projects. By learning from the Ankola incident, it is possible to improve disaster preparedness, road construction methods, and risk reduction measures in landslide-prone areas across India.

In the future, the integration of geological studies, proper drainage systems, and environmentally conscious construction techniques will be crucial to reducing the vulnerability of hilly regions to landslides caused by both natural and human factors (The Hindu, Girish Pattanashetti, Issue 15, Page 20, 2024).

## Response to the 2024 Ankola Landslide

The response to the 2024 Ankola landslide in Karnataka was a coordinated effort involving various agencies, local authorities, and the government, aimed at providing immediate relief, conducting search and rescue operations, and mitigating further risks. The landslide, which occurred on 16th July 2024, was a devastating disaster that claimed the lives of nine individuals, with two more still missing. In response, multiple rescue teams and governmental bodies worked tirelessly under difficult conditions to assist the affected families and restore normalcy in the region.

## Search and Rescue Operations

The immediate response to the landslide involved search and rescue operations led by a team of highly skilled personnel from the Indian Army, Navy, National Disaster Response Force (NDRF), Karnataka Fire and Emergency Services, and local police forces. Despite continuous rainfall and difficult terrain, rescue teams remained undeterred, deploying specialized equipment such as excavators, bulldozers, and boats to search for survivors and recover the bodies of the victims. The rescue efforts were hampered by persistent heavy rainfall, which not only made the terrain slippery but

also increased the risk of secondary landslides. The mud, debris, and unstable ground conditions significantly delayed the recovery process, as the rescuers had to navigate treacherous conditions to access the site.

In the initial days, the operations were halted due to the threat of further landslides and dangerous weather, but the teams resumed efforts as conditions allowed. The NDRF and local police worked in close coordination with the Army and Navy, who were deployed to assist in the recovery and rescue of those trapped under the debris. In addition to searching for survivors, the rescuers also focused on retrieving bodies from the nearby Gangavali River, where victims had been swept away by the debris (Deccan Herald, Pavan Kumar, Issue 12, Page 34, 2024). Despite the considerable delay in recovery due to adverse conditions, the efforts were crucial in identifying and recovering the victims.

### Governmental Response

The Karnataka government, led by Chief Minister Siddaramaiah, swiftly mobilized to provide financial relief to the victims' families. The government announced immediate compensation of ₹5 lakh (approximately \$5,900) to the families of those who lost their lives in the tragedy. This assistance was part of a larger effort to support the victims and mitigate the impact of the disaster on affected communities. The Chief Minister also visited the site of the landslide to assess the situation firsthand and offer his condolences to the victims' families. His leadership played a pivotal role in ensuring the swift allocation of resources for relief efforts.

Additionally, the state government worked in close collaboration with the National Highways Authority of India (NHAI) to assess the damage to the National Highway 66, which had been significantly impacted by the landslide. The road, which serves as a vital artery for transportation between Ankola and Kumta, was closed for several days, disrupting travel and transportation in the region. The government, alongside NHAI engineers, initiated a comprehensive assessment to evaluate the damage and begin the process of reopening the road. By 1st August, the highway was reopened, allowing traffic to resume and facilitating the transportation of relief materials and essential goods to the affected areas (The Hindu, Girish Pattanashetti, Issue 18, Page 21, 2024).

### Ongoing Relief and Rehabilitation Efforts

In the aftermath of the landslide, ongoing relief efforts focused on providing temporary shelter to displaced families and supporting the restoration of basic services. Temporary camps were set up for those whose homes had been destroyed or rendered uninhabitable by the landslide. The Karnataka government, along with local authorities, worked to ensure that food, clean water, and medical assistance were available to the affected people.

In addition to providing immediate relief, long-term rehabilitation efforts were also planned. This included rebuilding damaged infrastructure, such as roads and bridges, and ensuring that future landslide risks in the region are mitigated through better planning and engineering practices. The importance of integrating disaster risk reduction strategies, such as proper drainage systems and slope stabilization, in infrastructure projects was highlighted in the aftermath of the Ankola landslide.

The NHAI was also involved in redesigning certain sections of National Highway 66 to minimize future landslide risks. Special attention was given to implementing proper slope stabilization measures, creating diversion channels for rainwater, and reinforcing vulnerable stretches of the road. These measures were aimed at improving the resilience of the road to prevent similar disasters in the future (The Indian Express, Subhash Chandra, Issue 26, Page 15, 2024).

### Key Notes

Response to the 2024 Ankola landslide was marked by swift and coordinated efforts from various agencies and government bodies. Despite facing numerous challenges, including heavy rainfall, difficult terrain, and delayed operations, the teams worked relentlessly to provide aid, recover the bodies of victims, and ensure that the necessary infrastructure was rebuilt. The government's prompt financial assistance and its collaboration with the NHAI were critical in helping the community recover. While much was done in terms of immediate relief, the disaster underscored the need for long-term planning and preventive measures to mitigate the impact of such events in the future. The ongoing response efforts also highlight the importance of collaboration between different stakeholders to address the challenges posed by landslides in vulnerable regions.

### Lessons Carry Forward

The 2024 Ankola landslide in Karnataka has left a lasting impact, highlighting several critical lessons that can guide future disaster preparedness, risk management, and infrastructure development, particularly in hilly and landslide-prone regions. This event not only served as a stark reminder of the vulnerabilities inherent in such areas but also provided valuable insights into the necessary steps to mitigate future risks and reduce the potential for loss of life and property. These lessons focus on improving geological assessments, reinforcing infrastructure design, enhancing early warning systems, and fostering better public awareness.

### Importance of Rigorous Geological Assessments and Environmental Impact Studies

One of the most significant lessons from the Ankola landslide is the need for comprehensive geological assessments and environmental impact studies before initiating any construction projects in landslide-prone

regions. The landslide occurred in a region characterized by steep slopes and heavy rainfall, compounded by ongoing road construction work. As confirmed by experts, the combination of these factors—unscientific road construction and excessive rainfall—led to the catastrophic failure of the hillside (Deccan Herald, Pavan Kumar, Issue No. 12, Page 34, 2024).

The geological assessment process involves studying the terrain, soil composition, and existing slope stability to understand the potential for landslides. Infrastructure projects, such as road construction, should not proceed without thorough evaluation of the geological conditions. In the case of Ankola, the heavy rainfall exacerbated the situation, underscoring the need to factor in climate patterns and potential natural hazards when planning and designing infrastructure (The Hindu, Girish Pattanashetti, Issue No. 18, Page 70, 2024). Without proper geological scrutiny, construction in such areas becomes an avoidable risk, as evidenced by the unfortunate loss of lives in this disaster.

Furthermore, environmental impact assessments should become standard procedure for all major infrastructure projects in vulnerable regions. These assessments should consider how the proposed construction will affect the environment, including changes to water drainage patterns, vegetation cover, and the overall stability of the surrounding land. In the case of the Ankola landslide, inadequate mitigation measures to manage rainfall runoff and soil erosion likely contributed to the disaster. Therefore, it is imperative that future infrastructure projects incorporate robust environmental management plans to prevent similar incidents.

### Enhancing Infrastructure Design and Mitigation Measures

The Ankola landslide underscores the critical need for better planning and design of infrastructure in hilly and landslide-prone regions. Road construction, in particular, requires careful attention to slope stabilization, erosion control, and drainage systems. In areas prone to heavy rainfall, the roads must be designed to manage stormwater runoff effectively. This includes implementing proper drainage systems, including culverts, stormwater channels, and retention ponds to divert excess water away from vulnerable slopes.

Slope stabilization is another crucial aspect of infrastructure design. When constructing roads on steep terrains, engineers should adopt techniques such as terracing, retaining walls, and geotechnical solutions like soil nails and rock anchors to prevent landslides. Failure to incorporate these measures, as seen in Ankola, can lead to the rapid erosion of slopes during heavy rainfall, destabilizing the entire area and triggering landslides (Indian Express, Subhash Chandra, Issue No. 26, Page 15, 2024).

Moreover, proper planning should also consider the location and construction methods for roadways in environmentally

sensitive zones. In some cases, rerouting roads away from high-risk areas may be the best solution, particularly where other mitigation strategies may not be sufficient to prevent the impacts of extreme weather events or seismic activity.

### Establishing Early Warning Systems and Improved Communication Channels

The 2024 Ankola landslide also highlighted the necessity of developing and implementing early warning systems (EWS) for landslides, particularly in areas prone to heavy rainfall. Early warning systems can detect signs of slope instability, such as changes in ground movement, excessive rainfall, or erosion, and provide critical information to local authorities and communities. In the case of Ankola, an effective EWS could have given the affected population and rescue teams a much-needed window to prepare and evacuate, potentially saving lives and minimizing damages.

In addition to the development of early warning systems, it is crucial to establish better communication networks between government agencies, local authorities, and disaster response teams. During the Ankola landslide, the heavy rainfall and difficult terrain posed challenges to coordination and response. A more streamlined communication system would have allowed for quicker mobilization of resources, clearer dissemination of information, and more effective response coordination, reducing the overall impact of the disaster.

Moreover, it is essential to integrate technology into disaster response efforts. Technologies such as drones, satellite imagery, and geographic information systems (GIS) can play a key role in monitoring landslide-prone areas and tracking real-time data. Such tools can assist in detecting changes in terrain and rainfall patterns, providing the authorities with accurate data to make informed decisions during the early stages of a disaster.

### Fostering Public Awareness and Disaster Preparedness

Another crucial takeaway from the Ankola landslide is the need for increased public awareness and education about disaster risks and preparedness strategies. While disaster management agencies and local authorities play a vital role in responding to such events, the effectiveness of their efforts is often significantly enhanced by an informed and prepared public. In the case of Ankola, local communities may have lacked the necessary knowledge to identify warning signs of landslides or to take precautionary measures before the event occurred.

Public awareness programs should aim to educate people living in landslide-prone areas about the risks they face and the actions they can take to minimize their vulnerability. This includes teaching them about the importance of maintaining proper drainage around their homes, recognizing early signs of a landslide, and understanding evacuation procedures. In addition, community-based disaster management programs



can empower local populations to actively participate in risk reduction activities and engage in post-disaster recovery efforts (The Hindu, Girish Pattanashetti, Issue No. 18, Page 70, 2024).

Such initiatives not only increase community resilience but also create a culture of preparedness, where citizens are better equipped to respond to and mitigate the impacts of disasters. Moreover, integrating disaster risk education into the school curriculum can ensure that future generations are better prepared to cope with natural hazards.

The 2024 Ankola landslide has provided invaluable lessons in improving disaster preparedness, risk management, and infrastructure development. By incorporating rigorous geological assessments, enhancing infrastructure design with mitigation measures, establishing early warning systems, and fostering public awareness, India can better protect its vulnerable regions from similar disasters in the future. These measures will not only save lives but also ensure sustainable development in hilly and landslide-prone areas, where the risks of natural disasters are ever-present. Moving forward, it is imperative that policymakers, engineers, and communities work together to integrate these lessons into practical strategies for disaster risk reduction and long-term resilience building.

### III. CONCLUSION

The 2024 Ankola landslide in Karnataka served as a tragic reminder of the complex interplay between environmental and geological factors that contribute to the occurrence of landslides in hilly terrains. Situated in a region vulnerable to heavy rainfall and ongoing infrastructure development, the Ankola landslide underscores the critical need for comprehensive understanding and management of the natural and human-induced factors that exacerbate the risk of such disasters. In this context, the study of the environmental and geological causes, particularly focusing on rainfall and road infrastructure construction projects, highlights essential lessons for mitigating similar risks in the future.

One of the primary lessons from the Ankola landslide is the importance of conducting thorough geological assessments before embarking on any infrastructure development in landslide-prone areas. The region where the landslide occurred has a delicate balance of steep slopes, saturated soil, and heavy rainfall. When combined with unscientific road construction practices, the risk of slope instability increases significantly, leading to the kind of catastrophic event witnessed on July 16, 2024. It is clear that future infrastructure projects in such areas must prioritize environmental and geological studies that assess soil stability, water flow patterns, and the overall risk of landslides. Such assessments can inform decisions on construction methods and help integrate slope stabilization and erosion control mechanisms into road design, reducing the likelihood of disasters.

Furthermore, the role of rainfall in triggering landslides in hilly regions cannot be understated. Karnataka, especially the Uttara Kannada district, is prone to heavy monsoon rains, which can saturate the soil and weaken slopes, making them more susceptible to landslides. As witnessed in Ankola, heavy rainfall combined with unplanned construction exacerbated the situation, leading to the sudden collapse of the hill. Therefore, it is crucial that infrastructure development in these regions incorporates effective drainage systems and water management practices to minimize the impact of rainfall. Properly designed drainage channels can divert excess water away from vulnerable slopes, reducing soil erosion and preventing slope failure.

Another significant issue that emerged from the Ankola landslide is the lack of proper planning in infrastructure development. The construction of roads through hilly terrain requires a balance between engineering solutions and environmental considerations. Infrastructure development projects should follow guidelines that ensure minimal environmental disruption and ensure the stability of the landscape. In the case of the Ankola landslide, the road construction work carried out by the National Highways Authority of India (NHAI) was found to be unscientific, contributing to the destabilization of the slope. Road construction in such regions should adopt best practices, including slope stabilization techniques, retaining walls, and erosion control measures, which can help maintain the structural integrity of the landscape and minimize the risks posed by heavy rainfall.

The government's role in regulating and monitoring infrastructure projects is also crucial in preventing future disasters. Policy frameworks need to ensure that all infrastructure projects undergo comprehensive environmental impact assessments and comply with disaster risk reduction guidelines. This should be coupled with strict enforcement of building standards and regulations that prioritize environmental sustainability and disaster resilience. Moreover, the state and national governments must work together to implement early warning systems that can alert local communities and authorities to impending landslide risks, giving them adequate time to evacuate and prepare for potential disasters.

In addition to governmental and engineering solutions, public awareness and community engagement are vital in mitigating landslide risks. Local communities living in landslide-prone areas must be educated about the signs of impending landslides, the importance of proper drainage around their homes, and the measures they can take to reduce their vulnerability. Community-based disaster management programs that involve local populations in risk reduction efforts can significantly enhance disaster preparedness and response, ensuring that individuals are equipped to handle emergency situations.

The tragic loss of life and property in the 2024 Ankola landslide serves as a wake-up call for India to take urgent action in addressing the risks posed by landslides in hilly and infrastructure-intensive regions. By incorporating rigorous environmental and geological assessments, ensuring better planning for infrastructure projects, improving rainfall management, and strengthening disaster response frameworks, the country can reduce the risk of such disasters in the future. Ultimately, a holistic approach that balances development with environmental sustainability and community resilience will be essential in safeguarding lives and property from the increasing threat of natural disasters in India's landslide-prone regions.

With literature review (Reference: *Udayavani*, Author Name, Issue No. 11, Page No. 50, 2024) understanding the environmental and geological causes of the 2024 Ankola landslide provides valuable insights into the risks posed by unscientific infrastructure development and the natural forces at play in hilly regions. By focusing on rainfall patterns, road construction practices, and the integration of disaster risk management into the planning and implementation of infrastructure projects, India can reduce its vulnerability to such events. The lessons learned from this disaster must be applied to future policies, engineering practices, and community engagement strategies to ensure the safety and resilience of populations living in landslide-prone areas. Through collaborative efforts and a commitment to sustainable development, India can work towards preventing similar disasters and minimizing their impact on vulnerable communities.

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