by Pierre Delage (France), Marc Ballouz (Lebanon - USA), Bernardo Caicedo (Colombia), Ahmed Chraibi (Morocco), Hemanta Hazarika (Japan), Jan Kupec (New Zealand), Fernando Marinho (Brazil), Daniela Pollak (Chile), Neelima Satyam (India).

Introduction

The Geoengineers Without Borders Committee of the ISSMGE (GeoWB) has been started in 2022 by President Marc Ballouz at the beginning of his term in Sydney. He asked Pierre Delage to start and manage the actions of the Committee, with the help of Daniela Pollak, Board member from Chile. This initiative was placed in a context of the beginning of the XXIst century, with more and more frequent geo-disasters in conjunction with climate change. Besides earthquakes, that still constitute a significant threat for people and infrastructures, extreme climate events and their consequences in the case of heavy rainfalls, such as floods, landslides and dam failures, cause devastating impacts on communities worldwide.

To foster resilience and prevent the recurrence of such tragedies, it is necessary to address structural issues that may exacerbate the impacts of extreme climate events through planning and adapting infrastructures, based on a relevant risk assessment. This approach requires integrated efforts from experts, governments and communities, combining scientific and technical knowledge, together with social engagement. In this context, the technical and scientifical strength of the worldwide ISSMGE network (around 90 countries and 38 Technical Committees) provides a unique tool to serve the human Society.

Organisation

The aim of the GeoWB Committee is to propose to send volunteer geo-engineers from the ISSMGE network over the world to areas affected by geo-disasters such as earthquakes, landslides, floods, failure of dykes, dam and tailing dams, collapse of geotechnical structures, to mention a few. The GeoWB committee is composed of 20 members from many countries from all ISSMGE regions, including outstanding specialists in the various fields concerned. Members speak a significant number of languages: Arabic, Brazilian, Chinese Mandarin, English, French, Greek, Indian, Indonesian, Italian, Japanese, Spanish, Turkish, Persian. The composition is as follows:

- Prof. Pierre Delage, Chair (France - Europe)
- Eng. Daniela Pollak, Board member (Chile - South America)
- Dr. Léo Alibert (Lebanon - Asia)
- Prof. Tugce Baser (US - North America, Turkey - Asia)
- Prof. Bernardo Caicedo (Colombia - South America)
- Prof. Qun Chen (China - Asia)
- Eng. Ahmed Chraibi (Morocco - Africa)
- Dr. Lawrence de Leeuw (UK - Europe)
- Prof. Behrouz Gatmiri (Iran - Asia)
- Prof. George Gazetas (Greece - Europe)
- Prof. Antonio Gens (Spain - Europe)
- Prof. Hemanta Hazarika (Japan - Asia)
- Eng. Will Ibim (Nigeria - Africa)
- Dr. Jan Kupec (New Zealand - Australasia)
- Prof. Enlong Liu (China - Asia)
- Prof. Fernando Marinho (Brazil - South America)
- Prof. Luciano Picarelli (Italia - Europe)
- Prof. Neelima Satyam (India - Asia)
- Dr. Ezra Tjung (US – N. America, Indonesia - Asia)
- Prof. Shu Yu (China - Asia)

This membership has been reinforced by liaison members of the ISSMGE Member Societies who responded to a call made by GeoWB (note that interested Member Societies not represented may still propose liaison members). The motivation and competence of liaison members and the contact they make with their Member Society significantly reinforced the GeoWB efficiency. Members and liaison Members regularly meet in on-line meetings, where GeoWB activities are discussed and Members present data from their missions (as recently done by H. Hazarika on the Myanmar earthquake and N. Satyam on rain induced debris flow in Northern India).

The liaison Members are the following:

Member Society			
Canada	Prof.	Kshama	Roy
China	Prof.	Enlong	Liu
France	Eng.	Sylvie	Bretelle
Hong-Kong	Prof.	Anthony	Leong
Italy	Prof.	Sabatino	Cuomo
Mexico	Prof.	Eduardo	Botero Jaramillo
New Zealand	Dr.	Jan	Kupec
Portugal	Dr.	Luis	Miranda
Romania	Prof.	Andrei	Olteanu
Singapore	Prof.	Darren	Chian
Ukraine	Prof.	Viktor	Nosenko
USA	Dr.	Yue	Xu

The GeoWB committee made a voluntary commitment to the United Nations Disaster Risk Reduction (UNDRR) office. It has close connections with other similar organisations like ICOLD (International Committee on Large Dams), GEER (Geotechnical Extreme Events Reconnaissance, USA), RedR-UK (people and skills for disaster relief) and the ISSMGE Technical Committee TC302 on Forensic Engineering.

GeoWB missions are proposed and organised after analysing the local context and expertise in the affected country, utilising where possible local contacts from the ISSMGE network (Member Societies, Regional Vice-Presidents, members of Technical Committees, and the GeoWorld network). Besides those, our experience demonstrated the fundamental importance of also having reliable personal local contacts.

Great care is devoted to safety and logistical aspects, with all travel expenses supported by the ISSMGE. Geo-engineers prepare afterwards a comprehensive report for national and international authorities. The report includes the following:

- Description and causes of the disaster
- Damages arising from the geo-disaster
- Diagnosis of failures
- Potential remedial measures.

Particular attention is also paid to risk analysis and possible preventive measures for the future, defined in close conjunction with stakeholders and local competences.

Since GeoWB started, their members have been involved in various geo-disasters, with the production of reports that can be found in the GeoWB website (https://www.issmge.org/committees/geo-engineers-without-borders) and the ISSMGE Bulletins. During the 2024 – 2026 term, GeoWB members have been involved in missions in Libya, Papua-New Guinea, Brazil, Bolivia and Myanmar.

This report describes the actions carried out by GeoWB members in geo-disasters resulting in large humanitarian impact such as the Derna dams failure (with Eng. A. Chraibi from Morocco, with the support of UNESCO and ICOLD), the Mulitaka landslide in Papua-New Guinea (PNG, with Dr. Jan Kupec through the New Zealand Urban Search and Rescue organisation), the damages due to heavy rains in Rio Grande do Sul, Brazil (with Prof. F. Marinho from Brazil, with the support of ISSMGE), the Myanmar earthquake (with Prof. H. Hazarika from Japan, with the support of the Japanese Geotechnical Society) and the Rainfall induced disaster in the district of Mandi, Himachal Pradesh (India) (with Prof. N. Satyam from India). A technical support provided to the municipality of the city of la Paz (Bolivia) w/r to risk assessment of slope stability in urban context, by F. Marinho and B. Caicedo, is also described.

The failure of the Derna dams, Libya, September 2023

On September 10-11, 2023, Storm Daniel, after causing important damage in Greece (Garini and Gazetas 2023), moved over the Mediterranean Sea and caused catastrophic flooding in Libya, particularly in Derna, where 10 to 20% of the around 90,000 Derna's population were reported dead and missing, along with 35,000 displaced (Ashoor & Eladawy 2024, see Figure 1). This was due to the collapse of the cascade Abu Mansur (upstream) and Derna (downstream) dams, both along the Derna wadi (dry ravine).

UNESCO, with the support of ICOLD, deployed experts, among which was A. F. Chraibi, to assess the disaster's causes and recommend remedial measures. As direct site inspections were not possible, due to safety reasons, the analysis relied on documents related to dams' design and monitoring provided by local authorities. Meetings with local officials also helped refine the analysis carried out.

Figure 1. Views before and after the devastation due to the floods in Derna, Libya, on September 18, 2023 (Google earth).

As seen in Figure 2 (showing Abu Mansur dam before and after failure), both dams were embankments dams with (too) thin clay core founded on karstic limestone, built in the 70's. They were 73 and 40 m high above foundation for Abu Mansur and Derna, respectively. They had known structural weaknesses, including excessive settlement significant seepage, sometimes conveying dirty water, reported since the 1980s. It appeared that both dams were in such a weak condition that the flood of September 2023 was almost a trigger that led to their failure. Unfortunately, this flood was so massive that the dam failures resulted in a tragedy.

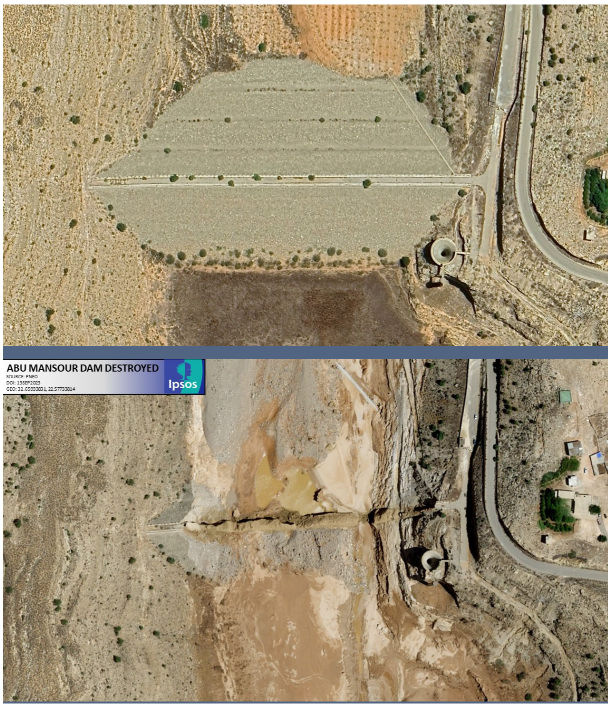


Figure 2. The Abu Mansur embankment dam, before (Google Earth) and after collapse (IPSOS image).

Challenges in estimating rainfall, such as spatial variability and limited reliable data, added uncertainty to determining the event's return period, which ranged from 500 to 5,000 years. Due to poor bedrock conditions, it was recommended that the foundation conditions should be carefully assessed before building new dams upstream of this heavily urbanized area. The design flood should be reassessed in a conservative approach taking into account the effect of climate change. It is noted that efficient flood protection does not necessarily mean rebuilding storage dams. Any long-term solution should rely on an urban development plan taking into account the right-of-way of the flood control arrangements to be built.

The Mulitaka landslide, Papua New Guinea, May 2024

In the Enga Province of Papua New Guinea's Highlands, part of Melanesia, an approximately 650 m long and 150 to 200 m wide landslide occurred on 24 May 2024 at 03:00 local time.

Given the damage to critical infrastructure and the high number of fatalities, the government of Papua New Guinea requested international assistance from experts from New-Zealand and Australia. Their mission was to conduct a geotechnical hazard assessment and provide short-term, medium-term, and long-term options for the recovery of the community. The reinstatement of the highway connection across the landslide was considered a critical issue, as a community of over 100,000 people was cut off from essential supplies.

Jan Kupec and John Seward were part of the specialist New Zealand Urban Search and Rescue (NZ USAR) team, who worked closely with Australian USAR colleagues, who brought Unmanned Aerial Vehicle (UAV, i.e. drones) capabilities with them, (Kupec & Seward, 2025).

The landslide inundated multiple dwellings, resulting in several hundred fatalities. It is believed to be a rock topple mechanism where toe buckling occurred on very steep bedding (Figure 3), affecting dwellings located near the Highland Highway. Authorities estimate that hundreds of people were living directly below and in the run-out area. The landslide also appears to have triggered multiple rotational and translational landslides, some of which were several hundred metres away from the initial debris run-out area.

Figure 3. The Mutilaka landslide in Papua New Guinea (24/5/2024). The landslide is 650 m long. (Photo Dr. Jan Kupec).

Access to the site was challenging due to its remoteness, on-site security issues, and ongoing landslide movement. The fallen debris, combined with the reactivation of adjacent landslides, created a tough operational environment.

Besides a better understanding of the landslide mechanisms, an important geotechnical challenge was to ensure the people safety with respect to other instabilities developing close to the first one. The field team was collaborating closely with geo-engineers in New Zealand to provide numerical modelling and hazard maps. This back-office support with further satellite observation was found of great help while on site.

The team proposed a realignment of the roading corridor to avoid an area considered highly susceptible to further landslides, including rainfall triggered slope instability.

Heavy rains in Rio Grande do Sul, Brazil, May-June 2024

Between end of April and beginning of May 2024, the state of Rio Grande do Sul in Brazil experienced an extreme rainfall event classified as a long-duration extratropical system, with totals exceeding 300 mm in less than a week in several locations, far above the historical average. Persistent and heavy rains were caused by the combined action of a semi-stationary frontal system, a low-level jet stream, and the intensification of moisture transport from the Amazon region (atmospheric rivers).

The intense rainfall triggered widespread flooding, slope failures, landslides, and severe damage to urban and rural infrastructure, especially in areas with steep terrain and poor drainage. The antecedent rainfall led to soil saturation, significantly reducing the infiltration capacity and promoting the development of positive pore-water pressures, which intensified slope instability.

Local contacts were provided to GeoWB by Prof. Gabriela Medero (Heriot-Watt University in Scotland, born in Porto Alegre), which resulted in the mission carried out by Fernando Marinho, who already had some experience in investigating heavy rain geo-disasters in Brazil.

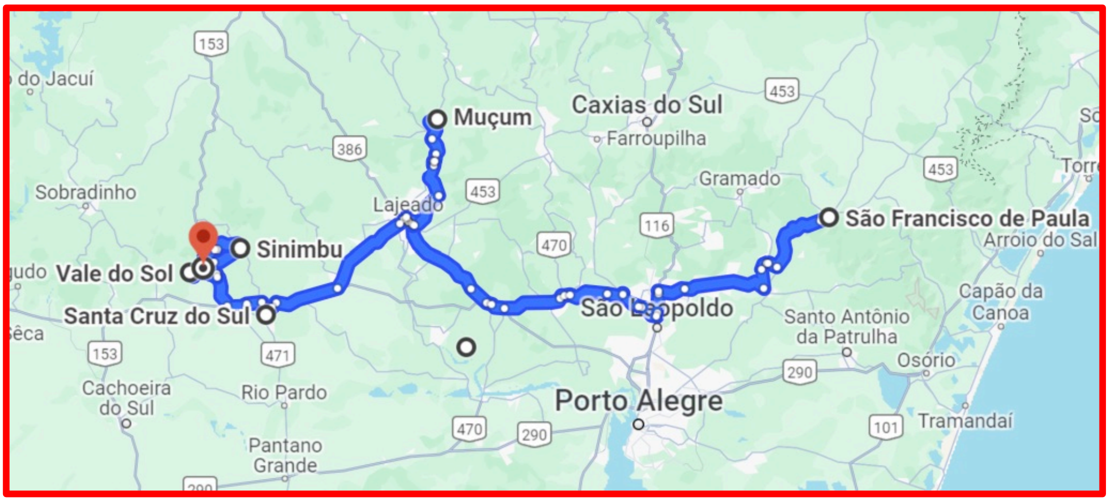


Figure 4. Route of the GeoWB mission in Rio Grande do Sul (June 2024).

Given that the airport of Porto Alegre was neutralised by flood and no longer working, Fernando Marinho conducted his mission along a route of 430 km along various damaged locations, starting from a smaller (still working) airport at São Francisco de Paula and going through Muçum, Vale do Sol, Santa Cruz do Sul and Sinimbú (see Figure 4).

The objective was to assess geotechnical risk conditions resulting from the intense rainfalls, focusing on the identification of instability processes, the failure mechanisms, and the proposal of emergency mitigation measures in urban and rural areas. To do so, the methodology adopted was based on an integrated field approach, consisting of on-site visual inspections that enabled the identification of signs of instability. Detailed mapping of cracks, landslides, and erosive processes was carried out, as well as the collection of geographic coordinates for the observed critical points. This information supported a preliminary assessment of failure mechanisms and surface and subsurface drainage conditions, allowing an initial understanding of the factors that contributed to the instability of the analysed slopes. Some illustrative observations made during the mission are now presented.

Figure 5 shows a downslope movement towards the Salto dam reservoir close to Santa Francisco de Paula, with the cracks parallel to the streets observed, the probable wedge failure derived from our observations and the probable direction of sub-superficial flow. A critical issue was to know whether or not it was possible to reopen the school whose classes had been suspended. Together with the Geological Survey of Brazil, we concluded that it was located outside the risky zone and could be reopened.

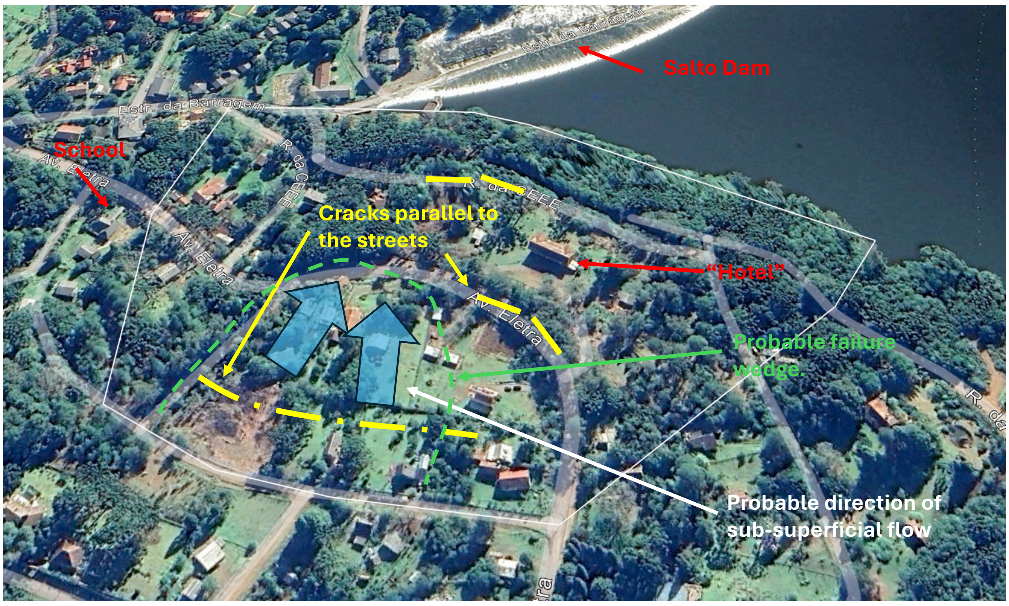


Figure 5. Downslope movement toward the Salto Dam Reservoir and nearby school outside the risk area.

In Santa Cruz do Sul, observations showed that the main cause of the problems lied in pre-existing instabilities that were worsened by rainfall. The entire region has been subject to ground movements for years, and this intense event not only intensified the problem (see Figure 6) but also, in a way, exposed the underlying causes.

Figure 6. Cracks in streets and instability suggesting large scale ground failure.

The combination of the following factors created a scenario conducive to infrastructure collapses, threats to community safety, and the urgent need for mitigation actions:

- Rainfall exceeding normal levels,
- Unregulated occupation of slopes,
- Insufficient or non-existent drainage systems, and
- Soils with strength are already mobilized due to saturation.

The Myanmar earthquake, March 2025

On March 28, 2025, at 12:50 MMT, a Mw 7.7 earthquake struck near Mandalay, Myanmar, along the Sagaing Fault (one of Southeast Asia's most seismically active fault systems) at a shallow depth of 10 km (see Figure 7, that also shows strong earthquakes occurred since 1929). This earthquake was one of the largest to hit the region in decades and caused widespread destruction across central Myanmar. Its impacts extended beyond Myanmar's borders, with shaking felt in neighbouring countries as well, including in Bangkok, 1000 km away. The scale of damage to infrastructures, buildings, and cultural heritage sites underscored the seismic vulnerability of the country.

A reconnaissance mission was organized from June 13 to 16, 2025 by the Japanese Geotechnical Society (JGS) under the leadership of Prof. Hemanta Hazarika (Kyushu University, Japan), with the local support of the Myanmar Geosciences Society (MGS), the Federation of Myanmar Engineering Societies (MES) and several international partners.

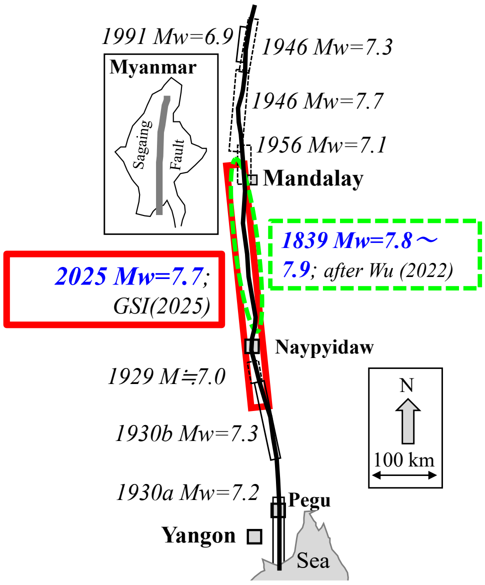


Figure 7. Historical earthquakes caused by Sagaing fault (Modified from Soe and Watkinson, 2011 and Wang et al., 2014).

The earthquake severely impacted Myanmar's transportation network, especially the Yangon–Mandalay Highway. Extensive liquefaction-induced settlement led to uneven road surfaces and distorted alignment. The photo in Figure 8a shows bridge abutment damaged due to lateral spreading of soils, resulting in severe structural failure. Liquefaction damage with sand boils were also observed in an under-construction site of shopping mall in Mandalay (Figure 8b) and widespread in a village close to Naypyidaw, the capital of Myanmar. In this area, low converted N value based on dynamic cone penetration tests and a shallow groundwater table approximately 1.2 meters below the ground surface confirmed high susceptibility to liquefaction.


a) *b)*

Figure 8. a) Abutment damage along the Yangon – Mandalay highway; b) sand boils at shopping mall site, Mandalay.

In various buildings in which ground floors consisted of columns with very few shear walls (Figure 9a), it was observed that lower stories completely crushed, whereas upper floors resisted better. This highlighted a fundamental design deficiency that must be urgently addressed in future seismic design codes and retrofitting programs, particularly for reinforced concrete buildings in high-risk areas.

In some places, the fault could directly be observed at surface, like in Naypiydaw where the observed ground motion intensity was high. Figure 9b shows a significant right-lateral displacement accompanied by shear deformation of the ground surface in the Children’s Specialized Hospital. Buildings situated directly atop the fault rupture that sustained severe damage, whereas a room located about ten meters away from the rupture suffered much less damage. This confirmed that, in this area, the primary cause of fault-induced damage was surface deformation rather than ground shaking.

Devastating losses to Myanmar’s rich cultural heritage (temples, pagodas, historic buildings) were also observed, raising the fundamental question of whether to prioritize authentic restoration using original materials or to focus on rapid recovery using modern method.

a) *b)*

Figure 9. a) Sky Villa condominium in Mandalay (207 fatalities); b) Children’s Specialized Hospital in Naypiydaw.

The 2025 Myanmar Earthquake caused a wide spectrum of damage, including liquefaction-induced failures, slope failures, building collapse, and cultural heritage destruction. The reconnaissance survey confirmed that Myanmar’s infrastructure and building stock remain highly vulnerable to strong earthquakes. Moving forward, Myanmar must prioritize:

- Strengthening foundations and embankments against liquefaction,
- Retrofitting vulnerable soft-storey structures,
- Expanding seismic monitoring networks,
- Developing regional hazard assessments that incorporate long-period seismic impacts.

This reconnaissance also provided critical lessons for seismic risk management throughout Southeast Asia, based on which academia, governments and industries can collectively take measures to reduce future losses and build greater resilience against major earthquakes.

Slope stability in the city of La Paz, May 2025

The GeoWB technical visit to La Paz resulted from a query of a technical manager of the municipality of la Paz during the PanAmGeo conference in La Serena, Chile (November 2024). The visit was carried out at the invitation of the Gobierno Autónomo Municipal de La Paz (GAMLP), in close collaboration with the Secretaría Municipal de Resiliencia y Gestión de Vulnerabilidades, whose ongoing efforts in risk reduction and slope stabilization provide a valuable institutional framework. The mission, made (in Spanish) by Profs Fernando Marinho (Brazil) and Bernardo Caicedo (Colombia), focused on evaluating slope stability conditions and assessing the effectiveness of local mitigation strategies. The city’s complex topography and widespread hillside occupation, often in geologically unstable zones, pose significant geotechnical challenges.

Figure 10. Slope in partially saturated soil in the city of La Paz.

Among the numerous slope stability problems that occur in the city of La Paz, two of them are the most evident:

- Slopes in partially saturated soils that can remain stable with almost vertical gradients as long as the suction pressure remains sufficiently high (Figure 10).
- Colluvial deposits that, due to precipitation conditions, increase their interstitial pressure and induce large-scale movements.

For the second type of movement, deep piles, occasionally combined with drainage tunnels, have been employed to intercept known failure planes, as revealed by inclinometer data. While numerous drainage tunnels have been constructed across the city, their long-term effectiveness remains uncertain, and the associated high costs raise concerns about financial sustainability. The visit also underscored the lack of regulation and enforcement in hillside development, where informal construction continues to expand into high-risk areas. Social and economic pressures frequently outweigh technical considerations, increasing the population's exposure to landslide hazards.

A growing concern is the impact of climate change, particularly the projected increase in precipitation intensity and frequency. Such changes are likely to result in higher infiltration rates, progressively reducing matric suction on currently unsaturated slopes. As pore-water pressures rise, these slopes, once stable under unsaturated conditions, may reach critical thresholds, leading to failure and placing densely populated communities at elevated risk. This highlights the need to integrate climate projections into slope stability assessments and mitigation planning.

The La Paz Formation offers considerable potential for further geological and geotechnical research, particularly in evaluating the performance of current stabilization techniques and exploring cost-effective, scalable alternatives. Although existing mitigation strategies demonstrate technical merit, their success is constrained by rapid, unregulated urban expansion, economic limitations, and the increasing influence of climate-driven hydrological stressors.

During the visit, the GeoWB geo-engineers were able to verify that the studies and stabilization works being carried out in the city of La Paz are being carried out using state-of-the-art geotechnical engineering techniques. Nevertheless, the delegation engineers recommend considering the following:

- While the city has reportedly implemented deep drainage tunnels as part of its slope stabilization program, no detailed georeferenced information on their location or monitoring results was found in the available documentation, highlighting a need for improved transparency and post-construction evaluation.
- It may be useful to emphasize the role that local institutions, such as universities and professional associations, can play in strengthening technical capacity, promoting applied research, and supporting the long-term sustainability of mitigation efforts.
- Adopting a monitoring system based on satellite interferometry can be very useful for accurately measuring changes in the Earth's surface, such as ground movements. This would be an initial phase for detecting unstable areas, which can then be monitored more precisely with the inclinometer technology already used in the city.

Finally, it is important to remark that effectively addressing slope instability in La Paz will require a multidisciplinary, integrated approach that combines geotechnical engineering, hydrological analysis, climate resilience strategies, and a deep understanding of local socio-economic dynamics.

Rainfall induced disaster in the district of Mandi, Himachal Pradesh, July 2025

Between June 29 and July 25, 2025, the Mandi district of Himachal Pradesh endured a devastating spell of extreme rainfall (217 mm on July 1 and 199 mm on July 29) that led to flash floods and landslides, resulting in significant human and infrastructural losses (Pandey & Satyam, 2026). Professor Neelima Satyam, as part of the evaluation committee, visited the affected sites to assess both the causative factors and the efficiency of the disaster response mechanisms.

Triggered by a series of cloudbursts and sustained heavy rain, the disaster has taken a heavy toll on the region, with at least three lives lost, one person injured, and another still missing. Torrents of water inundated residential areas, submerged homes, and buried over 20 vehicles under debris. Roads, including key national highways, have been rendered impassable, and basic utilities such as electricity and water supply have been severely disrupted, particularly in areas like Jail Road, Saini Mohalla, and the vicinity of the Zonal Hospital.

Highest rainfalls played a critical role in triggering flash floods and landslides. Emergency response teams, including the NDRF, local police, and home guards, swiftly launched rescue operations, evacuating around 15 to 20 people and setting up a relief camp at Vipasha Sadan. Meanwhile, departments such as Public Works, Jal Shakti, and power utilities are working to clear debris and restore essential services. With the monsoon causing over ₹1,539 crore in damages across Himachal Pradesh so far, this incident underscores the escalating vulnerability of the region to climate-induced disasters, despite existing preparedness plans by the local disaster management authorities.

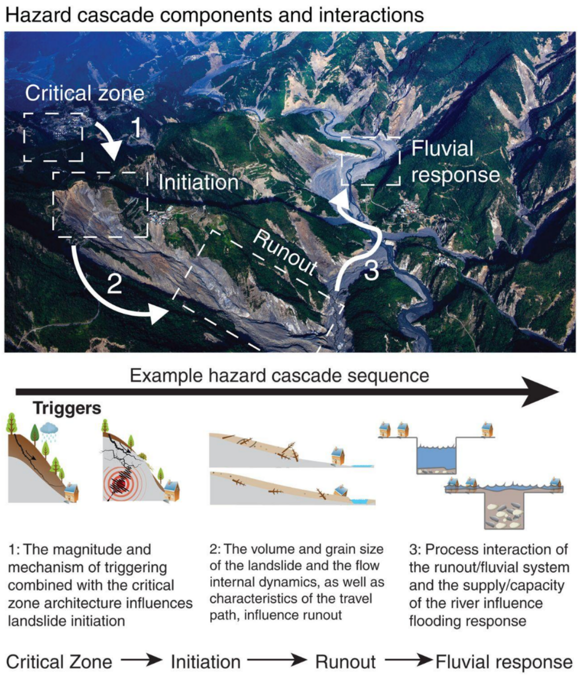


Figure 11. Schematic events unfold during cascading events (modified from Yanites at el. 2025)

To assess the extent and nature of the disaster, the group conducted detailed field visits to seven critical locations across the Mandi district, each selected based on reported severity and diversity in the type of geomorphic failures. Based on our initial assessment and drawing upon the conceptual framework proposed by Yanites et al. (2025, Figure N), we observed that the events in Mandi represent a classic case of multiple cascading hazards.

Figure 12 shows a picture of the Sarkol Nala site, which primarily exhibited dry granular flow, with minimal presence of fines or saturated slurry. The failure here was dominated by mechanical entrainment and downslope movement of colluvial material. Scrapping of surface layers exposed bedrock, while the gully system served as the main transport path. There was little evidence of cascading processes; the flow was mostly limited to a single-stage event.

a) b)

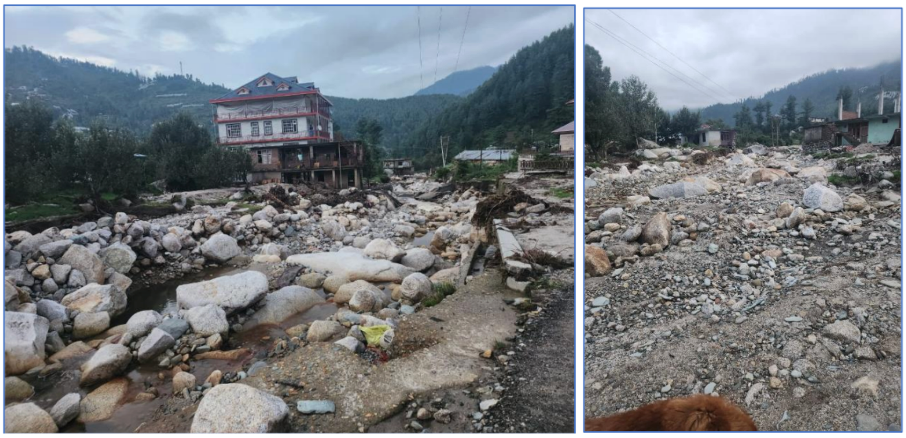
Figure 12. Granular flow in Sarkol Nala a) Scrapping and exposed bed rock b) entrainment over the Gulley

Figure 13 shows that, in the Shankar Dera site, the interaction between mass movement and vegetation was significant. Uprooted tree trunks, broken roots, and other organic debris blocked multiple culverts, suggesting a prominent flow-structure interaction. This led to the redirection and accumulation of flow, aggravating the failure. The presence of both debris and flowing water suggested partial saturation.

a) b)

Figure 13. Landslide in Shankar Dera a) uprooting of vegetation b) blockage of culvert due to flowing trunks/roots of vegetation

The area of Janjehli (Figure 14) demonstrated a typical cascading scenario, where coarse particles, including large boulders, were transported and deposited across dry and semi-active gulleys as well as into the riverbed. The interaction of dry flow over existing channels suggests intermittent flow activation. Exposed bedrock and the collapse of multiple houses were observed in the deposition zone.



a) b)

Figure 14. Landslide in Janjehli a) exposed bed rock with big boulders and rocs b) multiple houses collapsed with left out deposition of debris over bed

In Pandav Shila (Figure15), the failure included riverbank erosion and a strong flow-structure interaction. The mass movement here dammed the local river and destroyed nearby homes, primarily due to the impact of boulders within the debris striking built structures. This is another instance of cascading failure, where an initial slide evolved into a debris flow that altered the river course and intensified destruction.

Figure 15. Landslide in Pandav Shila a) Eroded banks b) Flow-Structure interaction caused house collapse

The Thunag valley (Figure 16) represented the most complex and severely affected site, characterized by multiple overlapping processes like landslides, debris flows, bank erosion, and river damming which is occurring in close sequence and spatial proximity. This is a textbook case of a cascading geomorphic event, where each process fuelled the next, resulting in extensive landscape transformation and infrastructure damage. Figures 11 and 12 capture the progressive failure sequence, with river blockage, redirected flow paths, and significant debris deposition along both natural and built environments.

Figure 16. Landslide near Thunag Valley caused river damming and bank erosion

Brief analysis

Based on our field investigation across seven critical locations and supported by drone surveys and physical inspections, it is evident that July 2025 Mandi rainfall-induced disaster cannot be classified under a single failure type. Instead, using the JTC1 Landslide Classification (Hungr et al., 2014), the Mandi disaster spans multiple categories: debris slides, debris flows, debris avalanches, landslides, and mudflows. This diversity is a direct result of the region's geomorphology, particularly the abundance of unconsolidated colluvial material, which becomes highly mobile when overlain by intense surface runoff caused by flash floods.

Rainfall intensities approaching 200 mm/day, far exceeded Mandi's drainage and slope stability thresholds. Combined with poor drainage and fragile geology, they have exposed significant gaps in disaster preparedness. As observed in locations like Seraj College and Pandav Shila, human settlements placed in hazard-prone areas suffered the worst outcomes, often due to flow-structure interactions and riverbank erosion.

In contrast to similar events documented in Italy, China, or the USA, where finer material dominates (Gong et al., 2023), the Western Himalayan debris profiles involved large rock fragments capable of devastating impact forces, often resulting in total building collapse. This observation reinforces the need for region-specific mitigation strategies, including the construction of engineered barrier systems near vulnerable settlements, regulated land-use planning, and strict enforcement against unplanned construction on floodplains or former riverbeds.

Concluding remarks

The examples of GeoWB missions on geo-disasters demonstrates how a structured, volunteer-based mobilisation of geotechnical engineers can, within a reasonable cost, complement emergency response and support recovery and enhancing resilience, capitalising on the ISSMGE network and its commitment to UNDRR.

Across the six case studies presented, GeoWB actions illustrate several transferable contributions to soil mechanics and geotechnical engineering practice:

- The need to ensure safe working conditions for missions. This was particularly critical in Libya and Papua New Guinea due to general unsafe – if not dangerous – societal conditions, and safety was ensured with the support of armies, including to go in remote locations (helicopters, four-wheels cars…). Note that this was not the case in the central plain of Myanmar.
- Rapid, defensible risk screening for recovery decisions. In Papua New Guinea and Rio Grande do Sul, the mission combined field reconnaissance, mapping of cracks and slope processes, and preliminary mechanism assessment to support emergency mitigation and decision-making. A concrete example in Rio Grande do Sul was the assessment (jointly with the Geological Survey of Brazil) that enabled reopening a school after confirming it laid outside the risk zone. A similar process was followed in Papua New Guinea to know where it was possible to safely relocate displaced people. In all cases, local authorities, institutions and people were really very grateful with mission teams.
- Integration of field and remote technical capabilities under constrained access. In Papua New Guinea, the hazard assessment benefited from UAV-enabled reconnaissance and “back-office” numerical modelling, hazard mapping, and satellite support, improving situational awareness in a challenging operational environment. UAV was also successfully used in and Himachal Pradesh (India).
- Forensic-style diagnosis and prevention-oriented recommendations, as done in Myanmar and Himachal Pradesh. In Derna, where direct inspections were not feasible, expert assessment based on design and monitoring documentation supported causal interpretation and remedial recommendations, including conservative reassessment of design floods under climate change and careful appraisal of foundations prior to any rebuilding.

The GeoWB operational model contributes to the profession by formalising how geotechnical volunteer missions can be organised safely and effectively, producing, for reasonable cost, comprehensive reports that document causes, damages, diagnoses, remedial options, and preventive measures for authorities and stakeholders. Looking forward, the strongest impact of GeoWB actions will come from continuing to standardise mission workflows and strengthening interfaces with local institutions, so that post-event reconnaissance and engineering judgement translate consistently into actionable recovery priorities and sustained risk reduction. This translation crucially depends on coordinated engagement with affected communities, local competences, public authorities and private stakeholders, supported by professional organisations that can mobilise qualified expertise, provide ethical and technical guidance, and facilitate the timely exchange of data and responsibilities across response, recovery, and prevention.

Another action asked for by people in risky or geo-disasters affected areas is that of proposing local workshops to familiarise stakeholders, local authorities and geo-engineers to improve risk assessment and prepare local people to face possible geo-disasters through appropriate workshops in presence. This has been done with the Municipality of Bogota in Bolivia in May 2024 (Profs F. Marinho and B. Caicedo). It is presently in discussion with the Philippines Member Society (Prof. Mark Zarco) in conjunction with the South East Asia Geotechnical Society (SEAGS), following the earthquake and rain-induced landslides occurred in September 2025. Perspectives also exist in South America, where the GeoWB membership is strong and where the degradation of tropical soils and the resulting sensitivity to heavy rainfalls and the induced landslides is a widespread problem.

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