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? Artificial Intelligence Is Transforming Disaster Management Through Faster Early Warning, Hyperlocal Risk Mapping and Data-Driven Response

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Recent Developments:

- Recent disaster-response experience in **Nepal** has demonstrated how artificial intelligence, crowdsourced information, satellite imagery and thermal-imaging drones can supplement conventional disaster-management systems.
- During the 2026 Nepal floods, an **AI-enabled disaster-response portal** aggregated information from official sources, news reports, satellite services and crowdsourced missing-person reports, helping organise information on casualties, missing persons, rescue operations and damaged infrastructure.
- Another Nepal initiative used **computer vision and deep-learning technology** to compare photographs of missing persons with images of unidentified bodies, demonstrating the potential of AI-assisted identification during large-scale disasters.
- India is similarly integrating **AI, machine learning, high-performance computing and numerical weather prediction** into operational weather forecasting. The National Centre for Medium Range Weather Forecasting is providing AI/ML-based forecast guidance to improve forecasts of extreme weather events.
- The India Meteorological Department has operationalised a **Multi-Hazard Early Warning Decision Support System** and provides impact-based and risk-based warnings for hazards such as cyclones, heavy rainfall, heatwaves and other severe weather events.
- In 2026, India also expanded **AI-enabled hyperlocal weather forecasting**, including high-resolution rainfall forecasts and AI-driven forecasting products for multiple States and thousands of sub-districts.
- The **Disaster Management (Amendment) Act, 2025** mandates a National Disaster Database containing risk assessments, mitigation plans and real-time disaster information, creating an important data foundation for technology-enabled disaster management.
- India launched a nationwide **Cell Broadcast System** in 2026 for rapid, geo-targeted disaster alerts. The system integrates warning agencies with State Disaster Management Authorities and can disseminate alerts for cyclones, floods, lightning, avalanches, cloudbursts and other hazards.

Role of Artificial Intelligence in Disaster Management:

Early Warning and Prediction:

- AI can process **large historical datasets, real-time observations, satellite information and meteorological records** to identify patterns and generate faster, more location-specific forecasts.
- AI-based systems can complement conventional numerical weather prediction by improving **nowcasting, bias correction, cyclone tracking, rainfall prediction and hyperlocal forecasting**.
- The Ministry of Earth Sciences has reported the operationalisation of AI-based global weather models and indigenous AI/ML applications for severe-weather prediction.
- India's use of AI in forecasting therefore represents a shift from generic hazard warnings towards **impact-based and location-specific early warning**.

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Hazard Mapping and Risk Assessment:

- AI can integrate **satellite imagery, geographic information, meteorological observations, topographic maps, land-use data and administrative databases** to identify areas exposed to specific hazards.
- Machine-learning models can identify patterns associated with **flood-prone settlements, landslides, urban heat islands, coastal inundation and infrastructure vulnerability**.
- Such risk maps can support evacuation planning, infrastructure design, insurance assessment and prioritisation of mitigation investments.

Response, Relief and Rescue:

- Disasters generate massive quantities of information through **smartphones, social media, emergency calls, drones, satellite imagery and government databases**.
- AI can process this unstructured information rapidly, identify recurring patterns and extract information relevant to rescue and relief operations.
- Crowdsourced information can help identify **missing persons, blocked roads, damaged bridges, stranded populations and urgent medical requirements**, provided the information is verified.
- In Nepal, an AI-enabled portal helped connect crowdsourced information concerning missing persons with official casualty records, demonstrating how AI can act as an **information-integration layer** during chaotic emergencies.
- **Thermal-imaging drones** can detect human heat signatures beneath rubble or in difficult terrain and help rescue teams identify probable locations of survivors.
- AI can also prioritise incoming emergency information according to factors such as **location, severity, number of people affected and accessibility**.

Post-Disaster Recovery:

- AI and satellite-based analysis can identify **isolated settlements, destroyed infrastructure, blocked highways, damaged power networks and potential locations for emergency helicopter operations**.
- Authorities can use these assessments to prioritise the distribution of **food, medicines, temporary shelters and other relief material**.
- AI-assisted damage assessment can also accelerate compensation assessment, reconstruction planning and monitoring of infrastructure restoration.

Key Artificial Intelligence Applications:

GraphCast:

- **GraphCast** is an AI-based weather forecasting system developed by Google DeepMind that uses machine learning to generate global weather forecasts rapidly.
- It demonstrates the potential of AI-based models to complement conventional physics-based forecasting systems.

Google Flood Hub:

- **Google Flood Hub** uses hydrological and meteorological information to provide flood forecasts and advance information about flood hazards.
- Such systems can support early action by governments and communities before floodwaters reach vulnerable areas.

DisasterAWARE:

- **DisasterAWARE** integrates geographic and disaster-related information to support **hazard monitoring, risk assessment and situational awareness**.

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- It illustrates the importance of combining geospatial information with disaster intelligence.

SKAI:

- **SKAI** combines satellite imagery and artificial intelligence to rapidly analyse disaster damage.
- Such systems can reduce the time required for large-area damage assessment after earthquakes, floods, cyclones and other disasters.

India's Technology-Enabled Disaster Management Architecture:

AI-Based Weather Forecasting:

- The India Meteorological Department uses **AI/ML-based forecasting tools**, including GraphCast, Pangand FourCastNet, for experimental weather forecasting and applications such as nowcasting, bias correction and hyperlocal prediction.
- AI-based forecasting is being integrated with conventional **Numerical Weather Prediction, data assimilation, ensemble prediction and Earth-system modelling**, rather than replacing these systems entirely.
- This hybrid approach is important because disaster forecasting requires both **physical understanding of atmospheric processes and data-driven pattern recognition**.

Multi-Hazard Early Warning:

- The **Multi-Hazard Early Warning Decision Support System** provides an integrated platform for monitoring and forecasting severe weather.
- India provides district-level impact-based forecasts and risk-based warnings using different colour codes.
- The system is designed to support disaster managers before an event, during the event and during subsequent rescue and restoration activities.

Space Technology:

- ISRO and the Department of Space use satellite systems for **flood monitoring, glacial-lake monitoring, landslide assessment, lightning nowcasting and disaster damage mapping**.
- Operational flood early-warning capabilities are being used in parts of the **Brahmaputra, Godavari and Tapi basins**.
- Satellite-based landslide assessment and alert systems can provide valuable information for vulnerable mountainous regions.

Cell Broadcast and Geo-Targeted Alerts:

- India's **Cell Broadcast System** enables geo-targeted warnings to mobile devices in affected areas without requiring individual subscriptions.
- The system is based on the **Common Alerting Protocol** and integrates multiple warning-generating agencies with State Disaster Management Authorities.
- It is designed for hazards with short lead times, including **flash floods, lightning, thunderstorms, avalanches, cloudbursts and industrial disasters**.
- Alerts can be disseminated in the **language of the target population**, improving accessibility for vulnerable communities.

Institutional Framework of Disaster Management in India:

National Disaster Management Authority:

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- The **National Disaster Management Authority** is India's apex statutory body for disaster management and is headed by the Prime Minister.
- It lays down **policies, plans and guidelines** for disaster management and coordinates their implementation.
- The 2025 amendment strengthened the role of NDMA in preparing the National Disaster Management Plan and enhanced its institutional responsibilities.

National Executive Committee:

- The **National Executive Committee**, chaired by the Union Home Secretary, assists in coordinating disaster-management activities and supports implementation of the National Plan.
- It provides an important link between national policy decisions and executive implementation.

National Disaster Response Force:

- The **National Disaster Response Force** is a specialised force constituted under the Disaster Management Act, 2005, for rapid response to natural and human-induced disasters.
- It was established in **2006** and has **16 operational battalions**, with a sanctioned strength of 18,581 personnel.
- Its capabilities include **search and rescue, collapsed-structure rescue, flood rescue, canine operations and CBRN emergency response**.

National Institute of Disaster Management:

- The **National Institute of Disaster Management** is a premier institution for **capacity building, training, research, human-resource development and documentation** in disaster management.
- It supports evidence-based improvements in disaster preparedness and institutional capacity.

Disaster Management (Amendment) Act, 2025:

Background:

- The **Disaster Management (Amendment) Act, 2025** received Presidential assent on **29 March 2025** and came into force on **9 April 2025**.
- The amendment seeks to improve institutional clarity, strengthen accountability, enhance urban disaster management and improve the use of disaster-related data.

Transfer of Plan-Making Responsibilities:

- Under the amended framework, the **NDMA and State Disaster Management Authorities** are empowered to prepare the national and State disaster-management plans, respectively, replacing the earlier plan-making role of the National Executive Committee and State Executive Committee.
- This aims to reduce institutional bottlenecks and strengthen the role of specialised disaster-management authorities.

National and State Disaster Databases:

- The amendment provides for disaster databases at **national and State levels**.
- The National Disaster Database is intended to include **risk assessments, mitigation plans and real-time disaster information**.
- Such databases can become an important foundation for AI applications because reliable machine-learning systems depend on sufficiently large and high-quality datasets.

Urban Disaster Management Authorities:

- **Section 41A** enables State Governments to constitute **Urban Disaster Management Authorities** for State capitals and cities having Municipal Corporations, except the National Capital Territory of Delhi and the Union Territory of Chandigarh.
- The Urban Disaster Management Authority is chaired by the **Municipal Commissioner**, while the concerned District Collector serves as Vice-Chairperson.
- These authorities focus on city-specific vulnerabilities such as **urban flooding and heatwaves** and coordinate implementation of urban disaster-management plans.
- The provision recognises that rapid urbanisation has created disaster risks that require **city-specific planning and institutional capacity**.

State Disaster Response Forces:

- The amended framework enables State Governments to constitute **State Disaster Response Forces** with functions and service conditions determined by the respective State Government.
- State-level specialised forces can improve response capacity by supplementing the NDRF and providing **locally adapted rescue capabilities**.

Directives and Accountability:

- **Section 60A** empowers the Central or State Government to issue directions requiring persons or entities to take, or refrain from taking, specified actions to reduce disaster impact.
- Contravention of such directions can attract a statutory penalty as prescribed through the relevant notification.
- The provision strengthens the ability of governments to impose **time-bound preventive measures during hazardous situations**.

Global Frameworks and India's Leadership:

Sendai Framework for Disaster Risk Reduction:

- The **Sendai Framework for Disaster Risk Reduction, 2015–2030** seeks substantial reductions in disaster mortality, the number of affected people, economic losses and damage to critical infrastructure.
- It emphasises **understanding disaster risk, strengthening disaster-risk governance, investing in resilience and enhancing preparedness for effective response and recovery**.
- AI, satellite technology and real-time data can support all four priorities by improving risk assessment and early warning.

Coalition for Disaster Resilient Infrastructure:

- The **Coalition for Disaster Resilient Infrastructure** was launched by India as an international partnership focused on strengthening the resilience of infrastructure against climate and disaster risks.
- Its relevance is increasing as extreme weather events increasingly threaten **transport, energy, telecommunications and urban infrastructure**.

Prime Minister's Ten-Point Agenda:

- India's **Ten-Point Agenda on Disaster Risk Reduction** emphasises risk coverage, improved disaster-risk mapping, technology use, capacity building and greater participation of women in disaster management.
- It provides a domestic policy framework for integrating disaster resilience into development planning.

Challenges of Using AI in Disaster Management:

Data Quality and Availability:

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- AI models require **large, accurate and representative datasets**, which may be unavailable or disrupted during disasters.
- Poor-quality training data can produce unreliable predictions and incorrect risk assessments.

Digital Divide:

- Communities with limited access to **smartphones, internet connectivity and digital services** may be under-represented in AI-generated assessments.
- Over-reliance on digital data can therefore make the most vulnerable populations less visible to decision-makers.

Misinformation:

- Social media and crowdsourced platforms can generate large quantities of **duplicate, inaccurate or deliberately misleading information**.
- AI systems that automatically aggregate unverified information can amplify rather than solve an information crisis.

Transferability:

- AI models trained in one geographical region may perform poorly in areas with different **terrain, climate, hydrology, settlement patterns and infrastructure**.
- Local calibration and continuous validation are therefore essential.

Privacy and Data Protection:

- Information concerning **missing persons, locations, health conditions and affected communities** can contain sensitive personal information.
- Disaster-response systems must therefore incorporate appropriate data-protection safeguards while ensuring that critical information remains accessible to authorised responders.

Accountability:

- An AI-generated prediction may influence decisions concerning **evacuation, rescue, relief distribution or infrastructure closure**.
- Errors in such high-stakes contexts can result in serious consequences.
- AI should therefore function as a **decision-support tool rather than an autonomous replacement for accountable human decision-making**.

Way Forward:

Build India-Centric Disaster Datasets:

- India should develop high-quality, interoperable datasets covering **weather, terrain, infrastructure, demographics, vulnerability and historical disasters**.
- The National Disaster Database can become a foundation for such integrated risk intelligence.

Adopt Human-in-the-Loop AI:

- AI outputs should be verified by **meteorologists, disaster managers, local administrators and trained response teams** before high-consequence decisions are taken.
- Human oversight should remain particularly strong for evacuation, rescue prioritisation and relief allocation.

Develop Hyperlocal and Multilingual Systems:

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- AI-enabled disaster systems should generate **local-language, location-specific and accessible alerts**.
- Integration with cell-broadcast systems can ensure that warnings reach people even when conventional internet-based communication is disrupted.

Strengthen Institutional Interoperability:

- **IMD, ISRO, NDMA, State Disaster Management Authorities, telecom operators, financial institutions and local administrations** should operate through interoperable data and communication systems.
- Common standards can reduce duplication and improve real-time information sharing.

Combine AI with Community-Based Disaster Management:

- Technology should supplement **local knowledge, community volunteers and frontline responders** rather than replace them.
- Crowdsourced information should be incorporated through verification mechanisms that distinguish reliable observations from misinformation.

Value Addition for UPSC:

Prelims Facts:

- **NDMA:** Apex statutory disaster-management authority; chaired by the Prime Minister.
- **NDRF:** Specialised disaster-response force; established in **2006**; currently has **16 operational battalions**.
- **NIDM:** Institution for disaster-management training, capacity building, research and documentation.
- **Disaster Management (Amendment) Act, 2025:** Presidential assent on **29 March 2025**; provisions came into force on **9 April 2025**.
- **Section 41A:** Enables constitution of Urban Disaster Management Authorities.
- **Section 60A:** Enables Central and State Governments to issue directions for reducing disaster impact.
- **National Disaster Database:** Includes risk assessments, mitigation plans and real-time disaster information.
- **Sendai Framework: 2015–2030** global framework for disaster-risk reduction.
- **CDRI:** International partnership launched by India for disaster- and climate-resilient infrastructure.
- **Cell Broadcast System:** Enables geo-targeted emergency alerts through mobile networks.
- **Multi-Hazard Early Warning Decision Support System:** India's integrated platform for monitoring and forecasting severe weather.
- **GraphCast, Pangand FourCastNet:** AI-based weather forecasting models used experimentally by Indian meteorological institutions.