31 August 2025 Eastern Afghanistan Earthquake

A Joint Virtual Reconnaissance Report

Earthquake Engineering Field Investigation Team (EEFIT), Association Française du génie Parasismique (AFPS), NED University of Engineering & Technology, and RedR

Source: Radio Television Afghanistan (RTA)

In every area of the world where there is earthquake risk, there are still many buildings of this type; it is very frustrating to try to get rid of them.

Charles Francis Richter

31 AUGUST 2025 EASTERN AFGHANISTAN EARTHQUAKE

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Cite as: **Rafi, M.M., Aktas, Y. D., Smars, P., Veliu, E., Sabir, N., Chian, D., Khan, A., Micouraud, P., Kuchai, N., Abdulrazaq, H., Abiodun-Haruna, J., Ahmed, M., Avogadro, C., Bayann, M., Burton, P., Ercolino, M., Ferreira, T.M., Franco, C., Gaillac, J., Gilles, M., Khan, S., Khan, M.S., Koh, K.J., Lossignol, J., Magagnosc, J., Mohammad, A.F., Roosefid, M., Rasheed, A., Rehman, K., Rogers-Tizard, W., Sangirardi, M., Vleugels, C., White, T., Zwak, Q. (2026). 31 August 2025 Eastern Afghanistan Earthquake: A Joint Virtual Reconnaissance Report by EEFIT, AFPS, NED University and RedR, UK Institution of Structural Engineers (IStructE) EEFIT. https://doi.org/10.56330/KTBV3076.**

EXECUTIVE SUMMARY

A magnitude 6.0 earthquake (Mw) struck eastern Afghanistan near the border of Nangarhar and Kunar Provinces on the night of 31 August 2025. The earthquake generated violent ground shaking across several districts due to a shallow focal depth of 8 km, resulting in extensive loss of life, severe damage to housing and infrastructure, and significant disruption to essential services. The most severely affected districts were Nurgal, Chawkay, and Dara-e-Nur, where steep terrain, vulnerable construction practices, and limited access compounded the impacts.

This remote assessment synthesises available information, drawing on satellite-based analysis, humanitarian situation reports, media sources, and technical data to evaluate the spatial distribution of damage, underlying vulnerability drivers, and response challenges. Synthetic Aperture Radar coherence analysis provided rapid, large-scale insight into building damage patterns and identified the most heavily impacted districts, consistent with available field-based and inter-agency assessments. The convergence of remote sensing and ground reports highlights the value of satellite data for early damage estimation in cloud-prone and inaccessible mountainous regions.

Geotechnical conditions played a decisive role in amplifying earthquake impacts. The event triggered widespread slope failures, landslides, ground deformation, and foundation failures, particularly in steep, saturated, and geologically fractured terrain. Monsoon rainfall prior to the earthquake reduced slope stability and contributed to extensive landsliding, which caused direct casualties, destroyed housing, and severed critical access routes. Local site effects, including topographic amplification and soft valley sediments, further intensified ground shaking. Traditional unreinforced masonry construction and shallow, poorly engineered foundations proved highly vulnerable, explaining the concentration of severe damage in specific districts and settlements.

The earthquake also exposed systemic weaknesses across critical infrastructure systems. Transport networks were particularly affected, with landslides and debris blocking roads and isolating entire valleys, delaying rescue operations and the delivery of humanitarian assistance. Disruptions to electricity and communications increased isolation and constrained coordination during the early response phase. Drinking water infrastructure suffered extensive damage and contamination, sharply increasing public health risks. Health and education facilities experienced partial or full damage, overwhelming an already fragile service delivery system and disrupting access to care and schooling for tens of thousands of people.

Despite these challenges, the immediate response benefited from strong community mobilisation and rapid action by national authorities and humanitarian partners. Local residents carried out initial rescue efforts and provided emergency food support during the first hours following the earthquake. This was followed by a coordinated inter-agency response across health, food security, shelter, WASH, protection, and education sectors. Mobile health teams, emergency food distributions, water trucking, temporary shelter provision, and rapid needs assessments enabled life-saving assistance to reach most affected populations within weeks, although access constraints persisted in remote areas.

While the majority of emergency response activities were completed by late September, significant unmet needs remain. Many families continue to live in inadequate shelters, particularly as winter conditions worsen, and early recovery challenges related to livelihoods, infrastructure rehabilitation, and service restoration persist. The 2025 Eastern Afghanistan Earthquake demonstrated that impacts in mountainous regions are strongly influenced by geotechnical conditions, construction practices, and infrastructure fragility, highlighting the need to move beyond ground-shaking assessments alone. Integrated, multi-hazard risk reduction measures (including geotechnical hazard mapping, seismic microzonation, slope stability analysis, and hazard-resilient infrastructure design) alongside practical improvements to traditional construction practices are essential. Translating these lessons into coordinated recovery efforts and risk-informed planning will be critical to reducing future losses and strengthening resilience in eastern Afghanistan's high-risk mountainous regions.

د راپور لنډیز د راپور لنډیز

د ۲۰۲۵ کال د اګست د میاشتې پر ۳۱مه شپه د ریښتر په کچه ۶.۰ درجه زلزلې د افغانستان ختیځې سیمې، د ننګرهار او کونړ ولایتونو د سرحدي سیمو ته نږدې ولړزولې. د زلزلې کم ژوروالی (شاوخوا ۸ کیلومتره) د دې لامل شو چې په ګڼو ولسوالیو کې سختې ځمکنۍ لړزې رامنځته شي، چې په پایله کې یې پراخ انساني تلفات، د استوګنې ودانیو او بنسټیزو تاسیساتو ته جدي زیانونه، او د حیاتي خدماتو په وړاندې ستر خنډونه رامنځته کړل. تر ټولو ډېرې اغېزمنې شوې ولسوالۍ نورګل، څوکی، او درەنور وې، چې هلته د غرنۍ جغرافیې، زیان‌منو ساختماني دودونو، او محدود لاسرسي یوځای کېدو د زیان کچه نوره هم لوړه کړه.

د ۲۰۲۵ کال د نومبر تر نیمایي پورې شته معلومات (Remote Assessment) دا لیرې ارزونه رانغاړي. په دې ارزونه کې د سپوږمکۍ پر بنسټ تحلیلي ارزونې، د بشري وضعیت راپورونه، رسنیزې سرچینې، او تخنیکي معلومات کارول شوي دي، څو د زیانونو فضایي وېش، د زیان د بنسټیزو لاملونو د همغږۍ (SAR) پېژندنه، او د بیړني غبرګون اړوند ننګونې وارزول شي. د سنتېټیک اپرچر راډار تحلیلونو د ودانیو د زیان د نمونو په تشخیص کې چټک او پراخ لید وړاندې کړ او تر ټولو سخت اغېزمنې شوې ولسوالۍ یې په ګوته کړې، چې دا پایلې د ساحوي ارزونو او د ادارو ترمنځ موجودو راپورونو سره همغږې وې. د لیرې سنجش معلوماتو او مځکنیو راپورونو یوځای کېدل دا څرګندوي چې سپوږمکۍ پر بنسټ معلومات په وریځو پوښلو او ستونزمنو غرنیو سیمو کې د لومړني زیان د اټکل لپاره ډېر ارزښت لري.

جیوټکنیکي شرایطو د زلزلې د اغېزو په شدت کې ټاکونکی رول ولوباوه. دې پېښې پراخې ځمکښوییدنې، د ځمکې بدلونونه، د بنسټونو ناکامۍ، او د ځمکې د سطحې بې‌ثباتي رامنځته کړه، په ځانګړي ډول په هغو سیمو کې چې جغرافیه یې ولاړه یا څمڅې، خاوره یې لنده، او جیولوجیک جوړښتونه یې مات‌مات وو. د زلزلې نه وړاندې موسمي بارانونو د غرونو ثبات کمزوری کړی و، چې د پراخو ځمکښوییدنو لامل شو. دغو ښوییدنو مستقیماً انساني تلفات واړول، استوګنیزې ودانۍ یې ویجاړې کړې، د تګ راتګ لارې او توکو د لاسرسي لارې یې پرې کړې. سربېره پردې، ځایي ساحوي اغېزې لکه د توپوګرافیک تقویت او د درو نرمې رسوبې خاورې د ځمکې لړزه نوره هم شدیده کړه. د کچه خښتو ودانیو، د دېوالونه نه تاداب، او غیرانجینري بنسټونه د زلزلې پروړاندې خورا زیانمن ثابت شول، چې دا چاره په یادو ولسوالیو او استوګنځایونو کې د سختو زیانونو تمرکز روښانه کوي.

زلزلې همدارنګه د بنسټیزو تاسیساتو په سیستمونو کې ډېرې جوړښتي کمزورۍ رابرسېره کړې. د ټرانسپورټ شبکې تر ټولو ډېرې اغېزمنې شوې، ځکه چې ځمکښوییدنو او ډبرو لارې وتړلې، ان تر دې پورې چې بشپړې درې یې بندي کړې، او د ژغورنې عملیاتو او بشري مرستو رسونه یې وځنډوله. د برېښنا او مخابراتو پرې کېدو د سیمو انزوا زیاته کړه او د لومړني غبرګون پرمهال یې د همغږۍ وړتیا محدوده کړه. د څښاک اوبو بنسټونه سخت زیانمن او ککړ شول، چې د عامې روغتیا خطرونه یې په چټک ډول لوړ

کړل. روغتیایي او تعلیمي تاسیساتو جزوي یا بشپړ زیان ولید، چې له وړاندې کمزورۍ خدماتي سیستم یې نور هم تر فشار لاندې راوست او د لسگونو زرو خلکو لپاره یې د درملنې او زدهکړې لاسرسی گډوډ کړ.

سره له دې ننگونو، بیړني غبرگون د ټولنې د قوي بسیج او د ملي ادارو او بشري سازمانونو د چټک اقدام له امله د پام وړ اغېز درلود. ځایي اوسېدونکو د زلزلې په لومړیو ساعتونو کې د ژغورنې لومړني فعالیتونه ترسره کړل او بیړنۍ خوراکي مرستې یې برابرې کړې. وروسته، د روغتیا، خوړو خوندیتوب، سرپناه، ساتنې، او تعلیم په برخو کې یو منظم بینالاداري غبرگون پیل شو. گرځنده روغتیایي ټیمونه، WASH، بېړني خوراکي وېشونه، د اوبو ټانکرونه، لنډمهاله سرپناه، او د چټکې اړتیا ارزونې دا امکان برابر کړ چې د ژوند ژغورونکې مرستې د څو اوونیو په موده کې ډېرى اغېزمنو خلکو ته ورسېږي، که څه هم په لیرې پرتو سیمو کې د لاسرسي محدودیتونه لا هم موجود وو.

که څه هم د سپټمبر تر پای پورې د بیړني غبرگون ډېرى فعالیتونه بشپړ شوي وو، خو لا هم د پام وړ ناپوره شوې اړتیاوې پاتې دي. لکه کورنۍ چې په ځانگړي ډول د ژمي د سختېدو له امله لا هم په نامناسبو سرپناوو کې ژوند کوي. د لومړني بیارغونې په برخه کې د معیشتونو بیا رغونه، د بنسټیزو تاسیساتو ترمیم، او د خدماتو بیا فعالول لا هم جدي ننگونې دي. د ۲۰۲۵ کال د ختیځ افغانستان زلزلې وښودله چې په غرنیو سیمو کې د زلزلو اغېزې تر ډېره د جیوتکنیکي شرایطو، ساختماني دودونو، او د بنسټیزو تاسیساتو د کمزورۍ تر اغېز لاندې وي، او یوازې د ځمکنۍ لړزې ارزونه بسنه نه کوي. مدغم ، څو-خطره (multi-hazard) د خطر کمولو تگلارې (لکه د جیوتکنیکي خطر نقشه جوړونه، د زلزلي مایکروزونیشن، د غرونو د ثبات تحلیل، او د خطر پر وړاندې مقاوم بنسټیز ډیزاین) د دودیزو ودانیزو کړنو له عملي پیاوړتیا سره یوځای اړینې دي. ددغو درسونو ژباړه په همغږو بیارغونې هڅو او خطر-خبره پلان جوړونه کې به د راتلونکو زیانونو د کمولو او د افغانستان د ختیځو لوړې خطر لرونکو غرنیو سیمو د تابیا او مقاومت د پیاوړتیا لپاره گټور وي.

LIST OF ABBREVIATIONS

ACTED – Agency for Technical Cooperation and Development

ADA – Afghan Development Association

AFPS – Association Française du génie Parasismique

CWSA – Coordination of Welfare and Support for Afghanistan

DRC – Danish Refugee Council

EEFIT – Earthquake Engineering Field Investigation Team

FAO/TPM – Food and Agriculture Organization of the United Nations / Third-Party Monitoring

HNTPO – Humanitarian Network and Technical Project Organization

IOM – International Organization for Migration

OAWCK – Organization of Afghan Women's Capacity and Knowledge

PU-AMI – Première Urgence – Aide Médicale Internationale

SCI – Save the Children International

UNFPA/AFGA – United Nations Population Fund / Afghan Family Guidance Association

UNHCR/CHA – United Nations High Commissioner for Refugees / Coordination of Humanitarian Assistance

UNICEF/AYSO – United Nations Children's Fund / Afghan Youth Services Organization

UNICEF/HNTPO – United Nations Children's Fund / Humanitarian Network and Technical Project Organization

UNOCHA – United Nations Office for the Coordination of Humanitarian Affairs

UNW/AWUDO – UN Women / Afghan Women United Development Organization

WFP/TPM – World Food Programme / Third-Party Monitoring

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ACKNOWLEDGEMENTS

This Remote Reconnaissance Survey was made possible through the collective efforts and collaboration of numerous individuals and organisations who contributed their time, expertise, and commitment despite challenging operational conditions. The assessment benefited from a coordinated, multi-disciplinary approach that brought together technical, humanitarian, and contextual knowledge to document impacts and inform response and recovery planning.

The editorial team would like to express its sincere appreciation to the Chapter Coordinators, whose leadership, technical oversight, and coordination ensured the coherence, quality, and timely completion of this report. Their guidance was instrumental in integrating multi-sectoral perspectives and maintaining analytical rigor throughout the data compilation and chapter writing process.

The editorial team is equally grateful to the Team Members, whose contributions to data review, analysis, mapping, interpretation, and report drafting formed the backbone of this remote assessment. Their dedication and collaborative spirit were critical in translating remote data sources and partner inputs into meaningful findings and recommendations.

The editorial team would also like to extend special thanks to a number of individuals who, while not formally part of the chapter coordination or writing teams, provided valuable technical advice, contextual insights, data support, and peer review that significantly strengthened this report. Their contributions are gratefully acknowledged: Hayatullah Haqvesh, Zakir Khan, Didier Combescure (AFPS), Abdul Wakil Motawakil.

The authors are indebted to the following for permission to publish figures and photos:

Muhammad Ahmed – Figure 1.1, Zeeri Baba – Figure 3.1, Pierre Smars – Figures 5.3, 5.9, and 5.21, Muhammad Haroon – Figure 5.7, Abdullah Wadan – Figure 5.7, Hakeem Muntazer khan – Figure 5.8, Rafiq Sahil – Figure 5.8, Amjad Khan – Figures 5.10, 5.16, and 5.17, Aimal Zahir – Figure 5.12, Wakil Kohsar – Figure 5.20, Abdul Waki Motawakil – Figures 6.2 and 6.11, Emergency Response Coordination Centre – Figure B.1, UNOCHA Afghanistan – Figure B.2, NCRO and Hamkaro – Figure B.3, NCRO – Figures B4 and B5.

The authors are grateful to Arup's Sebastian Kaminski for a thorough review of the report that provided valuable feedback and helped improve its clarity, technical accuracy, and overall quality.

Special thanks are also extended to humanitarian partners, local organisations, and community networks who supported information sharing and contextual understanding, as well as to coordination mechanisms that facilitated collaboration across sectors. The editorial team also acknowledges the efforts of agencies and technical partners who provided secondary data, imagery, and insights that further strengthened the analysis.

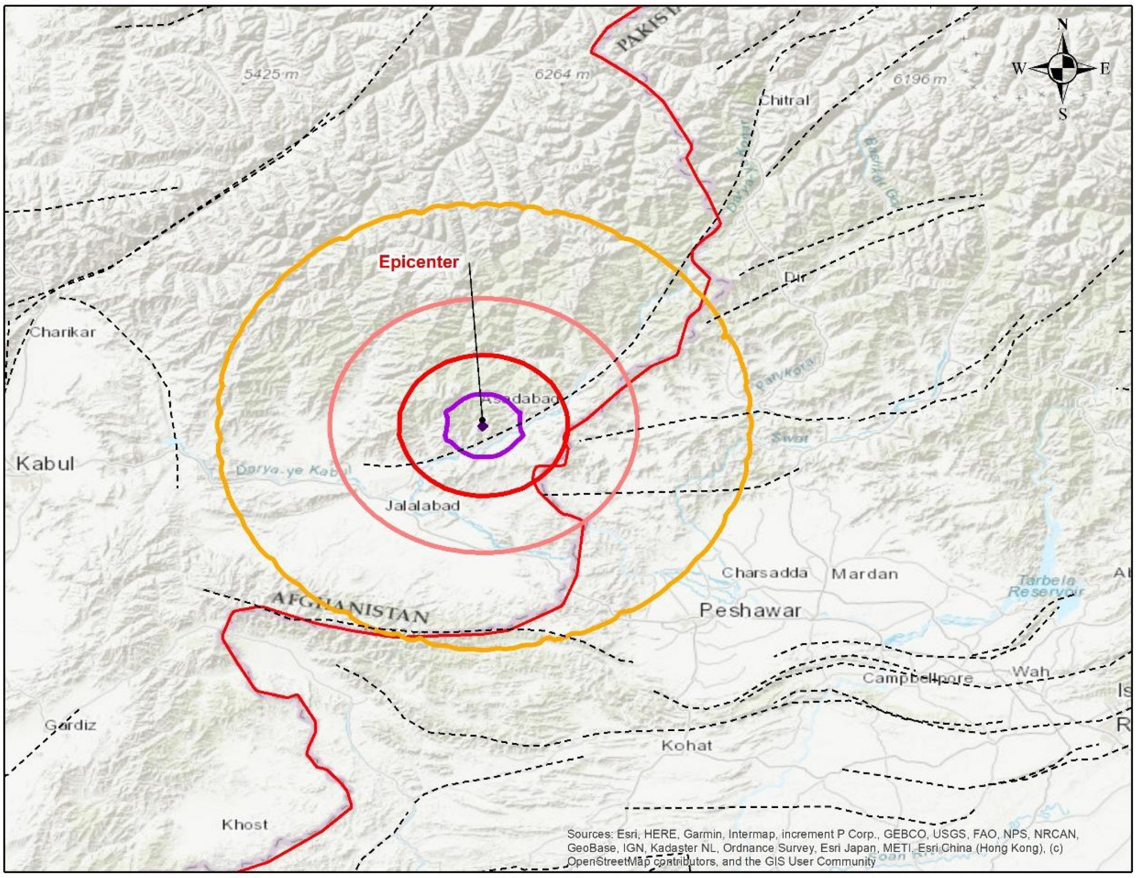
Finally, the editorial team recognises the resilience of affected communities, whose experiences and realities remain at the centre of this work. It is hoped that the findings of this survey will contribute to safer reconstruction, improved preparedness, and more resilient communities in earthquake-prone regions of Afghanistan.

1. INTRODUCTION

A magnitude 6.0 earthquake (Mw) struck eastern Afghanistan at 23:47:34 local time on 31 August 2025. The event was a shallow (8 km depth), thrust-type earthquake with an epicentre located at 34.706°N, 70.793°E (USGS, 2025a). The location was approximately 27 km east-northeast of Jalalabad in Nangarhar Province near the border with Kunar Province (Figure 1.1). Dozens of aftershocks followed the main event over the next few days, ranging from 5.2 to 6.2 (Yawar, 2025; The Guardian, 2025a), further compounding the damage and distress in affected communities.

The earthquake was widely felt across Nangarhar, Kunar, Laghman, and Nuristan Provinces, with shaking extending as far as Kabul and northwestern Pakistan. Severe ground motion was reported in rural and mountainous areas, where unreinforced stone and mud masonry buildings are prevalent. Field observations and early assessments confirmed extensive destruction, particularly in steep valleys and on densely populated slopes. Initial situational reports indicated significant loss of life and numerous injuries, with a large proportion of the affected population residing in remote and difficult-to-access valleys. Subsequent assessments estimated approximately 2,000-2,200 fatalities and over 3,400 injuries by mid-September 2025, as responders reached more communities and consolidated data (UNICEF, 2025).

In addition to residential damage, the earthquake caused extensive disruption to public infrastructure, including water supply systems, irrigation networks, and educational facilities. These impacts heightened the risk of waterborne disease outbreaks and contributed to concerns about long-term displacement. The loss of livestock further exacerbated livelihood insecurity among affected households, particularly those dependent on subsistence agriculture and pastoral activities.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 1.1: Epicentre of 2025 Afghanistan earthquake and influence region

This report compiles available information on various aspects of the earthquake's impacts and aftermath. Due to limited field access arising from security and logistical constraints, the analysis relies on a synthesis of multiple data sources, including news reports, remote sensing products, damage assessments conducted by international organisations (such as UN agencies and Miyamoto International), limited field reports from Afghan authorities and non-governmental organisations operating in the region, and crowd-sourced information platforms.

Key data sources used in this report include the following:

1) Satellite imagery and interferometric synthetic aperture radar (InSAR) analysis
2) Post-earthquake damage assessment reports
3) Preliminary structural and geotechnical surveys
4) Seismological data from regional monitoring agencies
5) Eyewitness accounts and photographic evidence from affected communities

The report has been put together jointly by EEFIT, NED University, AFPS, and RedR and is organised as follows. The content reflects information available during the period of report preparation (October-November 2025). Chapter 2 presents a characterisation of the seismic event, including its tectonic and seismological context. Chapter 3 describes the initial response and relief operations. Chapter 4 examines the geotechnical failures triggered by the earthquake. Chapter 5 assesses the performance of the built environment, followed by an evaluation of infrastructure performance in Chapter 6. Lessons learned and key recommendations are presented in Chapter 7.

2. CHARACTERISATION OF THE EVENTS

2.1. Regional Tectonic Setting and Seismicity

Eastern Afghanistan lies within an active tectonic zone shaped by the ongoing convergence between the Indian and Eurasian plates (Figure 2.1). This convergence (occurring at an estimated rate of approximately 40-50 mm/year) generates significant crustal deformation and frequent seismic activity across the region (Turner et al., 2013). As a result, regional seismicity is characterised by a combination of reverse, strike-slip, and oblique faulting mechanisms.

The 31 August 2025 earthquake is interpreted as a thrust-type event associated with compressive stresses arising from India-Eurasia plate collision (USGS, 2025a). Although the specific causative fault has not yet been definitively identified, the epicentral region is known to contain a dense network of active thrust faults, including south-dipping structures that accommodate dominant north-south compression (Faryad et al., 2013; Shnizai and Walker, 2024; GFZ, 2025). Previous severe earthquakes in eastern Afghanistan have similarly involved reverse faulting on comparable tectonic structures, reinforcing this interpretation (USGS, 2023).

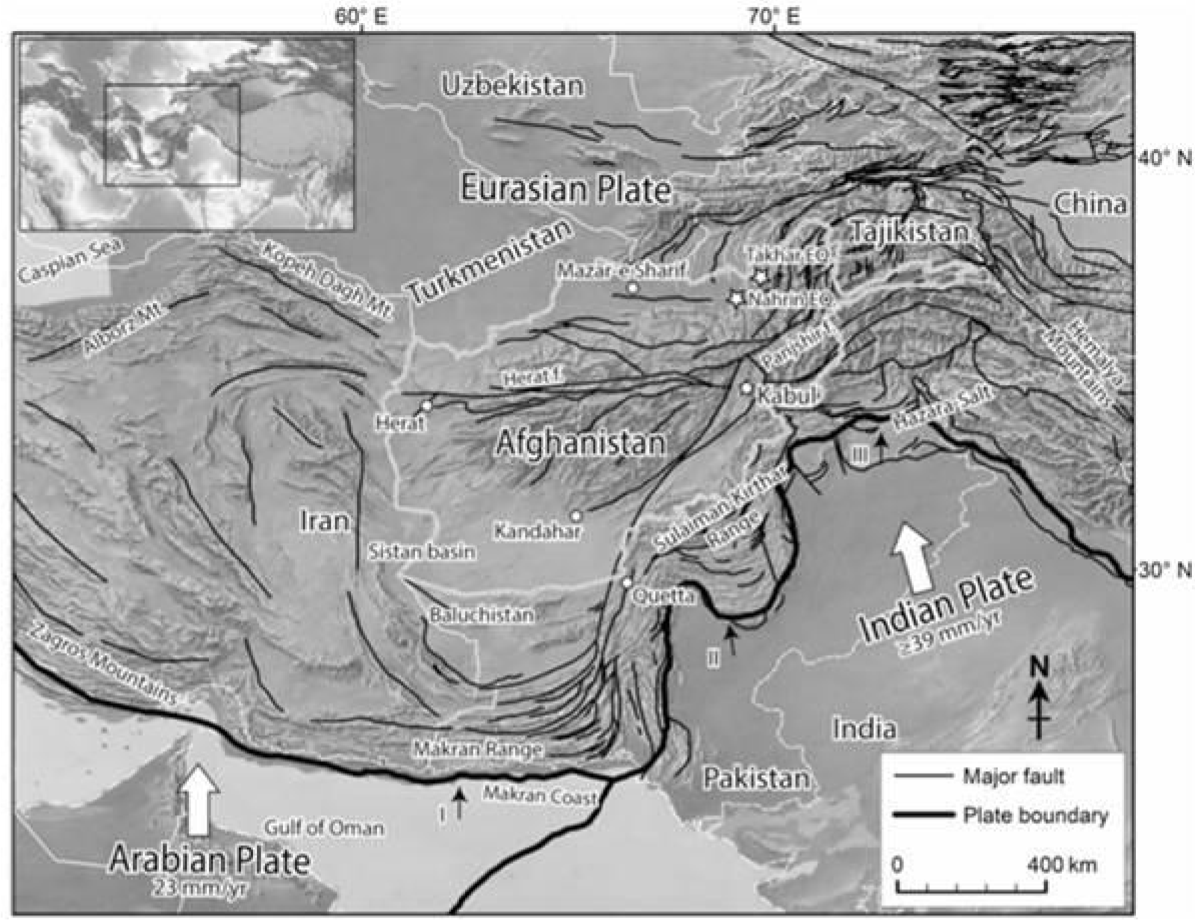


Figure 2.1: Tectonic setting of Afghanistan and surrounding regions. White arrows show relative plate motion directions of the Arabian and Indian plates with respect to the Eurasian plate (Shnizai, 2020; plate velocities from Ambraseys and Bilham, 2003)

The earthquake primarily affected Kunar and Nangarhar Provinces but was widely felt across Laghman, Nuristan, and Panjshir Provinces, with reports of shaking extending into surrounding regions (Associated Press, 2025a; The Guardian, 2025b; UNFPA, 2025; IOM, 2025a). The event caused catastrophic human losses, with reported fatalities exceeding 2,200, including a high proportion of women and children (British Red Cross Society, 2025). The severity of the impacts reflects both the high level of seismic hazard inherent to the regional tectonic setting and the pronounced vulnerability of exposed communities, particularly those residing in remote mountainous terrain with non-engineered construction.

2.2. Ground Shaking and Site Response

The intensity and spatial variability of ground shaking during the 2025 Eastern Afghanistan Earthquake played a critical role in determining the distribution and severity of damage. Ground motion characteristics were strongly influenced by local geological and geomorphological conditions, including soil type, topography, and basin geometry. Understanding these factors is essential for interpreting observed geotechnical failures and damage patterns.

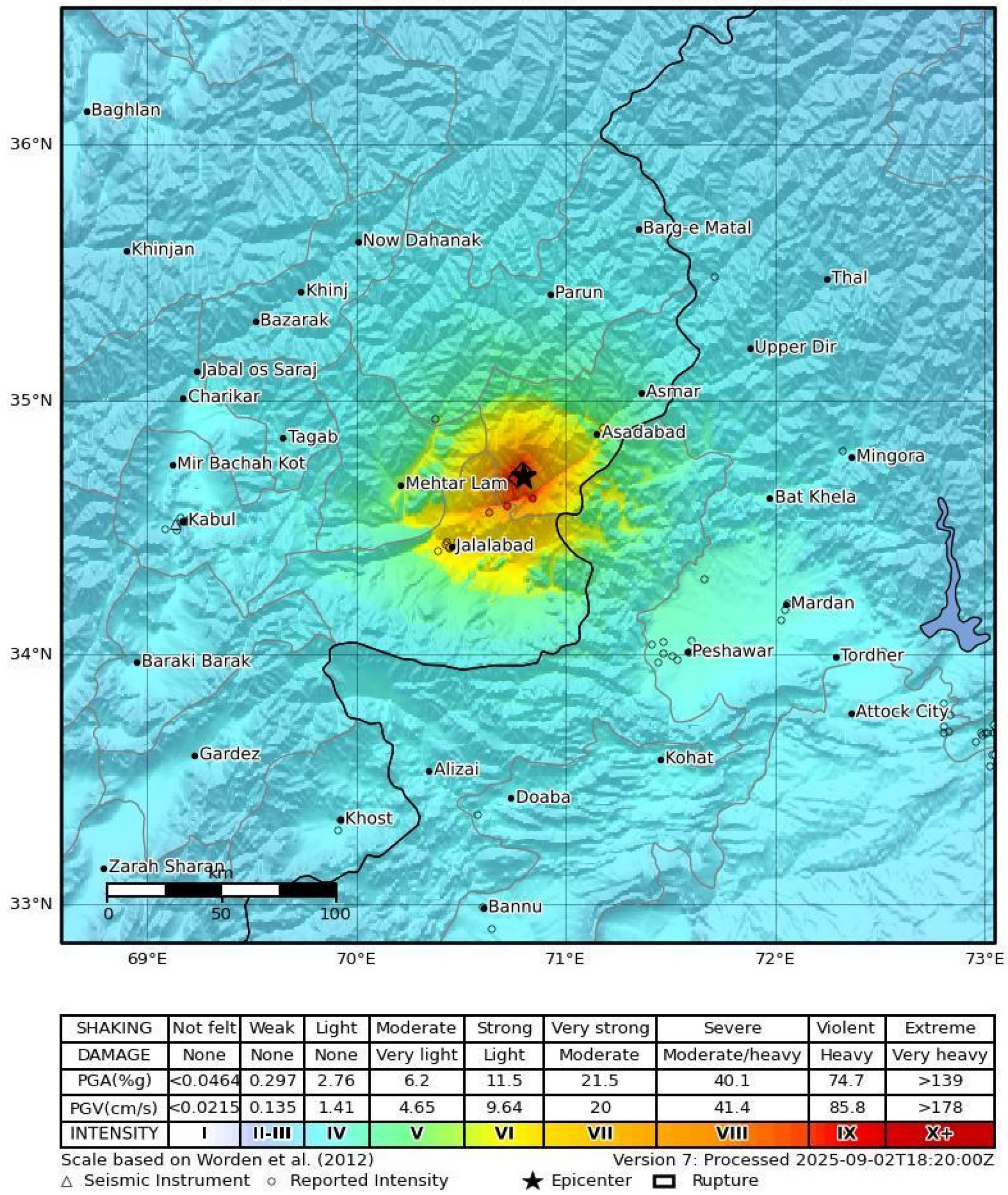
2.2.1. Ground motion characteristics

The mainshock, with a magnitude of 6.0 (Mw) and a shallow focal depth of approximately 8 km, generated strong ground motions concentrated near the epicentre, particularly in parts of Kunar Province. Figure 2.2 illustrates the USGS ShakeMap, which provides detailed insight into the spatial distribution and severity of ground shaking (USGS, 2025b). It is seen in Figure 2.2 that the maximum Modified Mercalli Intensity (MMI) reached IX (Violent) in Nurgal District, indicating extremely destructive shaking conditions. Intensity levels of VIII (Severe) were recorded in Chawkay and Kuz Kunar Districts, while MMI VII (Very Strong) shaking was observed in Jalalabad. Lower but still perceptible shaking, corresponding to MMI IV (Light), extended as far as Kabul and across the border into Peshawar and Islamabad, demonstrating the wide regional extent of the tremors.

The observed high intensities are consistent with the shallow focal depth (~8 km) of the earthquake, which significantly amplified near-surface ground motions. Peak ground acceleration (PGA) values in the epicentral region are estimated to have exceeded 0.35-0.40 g, with strong shaking concentrated within approximately 50-60 km of the epicentre. Although seismic energy decayed rapidly with distance due to crustal damping in the mountainous terrain, pronounced localised amplification occurred in sediment-filled valleys, contributing to spatial variability in damage.

Population exposure estimates indicate that approximately 18,000 people were subjected to Violent (MMI IX) shaking, while around 107,000 experienced Severe (MMI VIII) intensity levels (USGS, 2025c). This distribution closely corresponds with the areas of highest casualty rates and the zones where structural damage was most extensive.

Numerous aftershocks (several exceeding magnitudes 4.5 (Mw)) followed the main event. These aftershocks further destabilised already weakened slopes and structures, contributing to delayed ground failures and progressive damage. Figure 2.3 presents the spatial distribution of the strongest recorded aftershocks.



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012) Version 7: Processed 2025-09-02T18:20:00Z

△ Seismic Instrument ○ Reported Intensity ★ Epicenter ☐ Rupture

Figure 2.2: Macroseismic intensity map for 2025 Afghanistan earthquake (USGS 2025b)

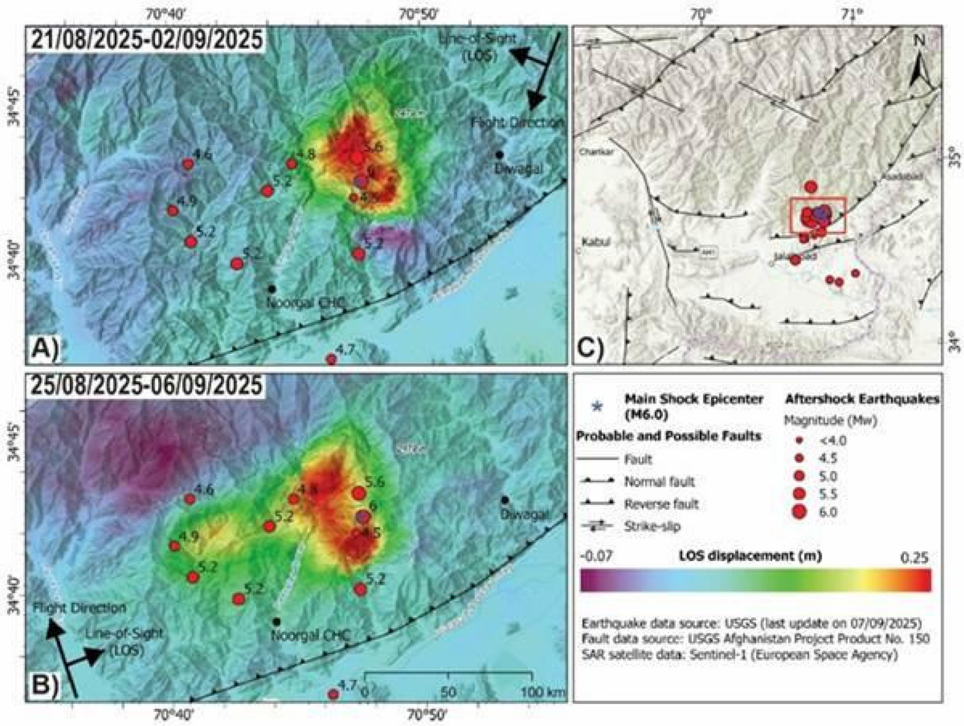


Figure 2.3: A) Surface displacement derived from InSAR processing of an image pair acquired in descending orbit of Sentinel-1 satellite during August 21 to September 2, 2025. The map shows up to 23 cm uplift (positive values) in LOS at the epicentre of the August 31 earthquake. Figure B) Cumulative surface displacement from InSAR processing of an image pair acquired in the ascending orbit of Sentinel-1 satellite during August 25 and September 6. Map shows up to 23 cm uplift in LOS at the epicentre of the August 31 earthquake and about 17 cm above the aftershock of September 4. C) Regional seismotectonic, including active faults and largest aftershocks. Source: US Geological Survey. (Shirzaei et al., 2025)

2.2.2. Local site effects and soil amplification

Local site conditions played a decisive role in amplifying ground motion and exacerbating damage in specific areas. Amplification effects were most pronounced in locations underlain by soft, unconsolidated sediments, particularly

1) Alluvial plains and river terraces, where seismic waves were trapped and amplified.

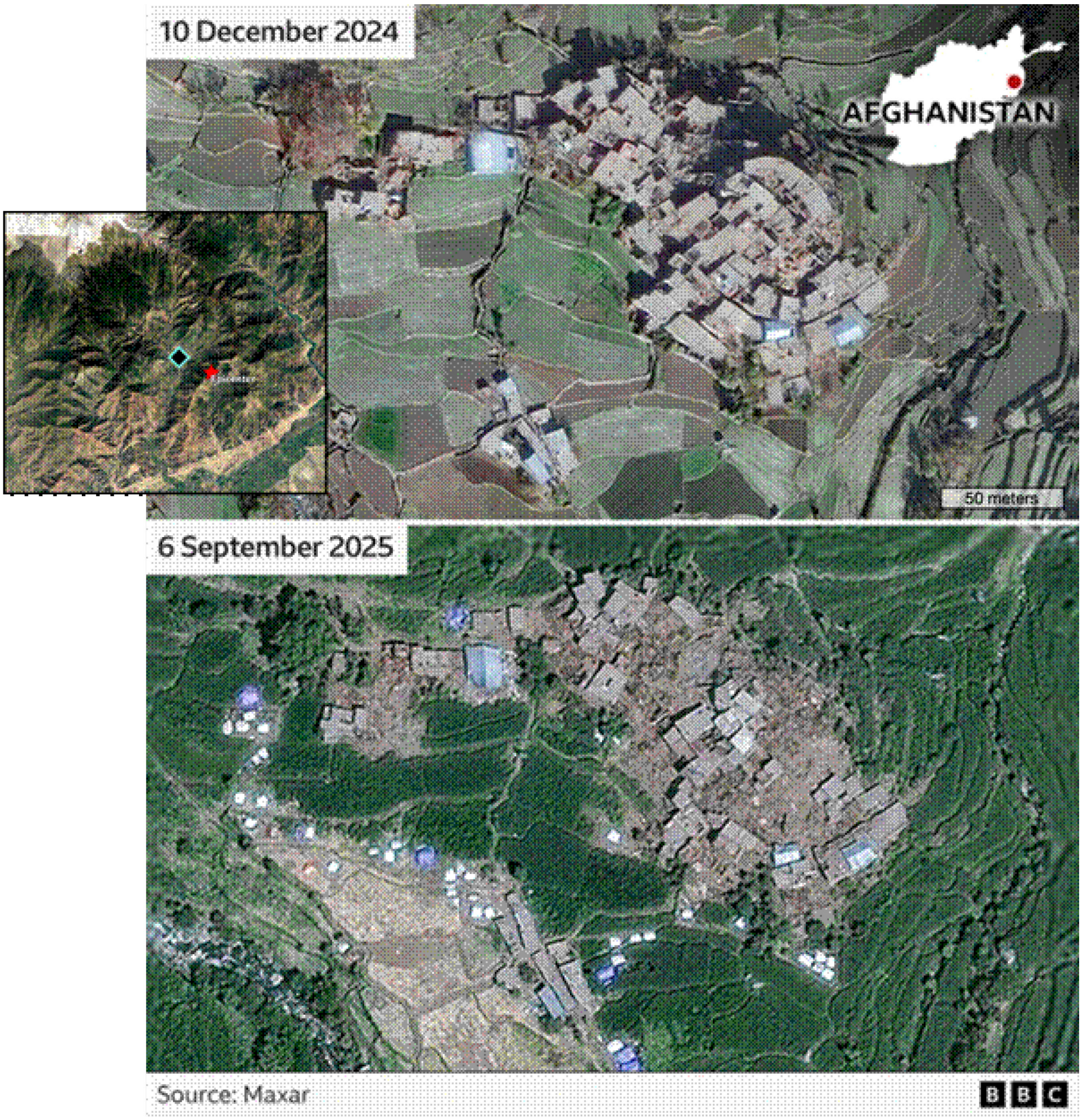
2) Valley bottoms with deep sedimentary deposits, which acted as natural resonance chambers.

3) Areas with thick weathered soil profiles, resulting in prolonged shaking and increased ground settlement.

Settlements located on soft ground experienced disproportionately high levels of structural and foundation damage compared to those founded on competent rock. Unreinforced masonry and mudbrick buildings in these areas commonly suffered partial to complete collapse. Remote sensing analysis and eyewitness accounts indicate that soil amplification effects were particularly severe in parts of the Nari, Bar Kunar, and Shegal districts (Ambrose et al., 2025), where ground conditions were both soft and locally water-saturated.

Figure 2.4 illustrates the extent of damage in affected villages in Ghaziabad District, which are situated on vulnerable ground conditions. Approximately half of the buildings in these settlements were reduced to rubble, with many of the remaining structures showing signs of significant structural distress.

While the observed damage patterns are consistent with the influence of local site amplification and basin effects, they should be interpreted within a broader framework of interacting controls. In particular, damage severity in the affected settlements reflects the combined effects of soft and locally water-saturated soils, proximity to the seismic source, and geomorphic setting, including valley confinement and slope-related processes. Remote sensing observations emphasise the spatial correspondence between heavily damaged villages and sediment-filled basins, whereas eyewitness accounts and site observations highlight localised foundation failure, settlement, and structural collapse on weak ground. These complementary data sources may therefore emphasise different aspects of the damage process at different spatial scales. A more quantitative evaluation of the relative contribution of soil amplification, near-surface shear-wave velocity (VS30), slope instability, and source-related effects requires detailed analysis of ground motion records and geotechnical parameters, which is undertaken in subsequent chapters.



Source: Maxar

Figure 2.4: Before-and-after optical satellite images from MAXAR of villages in Afghanistan impacted by the earthquake (Top: https://www.bbc.com/news/live/cq5jgz23l14t; Bottom: https://www.bbc.com/news/live/cq5jgz23l14t)

Source: Maxar

Figure 2.4: Continued

3. INITIAL RESPONSE AND RELIEF OPERATIONS

3.1. First-aid and Humanitarian Response

Immediately after the earthquake, local communities, health workers, and humanitarian partners initiated first-aid and lifesaving support to the affected population in Kunar province (Figure 2.2). The first responders were the local communities, who initiated the rescue operation. Efforts were carried out in the Mazar Dara Valley of Nurgal district, the Dewagal Valley in Chawkay district of Kunar Province, and in Dara-e-Nur district of Nangarhar Province, where community members worked to rescue trapped individuals and provide initial assistance to the injured.

The Ministry of Defence (MoD) deployed three helicopters to evacuate seriously injured individuals from the affected areas, transporting patients to Nangarhar Regional Hospital and Fatima Zuhra Hospital in Nangarhar Province. On Monday, 1 September 2025, UNOCHA reported that static health facilities, along with 15 Mobile Health Teams, had been mobilised by Basic Package of Health Services (BPHS) implementing agencies, with Community Health Workers actively supporting health service delivery in the affected communities (UNOCHA, personal communication). Access to the disaster-affected areas initially remained a significant challenge, as routes to the Mazar Valley in Nurgal District and the Dewagal Valley in Chawkay District were blocked, requiring a 2-3 hour walk from the point of obstruction. In response, the Department of Public Works deployed heavy machinery to clear roads and restore access, with the Dewagal Valley subsequently reopened through combined efforts of government teams and local residents. In parallel, interagency coordination was initiated, with 25 agencies (20 of which were deployed) agreeing to conduct a coordinated needs assessment. The assessment, led by sub-national clusters through the Operational Coordination Teams (OCTs), commenced on 1 September 2025, with participation from agencies including IOM, WFP/TPM, UNICEF/AYSO, UNICEF/HNTPO, UNHCR/CHA, UNW/AWUDO, FAO/TPM, PU-AMI, HNTPO, AYSO, SCI, DRC, CWSA, UNFPA/AFGA, ADA, ACTED, OAWCK.

3.1.1. Response capacity

Sub-National Humanitarian Clusters confirmed that adequate resources were available in the region to support the response. Emergency shelter assistance was provided by IOM and UNHCR through the Emergency Shelter and Non-Food Items (ES/NFI) sector, including the distribution of emergency shelters, NFIs, and cash for NFIs. The Food Security and Agriculture Cluster (FSAC), led by WFP, immediately distributed High Energy Biscuits (HEB) and planned follow-up food assistance upon completion of the needs assessment. FAO undertook the safe disposal of livestock killed during the disaster and conducted assessments to determine the scale of livestock losses. The UNICEF-led WASH Sub-National Cluster identified priority needs and initiated responses, with immediate interventions focusing on the provision of safe drinking water and additional WASH support following the needs assessment. Protection needs and concerns were identified through the UNHCR-led Protection Cluster, contributing to the overall assessment process, while DRC, SCI, and ACTED reported the activation of crisis modifiers, subject to donor confirmation. In parallel, the Education in Emergencies (EiE) partners, coordinated by UNICEF, mobilised to identify education-related needs in close coordination with other clusters.

On 15 September 2025, UNOCHA (UNOCHA, personal communication) provided an update to humanitarian actors on assessment findings and response progress based on the Multi-Sectoral Rapid Assessment Form (MSRAF). The assessment revealed that a total of 8,230 families, comprising 53,881 individuals across 118 villages, had been affected by the disaster. Reported casualties included 1,984 fatalities and 3,617 injured individuals. A total of 8,230 shelters were damaged or destroyed, leaving approximately 94 per cent of affected families currently living in open-air conditions. Critical public health concerns were identified, including widespread open defecation, an elevated risk of communicable disease outbreaks such as cholera and acute watery diarrhoea, the presence of animal carcasses, and other associated public health risks.

3.1.2. Responses

Response updates from agencies and clusters indicate ongoing multi-sectoral assistance to earthquake-affected populations. WFP provided food assistance through multiple modalities to 5,656 families, benefiting approximately 39,592 people, and is planning to launch the SCOPE registration process to help prevent duplication of assistance. IOM supported 3,375 families, equivalent to 20,250 people, through the distribution of non-food items (NFI) kits. In the health sector, the Health Cluster reported that static health facilities, together with 20 Mobile Health and Nutrition Teams (MHNTs), are actively delivering health services across the earthquake-affected areas. To further strengthen service delivery, the Health Cluster, through its partners, distributed an additional 46.1 metric tons of medical and non-medical supplies to health partners, mobile health teams, and static health facilities, expanding access to basic health care for affected populations.

3.1.3. WASH, health, protection, and early recovery response

From early September 2025 (following initial Health Cluster situation reports issued on 2 September 2025), the WASH Cluster continued to deliver life-saving services to earthquake-affected populations, providing approximately 200,000 litres of safe drinking water daily to IDP settlements in Khaskunar, Pattan, Zeri-Baba, and affected locations in Chawkay and Nurgal districts, in coordination with local authorities. Hygiene kits were distributed to around 80 per cent of earthquake-affected populations, alongside hygiene promotion activities conducted within affected communities. Waste management teams were deployed at IDP sites to reduce public health risks, and emergency latrines were installed, with additional sanitation facilities currently under construction to meet growing needs.

Complementing WASH interventions, WHO is preparing to deploy a team to conduct a health system capacity assessment aimed at strengthening health response efforts in affected areas. UNFPA is currently supporting five health teams and plans to allocate additional resources based on evolving needs. UNDP is also planning to initiate early recovery activities, including road clearance, restoration of water sources, and other community recovery projects, with OCHA requesting regular updates to the Operational Coordination Team (OCT) to ensure alignment and coordination. In parallel, the Protection Cluster conducted a Protection Rapid Needs Assessment to identify key protection risks and inform targeted interventions.

3.1.4. Agriculture and livelihoods response

Under the Food Security and Agriculture Cluster (FSAC), FAO safely disposed of approximately 4,000 livestock carcasses and provided treatment to 600 injured animals, with operations ongoing. Technical teams were also deployed to assess damage to agricultural land, irrigation systems, and livestock assets, forming the basis for early livelihood recovery planning and future agricultural support.

3.2. Food Assistance and Community-Led Relief Response

Immediately after the earthquake, local residents were the first to respond by organizing and delivering hot meals to impacted populations. This community-led response was followed by support from local NGOs and civil society organizations (CSOs), who extended hot meal provision not only in affected villages but also to hospitals, where food was provided to injured individuals and their accompanying family members. This early response played a critical role in addressing immediate food needs during the first hours and days following the disaster.

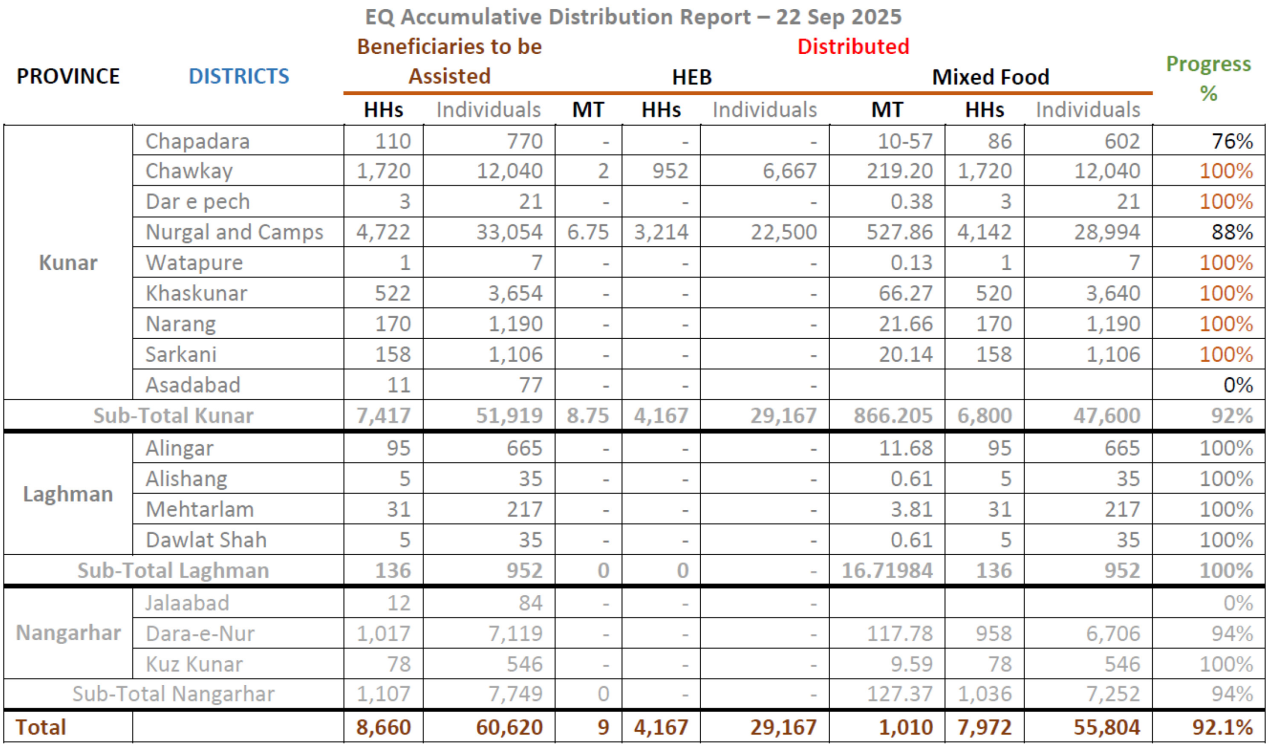
As of 22nd September, 60,620 people (8,660 HHs) were identified by the Joint Assessment Team as eligible for assistance. The number of severely impacted populations does not include populations indirectly affected by the earthquake through damaged infrastructure, disrupted livelihoods, or other cascading impacts.

Impacts were recorded across 15 districts of Kunar, Nangarhar, and Laghman provinces, with the most severe damages including infrastructure damage, road disruptions, and casualties concentrated in three districts: Nurgal, Chawkai, and Dara-e-Nur.

WFP reached the locations and provided High Energy Biscuits to 29,167 people in the first 24 hrs and, followed by the emergency mix food ration to 7,972 HHS (55,804 people). The first round (August) emergency food assistance was completed for the affected people, followed by the next month (September) assistance. WFP is also committed to provide 50% mix of food assistance to 150,000 affected people for another 6 months. Table 3.1 indicates WFP assistance across the region, segregated by district.

Parallel to WFP distributions, local NGOs and civil society organizations played a critical role in providing cooked meals during the early response phase, particularly in hard-to-reach areas and health facilities (Figure 3.1). In the Nurgal district of Kunar Province, the Afghan Youth Service Organization (AYSO) provided hot meals to 1,000 people. AWEC also delivered hot meals to an additional 1,000 people in the same district. JEN/JENHO initiated a sustained cooked meal program, providing rice, meat, chickpeas, bread, and bottled water to approximately 500 households daily for 21 consecutive days in Nurgal and Chawkay districts.

Table 3.1: Assistance provided by WFP



EQ Accumulative Distribution Report – 22 Sep 2025

PROVINCE	DISTRICTS	Beneficiaries to be Assisted		Distributed						Progress %
				HEB			Mixed Food			
		HHs	Individuals	MT	HHs	Individuals	MT	HHs	Individuals	
Kunar	Chapadara	110	770	-	-	-	10-57	86	602	76%
	Chawkay	1,720	12,040	2	952	6,667	219.20	1,720	12,040	100%
	Dar e pech	3	21	-	-	-	0.38	3	21	100%
	Nurgal and Camps	4,722	33,054	6.75	3,214	22,500	527.86	4,142	28,994	88%
	Watapure	1	7	-	-	-	0.13	1	7	100%
	Khaskunar	522	3,654	-	-	-	66.27	520	3,640	100%
	Narang	170	1,190	-	-	-	21.66	170	1,190	100%
	Sarkani	158	1,106	-	-	-	20.14	158	1,106	100%
	Asadabad	11	77	-	-	-				0%
Sub-Total Kunar		7,417	51,919	8.75	4,167	29,167	866.205	6,800	47,600	92%
Laghman	Alingar	95	665	-	-	-	11.68	95	665	100%
	Alishang	5	35	-	-	-	0.61	5	35	100%
	Mehtarlam	31	217	-	-	-	3.81	31	217	100%
	Dawlat Shah	5	35	-	-	-	0.61	5	35	100%
Sub-Total Laghman		136	952	0	0	-	16.71984	136	952	100%
Nangarhar	Jalaabad	12	84	-	-	-				0%
	Dara-e-Nur	1,017	7,119	-	-	-	117.78	958	6,706	94%
	Kuz Kunar	78	546	-	-	-	9.59	78	546	100%
Sub-Total Nangarhar		1,107	7,749	0	-	-	127.37	1,036	7,252	94%
Total		**8,660**	**60,620**	**9**	**4,167**	**29,167**	**1,010**	**7,972**	**55,804**	**92.1%**

Figure 3.1: Humanitarian Hubs: WFP along with other agencies established humanitarian hub in Mazar Dara of Nurgal and in Dewagal village of Chawkai districts and also installed MSUs in each camp

Shpoul organisation implemented a two-week hot meal response in Mazar Dara, Nurgal district, delivering daily cooked food packages to approximately 500 people. In addition to food assistance, Shpoul deployed a Mobile Health Team comprising a medical doctor, a female nurse, and a midwife, provided basic first aid services, and established a mental health and psychosocial support and information help desk.

CWSA delivered two hot meals per day for five days to approximately 720 households in Mazar Dara, Nurgal district. NCRO provided cooked meals and drinking water in Nangarhar Regional Hospital as well as Fatima Zuhra Hospital, Nangarhar Province, delivering food packages three times per day to 500 people, totaling approximately 1,500 meal packages per day.

3.3. Temporary Housing and Emergency Shelter Response

Humanitarian actors, including the Afghan Red Crescent Society (ARCS) with support from the International Federation of Red Cross and Red Crescent Societies (IFRC), established temporary camps and shelter sites in Kunar province. These sites hosted displaced families, provided tents, hot meals, clean water, basic household items, and emergency relief supplies. On 24 September 2025, UNOCHA reported that ARCS, IFRC, and the International Committee of the Red Cross (ICRC) had installed approximately 300 tents at the Pattan IDP sites, with an additional 250 tents planned for installation. International and local NGOs complemented these efforts by distributing tents and tarpaulins and installing temporary latrines and hygiene facilities to improve living conditions in displacement sites.

Despite these response efforts, many families continued to face inadequate shelter conditions, particularly in remote and hard-to-reach villages where access remained constrained due to damaged roads. The onset of winter further increased the urgency for strengthened temporary and transitional housing solutions. In response, the Emergency Shelter and Non-Food Items (ES/NFI) Cluster planned winterization support for approximately 6,000 to 7,000 families and requested an estimated USD 2 million to deliver standard winterization assistance. In coordination with the Durable Solutions Working Group (DSWG), the ES/NFI Cluster is also developing plans for permanent housing solutions for families whose homes were fully destroyed.

As of 23 September 2025, about 90%-95% of planned shelter and NFI responses had been completed, with several locations reporting near-complete coverage. In recognition of the timely assessments and rapid response, OCHA conveyed its appreciation to humanitarian organizations, response teams, charity organizations, and Red Crescent partners for their collective efforts.

3.4. Conclusions

The earthquake resulted in widespread human, infrastructural, and livelihood impacts across eastern Afghanistan, with the most severe damage concentrated in Nurgal, Chawkay, and Dara-e-Nur districts. Remote sensing-based damage assessment using Sentinel-1 SAR coherence analysis proved to be a valuable tool for rapid, large-scale identification of affected built-up areas. The SAR-derived damage proxy consistently highlighted the same high-impact districts identified through independent assessments, including the Copernicus Emergency Management Service, reinforcing confidence in the spatial pattern and severity of damage observed.

Immediate life-saving response efforts were initiated primarily by affected communities, demonstrating strong local coping capacity in the critical first hours following the earthquake. These efforts were subsequently reinforced by national authorities and humanitarian partners through medical evacuations, deployment of mobile health teams, and rapid restoration of access to previously isolated valleys. Despite initial access constraints caused by damaged roads and terrain, coordinated efforts by government departments, humanitarian actors, and local residents enabled the gradual restoration of connectivity to the hardest-hit areas.

Multi-sectoral assessments confirmed extensive humanitarian needs, including high levels of fatalities and injuries, widespread housing destruction, and significant public health risks. Nearly all affected families experienced housing damage, with the majority temporarily living in open-air conditions, underscoring the urgency of emergency shelter and winterisation support. Health and WASH concerns (particularly open defecation, communicable disease risks, and environmental contamination) were appropriately prioritised and addressed through coordinated cluster responses.

The humanitarian response benefited from strong inter-agency coordination and pre-positioned response capacity at the sub-national level. Food assistance, non-food items, health services, water provision, and protection activities reached a substantial proportion of the affected population within the first weeks of the emergency. In parallel, local NGOs and civil society organisations played a critical complementary role, particularly in delivering cooked meals and first aid services in hard-to-reach locations and health facilities, filling critical gaps during the early response phase.

While the majority of immediate emergency responses were completed by late September, significant challenges remain. Remote and mountainous areas continue to face access limitations, and many families remain in inadequate shelter conditions as winter approaches. Longer-term recovery needs (including permanent housing, restoration of livelihoods, rehabilitation of infrastructure, and strengthening of health and WASH systems) require sustained funding and coordinated planning. Continued monitoring, targeted assistance to the most vulnerable households, and integration of early recovery activities will be essential to transition from emergency response toward durable recovery and resilience-building in the affected districts.

4. GEOTECHNICAL FAILURES

4.1. Overview

This chapter documents and analyses the geotechnical failures triggered by the 2025 Eastern Afghanistan Earthquake. The main objectives are the following:

1) Identify the types and distribution of geotechnical failures during the event.

2) Analyse the geological and geotechnical conditions that contributed to ground-related hazards.

3) Evaluate the impact of these failures on infrastructure, buildings, and emergency response.

4) Discuss lessons learned and recommend mitigation strategies for future seismic events in similar terrains.

This chapter provides a foundational understanding of the primary geotechnical mechanisms at play and sets the stage for more in-depth investigations.

4.2. Geological and Geotechnical Context

Understanding the regional geology and soil characteristics of eastern Afghanistan is crucial to interpreting the types and distribution of geotechnical failures triggered by the 2025 earthquake. As previously noted, the presence of soft sediments and locally high water tables played an important role in amplifying earthquake impacts. In addition, the combination of active tectonics, steep topography, and highly variable geologic formations contributed significantly to landslides, ground cracking, and foundation failures observed during the event.

4.2.1. Regional geology and seismotectonic setting

The affected region lies along the complex boundary between the Indian and Eurasian plates (Figure 2.1), characterised by active thrust faulting, crustal deformation, and frequent moderate-to-strong earthquakes (Wheeler et al., 2005). Dominated by the Hindu Kush and Safed Koh mountain ranges, the topography comprises metamorphic rocks, igneous intrusions, and sedimentary sequences (Faryad et al., 2013). Figure 4.1 shows a simplified geological map of Afghanistan.

The geology of eastern Afghanistan is characterised by variably fractured and weathered metamorphic, igneous, and sedimentary formations (Faryad et al., 2013; Shroder et al., 2011). These materials, particularly in proximity to active fault zones, are susceptible to seismically induced slope instability due to structural weakening and steep terrain.

The Hindu Kush region has repeatedly experienced destructive earthquakes, as reported in Table 4.1 (Ansari et al., 2023), including shallow events (e.g., the 25 March 2002 earthquake at ~8 km depth), which triggered landslides and ground deformation (Simmon, 2002; OCHA, 2002; Yeats and Madden, 2003). While focal mechanism data for the 2025 eastern Afghanistan event are still preliminary, its shallow hypocentral depth suggests that ground motions likely contributed to significant geotechnical failures. Similar instabilities have historically occurred in the region under comparable terrain and seismic forcing.

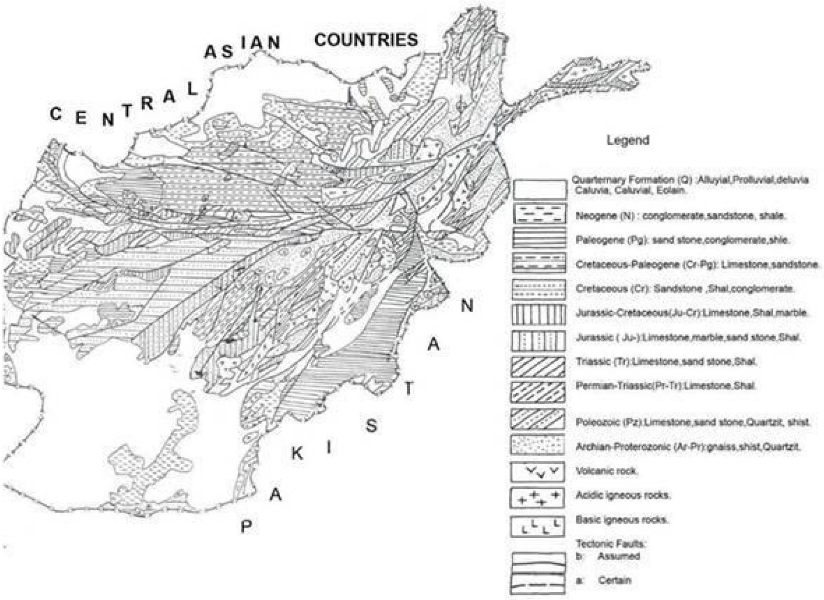


Figure 4.1: Geological Map of Afghanistan (Slawin, 1984; Reproduced by Saffi, 2007)

Table 4.1: List of historical earthquakes in Hindu Kush region (Ansari et al., 2023)

Date	Mw	MMI	Date	Mw	MMI
25 March 2002	6.1	VII	31 January 1991	6.9	VII
03 March 2002	7.4	VI	15 May 818	7.8	VIII

4.2.2. Soil and rock types

The region exhibits heterogeneous geological materials with varying seismic responses and each has an influence on ground stability.

1) Residual soils and colluvium on slopes: These consist of loose, weathered soil deposits found on steep terrain. Due to their poor consolidation and high susceptibility to seismic shaking, they are particularly prone to landslides and slope failures during earthquakes (Yeats and Madden, 2003).

2) Alluvial deposits in valleys: Comprised primarily of unconsolidated sand, silt, and gravel, these deposits can amplify seismic waves and are susceptible to liquefaction under strong shaking conditions. Observations from recent earthquakes in Afghanistan highlight significant damage and ground failure in alluvial valley fills (OCHA, 2002).

3) Bedrock zones: Although generally more stable, fractured and weathered bedrock in the Hindu Kush and Safed Koh mountain ranges contributes to rockfalls and toppling failures along cliffs and escarpments, exacerbated by seismic shaking (Faryad et al., 2013).

4) Artificial fill and terrace deposits: In rural settlements, many structures are built on embankments or modified terraces using non-engineered fill material. These deposits lack proper compaction and engineering controls, increasing vulnerability to collapse and ground deformation during seismic events (Shnizai et al. 2022).

Monsoon rainfall preceding the earthquake saturated soils, further increasing landslide susceptibility during the 2025 earthquake.

4.2.3. Groundwater and weather influence

Seasonal monsoon rainfall elevated groundwater levels (Shirzaei et al., 2025), reducing soil shear strength and increasing pore pressure. Saturated slopes facilitated retrogressive landslides, debris flows, and extended runout distances. These conditions also complicated rescue operations due to blocked and impassable roads. Villages in Nurgal, Chapa Dara, and Asadabad districts experienced catastrophic building collapses (Figures 4.2 and 4.3) (Ambrose et al., 2025; Compassionate Afghanistan, 2025). Figure 4.4 shows the building damage map of the affected region.

The combination of the earthquake's impact and the subsequent landslides led to widespread devastation across these districts, with numerous casualties and significant infrastructure damage. Efforts to reach and assist affected communities were severely hindered due to blocked roads and challenging terrain.

4.2.4. Earthquake hazard level

Kunar Province exhibits a predominantly moderate seismic hazard, consistent with both national and international hazard assessments. While detailed national seismic hazard maps for Afghanistan are limited, global models such as the GEM Global Seismic Hazard Model (Johnson et al., 2023) provide standardised estimates of PGA for a 475-year return period. These models indicate elevated shaking hazard across eastern Afghanistan, including Kunar, associated with the active tectonics of the Hindu Kush region.

Earlier probabilistic seismic hazard assessments for Afghanistan, including the USGS national hazard model (Boyd et al., 2007) and subsequent studies (e.g. Waseem et al., 2019), similarly indicate that eastern provinces experience among the highest PGA values nationwide for return periods ranging from 475 to 2475 years. This

Figure 4.2: Complete collapse of unreinforced house at Nurgal district of Kunar province (Xinhua, 2025)

Figure 4.3: Houses built onto slopes damaged by differential movement at Nurgal district of Kunar province (Xinhua, 2025)

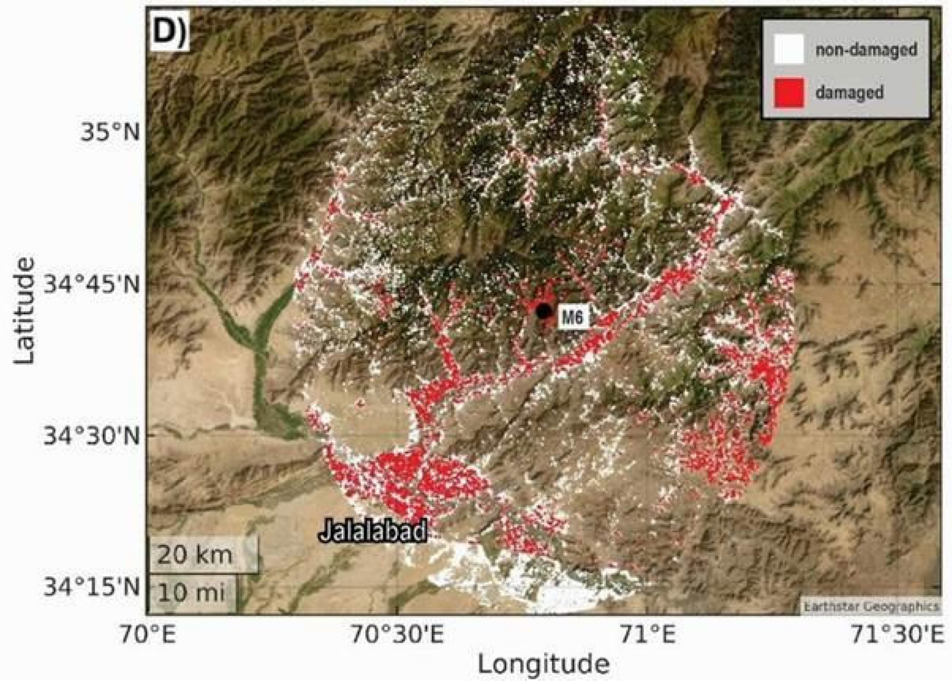
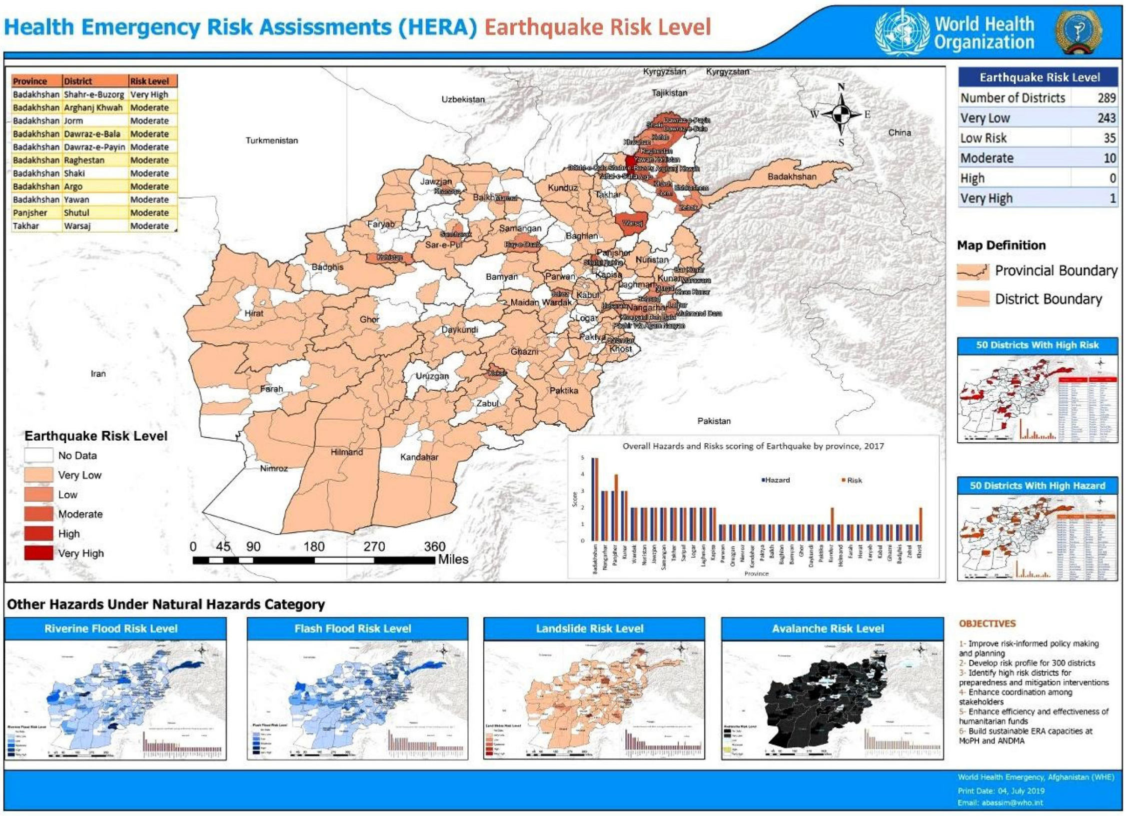


Figure 4.4: Building damage map associated with the 31 August event, showing the location of all buildings within 50 km of the epicentre, with non-damaged buildings (white) and likely damaged buildings (red) identified from analysis of the coherence change in the pair formed using SAR images acquired between 21 August and 2 September (Shirzaei et al., 2025)



Health Emergency Risk Assessments (HERA) Earthquake Risk Level

World Health Organization

Province	District	Risk Level
Badakhshan	Shahr-e-Buzorg	Very High
Badakhshan	Arghanj Khwah	Moderate
Badakhshan	Jorm	Moderate
Badakhshan	Dawraz-e-Bala	Moderate
Badakhshan	Dawraz-e-Payin	Moderate
Badakhshan	Raghestan	Moderate
Badakhshan	Shaki	Moderate
Badakhshan	Argo	Moderate
Badakhshan	Yawan	Moderate
Panjsher	Shutul	Moderate
Takhar	Warsaj	Moderate

Earthquake Risk Level	
Number of Districts	289
Very Low	243
Low Risk	35
Moderate	10
High	0
Very High	1

Map Definition

Provincial Boundary

District Boundary

50 Districts With High Risk

50 Districts With High Hazard

Other Hazards Under Natural Hazards Category

Riverine Flood Risk Level

Flash Flood Risk Level

Landslide Risk Level

Avalanche Risk Level

OBJECTIVES

1- Improve risk-informed policy making and planning
2- Develop risk profile for 300 districts
3- Identify high risk districts for preparedness and mitigation interventions
4- Enhance coordination among stakeholders
5- Enhance efficiency and effectiveness of humanitarian funds
6- Build sustainable ERA capacities at MoPH and ANDMA

World Health Emergency, Afghanistan (WHE)
Print Date: 04, July 2019
Email: abassim@who.int

Figure 4.5: Earthquake risk level based on health emergency risk assessment (WHE, 2024)

consistency across multiple studies reinforces the classification of Kunar as part of a broader high-hazard seismic belt extending from Badakhshan through Nuristan.

The WHE HERA seismic hazard map (WHE, 2024) (Figure 4.5) further contextualises this exposure within a multi-hazard framework. While much of Afghanistan is classified as having a very low seismic hazard, the eastern and northeastern regions (including Kunar) stand out as areas of significantly higher hazard and risk. Regional hazard bar charts (Figure 4.5) highlight that eastern provinces score above the national average, and secondary hazard panels indicate that Kunar also overlaps with zones of notable landslide susceptibility. All these factors point to meaningful earthquake exposure and compounded operational risk for health facilities, highlighting the need for targeted preparedness and risk-reduction measures.

4.2.5. Effects on structural behaviour

Pre-existing seismic hazard maps of Afghanistan had identified the eastern provinces, particularly Kunar and Nangarhar, as high-hazard zones based on historical seismicity, fault proximity, and regional geological and soil classifications. An example of such a regional-scale hazard assessment is shown in Figure 4.6. According to the GEM Global Seismic Hazard Map (Johnson et al., 2023), PGA values across much of eastern Afghanistan (including Kunar and adjacent provinces) exceed 0.30-0.40 g on reference rock conditions for a 10 % probability of exceedance in 50 years (equivalent to a 475-year return period) with the highest hazard zones approaching or exceeding 0.40-0.50 g. These values indicate stronger expected ground shaking in the east relative to the rest of the country and help explain why Kunar lies within a broader cluster of elevated seismic hazard.

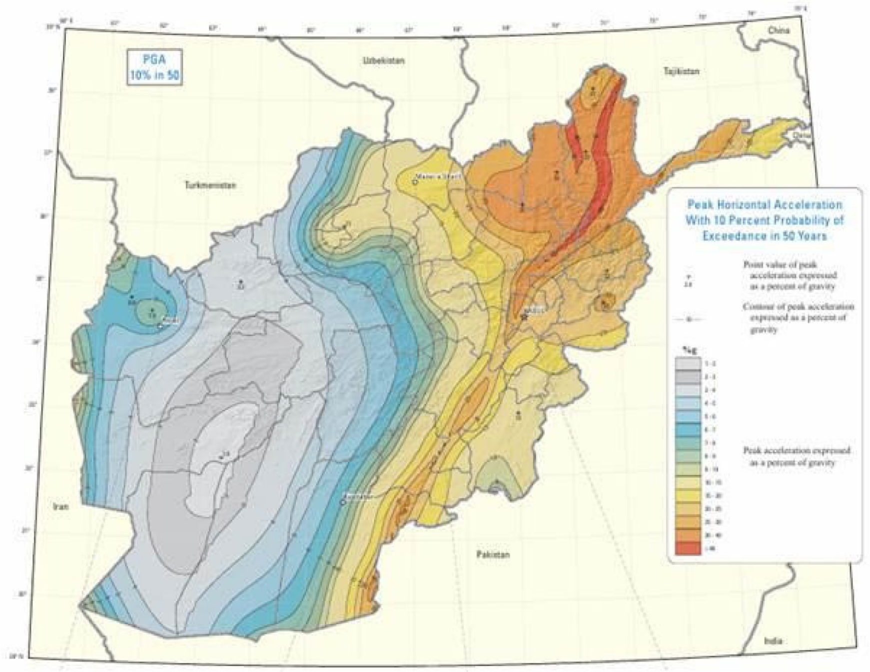


Figure 4.6: Earthquake hazard map for Afghanistan presented in peak horizontal acceleration (Boyd et al., 2007)

While these maps provide a broad framework for seismic hazard, they do not resolve site-specific ground conditions (such as local soil amplification, basin effects, or topographic amplification) that influence local damage patterns.

At the local scale, post-event field and satellite observations indicate that site effects related to topography, near-surface geology, and ground conditions played an important role in controlling the distribution and severity of damage (Shirzaei et al., 2025). Variations in ground response at short spatial scales likely contributed to the uneven impact observed among neighbouring settlements subjected to similar levels of regional shaking.

In many affected areas, buildings were founded on shallow or informal foundation systems constructed directly on existing ground, including vegetable topsoil, non-engineered or inadequate fill, or cut-and-fill platforms. The use of vegetable topsoil as fill material (common in informal construction) results in inherently weak, compressible foundation support that cannot be effectively compacted, rather than simply poorly compacted fill. Such foundation conditions, when combined with strong ground shaking, increase susceptibility to differential settlement, tilting, and local loss of bearing capacity. These ground-related vulnerabilities interacted with prevailing construction practices (primarily unreinforced masonry using either burnt or sun-dried bricks) to exacerbate structural damage (Mohammadi and Fujimi, 2021). In several cases, structures that sustained partial damage during the initial shaking experienced further degradation or collapse during subsequent seismic events (Kawoosa and Arranz, 2025).

Topographic amplification along ridge crests and steep slopes likely intensified shaking in mountainous terrain, increasing demands on already vulnerable foundation-soil systems. In fault-proximal areas, stronger ground motion accompanied by near-surface ground cracking, settlement, and localised shallow slope movements further affected structural performance. Settlements constructed on man-made cut-and-fill platforms were particularly vulnerable where soil compaction and slope stability measures were insufficient, leading to disproportionate damage driven by adverse ground-structure interaction rather than by structural deficiencies alone.

This event highlights the need for hazard assessment approaches that move beyond regional seismic zoning to better account for geotechnical controls on structural behaviour. Integrating surface geology, soil conditions, slope stability, and local site response into hazard mapping and development planning would improve the identification of locations where ground-related effects are likely to govern damage outcomes in future earthquakes.

4.3. Slope Instability and Landslides

4.3.1. Overview

Slope instability was one of the most prominent and destructive geotechnical outcomes of the 2025 Eastern Afghanistan Earthquake. The affected region, characterised by steep mountain terrain and deeply incised river valleys, proved highly susceptible to a range of earthquake-induced slope failures. These landslides caused loss of life, destroyed infrastructure, and significantly hampered rescue and relief efforts.

The landslides were primarily triggered by strong seismic shaking, which caused a rapid reduction in shear strength along pre-existing failure planes. Several compounding factors increased the vulnerability of slopes in the region. These included increased water saturation in the surface soil resulting from pre-earthquake monsoon rains, the presence of weak or weathered geologic materials, and steep slope gradients, many exceeding 35 to 40 degrees. Additionally, anthropogenic modifications, such as roads, terraces, and unreinforced slope cuts, further destabilised slopes. The cumulative effect of the main shock and multiple aftershocks also played a significant role.

Together, these factors contributed to widespread slope failures, especially in areas where natural and human-altered terrain overlapped.

The earthquake occurred shortly after a weekend of flash flooding that, according to local media (Afghanistan Peace Campaign, 2025), claimed at least five lives. The floods triggered landslides, damaged infrastructure, and temporarily disrupted transportation between Pakistan and Afghanistan.

4.3.2. Inventory of earthquake-induced landslides

Preliminary landslide inventories compiled from satellite imagery, aerial reconnaissance, and field reports identified hundreds of slope failures across Kunar and Nangarhar provinces. Key characteristics of the inventory include the following:

1) Spatial clustering of failures near the epicentre, especially along the Kunar River Valley and its tributaries.

2) Occurrence of both shallow soil slips and deep-seated rockslides, depending on lithology and slope geometry.

3) Numerous secondary slides triggered by aftershocks or progressive failure of already destabilized slopes.

4) Road-blocking landslides in key districts such as Chapa Dara, Dangam, Nari, and Khas Kunar.

The high density of landslides in seismically active and rainfall-prone areas suggests a compounded hazard environment, where seasonal wetting preconditioned slopes for failure.

4.3.3. Types of landslides

A variety of landslide types were documented during the earthquake, reflecting the complex geological and geomorphological setting (Ellis-Petersen et al., 2025; Miyamoto International, 2025a; Tareq, 2025):

Rockfalls and topples were common along steep cliffs during the earthquake, triggered by seismic shaking that dislodged loosened rock masses. These events frequently impacted roads, often cutting off access to rural communities (Figure 4.7). The fear of rocks falling from the mountains at any time has also frightened earthquake victims in Masood village, who have refused to return to their destroyed villages and have set up camp in fields and riverbanks despite having no tents to protect them from the rain (Dawn News Urdu, 2025).

Additionally, shallow translational slides were observed on slopes composed of colluvial soil and weathered rock. These slides, typically less than 2 to 3 meters deep but highly mobile, occurred on steep natural slopes as well as along road cuts, further contributing to disruptions in the affected areas (Figure 4.8).

4.4. Ground Deformation and Surface Ruptures

In addition to localised slope failures, the 2025 Eastern Afghanistan Earthquake induced broader-scale ground deformation observed from satellite-based data, revealing significant crustal movement and surface manifestations of underlying tectonic dislocation. Ground deformation can contribute to secondary hazards such as settlement, ground fissuring, and altered drainage patterns.

Figure 4.7: Rockfall blocking road access (Miyamoto International, 2025a)

Figure 4.8: Devastation of villages sited on sloping terrain aggravated by landslides (Left: Tareq, 2025; Right: Islamicreliefau, 2025)

Interferometric Synthetic Aperture Radar (InSAR) data collected shortly after the event revealed measurable vertical and horizontal displacements in the affected region (Shirzaei et al., 2025; Hubbard and Bradley, 2025). Notably, vertical uplift of up to 23 centimetres was recorded near the epicentral zone in Kunar Province. The displacement patterns observed were broadly consistent with a south-dipping reverse fault, which is typical of tectonic compression occurring between the Indian and Eurasian plates. This faulting style reflects the ongoing convergence and collision of these major tectonic plates. In addition to vertical movement, horizontal shortening was also detected, though it was less uniform across the region. This uneven shortening suggests complex deformation processes operating within the folded and faulted terrain surrounding the epicentre.

4.5. Liquefaction

Superficial deposits such as loose residual soils are highly susceptible to liquefaction. Alluvial deposits that comprise primarily unconsolidated sand and silt can lose shear strength during strong seismic shaking and are therefore highly susceptible to liquefaction. The presence of highly susceptible soils where groundwater is shallow and earthquake shaking is strong results in liquefaction potential. Due to limited field data, it is difficult to identify any locations of liquefaction or observe signs of liquefaction (such as settlement/rotation of structures, lateral spreading, ground failure). UNDP (2025a) estimates 246k buildings are within high-impact zones where strong to severe shaking was experienced. While such exposure in high-impact zones could lead to partial damage or collapse of some of the structures, liquefaction potential may be limited due to the presence of mountainous or rocky terrain, where soils are dense.

4.6. Foundation Failures and Ground-Structure Interaction

A significant proportion of structural damage during the 2025 Eastern Afghanistan Earthquake was closely linked to the geotechnical behaviour of the ground beneath buildings and infrastructure. Foundation failures, ranging from tilting and differential settlement to total collapse, were widespread in both rural and semi-urban settlements. This section explores how inadequate foundation systems, poor construction practices, and challenging ground conditions contributed to structural damage through mechanisms of ground-structure interaction.

4.7. Conclusions

The 2025 Eastern Afghanistan Earthquake demonstrated the critical role of geotechnical conditions in shaping the severity and spatial distribution of earthquake impacts across the region. The event triggered a wide range of ground-related failures, including slope instabilities, landslides, ground deformation, and foundation failures, which collectively amplified structural damage and significantly hindered emergency response efforts.

The geological and tectonic setting of eastern Afghanistan, located within the active collision zone between the Indian and Eurasian plates, strongly influenced the observed failure mechanisms. Steep mountainous terrain, fractured and weathered rock masses, and heterogeneous soil conditions created an inherently unstable environment that was highly sensitive to seismic shaking. Shallow hypocentral depth and strong ground motions further exacerbated these vulnerabilities, consistent with historical earthquake behaviour in the Hindu Kush and Safed Koh regions.

Slope instability emerged as the most widespread and destructive geotechnical failure. Earthquake-induced landslides were strongly controlled by slope gradient, lithology, and antecedent rainfall conditions. Monsoon-driven soil saturation prior to the earthquake significantly reduced shear strength, preconditioning slopes for failure. Both natural slopes and anthropogenically modified terrain, including road cuts and agricultural terraces, experienced extensive failures. These landslides not only caused direct loss of life and property but also severed critical transportation routes, delaying rescue and relief operations in already remote and mountainous districts.

Ground deformation associated with fault movement was evident at a regional scale, with satellite-based observations indicating substantial vertical and horizontal displacements near the epicentral zone. These deformation patterns are consistent with reverse faulting typical of compressional tectonics in the region. While such deformation has the potential to influence surface processes, including localised ground cracking, settlement, and drainage disruption, its primary significance in this study lies in defining the broader tectonic and geotechnical context within which damage occurred.

Although clear field evidence of liquefaction was limited, the presence of loose alluvial deposits in valley floors, combined with strong shaking in some areas, indicates that liquefaction cannot be excluded as a potential secondary hazard under favourable soil and groundwater conditions. However, the predominantly mountainous and rocky terrain of the affected region suggests that liquefaction was unlikely to have been a dominant contributor to the observed damage patterns during this event.

Foundation-related damage and adverse ground-structure interaction were key contributors to building collapse, particularly in rural settlements where non-engineered construction predominates. Observations indicate that failures were frequently associated with buildings founded on inadequate fill, cut-and-fill platforms, and sloping ground, where differential settlement and loss of bearing capacity were common. In such settings, unreinforced masonry structures exhibited pronounced vulnerability, resulting in tilting and partial or total collapse. These outcomes reflect the interaction between ground conditions and construction practices rather than the influence of any single geotechnical process.

The geotechnical impacts observed during the 2025 Eastern Afghanistan Earthquake reflect a compounded hazard environment in which seismic loading, geological conditions, topography, and land-use practices interact to control damage outcomes. Rather than the absence of formal seismic microzonation, the spatial variability of damage is best explained by local differences in ground conditions and construction approaches. In this context, future risk-reduction efforts should prioritise improved understanding of site conditions, more appropriate settlement siting, and construction practices that account for slope stability and foundation performance, particularly in mountainous terrain where ground instability poses a persistent constraint.

5. BUILT ENVIRONMENT

Damage estimation following earthquakes is especially challenging in Afghanistan, a country characterised by mountainous terrain, limited accessibility, and scarce resources for systematic field-based damage assessment. These constraints significantly affect the ability to document impacts on the built environment using conventional survey methods. Under such conditions, remote sensing (particularly Synthetic Aperture Radar (SAR)) now provides a critical means of establishing the spatial extent and relative severity of damage to buildings, especially in areas that are inaccessible or sparsely documented. This chapter, therefore, begins with a SAR-based overview of built-environment damage, followed by a description of the building stock and an assessment of observed building performance.

5.1. SAR-based Damage Estimation of the Built Environment

Early assessment of damage to the built environment is essential for understanding the scale and spatial distribution of earthquake impacts and for guiding emergency response. In Afghanistan, where cloud cover, rugged terrain, and access limitations frequently hinder optical satellite analysis and field investigations, SAR data offer a robust and timely alternative. Unlike optical imagery, SAR observations are independent of cloud cover and solar illumination and can therefore provide an unobstructed view of affected areas shortly after an event. SAR-based damage estimation results are presented in this section to identify districts where damage to buildings was most widespread following the 31 August 2025 earthquake.

Early damage estimation maps are commonly derived with remote sensing data, such as Synthetic Aperture Radar (SAR) and optical data. Such maps are critical to understand the scale of civil protection response required. Optical data are frequently used for early response, for example, by the Copernicus Emergency Management Service (CEMS) and United Nations Satellite Centre (UNOSAT). However, the optical data collected in the CEMS activation EMSR839 for the 31 August event could not be used to evaluate various districts as a result of cloud cover (Copernicus Emergency Management Service, 2025).

To infer relative damage to the built environment from SAR observations, changes in interferometric coherence are commonly used as a proxy for structural and surface disturbance. A widely applied SAR metric for rapid estimation of affected areas is coherence (e.g., Yun et al. 2015), which is derived from the radar signal phase and amplitude measured at two different times. Coherence quantifies the level of correlation of the backscattered signal between two images and takes values between 0 and 1. Low co-event coherence (i.e., estimated from one pre-event and one post-event image) is generally associated with surface or structural change. Accordingly, in coherence time series, a decrease in co-event coherence relative to pre-event coherence is expected in damaged areas. Coherence time series have proven effective for rapid damage assessment over large spatial scales (Ainscoe et al. 2025).

SAR coherence time series derived from ESA Sentinel-1 data were analysed for this report to reveal the spatial extent of damaged areas associated with the 31st August event. Details of the processing methodology are provided in Appendix A. The analysis was restricted to built-up areas to reduce the influence of surface changes unrelated to the built environment. Built-up extent within the study area was defined using a combination of Global Human Settlement Layer (GHSL) built-up surface pixels (Pesaresi et al. 2024) and Overture Maps building footprints (Overture Maps Foundation, 2025). Coherence was estimated for each SAR image pixel intersecting either a GHSL pixel or an Overture building polygon. The resulting output is a SAR-derived damage proxy value assigned to each built-up image pixel, ranging between 0 and 1, with higher values indicating an increasing likelihood of change within the coherence estimation window.

To interpret the extent on a district scale, the pixel-level damage proxy values per district were aggregated. This yields a distribution of damage proxy values for each district. The distribution of damage proxy values from pre-event imagery represents district-level statistics in the absence of earthquake-induced damage. For example, noisier regions will have wider distributions of damage proxy values. Therefore, the pre-event damage proxy value distribution was subtracted from the co-event damage proxy value distribution for each district to reveal changes in building signal response caused by the earthquake. Positive counts indicate that a particular range of damage proxy values is more prevalent in co-event data than in the pre-event data. Only positive counts are included in further analysis. Figure 5.1 shows a map of the median of the resulting distributions for several districts near the earthquake epicentre. Figure 5.2 shows the resulting distributions for the same districts. It is seen in Figure 5.2 that districts in the Kunar province are most affected. In particular, damage to built-up areas is most widespread in the Nurgal and Chawkay districts, where most built-up pixels have a damage proxy value near 1. These districts are located nearest to the epicentre.

Note that these results provide a relative ranking of districts by degree of coherence change and should be interpreted as an indicator of likely damage extent rather than a direct estimate of structural damage or loss. Further, it should be noted that coherence loss can also be influenced by non-damage-related factors such as soil moisture changes, steep terrain, or residual vegetation effects. Consequently, the SAR-derived damage proxy represents a relative indicator of change rather than a direct measure of structural damage.

The SAR-derived damage proxy presented here provides a spatially continuous, district-scale overview of where damage to the built environment was most extensive following the 31 August event. While this approach does not directly resolve building typologies or failure mechanisms, it establishes a first-order picture of impact patterns under severe observational constraints. These results provide essential context for the following sections, which describe the characteristics of the building stock and examine observed building performance and failure mechanisms in the most affected areas.

5.2. Building Stock Description

5.2.1. Introduction

Building stock characteristics play a central role in shaping the damage patterns identified in the SAR-based analysis presented above. Afghanistan's building stock reflects its predominantly rural population and rapid urbanization. Approximately 73% of the population lives in rural areas, with 27% residing in urban centres such

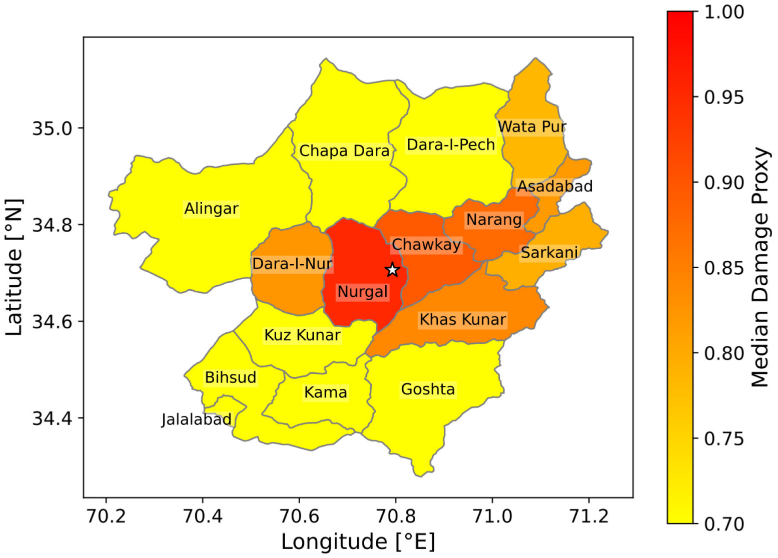


Figure 5.1: Map of the median damage proxy value of the differenced histograms (Figure 5.2) at district level. The damage proxy values are derived from coherence time series as described in Appendix A. Increasing damage proxy values correspond to increasing likelihood of change. The epicentre of the 31 August event is indicated with a white star.

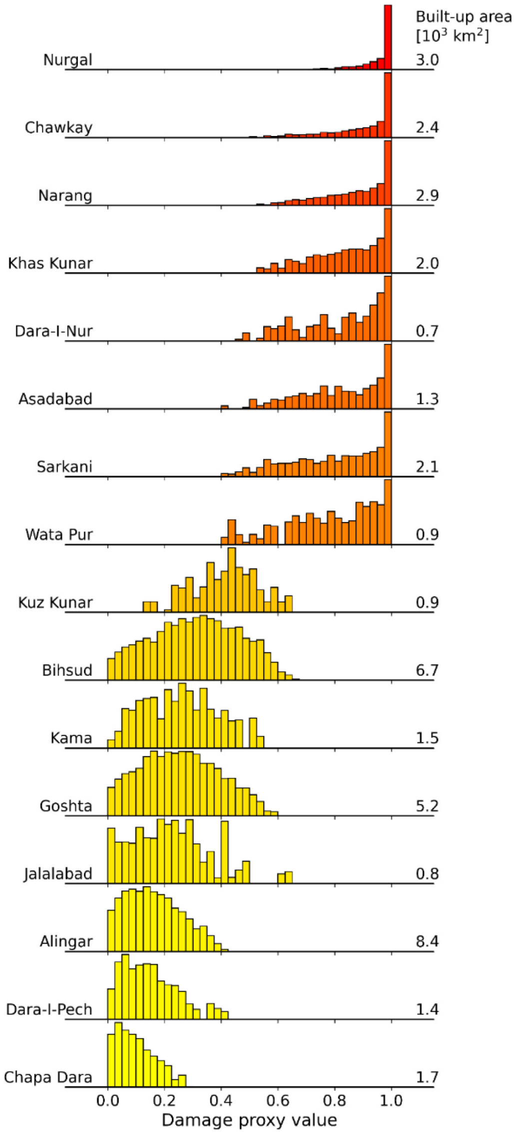


Figure 5.2: Differences of the histograms of damage proxy values between a pre-event and a co-event coherence image for several districts near the earthquake epicentre. Values below 0 are not shown. The damage proxy values are derived from coherence time series as described in Appendix A. Increasing damage proxy values correspond to increasing likelihood of change. The total built-up area mapped per district is indicated on the right.

as Kabul, Herat, and Mazar-i-Sharif (UN-Habitat, 2023). Urban areas are growing at an annual rate of 3.3%, and Kabul alone accounts for 57% of the total urban population (World Bank, 2025a).

Urban expansion, especially in Kabul, has led to widespread informal construction. Many buildings are constructed using unregulated masonry and concrete, often without engineering oversight or adherence to codes (JICA, 2014). Hybrid layouts that mix traditional spatial arrangements with modern materials are common, resulting in incoherent structural systems (Nemat, 2018).

Informal housing accounts for up to 80% of urban residences, often overcrowded and poorly serviced (UN-Habitat, 2023). These buildings are particularly vulnerable to earthquakes and other hazards due to poor material quality and a lack of seismic detailing.

The country faces a significant housing deficit. In 2017, UN-Habitat estimated that 1.5 million housing units were needed to meet demand, with the number projected to rise due to population growth and urbanization (UN-Habitat, 2017). Afghanistan's urban population grew from 4.6 million in 2002 to 7.1 million in 2012, and is expected to reach 24 million by 2050 (World Bank, 2025a).

In rural areas, traditional structures generally use locally available materials such as unreinforced unfired earth, fired clay brick masonry and stone, and timber frames. Reinforced concrete (RC) is less common in these areas. Buildings in rural areas are normally self-built and generally lack formal engineering input. In contrast, urban areas feature significantly more RC frames with masonry infill, with a smaller proportion of unreinforced earth, masonry, and stone, and very rarely steel structures. Many buildings in urban areas are also informal, self-built, and lack seismic resilience.

Access to basic services remains uneven. As of 2023, 85.3% of the population had access to electricity, but rural areas lag significantly behind urban centres (World Bank, 2023a).

5.2.2. Regional context

Afghanistan's vernacular architecture reflects centuries of adaptation to diverse climates, cultural traditions, and locally available resources. These traditional building forms are deeply embedded in local knowledge systems and continue to provide housing solutions that are culturally appropriate and, in some respects, sustainable. While Afghan vernacular traditions include vaulted and domed buildings, tents and yurts (Hallet and Samizay, 1980; Szabo and Barfield, 1991; Gilmour, 2020), and Wakhi houses (Medi and Fedelle, 2021), these typologies fall outside the geographical scope of the present report.

The typical fortified compounds known as qal'ahs (also spelled qala; Hesari, 2006; IJCRT, 2020) are present in eastern Afghanistan, although they are generally smaller than those found in other regions of the country. Architecture in the provinces of Kunar, Nangarhar, Laghman, and Nuristan displays considerable diversity, with variations in construction typologies and observed damage patterns arising from multiple, interrelated factors.

Ethnic diversity is a defining feature of the region. Pashtuns constitute the predominant group, except in Nuristan, which is primarily inhabited by Nuristani populations. Pashayi and Tajik communities are also present, particularly in Nangarhar and Laghman. Cultural differences among these groups influence living arrangements and construction practices, including variations in the importance attributed to clan and village structures, household organisation, livelihoods, and the social position of women.

The area affected by the earthquake is largely mountainous, forming part of the Hindu Kush range (Figure 5.3), with relatively narrow yet fertile valleys. In Kunar Province, the Kunar River valley runs longitudinally through the province, while the Pech River and smaller tributaries descend from the Hindu Kush and join the Kunar River from the right bank. In Laghman Province, the Alingar River forms the largest and most densely populated valley. In Nangarhar Province, within the earthquake-affected area, the Kunar River joins the Kabul River at an elevation of approximately 580 m. This zone is comparatively flatter and constitutes one of Afghanistan's major agricultural regions (Affleck et al., 2011). Nuristan, by contrast, is predominantly mountainous, with elevations ranging from about 1,000 m to over 4,000 m.

Topography has a direct influence on population density, which varies significantly between plains, valleys, and mountainous areas. Nangarhar Province, with approximately 582 inhabitants per square kilometre, is the most densely populated province after Kabul. Kunar (117 inh./km^2) and Laghman (138 inh./km^2) have intermediate population densities, while Nuristan, at approximately 18 inh./km^2, is among the least densely populated provinces in Afghanistan.

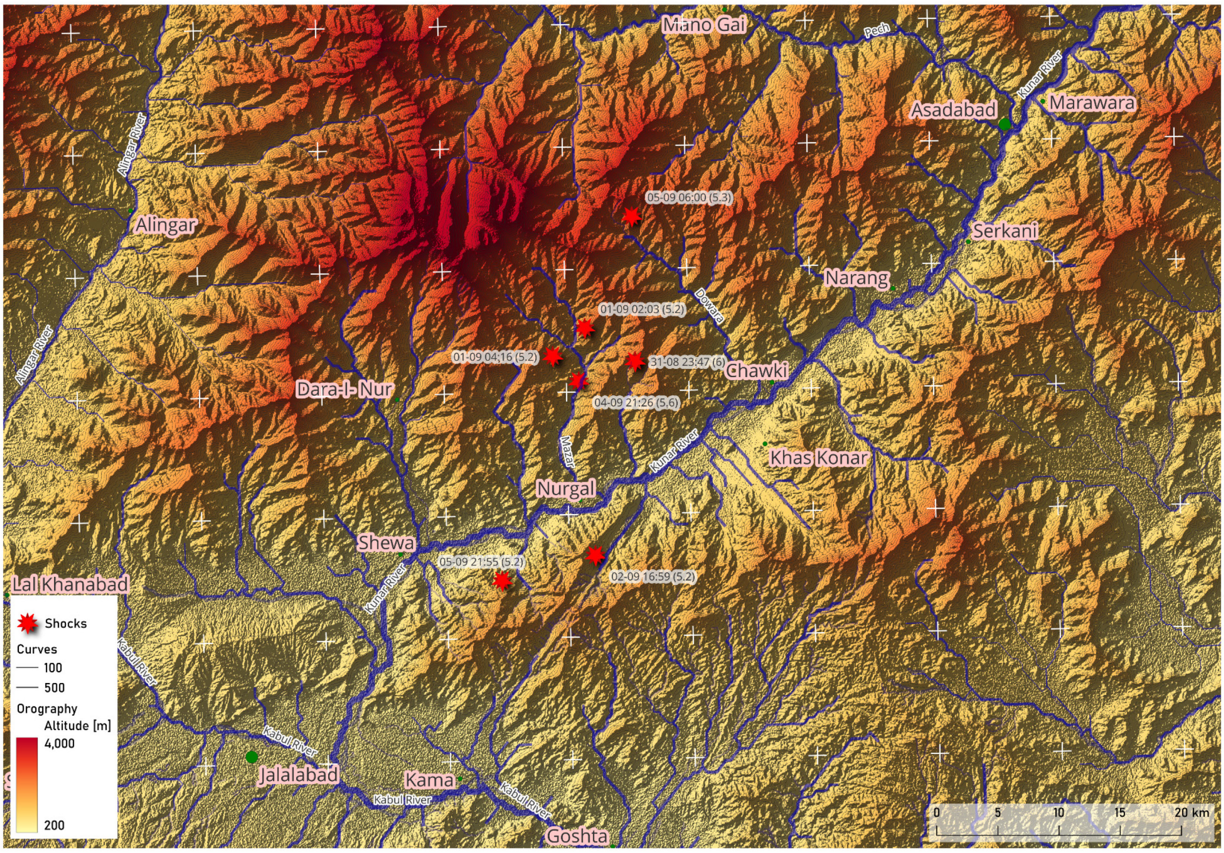


Figure 5.3: Topography of the area affected by the earthquake; with added position of epicentres, AFT time and magnitude of aftershocks

Vernacular architecture in the region is strongly dependent on locally available materials. While trees are scarce in many parts of Afghanistan, they are relatively abundant in the earthquake-affected area. Coniferous species such as cedar, pine, and spruce are found in mountainous areas above approximately 1,800 m, while deciduous species, including birch and poplar, are more common at elevations between 1,300 m and 1,800 m (Affleck et al., 2011).

Geological conditions also vary considerably. According to the USAID geological map (Figure 5.4), mountainous areas include formations of sandstone and siltstone (ssl), gneiss (gn), gabbro and monzonite (gbm), granodiorite and granosyenite (gdy), and granodiorite and granite (gdg). Valley areas are characterised by fan alluvium and colluvium (ac), loess (loe), conglomerates and sandstones (cgs, a), as well as zones with ultramafic intrusions. Soil mapping (Affleck et al., 2011) identifies extensive areas of sandy loam (SM, USGS soil class) and rubble-and-loam or rubble-and-sandy-loam soils (GM), conditions that directly influence foundation practices and structural performance.

Most damage images found in the media depict destruction in mountainous areas. However, generalisation is not possible. For example, Figure 5.5 shows an unidentified village in a flat area that appears to have been completely flattened, suggesting that severe damage was not limited to steep terrain, even if such cases appear less frequently documented.

Accessibility is a particularly important factor in the affected regions, and levels of remoteness vary considerably. The area around Jalalabad faces far fewer access constraints than the most remote parts of Nuristan. Prior to the earthquake, remoteness already influenced development, education, economic exchange, material availability, and local identity. During the earthquake, it strongly affected the effectiveness of emergency response, and in the post-disaster context, these constraints are unlikely to change rapidly. Any pragmatic and effective reconstruction or risk-reduction policy must take these conditions into account.

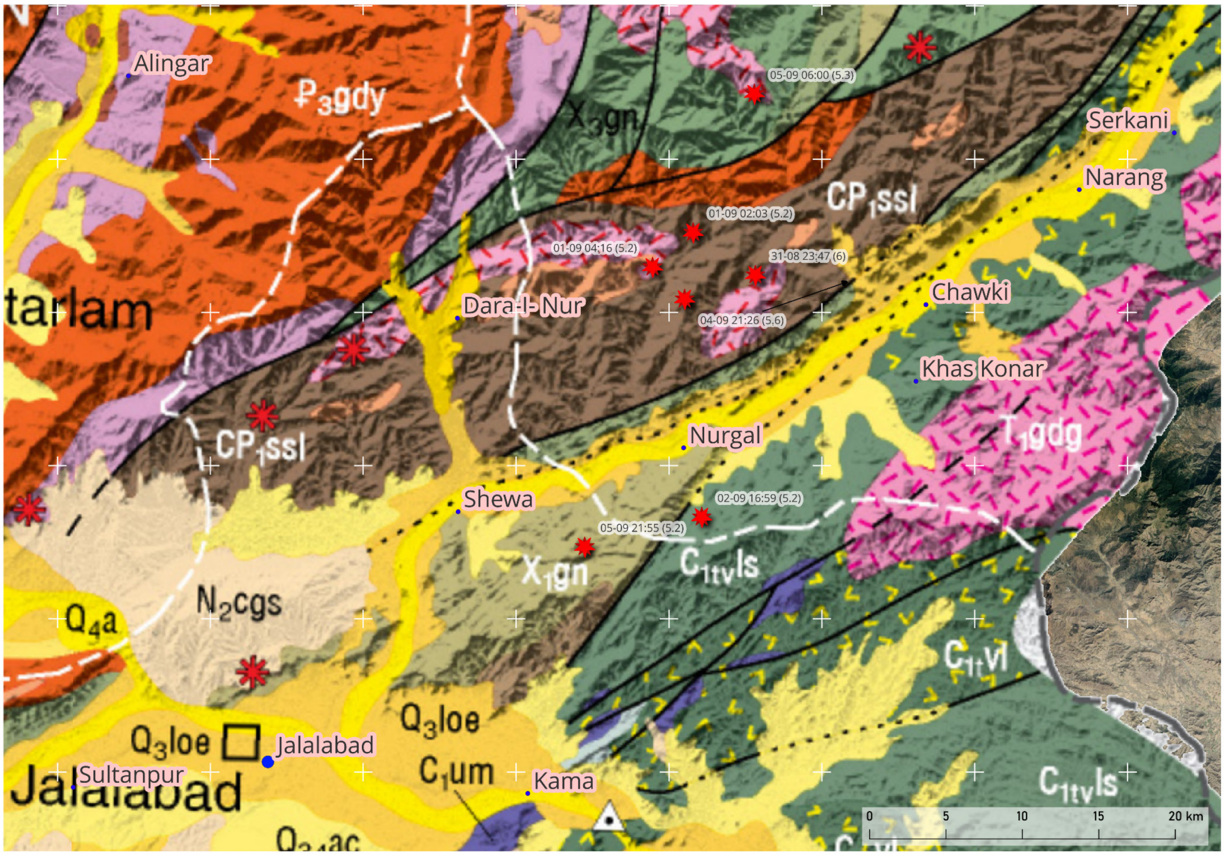


Figure 5.4: Geological map of the area affected by the earthquake (Doebrich aad Wahl, 2006)


6.0 Strong Earthquake in Afghanistan Today! Kunar Destroyed,800+ Dead,Tremor in Pakistan!

rubble. Taliban officials announced that
some villages were completely destroyed.

Figure 5.5: Completely destroyed village (Youtube, ‘Disaster Today’ channel https://tinyurl.com/2ewrd2fn)

Variations in accessibility also directly influence the building sector and construction practices. Many houses are self-built, particularly in remote areas. Closer to economic centres, photographic evidence suggests a higher density of constructions likely built by local contractors. A more granular understanding of the local construction sector would be necessary to assess capacities, limitations, and realistic pathways for improvement.

5.3. Current Design Guidelines in Afghanistan

Afghanistan's approach to seismic safety has evolved slowly and unevenly, shaped by decades of conflict, limited institutional capacity, and recurring earthquake disasters. The first formal attempt to introduce earthquake-resistant design guidelines occurred in 2003, when the Ministry of Urban Development and Housing (MUDH), in collaboration with the United Nations Centre for Regional Development (UNCRD), published the *Guidelines for Earthquake Resistant Design, Construction, and Retrofitting of Buildings in* Afghanistan (Arya, 2003).

These guidelines were largely adapted from Indian Standards (Bureau of Indian Standards, 1993) and focused on non-engineered masonry and earthen structures, which dominate Afghanistan's rural housing stock. They provided prescriptive measures such as seismic bands, vertical reinforcement bars, and improved bonding for stone and adobe walls. Although advisory rather than enforceable, these recommendations introduced critical principles for safer construction.

A major milestone came in 2012, when the Afghanistan Building Code (ABC) (Government of the Islamic Republic of Afghanistan, 2012) was officially introduced by the Afghanistan National Standards Authority (ANSA). The ABC references the 2009 International Building Code (IBC) and includes provisions for earthquake loads, structural integrity, and detailing for RC, steel, and masonry structures (Afghan Structural Code, 2012). Chapter 3 of the code addresses earthquake loads, while Chapter 5 includes specific requirements for earthquake-resistant structures, such as detailing of reinforcement and anchorage.

However, implementation has been extremely limited due to the following factors.

1) The code is published in English, making it inaccessible to most local engineers and builders.
2) Local government capacity for enforcement is weak.
3) Widespread institutional and economic constraints make many of these details unaffordable for low-income communities (Shnizai et al., 2022; UNDP, 2024).
4) Limited technical training, combined with weak oversight and accountability mechanisms, further undermines construction capability and the consistent application of hazard-resistant practices (Haziq and Kiyotaka, 2017).
5) Limited understanding of the importance of these details, particularly in rural and peri-urban areas where informal construction dominates.

5.3.1. Foundation design specifications

According to the national design guidelines in seismic-prone areas (*Guidelines for Earthquake Resistant Design, Construction, and Retrofitting of Buildings in Afghanistan, 2003*), the typical foundation systems of the most recent constructions and buildings in the region can be described.

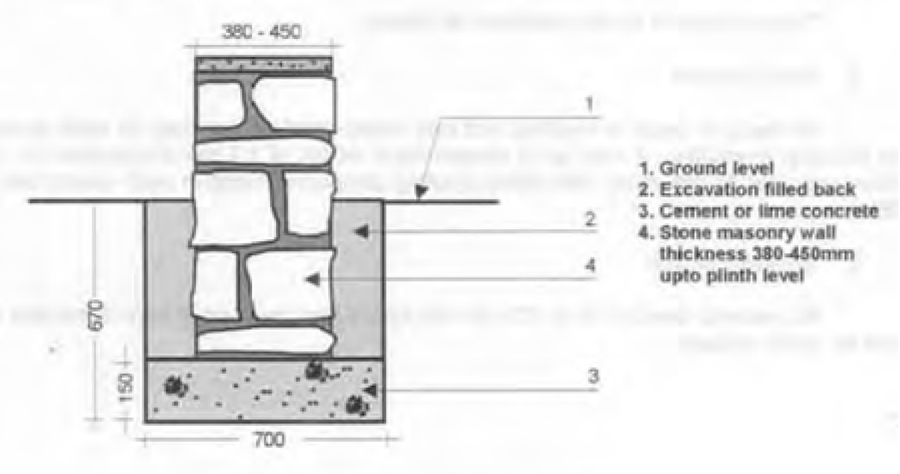


Figure 5.6: Strip Foundation (Guidelines for Earthquake Resistant Design, Construction, and Retrofitting of Buildings in Afghanistan, 2003)

The guidelines classify soils in seismic zones into three categories based on the standard penetration resistance (N value): Type I – Hard soil (N > 30), Type II – Medium soil (10 ≤ N ≤ 30), and Type III – Soft soil (N < 10). In these regions, stone is commonly used for constructing foundations and plinths. The typical construction practice involves the use of dry rubble masonry, either with sand packing or bound with mud mortar, for foundation systems.

For masonry and stone buildings, the guidelines recommend stepped strip foundations. A minimum base width of 700 mm is recommended on soil sites for buildings up to two storeys, with the width increased by about 300 mm for each additional storey. A stepped strip footing may be built on rock sites with a base width of 600 mm on weathered or jointed rock and 700 mm on massive rock for up to two storeys, again increasing about 300 mm per additional storey. A concrete levelling course of at least 100 mm thickness should be provided on top of the stone sub foundation before masonry is laid. When using existing pre-earthquake foundations, a 150 mm thick concrete base is recommended over the existing footing before continuing construction (Figure 5.6).

5.3.2. Challenges and recommendations

In practice, Afghanistan's building stock remains highly vulnerable because the ABC (Government of the Islamic Republic of Afghanistan, 2012) is rarely applied outside donor-funded projects in major cities. Rural and peri-urban areas continue to rely on traditional construction methods without seismic detailing, despite being located in high-hazard zones (Shnizai et al., 2022). Recent research highlights the urgent need for localized seismic microzonation, capacity-building for engineers, masons, and communities, and integration of vernacular techniques with modern seismic principles (Akhundzadah, 2025).

To mitigate risk to life and infrastructure, the development and enforcement of codes is certainly useful. To be effective, a policy should have priorities fitting the specific context of Afghanistan. It is unlikely that, for questions of cost, access, culture, education, and materials, the existence of codes will have a direct impact on the remote areas. Urban and accessible or remote rural places face different challenges. In the less developed regions, solutions are more likely to emerge by refining vernacular techniques, using traditional materials and techniques informed by a deeper understanding of modern seismic principles. Drawing inspiration from traditions and experience in other regions and respecting the means and aspirations of local communities is likely to be more productive. Investing in education and capacity building should be a top priority in Afghanistan.

Training programs for masons and builders have been initiated in several regions. Miyamoto International, in collaboration with UNOPS and UNDP, conducted seismic training in Herat in 2025, combining technical lectures with hands-on sessions led by Afghan engineers and masons. These sessions focused on reinforcing vernacular structures using culturally appropriate, low-carbon methods (Miyamoto International, 2025a). RedR UK also delivered retrofitting workshops for vernacular houses in Herat, addressing the expertise gap in repairing traditional and modern buildings (RedR UK, 2024).

Community awareness campaigns have complemented these efforts. ADRA launched a disaster education initiative in Herat, training local committees and first responders in risk reduction techniques (ADRA, 2024). UNDP has emphasized the importance of preserving vernacular architecture while improving seismic resilience through inter-agency coordination and local engagement (UNDP, 2024). However, these programs remain geographically limited, and coverage is insufficient to meet the widespread need for safe construction practices across Afghanistan's high-risk seismic zones.

Recommendation manuals and studies developed in similar contexts (vernacular architecture in seismic areas) often stress the potential of local traditions, their strengths and weaknesses, proposing improvements and capacity building initiatives based on contemporary structural understanding (Bothara and Brzev, 2011; UNESCO-UNDP India, 2007; UNESCO, 2016; Langenbach, 2010).

5.4. Construction Techniques and Typologies

5.4.1. Modern construction practices

Modern construction in Afghanistan is characterised by a mix of formal and informal practices, especially in urban centres. RC frame structures are commonly used in public buildings such as schools, hospitals, and government offices (Figure 5.7). However, many of these suffer from inadequate design for seismic loading, poor construction quality, inadequate seismic detailing, and a lack of maintenance, which compromise their structural integrity (World Bank, 2020).

Steel structures are less common but are increasingly used in institutional and commercial buildings due to their faster construction timelines (JICA, 2014). Despite their advantages, cost and technical expertise remain barriers to widespread adoption.

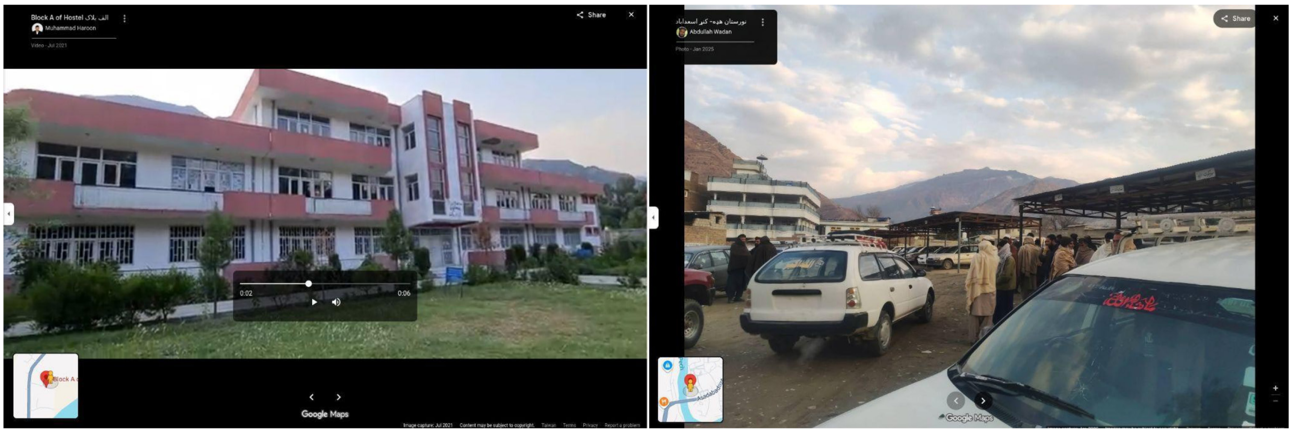


Figure 5.7: Left: Sayed Jamaluddin Afghani University, South of Asadabad; Right: Asadabad

Figure 5.8: Kunar Valley. Top: typical RC and masonry construction; Bottom: RC, masonry and steel

In residential construction, particularly in peri-urban areas, a hybrid approach is often observed. Builders combine traditional materials like unfired mudbrick or stone with modern elements such as concrete columns or steel reinforcement (Figure 5.8). These hybrids aim to improve resilience but often lack proper engineering input, resulting in inconsistent performance during earthquakes. While some structures were likely damaged, no media photos documenting such cases were found - possibly because the damage was relatively minor compared to other areas affected by the earthquake.

Post-disaster reconstruction efforts have promoted the use of seismic-resistant features, including reinforced foundations, ring beams, and improved roof anchorage. These interventions are sometimes integrated into traditional layouts to maintain cultural appropriateness while enhancing safety (UN-Habitat, 2011).

5.4.2. Building elements: traditional techniques

Three wall construction techniques are commonly used in the areas hit by the August Earthquake:

1) Cob (*Pakhsa);*
2) Timber reinforced stone masonry;

3) Adobe

The three wall types above can be found in a variety of buildings (Section 5.3.3) and settlement types (Section 5.3.4), responding to topographical, cultural, and other factors discussed above. Roof construction and other elements of structural significance will also be briefly described.

Each of these techniques, buildings, and settlements exhibits distinct structural characteristics. Their performance, vulnerabilities, and modes of failure under seismic loading are discussed in Section 5.4.

A field survey was conducted on more than 10 traditional buildings in each of the three villages: Shomaash (stone masonry typologies), Ghaziabaad, also known as Wadeir (stone and mud masonry typologies), and Patang (mud masonry typologies). The affected region was divided into two impact zones based on observed ground-shaking intensity and damage patterns. Zone 1 represents settlements exposed to comparatively higher shaking intensity and structural damage, while Zone 2 includes settlements that experienced relatively lower levels of shaking and damage.

Based on these surveys, broad typological information was developed for each of the three wall construction types listed above. Further details are provided in Appendix B.

Cob walls

Pakhsa, the local term, is one of the most widespread traditional wall construction methods in Afghanistan, particularly in central and eastern regions (Szabo and Barfield 1991, Kast et al., 2024). Like rammed-earth, pisé, it is built in horizontal layers, less than 1m high, using earth with low water content. Contrary to rammed-earth, no framework is used during construction and, consequently, earth cannot be as well compacted, therefore it is more similar to “cob”. Small lumps of earth (*jom*) are shaped by hand and are energetically thrown on the wall under construction by the masons (*bana*) (Figure 5.9). Shovels are used to pass earth to the mason and regularise the wall surfaces. Traces left by the layering process and by the lumps can be seen on the surface of the walls.

Figure 5.9: Walls under construction in the valley of Bamiyan, Afghanistan

These walls are typically self-built using locally available materials and simple tools. The construction of mud walls begins with the preparation of suitable soil. Locally available clayey soil is collected and mixed with water until it reaches the desired plastic consistency. The amount of water added depends on the intended application: for wall construction, the mixture should be stiff and cohesive, while for surface plastering (*kagal*), a softer and more workable mix is required. After mixing, the soil and water are thoroughly kneaded to ensure uniformity.

Traditionally, this mixing is performed manually, with builders walking through the mud to blend it properly, a process still widely practiced in rural Afghanistan. For larger construction projects, such as fortified walls or towers, modern builders now use mechanical means, such as tractor treading, to compact and homogenize the mixture.

Historically, the same process was carried out using animals such as horses, donkeys, mules, and oxen, which were driven repeatedly over the mud mixture. This practice, often observed in ancient and historic structures, produced highly compacted earthen material with remarkable resistance to rain and erosion. The repeated mechanical loading increased the density and cohesion of the mud, preventing it from washing away even during heavy rainfall.

However, due to economic constraints, many people in remote and poor regions still rely solely on manual methods and basic tools for mud preparation. Despite its limitations, this method remains affordable, locally sustainable, and suitable for vernacular construction, reflecting the region’s traditional engineering adaptation to available resources.

No apparent reinforcement, horizontal or vertical, of timber or other materials is observed for this kind of wall construction. More details can be found in Hesari (2006), Hallet and Samizay (1980), and Szabo and Barfield (1991).

Stone and timber walls

Stone masonry houses are prevalent in the mountainous regions of eastern Afghanistan. These structures use locally available stone, either dry-stacked or mortared with clay. Wall thickness and stone shape vary regionally.

Walls are often high (section 5.4.3). Construction technique, height, and weight of the roof impose them to be thick (60-80 cm according to Szabo and Barfield 1991). They are often tapered with a 1:6 to 1:10 batter to improve stability (Kast et al., 2024).

The walls are built using rubble masonry, where the stones are typically either uncoursed, roughly levelled or, in the highest-quality constructions, laid in uniform horizontal courses. The bonding quality exhibits considerable variations (Figure 5.10). Some walls were clearly built by skilled builders; others lacked professional care. Describing Nuristani architecture, Samizay (1975) and Oliver (1997) distinguish the skilled carpenters (bari) from the unskilled labourers (shewala). Financial constraints, lack or loss of traditional skills, and lack of engineering guidance often lead to structurally weak constructions.

Figure 5.10: Examples of bonds (Upper 4: Youtube, Hameshabahar Afghanistan channel https://tinyurl.com/3hwusksw)

Figure 5.11: Space with intermediate wooden pillars (Youtube, Hameshabahar Afghanistan channel https://tinyurl.com/3hwusksw)

Figure 5.12: Structural elements connections. Left - Getty images; Right, source unverified

Typical stones have an angular shape, are not dressed, but may have been roughly shaped. They are of manageable sizes (typically ranging from 30 to 60 cm) to ensure manual handling without mechanical assistance. Smaller, more rounded stones suitable rather as aggregates combined with a binder may also be found (Figure 5.11). Stone chips (*ghaz*) are inserted beneath unstable stones to prevent movement. Through stones, binding the inner and outer surfaces of the walls, appear to be lacking (Figures 5.12 and 5.13), at least from walls that failed. Szabo and Barfield (1991) state that larger stones (quoins) are used to reinforce corners. This may be observed on photos found in the media; cornerstones are often larger, but there are certainly not ashlars (Figure 5.10).

An element of particular structural (and cultural) interest is the use of horizontal timber members (chains, tie-beams) embedded in the masonry: one on the inside, one on the outside, or as a board through the whole thickness of the walls (Figure 5.14). For these elements too, differences in skills are observed: timber may be

Figure 5.13: Wall coherence. Left: delamination (Credit: Youtube, Aljazeera English channel https://tinyurl.com/8bhbe5x6), Right: absence of through stone (Credit: YouTube, Watan Nandara channel https://tinyurl.com/yxnchrsb)

Figure 5.14: Stone and timber structure beside cob construction (Youtube, NewsX World channel https://tinyurl.com/58sbnt8b)

rough-hewn (possibly shaped by axes or adzes) or left round (Figure 5.15). The presence or absence of connections between perpendicular members, on corners, and along the walls, through pegs or other means cannot be ascertained from the available data. The potential effectiveness of these timber members as reinforcing elements clearly depends on their interconnections and correct integration with the masonry fabric and consequently of skilled workers. When built in a continuous fashion, tie-beams enhance structural integrity and robustness of load-bearing masonry walls, and can reduce the risk of crack propagation - and were shown to change the seismic performance for the better (Vintzileou, 2008; Spense and Coburn, 1992; Aktas et al., 2022).

Figure 5.15: A series of damaged stone masonry buildings. Left: AFP/Getty Images; Right: Dewagal Valley (Youtube, Hameshabahar Afghanistan channel https://tinyurl.com/5xacux3v)

Fig. 5.16: Damaged adobe houses. Unidentified village (India Today NE https://tinyurl.com/2zrdve7e)

The timber structures also appear to have no vertical, diagonal or transversal members, similar to what can be observed in countries with an anti-seismic timber and stone tradition or in *sej* construction, another Afghan technique.

In less remote areas, rural or urban, stone may also be used as a veneer for its aesthetic appeal rather than for reasons related to structure, tradition, or culture.

Adobe walls

Adobe walls appear less often in the photographs found in the media. It is nevertheless known from the literature (Oliver, 1997) that adobe walls are often used in the *qala*-type houses, for the construction of the inner units inside family compounds and for smaller constructions (Figure 5.16). According to Affleck et al. (2011), 90% of constructions in Nangarhar are in adobe. But (for some reason) only a few images could be

Fig. 5.17: Damaged adobe houses. Unidentified village (BBC News, Getty Image https://tinyurl.com/yc3e8xma)

found of the earthquake impact on adobe constructions (Figures 5.3, 5.16, and 5.17). In the area of the 3rd November earthquake, which struck an area close to Kholm and Mazar-e-Sharif (North of Afghanistan), most of the damaged houses are Adobe houses.

In the mountains, upper floors may also be used with a timber structure (with horizontal, vertical, and diagonal members) infilled with adobe (*senj*) (Szabo and Barfield, 1991). No such example could be identified among the limited visual material available to the team for this report.

Adobe walls are formed of discrete building units, sun-dried bricks (*khesht-i-kham*), laid in courses using mud mortar. The preparation of the bricks requires more time and organisation. But thinner walls of more controlled dimensions are more easily constructed. According to Affleck et al. (2011), the most common size is 20x10x5 or 6 cm, but Figure 5.17 shows blocks clearly thicker and arguably with different proportions. It may be assumed that sizes vary.

As discussed for stone masonry walls, these unit-based walls rely on the cohesion of individual bricks and their mortar joints, unlike the monolithic mass of pakhsa walls.

Ceilings and roofs

In this region of Afghanistan, most roofs are flat. From what can be observed from photographs, similar construction techniques appear to be used in plains and mountains. They are constructed using timber joists spanning across walls. Beams are formed of unhewn timber. To span larger rooms, intermediate wooden pillars supporting transverse beams are sometimes used (Figures 5.10 and 5.18). It cannot be verified from photographs, but poplar is known to be commonly used in Afghanistan for these structural elements (Szabo and Barfield, 1991).

Figure 5.18: Ceiling structure

The roofs are constructed with layers of mud, applied over wooden planks, laths, or even brushwood. These layers are supported by the joists that span the walls, sometimes reinforced with intermediate pillars for added stability. Waterproofing is improved by a final layer of mud render on the surface, which (in theory) should be sloped out to facilitate drainage. This roof system provides insulation and water protection. To counteract erosion, it is customary to repair/maintain the roof by adding more mud on the surface after the rainy/snowy season. The roofs are therefore thick (around 20 cm according to Szabo and Barfield 1991) and heavy, which is problematic under earthquake loading. See Hesari (2006) for sections and more details.

According to Kast et al. (2024) and UN-Habitat (2017), embedment of roof joists into walls is typically shallow (10-15 cm). This does not seem to be supported by photos from the media. In mountain houses (Figure 5.18) and valley houses (Figure 5.16), roofs and their supporting joists frequently extend beyond the walls, diverting rainwater from the structure, a good practice to protect erosion from the rain. But, when the constructions have more than one floor, the extremities of floor beams do not reach the outer surface, indicating embedment. From the photographs, it appears that (aside from friction) there is no positive anchorage system securing the joists to the exterior walls, which would otherwise enhance the diaphragm action of the wooden structure.

Openings

Window and door lintels are made of sawn, roughly shaped, or even unhewn timber. Doors and windows frames and sashes are better crafted (Figures 5.13 and 5.19), with a solid built made of sawn timber. Colour differences observed on photographs may indicate that more durable wood species are used for joinery (oak and spindle tree wood).

Figure 5.19: Doors

Foundations

Foundations in the reviewed structures are scarcely visible in the available photographic media. However, multiple sources allow their characteristics to be inferred. According to the Miyamoto report (2025a), foundations are typically constructed from stones laid without a mortar binder. This approach aligns with traditional cob wall construction, which commonly incorporates a low stone basement made of rubble stones to protect earthen walls from moisture and splashing. Similar construction techniques are documented by Szabo and Barfield (1991) in their description of *qalas* construction, as well as by Affleck et al. (2011), suggesting a long-standing regional practice.

In the rural areas of Kunar and Nangarhar provinces, foundations are generally shallow and unreinforced, consisting of stones or mud placed directly on the ground with little or no levelling or stabilisation. Locally sourced materials (mud brick, stone, and timber) are widely used due to their availability in the mountainous terrain, but construction practices largely lack modern engineering input. As a result, these foundations provide minimal resistance to lateral seismic forces, significantly increasing structural vulnerability during earthquakes.

Post-earthquake assessments and photographic evidence from the 2025 seismic event reveal that many buildings were supported by shallow rubble strip footings (Figure 5.20) or compacted soil foundations. In some cases, stone platforms were placed directly on sloping ground or terraces, while in more remote settlements, buildings lacked any formal foundation system altogether. These foundation configurations often proved inadequate for load distribution and seismic resistance, contributing to widespread structural failure. Entire villages, such as Masoud village in Nurgal district, were reduced to rubble, with reports indicating near-total destruction in some areas (Ambrose et al., 2025; ICRC, 2025a).

The lack of adherence to formal building codes and the absence of seismic reinforcement in traditional construction practices significantly increase structural vulnerability during earthquakes. However, the wholesale adoption of advanced seismic design standards comparable to those of high-income countries is not realistic in the Afghan context. Most buildings are constructed to limited budgets using locally available materials and informal methods, often in the absence of regulatory oversight and skilled engineering input (Shamim, 2025).

Consequently, risk reduction efforts should prioritise incremental, low-cost improvements rather than the replacement of traditional construction systems. Simple and achievable measures, such as improved foundations, foundation ties, good regularity, detailing to ensure the wall acts monolithically, seismic bands, good wall-to-roof connections, and the avoidance of construction on highly unstable ground, can substantially

Figure 5.20: Unreinforced strip foundation of collapsed house at Nurgal district of Kunar province (Xinhua, 2025)

enhance seismic performance without requiring advanced technology or prohibitive costs. While traditional foundation practices are often well adapted to local materials and climate, they require modest modification to better resist dynamic loading, particularly in soft or heterogeneous ground conditions.

In this context, the development of simplified, locally adapted building guidelines, supported by community training and demonstration projects, represents a more effective and realistic strategy than the enforcement of complex international codes. Such an approach allows seismic risk reduction to be integrated into existing construction practices, thereby improving safety while remaining socially, economically, and technically more feasible.

5.4.3. Other typological characteristics and vernacular living cultures

The construction techniques of structural elements described in Section 5.3.2 are found across a variety of buildings with distinct yet related typologies. Social and cultural practices strongly influence dwelling layouts, with privacy and gender segregation (*satr*) remaining key considerations. Family living areas are typically organised around a courtyard enclosed by high walls without openings. Living units generally have small, irregularly positioned windows that are not constructed according to standardised specifications; their placement prioritises ventilation, privacy, and thermal comfort.

A large proportion of the population relies on agriculture and husbandry. The close integration of domestic, agricultural, and livestock functions within a single dwelling reflects both the rural economy and extended family living arrangements typical of the region.

In valleys and flat areas, individual buildings can be identified in satellite imagery, although densely compacted groups of houses are more common. In most instances, both settlement types use cob walls and are single-storey. According to the literature, stone is typically used for foundations and to form a plinth or socle that improves the resistance of cob walls to water splashing. While this is likely the case in the study area, it is not clearly substantiated by the available photographic documentation. In alluvial areas, where stone is less readily available, it remains unclear whether rounded cobbles or more angular stones are commonly used.

The first and less common building type consists of fortified compounds (*qalas*), which are found throughout Afghanistan. These structures are defined by high, tapering perimeter walls without openings, enclosing a square or slightly rectangular courtyard. In rare cases, corner towers (*borj*), uncommon in eastern Afghanistan, may be present. Living units are typically constructed against one or more perimeter walls. Smaller *qalas* house a single family, while larger ones accommodate extended families and tenants (Oliver, 1997). Within the courtyard, spatial organisation clearly reflects social hierarchy and gender segregation, with distinct areas for landlords and tenants and for men and women (Szabo and Barfield, 1991; Oliver, 1997). For structural and defensive reasons, perimeter walls are very thick, typically ranging from 100 to 150 cm (Szabo and Barfield, 1991). In mountainous areas, *qalas* are generally smaller, as mud is a limited resource; internal buildings are often constructed using adobe walls, which allow thinner sections (Szabo and Barfield, 1991).

The second category of settlement also consists of houses organised around courtyards, but with adjacent compounds sharing walls and often appearing smaller. Clear typological distinctions between house types are difficult to establish, as transitions between forms are gradual rather than discrete. Figure 5.16 illustrates a village where most houses are built in adobe and follow a regular pattern, while Figure 5.21 shows examples of settlements as observed in satellite imagery.

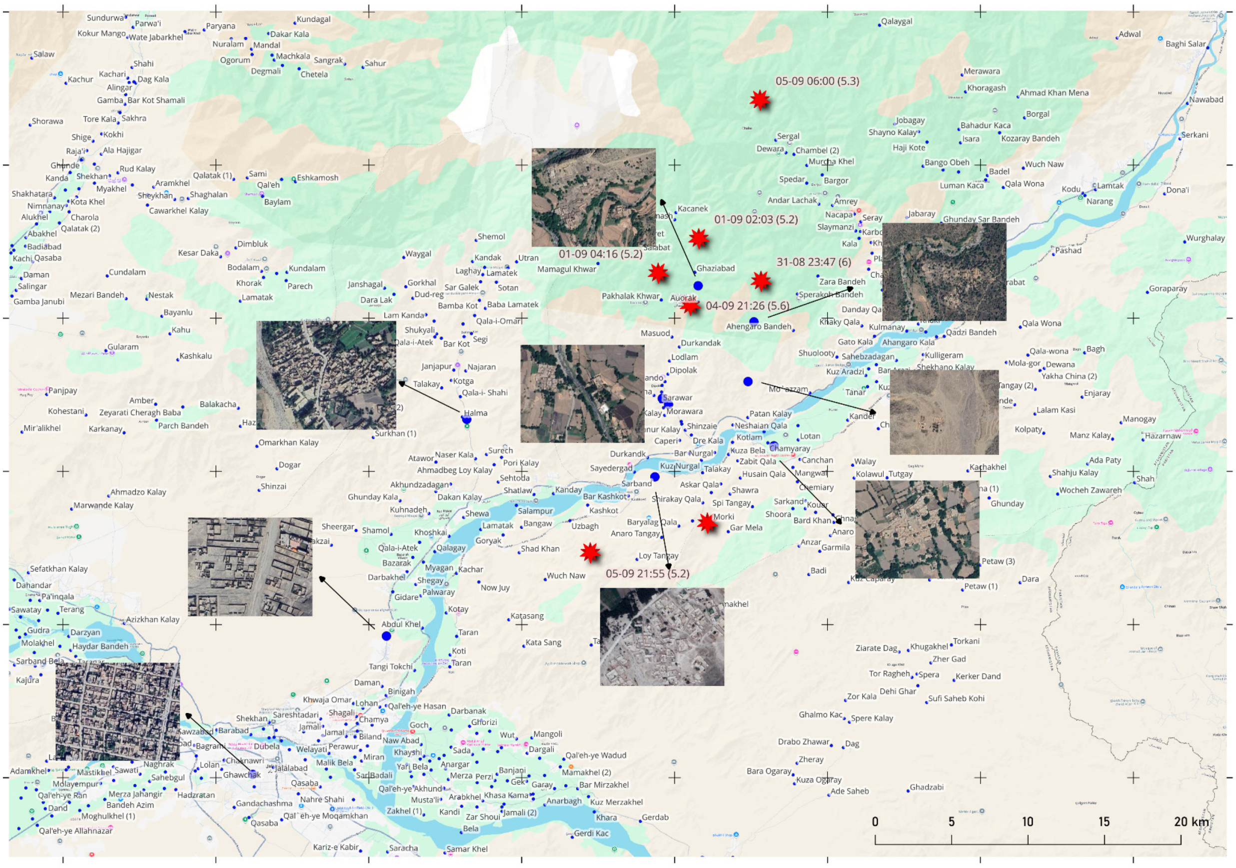


Figure 5.21: Typical examples of settlements patterns in the earthquake area

While *pakhsa* (cob) buildings are relatively easy to maintain and repair, they are highly vulnerable to seismic activity due to their low lateral strength and poor connection detailing. Nevertheless, their affordability, cultural familiarity, and climatic responsiveness make them a preferred option for many Afghan households (UNDP, 2023). Gilmour (2020) describes a typical cob house, including its dimensions and construction cost.

In mountainous areas, houses are typically multi-storey, with buildings of up to four floors not uncommon. As households expand and villages remain densely compacted, families often add additional storeys over time (Miyamoto, 2025a). Construction techniques frequently vary with height: the hybrid stone-and-timber construction described above is common, but cob walls are often used in upper storeys or throughout the entire structure (Figures 5.11, 5.22, 5.23). According to the literature, lighter upper storeys constructed using a timber frame with adobe infill (*senj*) may be added in some cases (Szabo and Barfield, 1991), although no such systems were identified in the available photographic data.

A complex network of internal and external staircases provides access to vertically expanded dwellings and connects different floors within the same household (Figure 5.24). This configuration is common in multi-storey dwellings across Kunar, Nangarhar, and Laghman. Lower floors are frequently used for livestock shelter or storage, while upper floors serve as living spaces, particularly in rural and high-altitude areas dependent on subsistence agriculture (Hallet and Samizay, 1975).

Finally, regional variations in construction practices are evident. For example, the Pashayi communities of the lower Kunar River tributaries commonly build houses in stone but use less timber than Nuristani populations (Szabo and Barfield, 1991).

5.4.4. Settlement typology

Jalalabad (about 200,000 inhabitants), capital of Nangarhar province, and Mihtarlam (about 140,000 inhabitants), capital of Laghman, are the largest urban cities. Asadabad (about 48,000 inhabitants), capital of the Kunar province, presents a more rural aspect. Higher-rise concrete buildings are mostly seen in Jalalabad.

In the plains formed by Afghanistan's largest rivers (the Kabul, Kunar, and Alingar) and their main tributaries, villages and smaller clusters of buildings are common. Most villages are organically arranged groups of

Figure 5.22: Cob walls. The lines marking the interfaces between layers can be clearly distinguished – this technique can be used in the whole structure (credit: NCRO [left]) or on top of a stone masonry ground floor (AFP via Getty Images)

Figure 5.23: Cob wall built on top of a stone wall (YouTube, Watan Nandara channel https://tinyurl.com/yxnchrsb)

Figure 5.24: Typical internal staircase arrangement in affected multi-story houses

squarish houses or compounds, ranging from a few buildings to several hundred. Streets within these villages are generally narrow and sinuous (satellite imagery, Miyamoto 2025a), although some settlements exhibit more regular layouts. Market streets (bazaars) are typical in towns, consisting of straight roads bordered by rows of shops with front facades opening directly onto the street. Outside larger cities, public buildings constructed with modern techniques (such as government offices, hospitals, schools, and military facilities) are dispersed across the territory.

In the mountainous regions and narrower valleys, villages are denser, often terraced, and closely follow the local topography. Settlements are typically located in piedmont areas, leaving valley floors available for cultivation. Detailed information on Afghan village types and spatial organisation is available in Balland and Bazin (1994), but the current data do not allow assessment of how these variations correlate with ethnic diversity.

5.5. Building Performance

5.5.1. Overview

The 31st August 2025 earthquake struck large parts of Kunar, Nangarhar, and Jalalabad provinces, with the most severe impacts observed in the districts of Nurgal (Mazar Dara), Chawkay, Watapur, Manogai, and Chapa Dara. The quake caused widespread devastation, leading to the complete or partial collapse of thousands of houses and several schools and healthcare facilities.

The majority of the impacted buildings were located in mountainous areas and were primarily constructed using traditional vernacular materials.

Most of the obtained photographic data of damaged buildings are from the less-densely populated mountains. Cob houses built in flatter areas seem to have been less affected, while there is little reason to believe that they were much more resistant to earthquakes. Arguably, the epicentre of the main shock and of the aftershocks is located in the mountains, but the Kunar river valley is not far (about 10 km).

Other factors contributing to the larger extent of damage in mountains than proximity to the epicentre could include the following:

1) Biased data. It would have been easier for responders and journalists to start by documenting damages in areas of easy access.
2) The geotechnical nature of the terrain: in the valleys, structures are generally low and rigid and therefore more vulnerable to high frequencies. Alluvial plains tend to amplify low and attenuate high frequencies.
3) As discussed extensively in the geotechnical chapter, many building collapses may have been triggered because of slope instability or weak foundations.

5.5.2. Failure mechanisms

General

Based on available post-event observations (including photographic documentation and remote assessments), several recurring patterns of building failure were identified. These observations suggest that many collapses were strongly influenced by ground and terrain-related processes rather than by isolated structural deficiencies alone.

A large proportion of building damage in hilly and mountainous areas appears to have been associated with slope instability and loss of ground support. In such settings, buildings experienced displacement, rotation, cracking, or collapse following downslope soil movement, localised ground deformation, or terrace and slope-edge failures (Figures 5.25 and 5.26). In these cases, foundations were frequently displaced, overturned, or fractured as a consequence of the failure of the supporting ground, rather than as a primary initiating mechanism.

Buildings founded on soft or moisture-sensitive soils were also affected by differential ground deformation, leading to wall cracking, misalignment of door and window frames, and (in more severe cases) partial or total collapse. Homes constructed on artificial terraces or near slope edges were particularly vulnerable to toe failure, where downslope soil movement or inadequate bearing capacity reduced support beneath foundations and resulted in progressive loss of stability of the superstructure.

Localised foundation distress was additionally observed in some cases, including cracking or crushing beneath heavily loaded walls. Such damage is interpreted as a secondary effect of uneven ground response and insufficient confinement at the wall-foundation interface, often exacerbated by the absence of tie beams or plinth-level reinforcement. The widespread use of vegetable topsoil and/or loosely compacted fill beneath foundations likely increased susceptibility to these ground-induced failure processes.

Figure 5.25: A damaged and tilted house situated on sloped terrain in Mazar Dara village, Nurgal district, Kunar province (Zahir, 2025)

Figure 5.26: Heavy damage to a house sited on sloped ground in Mazar Dara, Kunar province (Associated Press, 2025b)

Vernacular houses

1) Sources and Limitations of Available Evidence

Photographs and video footage documenting damage to vernacular constructions are relatively abundant in the media, and the following observations are primarily based on this material. Several important limitations must, however, be acknowledged. Most available documents understandably focus on the human tragedy caused by the earthquake rather than on technical or structural aspects. Images are rarely geotagged, captions seldom specify exact locations, and the material was largely produced by journalists, aid workers, or local residents rather than engineers. As a result, the documentation seldom captures entire buildings or all structurally relevant elements, whether of collapsed structures or of those that remained standing. The observations presented here should therefore be treated with caution, particularly with respect to their representativeness and potential for generalisation across locations.

2) General Damage Patterns and Extent of Collapse

Despite these limitations, a number of recurring failure mechanisms can be identified. The majority of observed damage affected houses constructed using earth, stone masonry (dry-laid or with mud mortar), and timber elements, as described in Sections 5.4.2 and 5.4.3. The synthesis of photographic evidence and existing literature in those sections provides a framework for interpreting the observed damage patterns.

A significant number of houses experienced total collapse (Figure 5.5), leaving only heaps of rubble and scattered timber elements. In such cases, detailed analysis of failure mechanisms is difficult, and it can only be inferred that the original structures were too weak or vulnerable to withstand the seismic shaking. Given the lack of pre-earthquake documentation, the absence of Google Street View coverage, and the imprecise location data associated with most images, it is not possible to determine which factors were decisive in explaining why some houses collapsed while others survived. However, these building typologies are well documented in the literature to be very vulnerable to earthquakes.

3) Material Vulnerabilities and Structural Configuration

Partially damaged structures provide greater insight into failure mechanisms. Two of the principal construction materials (earth and stone masonry) share an inherent limitation: negligible tensile strength. Roofs are typically heavy, and their mass clearly contributes to vulnerability. While roof weight likely triggered some collapses, walls are often thick and might have resisted horizontal seismic forces had effective elements promoting box behaviour been present or properly implemented.

In many cases, horizontal rings or diaphragms and effective connections between perpendicular walls were absent, insufficient, or ineffective. Timber joists often rested loosely on walls or were embedded without anchorage, providing little contribution to transverse stability (Kast et al., 2024; UN-Habitat, 2017).

4) Observed Failure Mechanisms

Photographic evidence indicates that out-of-plane wall failures were far more common than in-plane shear damage. Cracks were predominantly vertical rather than diagonal, and walls frequently detached at corners or separated from roof structures. In some cases, roofs collapsed while walls remained standing; in others, walls failed while roofs resisted, or both collapsed simultaneously. This suggests that walls behaved largely independently from other structural elements and were critically vulnerable to out-of-plane instability.

The proportion of wall openings is generally small and does not appear to constitute a dominant vulnerability factor.

5) Influence of Topography and Maintenance

Images of collapses are more common in mountainous areas than in flat valleys. As noted in Section 5.5.1, this is somewhat unexpected given the known seismic vulnerability of adobe and cob construction. Whether this reflects actual performance differences or a bias in the available data remains uncertain. However, (as mentioned in 5.5.1) topographic amplification and higher high-frequency content of the local accelerograms in mountainous areas (stiffer terrain) are possible explaining factors. In both areas, inadequate maintenance and water-induced erosion of walls and roofs likely increased vulnerability for adobe and cob buildings.

6) Performance of Hybrid Stone-Timber Construction

The hybrid stone-and-timber construction typical of mountainous areas reflects a possible local awareness of seismic risk (Figure 5.14), yet it often performed poorly. A fundamental deficiency remains the pronounced vulnerability of walls to out-of-plane failure. Stone masonry frequently exhibits weak bonding; even when mortar is present, it is typically mud mortar with negligible strength. Wall cohesion, therefore, depends largely on stone interlocking, friction, and the limited contribution of timber elements.

Low sectional coherence is common, and wall delamination was observed in several cases (Figure 5.12), often associated with the absence of through-stones. Timber elements embedded in masonry have the potential to tie walls together, act as ring beams, and improve confinement. However, these effects require continuous, well-connected timber members. Circular-section tie beams provide limited contact with masonry and reduced lateral restraint (Xekalakis et al., 2023), while discontinuities in timber bracing interrupt force transmission and undermine seismic performance (Patel, 2024). In addition, timber may not be naturally durable or treated, and therefore vulnerable to insect attack and rot.

Unlike other hybrid traditions (e.g., *saj* construction), diagonal timber bracing was not observed; only horizontal members were used. In some cases, timber frames appeared to prevent total collapse (Figure 5.27), while in others, poorly integrated timber may have reduced overall structural coherence (Figure 5.15). Well-documented examples of properly executed, resilient houses are unfortunately lacking.

7) Role of Workmanship and Broader Contributing Factors

Quality of execution is a critical issue. As noted in Section 5.3.2 and the Miyamoto report (2025a), workmanship varies significantly, and some houses clearly performed better than others. Factors such as location, craftsmanship, and material condition influence vulnerability. While better construction quality likely correlates with improved performance, this relationship cannot be conclusively demonstrated with the available data.

Hybrid timber-masonry construction has proven relatively effective in many seismic regions worldwide (e.g., Kashmir, Turkey, Portugal), and both deficiencies and best practices show strong commonalities (Langenbach, 2000; Ortega et al., 2014; Patel, 2024). A thorough investigation of failures, surviving structures, and comparable vernacular traditions is therefore essential to formulate actionable recommendations.

Additional contributing factors that warrant consideration are the following:

1) Slope instability, particularly with the approaching rainy season (December-April);
2) The moderate seismicity of the affected area relative to other parts of the region;
3) Erosion of traditional knowledge and skill transmission due to long duration between large seismic events;
4) Poverty and remoteness, which may shift priorities away from maintenance and structural improvement.

Figure 5.27: Stone/Timber connection. Left: YouTube, Watan Nandara channel https://tinyurl.com/yxnchrsb; Right: Youtube, Hameshabahar Afghanistan channel https://tinyurl.com/3hwusksw

5.5.3. Influence of terrain and soil conditions

A defining characteristic of the region affected by the 2025 earthquake is its rugged, mountainous topography. Many dwellings are constructed on cut-and-fill platforms or narrow terraces carved into steep hillsides. These sites are inherently unstable for several reasons. Fill material used to create building platforms tends to settle over time, a process that is significantly accelerated by seismic shaking. In addition, erosion at the slope toe progressively undermines foundation support. These vulnerabilities are often compounded by the absence of retaining walls or other forms of slope reinforcement, leaving structures highly susceptible to movement or collapse.

During the earthquake, seismic shaking frequently induced differential movement between natural ground and placed fill, leading to partial foundation collapse or lateral displacement. This loss of support compromised the integrity of the superstructure and resulted in severe structural damage or total failure in many cases.

In summary, foundation failures observed during the 2025 earthquake can be primarily attributed to a combination of poor construction practices, inappropriate site selection on sloping or unstable terrain, weak or water-saturated soils, and the lack of basic engineering considerations in traditional building methods. The disaster underscores the critical importance of integrating thorough geotechnical site assessments into rural housing development, particularly in seismically active regions with complex terrain. Such measures are essential to improving the resilience and long-term safety of vulnerable communities. However, these mountainous communities often have few appropriate alternative sites available, and, therefore, selecting alternative sites is not always possible.

5.6. Conclusions

The 2025 Eastern Afghanistan earthquake highlighted the profound influence of geotechnical conditions on seismic damage in mountainous and tectonically complex regions. Despite its moderate magnitude, the event triggered extensive geotechnical failures (including widespread landslides, localised ground deformation, foundation failures, and potentially isolated manifestations of liquefaction), which significantly amplified human and infrastructural losses.

The earthquake exposed critical vulnerabilities arising from steep topography, heterogeneous soil and rock conditions, and traditional construction practices that insufficiently account for seismic hazards. In narrow valleys, where flat terrain is scarce and preferentially reserved for agriculture, settlements are often forced onto marginal land such as piedmont zones, alluvial fans, and poorly consolidated valley-fill deposits. These settings (while unavoidable from a socio-economic perspective) are geotechnically unfavourable and prone to ground-motion amplification, differential settlement, and slope instability. Combined with shallow, poorly engineered foundations, these factors further exacerbated structural damage across affected settlements.

Key lessons from this event highlight the urgent need to integrate detailed geotechnical investigations with seismic hazard assessments to support microzonation, land-use planning, and risk mitigation strategies. Such assessments must explicitly consider the constraints imposed by valley geomorphology and land-use competition, rather than assuming ideal site conditions. Strengthening traditional building techniques, improving foundation practices, stabilising slopes, and enhancing the resilience of critical infrastructure are essential steps toward reducing future losses.

The event also demonstrated the importance of rapid, multidisciplinary post-disaster reconnaissance in identifying failure mechanisms and informing effective recovery and reconstruction efforts. Limited evidence of liquefaction (primarily in saturated fine-grained alluvial deposits near river channels) highlights the need for further site-specific investigations rather than indicating widespread susceptibility. Stronger collaboration among local authorities, engineers, geoscientists, humanitarian actors, and communities will be vital for translating technical knowledge into safer building practices.

As Eastern Afghanistan continues to rebuild, insights gained from the 2025 earthquake must be transformed into practical, context-appropriate interventions. The widespread reliance on vulnerable construction materials and techniques underscores the urgency of implementing earthquake-resistant building guidance and standards and expanding community access to safer construction methods. Without such measures, the region will remain highly vulnerable to future seismic events, with potentially devastating consequences.

6. INFRASTRUCTURE PERFORMANCE

6.1. Introduction

Afghanistan remains a country facing high climate and seismic risk, a situation stemming from high hazard and exposure, combined with a very fragile built environment. Coupled with conflicts and economic instability, these factors make Afghanistan one of the most vulnerable to humanitarian crises.

The quake of August 31, 2025, severely impacted the eastern mountain region of the country, further worsening this already fragile situation. With at least 2205 fatalities, this is the deadliest earthquake affecting Afghanistan since 1988. Critical infrastructures were damaged and disrupted. According to the GRADE report (2025), estimated economic losses to the infrastructure amounted to US$32.7 million, representing 0.16% of its Total Exposed Value (TEV). However, the impact was heavily concentrated in Kunar province, where economic losses in the transport sector reached 10.7% of the TEV.

The chapter provides insights into Afghanistan's infrastructure components, focusing particularly on the affected districts and their performance during the earthquake. It addresses the electricity, water supply, health, school, industrial, transport, and communication infrastructure. Primary sources of information on the infrastructure seismic performance include news reports, post-earthquake assessment and estimation reports released by various international organisations and UN agencies (such as the World Bank, UNDP, OCHA, FAO), and photographic evidence and firsthand accounts from contacts with access to the affected area.

6.2. Electricity Infrastructure

A remote sensing and satellite-based assessment by UNDP (UNDP, 2025b) estimates that infrastructure exposure within the high-impact earthquake zones is extensive: 246,000 buildings, including homes, schools, and clinics, and 462 km of electric grid lines exist in the high-impact area (Figure 6.1). Electric grid lines were exposed to strong shaking that can significantly damage them, disrupting schools, hospitals, and other services. According to the Emergency Response Plan by OCHA (OCHA, 2025a), electricity and communications were disrupted in several areas. In Kunar, electricity and communications were knocked out in many areas by the earthquake (OCHA, 2025a) as power lines fell, and several cell towers collapsed, leaving communities without electricity and isolated from communication through the internet or phone. As of 5 September 2025, power remained intermittent in remote parts of Kunar, and some villages have had no phone service for days (OCHA, 2025a).

6.3. Drinking Water Infrastructure Performance

6.3.1. Drinking water infrastructure

Drinking water security remains a persistent challenge in Afghanistan. The main source of water is snowmelt originating at elevations above 2000 m, primarily in the Hindu Kush Mountains. According to the International Organization for Migration (IOM, 2025), only 45% of communities have access to safe drinking water. In Kunar province, one of the most affected areas by the seismic sequences, the water-related infrastructure is largely dysfunctional. The Afghanistan Health Survey (2018) reported that in rural areas, only 18% of communities have access to piped water supply systems, while the remaining 82% rely on springs, wells, and traditional systems known as karez. The World Bank (2023a) indicates an even more critical situation, finding that only 6% of the rural population has access to a piped water supply. Furthermore, a study focused on ten provinces revealed that 84% of the rural population with basic access to water consumed water contaminated with Escherichia coli (E. coli). In the urban areas, however, the situation is better, with 45% of households supplied with drinking water through piped systems and 80% of communities having access to water inside their houses

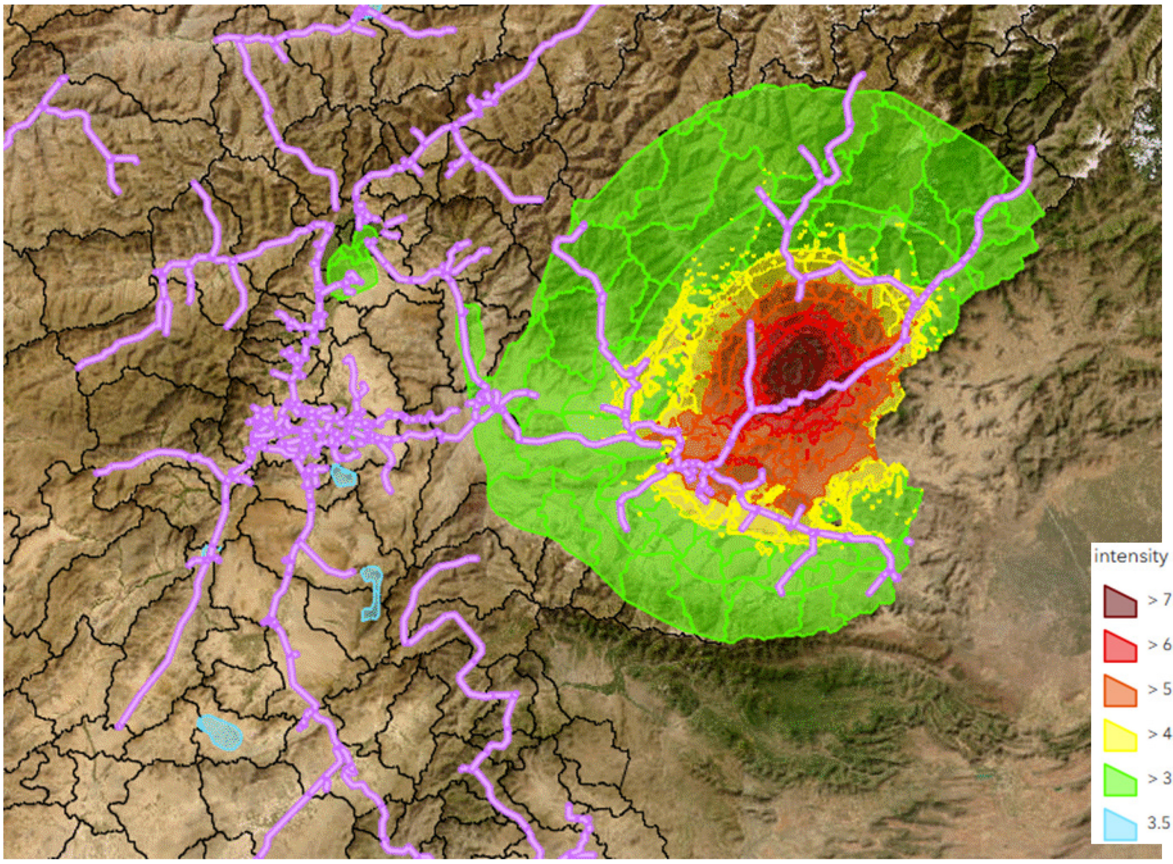


Figure 6.1: Electricity lines (purple lines) and high-impact zones in North-Eastern Afghanistan (UNDP, 2025a)

or plots. Despite these significant challenges, the coverage of piped water supply systems is expanding as a result of investments by national authorities and international organisations.

6.3.2. Performance during the earthquake sequence

The earthquake further exacerbated these pre-existing vulnerabilities, causing extensive damage to water and sanitation infrastructure in the affected communities. The landslides and rockfalls triggered by the seismic event were the primary factors disrupting the water supply systems. These hazards inflicted direct physical damage on the drinking water supply pipelines passing through the areas they impacted, as illustrated in Figure 6.2. Moreover, the landslides and rockfalls contaminated the streams and open-air canals with soil and rock masses, thereby compromising the quality of drinking water and posing serious public health risks (OCHA, 2025a). The widespread presence of dead livestock posed an additional source of water contamination, further increasing the likelihood of waterborne disease outbreaks and transmission.

According to Situation Report No. 8 issued by OCHA (2025b), 132 water sources were damaged or destroyed across 134 assessed villages. The level of destruction left most of the affected population without access to safe drinking water and handwashing facilities, thereby significantly increasing the risk of disease outbreaks. In several mountainous villages, communities reportedly lacked access to drinking water until relief teams arrived with emergency supplies. Rapid assessments conducted by the Food and Agriculture Organization of the United Nations (FAO, 2025) within days of the earthquake identified access to water as the most critical and urgent need.

Figure 6.2: Example of damages to a water supply pipe due to rockfalls

6.4. Health Infrastructure

6.4.1. Health facilities in Afghanistan

Health facilities in Afghanistan share similar architectural patterns shaped by cost constraints, rural accessibility, seismic risk, and local construction traditions. Health infrastructure in eastern Afghanistan is diverse, but most facilities are characterised by the widespread use of traditional construction materials. Many health facilities, particularly in rural and mountainous regions, are built using unreinforced mud, brick, and masonry structures highly susceptible to earthquake damage (Akhundzadah, 2024). These constructions are typically single-storey (rural) or 2-3 storeys (urban).

According to the Health Resources and Services Availability Monitoring System (HeRAMS) Afghanistan Baseline Report 2023 (HeRAMS, 2023), a total of 3,807 health facilities were operational or partially operational in 2023. These facilities follow Ministry of Public Health (MoPH) standards and are classified mainly into four categories: Basic Health Centres (BHCs), Comprehensive Health Centres (CHCs), District Hospitals, and Provincial Hospitals. BHCs are typically single-storey structures, while CHCs are generally one- to two-storey buildings. District Hospitals are commonly two- to three-storey facilities. Provincial Hospitals, which serve as higher-level referral centres, are usually multi-storey buildings constructed with reinforced-concrete structural systems.

The map in Figure 6.3 illustrates the distribution of operational health facilities across Afghanistan, with emphasis on both the absolute number of facilities and their density per 10,000 population. In the eastern region, the area affected by the main earthquake, Kunar Province, is shown to have 95 health facilities, placing it within a moderate range compared to neighboring provinces. In contrast, Nangarhar Province contains 211 operational health facilities, one of the highest totals nationally. Figure 6.4 presents the operational status of

600 health facilities in the Eastern region of Afghanistan, categorized by facility type. Each horizontal bar displays a color-coded breakdown of operational states, ranging from operational (dark blue) to closed (black), with additional categories such as partially operational, not operational, planned, and not reporting. The graph shows that the majority of health facilities are Sub-Health Centers, Mobile Health Teams, and Basic Health Centers (BHCs), which together account for 456 facilities, approximately 80% of the total. This distribution highlights the predominant role of primary-level service delivery in the region.

In the same context, Figure 6.5 presents the health facilities in Kunar province, the region most affected by the main earthquake. As of 2024, a total of 109 health facilities are reported. Of these, 53% (58 facilities) are permanent structures, while 21 are temporary structures. This figure is extracted from the HeRAMS interactive dashboard that provides an analysis based on the available data. This information was updated in December 2024.

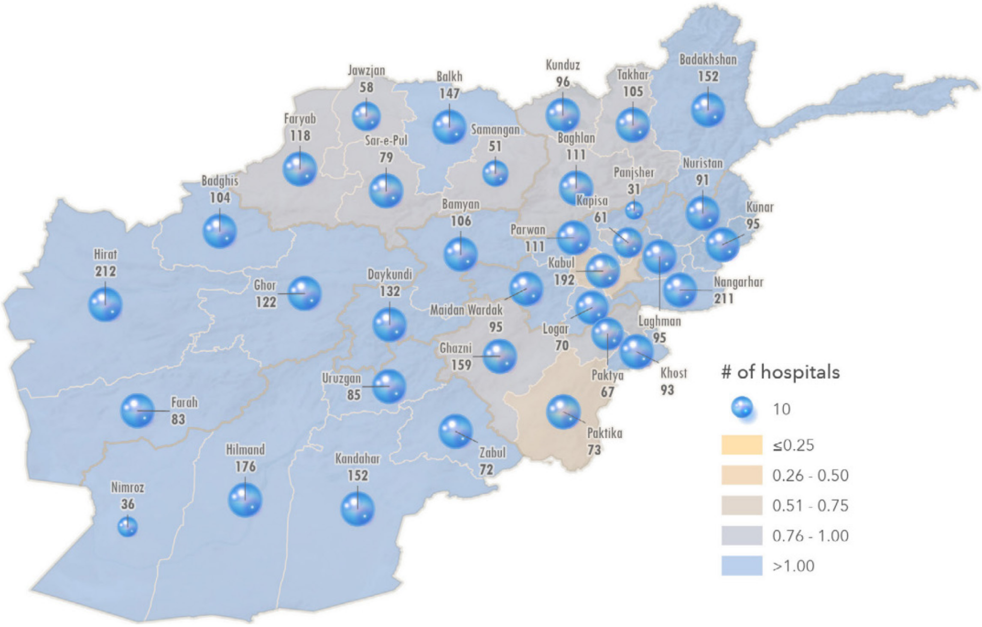


Figure 6.3: Operational health facilities by province (HeRAMS, 2023)

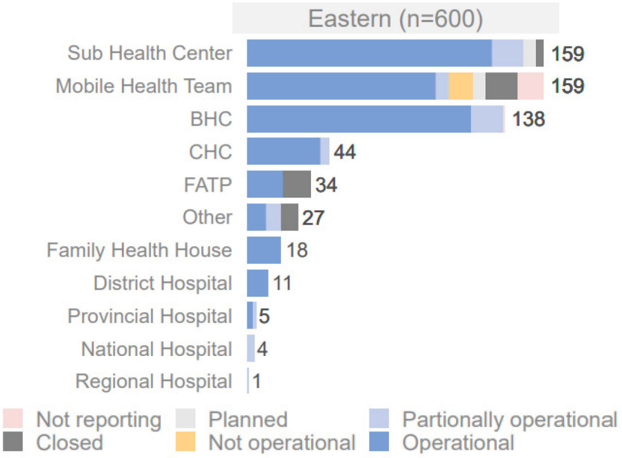


Figure 6.4: Health facility status by region and health facility type (HeRAMS, 2023)

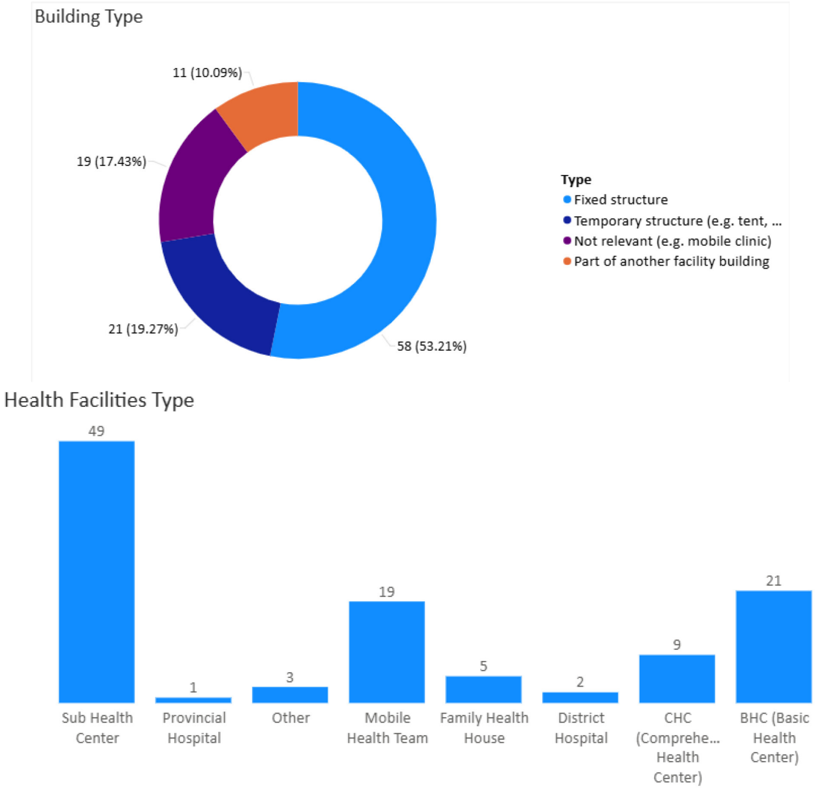


Figure 6.5: Health facilities in Kunar province (HeRAMS, 2024)

The following photos show typical type BHC health facilities in the eastern provinces of Afghanistan. These are single-story buildings, likely constructed from brick. A district hospital is also shown. This building is a two-storey building made of RC.

 Hazrat Sultan district's health clinic (source: WBA https://www.facebook.com/WorldBankAfghanistan/posts/established-40-years-ago-as-a-health-outpost-and-converted-to-a-health-center-in/896694510758773/)	 Health center in Zabul province (source: https://pajhwok.com/2022/09/27/health-center-built-inaugurated-in-zabuls-capital-qalat/)

BHC in Nangarhar Province (Google Maps image (2023) at 34.47736, 70.36486)

Manogai District Hospital in Kunar Province (Google Maps image (2024) at 34.97623, 70.90707)

6.4.2. Health facilities affected by main earthquake and aftershocks

According to the World Health Organization (WHO) rapid assessment (WHO, 2025e), one health facility was fully damaged while twenty were partially damaged, including 19 in Kunar and one in Nangarhar. Many health centres in the impacted districts were either non-operational, overwhelmed, or had reduced capacity. The affected facilities comprise 10 sub-health centres, six BHCs, two CHCs, one district hospital, and one provincial hospital (WHO, 2025d). Figure 6.6 illustrates the locations of health facilities on a seismic intensity map for the August 31 earthquake.

The earthquake struck an already fragile healthcare system, weakened by conflicts and underfunding. With 21 health facilities damaged, the healthcare system in affected areas became overwhelmed, with limited trauma care and surgical capacity. As the winter season approaches, respiratory infections are expected to increase, which will further increase the burden on the healthcare system. For patients who live with noncommunicable diseases (NCDs) such as diabetes, losing medicines or access to medical devices may be life-threatening (WHO, 2025e).

According to WHO situation reports, the key points for Kunar, Nangarhar, and Laghman (the three provinces most affected) are given in Table 6.1.

6.4.3. Health system recovery

Most health support has been provided by NGOs, with the WHO coordinating closely with health authorities, partners, and communities to reach those most in need. Within hours after the main earthquake, WHO delivered medicines and medical supplies to affected health facilities and deployed specialists in trauma, hospital care, and outbreak response for surge support (WHO, 2025b) (Figure 6.7).

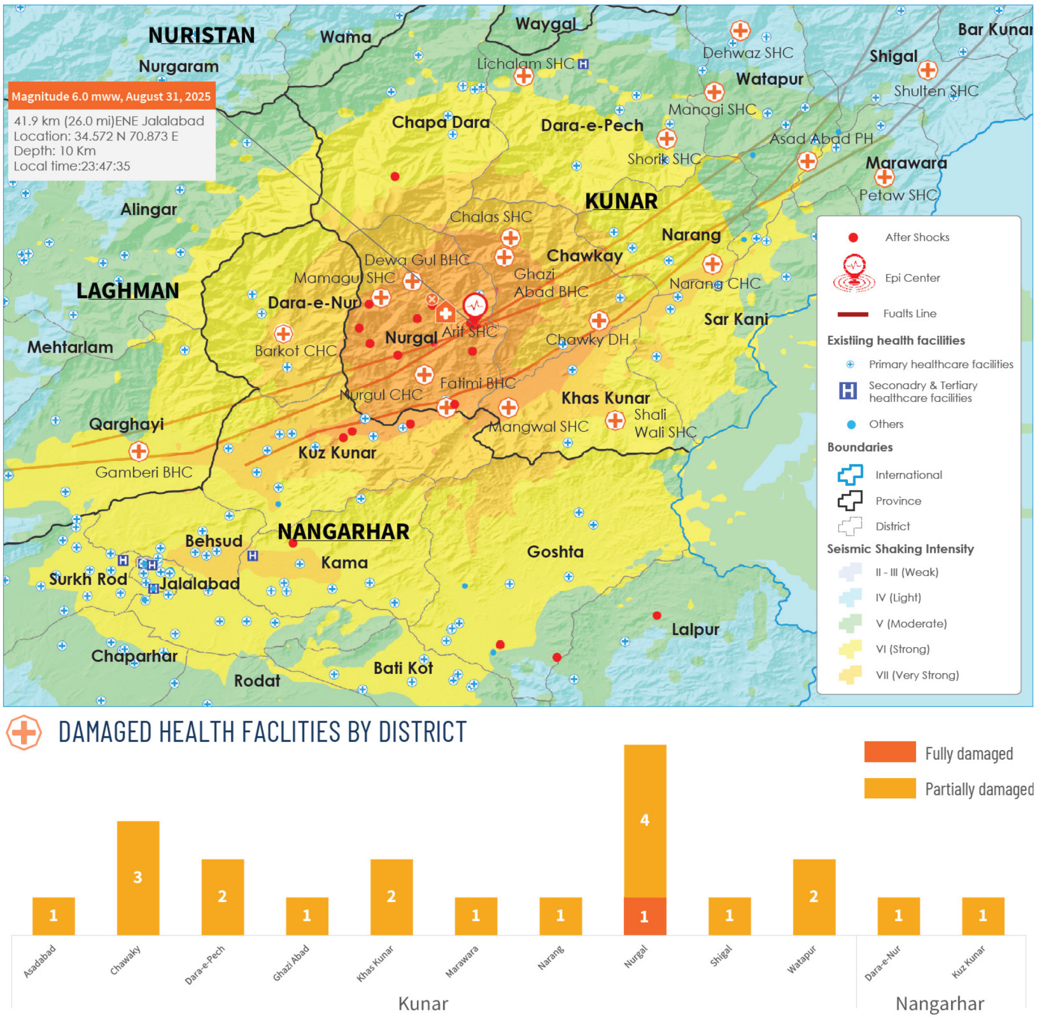


Figure 6.6: Earthquake impact on health facilities (WHO, 2025e)

Table 6.1: Key statistics of damage and recovery in Kunar, Nangarhar, and Laghman

Province	Districts / Key Areas Affected	Health infrastructure damage and status	Service restoration
Kunar	Chawkay, Nurgal, Dara-e-Pech, Khas Kunar, Chapa Dara, Watapur, etc.	Out of ~911 facilities in all affected provinces, rapid assessments found 20+ damaged in early reports. - Specifically, Arif Basic Health Center in Nurgal is reported to be *completely destroyed*. - Chawkay District Hospital (Kunar) is one of the referral hospitals.	Access issues: remote terrain and road blockages make reaching many sites very difficult ("geographic constraints, limited phone coverage").
Nangarhar	Kama (epicentre),	Among the four referral hospitals: Kama District Hospital (75 beds) in	Many people report limited female staff

Province	Districts / Key Areas Affected	Health infrastructure damage and status	Service restoration
	Jalalabad (regional hospital), Behsud, Goshta, etc.	Nangarhar. - Nangarhar Regional Hospital in Jalalabad (623 beds) is critical for specialized / severe cases. - Assessment reports mention 1 facility damaged in Nangarhar (from WHO situation report #8).	(gender barrier), especially in deep rural areas, which limits access to care for women & girls.
Laghman	Alingar, Mehtarlam, Qarghayi, etc.	Out of 911 health facilities in the 4 provinces, a non-trivial portion are in Laghman; some are partially damaged.	

Figure 6.7: WHO mobilises mobile health teams to remote areas of Nurgal District, Kunar Province (WHO,2025c)

Temporary hospitals were also set up by the Deputy Minister for Health Services at the Ministry of Public Health: For example, a 50-bed hospital in Khas Kunar was established soon after the earthquake to deal with victims (Ministry of Public Health 2024).

OCHA (2025a) reported that between September 1 and September 30, 2025, 25 Health Cluster partners supported earthquake-affected areas, reaching 98,411 people (25,461 women, 19,916 men, 26,436 girls, 26,598 boys) across 13 districts in Kunar, Nangarhar, and Laghman provinces. Of these, 63,629 received primary and secondary health care, 13,583 benefited from health promotion, 9,226 accessed MHPSS (Mental Health and Psychosocial Support), 6,249 received trauma care, 3,093 received reproductive, maternal, newborn, and child health services, and 2,572 were vaccinated.

Mobile Health and Nutrition Teams (MHNTs), mobile units of health workers that travel to hard-to-reach, underserved, or disaster-affected areas, have been crucial in the earthquake response in Afghanistan. Organizations such as AADA (in partnership with World Vision), UNICEF, CARE, and others have deployed MHNTs to temporary camps and affected villages. Figure 6.8 presents the number of MHNTs mobilised in September 2025. The provinces with the highest level of interventions were Nangarhar and Kunar, where 38 MHNTs were deployed by 15 organisations.

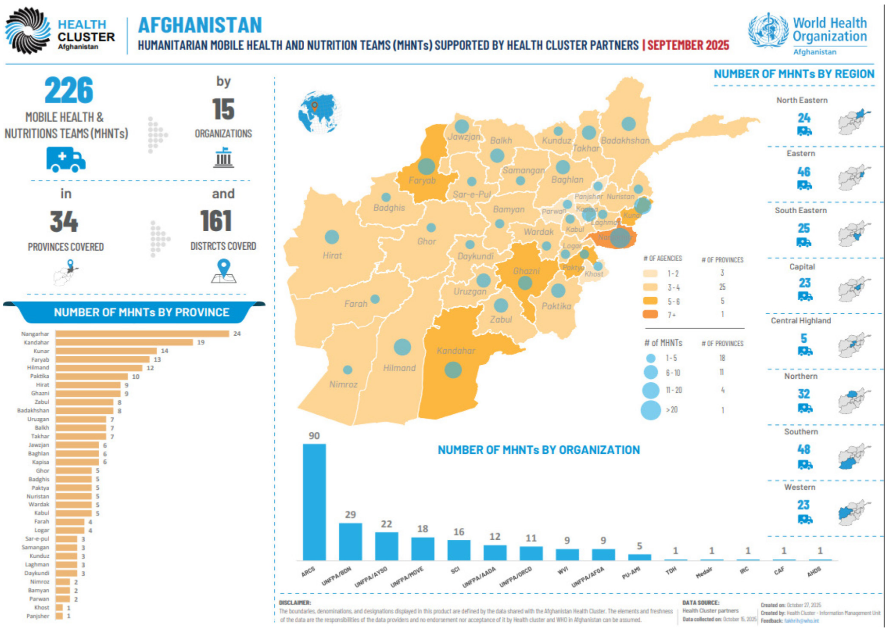


Figure 6.8: Humanitarian MHNTs report in September 2025 (WHO, 2025a)

6.5. School Infrastructure

6.5.1. Education systems in Afghanistan

The Ministry of Education oversees the administration of the Afghan education system, which is structured into three distinct levels. The first level is Primary Education (Grades 1-6), typically serving children between the ages of 7 and 12. This is followed by Lower Secondary Education (Grades 7-9) for students aged 13 to 15. The final stage is Upper Secondary Education (Grades 10-12), which accommodates learners between the ages of 16 and 18.

Education authorities in eastern Kunar province report that approximately 50,000 children residing in remote areas without access to formal schooling are currently being educated through community-based classes and religious seminaries. According to Mohibullah Haidari, Director of the Kunar Education Department, these alternative education initiatives have been implemented in locations where formal schools are absent. At present, 484 schools are operating across the province; however, 280 of these lack permanent infrastructure. With the support of various partner organizations, a total of 1,245 village-based classes have been established, providing early-grade education (up to Grade 3) to more than 37,000 children.

6.5.2. Educational structural systems in Kunar

Given that Kunar province lies within a high seismic risk zone, the potential for earthquake-induced damage was identified as a considerable concern for school infrastructure in the region (SIGAR, 2017). In this report, an assessment of the structural condition of schools in Kunar province indicated that while the overall integrity of the buildings was generally sound and suitable for continued educational use, certain seismic vulnerability aspects remain. Structural damage was documented in three of the four schools inspected due to past seismic events. In one case, a school located in Chawkai was found to have an inadequately sealed seismic joint, resulting in water infiltration into the interior. If unaddressed, such deficiencies may lead to more significant structural degradation in the event of future earthquakes.

6.5.3. Performance and damage during the main earthquake and aftershocks

According to the “Eastern Region Earthquake Response Plan Afghanistan” report (OCHA, 2025), approximately 177,460 individuals in the affected regions are in urgent need of educational support, with emergency assistance planned for over 88,700 learners. Widespread destruction of educational infrastructure has forced the closure of most schools, particularly in the Chawkay and Nurgal districts, where 78 community-based education classes and 40 formal schools collapsed. In Kunar district, 20 community-based education classes and related sanitation facilities have sustained damage, and one secondary school has been entirely destroyed. The timing of the event has significantly exacerbated the impact, as it coincided with the start of the new academic year on 6th September, leaving 50% of children in these areas without school and, therefore, increasing their vulnerability to protection risks. Teachers lack safe environments and basic instructional materials to resume teaching.

6.5.4. Education recovery

Immediate interventions are focusing on establishing Temporary Learning Spaces (TLS) and Temporary Learning Materials (TLM) (Figure 6.9). In particular, six TLS were established in Khas Kunar to serve 170 children, and an additional six TLS are being assessed across Chawkay, Nurgal, and Khas Kunar districts to support 6,000 children in different grades. 6,000 will access TLS and TLS in Kunar camp sites. Education Cannot Wait is providing $1.5 million for education in the earthquake-affected areas.

6.6. Industrial Infrastructure

6.6.1. Assessment of industrial infrastructure before earthquake

To properly analyse the situation, it is essential to consider the state of industrial infrastructure before the devastating events occurred. The most affected provinces, Kunar and Nangarhar, which are predominantly rural and mountainous, appear to have limited industrial development. Existing industrial infrastructure consisted mainly of small- to micro-scale processing facilities (primarily agrarian and livestock-related), local warehouses, basic irrigation systems, and simple non-residential buildings.

Figure 6.9: Temporary Classrooms (South Asian Desk, 2025)

Figure 6.10: Structural devastation of associated industrial infrastructure (UN News, 2025)

As previously discussed, construction standards were weak. As evidenced by the 2025 GRADE report on earthquake damages in Afghanistan (World Bank, 2025b) and the UNU-INWEH 2025 damage assessment report (UNU, 2025a), many buildings (including commercial and industrial structures) were built using unreinforced masonry, mud or stone, and heavy roofs with minimal seismic design considerations. This resulted in high vulnerability of industrial infrastructure, compounded by limited access roads, steep terrain, poor logistics, and a predominance of informal or micro-sized firms with little built-in disaster resilience.

6.6.2. Impact of the earthquake on industrial infrastructure and its performance

According to the World Bank's GRADE report (World Bank, 2025b), non-residential buildings and agricultural assets (such as storage facilities, livestock shelters, and irrigation systems) were the second and third most affected categories after residential buildings (Figure 6.10). As cited in §5.2, this is corroborated by the UNDP (UNDP, 2025a), which reported approximately 460 kilometers of electric grid lines and around 246,000 buildings (including homes, schools, and clinics) within the high-impact zone. While this data refers to general infrastructure, it implies significant damage to industrial infrastructure, which depends heavily on utilities and transport networks.

Field reports further confirm severe damage to irrigation canals and disruptions to agricultural processing and home industries.

6.6.3. Economic loss estimation

Due to the lack of detailed disaggregation in published data (e.g., distinguishing "factories, plants, machinery" from general residential and non-residential categories), damage estimates must be derived with caution.

According to the World Bank's GRADE report for the Eastern Afghanistan Earthquake (31 August 2025), approximately 35% of the total estimated damage (~US$64 million) was attributed to residential buildings. The remaining 65% (~US$119 million) covered non-residential buildings and agricultural assets. Within this US$119 million, agricultural facilities (storage, livestock shelters, irrigation) represent a significant portion, while industrial infrastructure (processing plants, warehouses, small factories) constitutes a smaller subset.

Based on this breakdown, industrial infrastructure damage is estimated to account for roughly 10-25% of the non-residential and agricultural category, in accordance with the UNDG, EU, and World Bank. Post-Disaster Needs Assessment Guidelines, Volume A. 2013; and UN-ECLAC. Damage and Loss Assessment Methodology (DaLA). Updated 2014. Thus, industrial infrastructure damage is expected to vary from approximately US $11.9 million to US $29.8 million in direct economic losses. Assuming an additional 50% lump-sum valuation for indirect impacts (e.g., production loss, labor disruption), the total estimated damage and near-term economic loss for industrial infrastructure may range from US$18-45 million across the affected provinces.

The persistence of downtime, asset loss, and impaired operational capacity could suppress local industrial output for an entire season or longer, with cascading effects on employment, livelihoods, and local tax revenues. It is important to note that the rural terrain, access challenges, and ongoing aftershocks may further amplify losses beyond what initial models capture.

6.7. Transport Infrastructure

6.7.1. General

According to the CIA Factbook (2024), the road network of Afghanistan consists of 34,903 km of both paved and unpaved roads. However, the World Bank (2023c) reports a significantly larger network of 123,000 km. Of this network, only around 20% are considered all-season roads, meaning the remaining 80% is not accessible year-round due to weather conditions. Road transport covers 90% of freight and 85% of intercity passenger transport, which highlights a near-total dependence on roads.

Air transport infrastructure includes 64 international and domestic airports and eight heliports. Rail transport remains marginal, limited to cross-border corridors and used exclusively for cargo rather than passenger services. Inland waterways, totalling approximately 1,200 km, provide an additional transport option but are primarily used for cargo and play a limited role nationally.

In the mountainous eastern provinces, which were most affected by the earthquake (particularly Kunar and Nangarhar) road transport is effectively the only viable mode of access. Kunar Province, in particular, is highly isolated due to its rugged terrain, and its road network consists predominantly of unpaved roads, making it especially vulnerable to disruption during seismic and hydrometeorological events.

6.7.2. Performance during earthquake sequence

The most widespread and critical form of transport infrastructure failure during the earthquake sequence was the blockage and destruction of roads by landslides and rockfalls triggered by the main shock and subsequent aftershocks (Figure 6.11). According to the United Nations University (UNU, 2025a), the earthquake was preceded by several weeks of intense monsoon rainfall, which saturated soils and significantly reduced slope stability. This preconditioning greatly increased susceptibility to landslides, while the steep valley morphology of the region further exacerbated rockfall activity.

As a result, numerous roads (particularly those traversing narrow mountainous valleys) were buried under large volumes of landslide debris or completely destroyed, causing severe delays to relief and rescue operations (Janjua and Ellis-Petersen, 2025). Additional road blockages were caused by debris from collapsed and damaged structures; UNDP (2025b) estimates that approximately 649,000 tonnes of debris were generated by structural failures alone.

Beyond road damage, critical transport infrastructure such as bridges and culverts also sustained significant damage. In several cases, these structures were either overwhelmed by landslide debris or undermined by scouring associated with redirected flows of sediment and water, further fragmenting transportation networks (Associated Press, 2025c). By contrast, alternative transport modes such as air and inland waterways were reported to have remained largely undamaged, although their limited availability constrained their effectiveness as substitutes for road access.

Figure 6.11: Examples of road passage blocking due to rockfalls

Blocked road access was widely reported as the most significant challenge faced by emergency response teams (Daily Sabah, 2025; Reuters, 2025). These disruptions cut off access to heavily affected districts, substantially slowing search and rescue operations, medical response, and damage and needs assessments. In many cases, SAR and relief teams were forced to walk for several hours (sometimes up to five hours) to reach affected communities, or to rely on helicopters for evacuating the injured and delivering critical medical assistance. Relief operations were further hampered as aftershocks repeatedly triggered new landslides and rockfalls, re-blocking cleared routes.

The consequences of transport disruption extended beyond immediate response delays. Many remote communities became effectively isolated, facing acute shortages of essential supplies such as food, water, medicines, and winterisation materials. Water sources were also contaminated as landslide debris entered streams and channels, posing additional public health risks and increasing the likelihood of disease outbreaks

(ICRC, 2025b; OCHA, 2025a). These compounded effects heightened the risk of internal displacement and worsened health outcomes among already vulnerable populations (Janjua and Ellis-Petersen, 2025; Shirzaei et al., 2025).

In summary, the 2025 earthquake highlighted the critical role of slope instability in disrupting transport infrastructure and access in eastern Afghanistan. The rapid unblocking and stabilisation of key road corridors is therefore of paramount importance, not only to enable emergency response but also to mitigate longer-term humanitarian, health, and socio-economic impacts on isolated communities.

6.8. Communication System

The communication system in eastern Afghanistan was severely disrupted following the earthquake on August 31, 2025, which particularly affected the provinces of Kunar and Nangarhar (US Geological Survey, 2025). The tremors caused widespread power outages and damaged telecommunications infrastructure, including fiber networks and mobile towers, leading to interruptions in both internet and mobile services across multiple districts (WHO, 2025c; UNICEF, 2025b).

Disruptions to internet services due to severed fibre optic connections have impacted humanitarian efforts, for instance, slowing down contact with frontline responders (OCHA, 2025). With the winter season approaching, communities living in remote and mountainous areas without heating face increased vulnerability (OCHA, 2025a).

Prior to the earthquake, the eastern region had limited communication services, such as mobile networks, fibre backbones, and ongoing expansion projects. However, coverage was inconsistent, especially in isolated mountainous areas, and rural populations were only loosely or partially connected (UNDP, 2025c; UNU, 2025a). The earthquake exposed this weak communications baseline, raising the risk of complete isolation for affected communities. Many residents in remote areas reported little to no phone coverage, which hindered their ability to report damage, request emergency assistance, or coordinate aid (The Guardian, 2025c; WHO, 2025c).

The situation was further exacerbated by landslides triggered by the earthquake, which obstructed access to damaged fiber cables and communication towers and delayed restoration efforts (Reuters, 2025; Daily Sabah, 2025). With standard communication lines disrupted, humanitarian response teams relied heavily on radio networks and satellite phones for coordination (WHO, 2025d; UNICEF, 2025). Reports from organizations such as the WHO Health Cluster and the CCCM Cluster indicated that public infrastructure connections were badly damaged, causing delays in rescue operations and the distribution of emergency aid (WHO, 2025c; British Red Cross, 2025).

The incident highlighted significant weaknesses in Afghanistan’s rural communication infrastructure, leaving populations in hilly and isolated regions effectively cut off after the earthquake due to poor redundancy and limited coverage (UNU, 2025b; World Bank, 2025a). Restoration of connectivity required extensive effort and time, underscoring the need for more robust, disaster-resilient telecommunications systems in high-risk areas (UNDP, 2025b; WHO, 2025b; Hasht-E Subh, 2025; South Asian Desk, 2025).

6.9. Conclusions

The 31 August 2025 Eastern Afghanistan Earthquake exposed and amplified long-standing vulnerabilities within the country’s infrastructure systems, particularly in the mountainous eastern provinces of Kunar and Nangarhar. The event demonstrated how high seismic hazard, difficult terrain, climate-related stresses, and a fragile pre-existing infrastructure baseline can interact to produce cascading failures across multiple critical sectors.

Across all infrastructure categories, damage patterns were strongly influenced by a combination of poor construction quality, limited redundancy, and dependence on a small number of lifeline networks. Electricity and communication systems experienced widespread disruption due to damaged power lines, collapsed towers, and severed fibre-optic cables, leaving many communities without power or connectivity for extended periods. These outages significantly constrained emergency coordination, delayed relief delivery, and increased the isolation of remote settlements.

Drinking water infrastructure proved particularly vulnerable to earthquake-induced landslides and rockfalls. Damage to pipelines, springs, and open channels, combined with contamination from debris and dead livestock, left large segments of the affected population without access to safe drinking water. The destruction of over one hundred water sources across assessed villages sharply increased public health risks and underscored the dependence of rural water systems on fragile surface infrastructure located in hazardous terrain.

Health infrastructure performance highlighted the compounded effects of structural vulnerability and system-wide fragility. Although only a limited number of facilities were fully destroyed, partial damage, reduced functionality, and overwhelming demand severely constrained healthcare delivery. The earthquake struck an already under-resourced health system, forcing reliance on temporary facilities, mobile health teams, and external humanitarian support. While rapid mobilisation by national authorities, WHO, and partner organisations mitigated some impacts, the event exposed the limited seismic resilience of many primary healthcare facilities and the risks posed by multi-hazard environments, including landslides and access disruption.

Educational infrastructure suffered extensive damage, particularly community-based and non-permanent school structures. The collapse and closure of schools at the start of the academic year significantly disrupted education for tens of thousands of children and increased exposure to protection risks. Recovery efforts through Temporary Learning Spaces and emergency education funding were essential stopgap measures but also highlighted the need for durable, hazard-resilient school construction in high-risk regions.

Industrial and agricultural infrastructure, though limited in scale, sustained notable losses due to building damage, disrupted utilities, and impaired transport access. Estimated economic losses indicate that indirect impacts such as production downtime and livelihood disruption may rival or exceed direct physical damage. These impacts are likely to persist beyond the immediate response phase, affecting employment, food security, and local economic recovery.

Transport infrastructure emerged as the most critical bottleneck in both emergency response and early recovery. Widespread road blockages caused by landslides, debris, and damaged bridges isolated entire districts, delayed search and rescue operations, and constrained the delivery of aid. The heavy reliance on road transport in a region with steep terrain and limited all-season roads made the transport network highly susceptible to seismic and hydrometeorological triggers. The repeated reactivation of landslides by aftershocks further demonstrated the fragility of access corridors.

The 2025 earthquake revealed a pattern of systemic infrastructure vulnerability in eastern Afghanistan, where failures in one sector rapidly propagated to others. The findings highlight the urgent need for integrated, multi-hazard-informed infrastructure planning that prioritises seismic resilience, slope stability, redundancy, and accessibility. Strengthening lifeline infrastructure (particularly roads, water systems, health facilities, and communications) will be essential not only for reducing disaster losses but also for improving long-term humanitarian resilience and development outcomes in high-risk, mountainous regions of Afghanistan.

7. LESSONS LEARNED

The 2025 Eastern Afghanistan Earthquake provided critical insights into the complex interactions between seismic forces and geotechnical conditions in mountainous, tectonically active regions. The wide range of geotechnical failures observed (from landslides and slope instability to foundation collapses and ground deformation) highlights important lessons for hazard assessment and engineering practice. However, these failures must be understood within a broader context of systemic vulnerability. As discussed in Section 6.5, Afghanistan represents a multi-hazard, multi-vulnerability setting in which geotechnical weaknesses interact with deficiencies in infrastructure, education, communication, accessibility, and disaster preparedness. It is the cumulative effect of these factors (rather than geotechnical conditions alone) that ultimately governs disaster severity. The lessons summarised below, therefore, extend beyond geotechnical performance to emphasise the need for integrated, cross-sectoral approaches to risk reduction in Afghanistan and similar environments.

- **Integration of Seismic Hazard and Geotechnical Data:** Traditional seismic hazard maps alone are insufficient without the incorporation of geotechnical parameters such as soil amplification potential, slope gradient and stability indices, liquefaction susceptibility, and groundwater influence (Chian and Wilkinson, 2014; Mishra, 2020; Karapınar et al., 2025). Integrated hazard assessments should be developed to provide microzonation maps that inform safe land-use planning and construction guidelines, minimising risk in vulnerable areas.
- **Need for Slope Stabilisation and Risk Reduction:** The high incidence of earthquake-triggered landslides stresses the urgency of slope stabilisation measures, including drainage control, retaining structures, and bioengineering. Avoidance of steep slope development without adequate reinforcement and maintenance of access routes vulnerable to blockage by landslides is critical. Community awareness programs on landslide risk, early warning, and emergency response are essential components of risk reduction (Kamal et al., 2023).
- **Strengthening Traditional Construction Practices:** Given the prevalence of unreinforced masonry and adobe structures, practical and culturally sensitive approaches to improve seismic resilience include introduction of simple foundation improvements (e.g., wider, deeper footings), incorporation of horizontal and vertical tying, e.g. by reinforcement compatible with local materials, and training local builders on earthquake-resistant construction techniques (Mohammadi and Fujimi, 2021; RedR UK, 2024; Miyamoto International, 2025b). Use of lightweight roofing materials to reduce seismic loads can also significantly reduce foundation failures and overall building collapse, potentially without prohibitive cost.
- **Addressing Infrastructure Vulnerabilities:** Infrastructure systems such as roads, bridges, retaining walls, and water channels require design adaptations to withstand seismic shaking and ground deformation, proper drainage to prevent hydrostatic pressure build-up behind retaining walls, and regular inspection and maintenance to identify early signs of slope or foundation distress (Esteban et al., 2022). Robust infrastructure enhances emergency response capabilities and long-term community resilience.
- **Enhancing Post-Disaster Reconnaissance and Data Collection:** Rapid, coordinated field reconnaissance (including geological, geotechnical, and structural assessments) is vital for documenting failure modes and extent, improving future hazard models, and guiding reconstruction priorities (Miyamoto International., 2025c). Use of remote sensing, UAV surveys, and community reporting tools can accelerate information gathering in difficult terrain (Chian et al., 2019).

REFERENCES

Affleck, R. T., Sargand, S., Russ, A., Momand, F., Canals, M. C. P. (2011). Designing Roads and Retaining Structures for Nangarhar Province, Afghanistan. US Army Corps of Engineers.

Afghanistan Peace Campaign. (2025). Afghanistan earthquake: What we know – and what we don't (September 1, 2025). Afghanistan Peace Campaign. https://afghanistanpeacecampaign.org/2025/09/01/afghanistan-earthquake-what-we-know-and-what-we-dont/

Ainscoe, E. A., Swaminathan, R., Way, L., Modugno, S., Chin, S. T., Panta, N., Crevoisier, T., Yun, S-H. (2025). Earthquake damage mapped more comprehensively and accurately by radar satellites than optical imagery. Communications Earth & Environment, 6(1), 631. doi:10.1038/s43247-025-02623-4.

Akhundzadah, N. A. (2024). Earthquake Risk Increasing Severity and Urgent Need for Disaster Management in Afghanistan. Preprints. https://doi.org/10.20944/preprints202409.1501.v1

Akhundzadah, N.A. (2025). "Earthquake Risk Severity and Urgent Need for Disaster Management in Afghanistan" GeoHazards 6/9. https://doi.org/10.3390/geohazards6010009

Aktas, Y.D., Ioannou, I, et al. (2022) Traditional structures in Turkey and Greece in 30 October 2020 Aegean Sea Earthquake: Field observations and empirical fragility assessment, Frontiers in Built Environment – Earthquake Engineering, doi: 10.3389/fbuil.2022.840159

Ambrose, T., Lowe, Y., & Yerushalmy, J. (2025). 'There is death in every home', families say, after at least 800 killed in Afghanistan earthquake – as it happened. The Guardian. https://www.theguardian.com/world/live/2025/sep/01/afghanistan-earthquake-live-hundreds-after-shallow-quake-strikes-countrys-east-state-media-reports

Ansari, A., Zaray, A. H., Rao, K. S., Jain, A. K., Hashmat, P. A., Ikram, M. K., & Wahidi, A. W. (2023). Reconnaissance surveys after June 2022 Khost earthquake in Afghanistan: implication towards seismic vulnerability assessment for future design: implication towards seismic vulnerability assessment for future design. Innovative Infrastructure Solutions, 8(3), 108. https://doi.org/10.1007/s41062-023-01077-x

Arya, A. S., Ministry of Urban Development and Housing, Government of Afghanistan, & United Nations Centre for Regional Development. (2003). Guidelines for earthquake resistant design, construction, and retrofitting of buildings in Afghanistan (June 2003). UNCRD/Ministry of Urban Development and Housing.

Associated Press. (2025a). A 6.0 magnitude earthquake shakes eastern Afghanistan near the Pakistan border (accessed on 5 September 2025). Available from https://apnews.com/article/afghanistan-earthquake-pakistan-border-c944cdc35f3fb5a6026b1ff02b232184

Associated Press. (2025b). An earthquake destroys villages in eastern Afghanistan and kills 800 people, with 2,500 injured. CTV News. https://www.ctvnews.ca/world/article/an-earthquake-destroys-villages-in-eastern-afghanistan-and-kills-800-people-with-2500-injured/

Associated Press. (2025c). An earthquake in Afghanistan's east wipes out homes, generations and livelihoods. Associated Press. https://apnews.com/article/b621e37d072489a345a1dc9da20de5d2

Bothara, J., Brzev, S. (2011). A Tutorial: Improving the Seismic Performance of Stone Masonry Buildings. Earthquake Engineering Research Institute, Oakland, California

Boyd, O. S., Mueller, C. S., & Rukstales, K. S. (2007). Preliminary probabilistic seismic hazard map for Afghanistan (U.S. Geological Survey Open-File Report 2007-1137). U.S. Geological Survey. https://pubs.usgs.gov/of/2007/1137/

Balland, D., Bazin, M. (1994) “DEH village, in Persia and Afghanistan” Iranica. 7/2. 2, pp. 204-209

British Red Cross Society. (2025). Afghanistan earthquake 2025: 2,200 reported dead and over 3,600 injured. Available at: https://www.redcross.org.uk/stories/disasters-and-emergencies/world/afghanistan-earthQuake-2025-updates

Bureau of Indian Standards. (1993). IS 4326: 1993 – Code of practice for earthquake resistant design and construction of buildings. Bureau of Indian Standards. https://law.resource.org/pub/in/bis/S03/is.4326.1993.pdf

Chian, S.C. & Wilkinson, S.M. (2014). Feasibility of Remote Sensing for Multihazard Analysis of Landslides in Padang Pariaman during the 2009 Padang Earthquake. Natural Hazards Review, ASCE, 16(1), 05014004. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000143

Chian, S.C., Wilkinson, S.M., Whittle, J.K., Mulyani, R., Alarcon, J.E., Pomonis, A., Saito, K., Fraser, S., Goda, K., Macabuag, J., Offord, M., Hunt-Raby, A.C., Sammonds, P., Franco, G., Stone, H., Ahmed, B., Hughes, F.E., Jirouskova, N.K., Kaminski, S. & Lopez, J. (2019). Lessons Learnt from the 2009 Padang Indonesia, 2011 Tōhoku Japan and 2016 Muisne Ecuador Earthquakes. Frontiers in Built Environment, 5(73). https://doi.org/10.3389/fbuil.2019.00073

Compassionate Afghanistan (2025). Emergency response: Kunar earthquake. Compassionate Afghanistan. https://www.compassionateafghanistan.org/emergency-response-kunar-earthquacke

Daily Sabah. (2025). Aftershocks blocked roads hamper Afghanistan quake relief. https://www.dailysabah.com/world/mid-east/aftershocks-blocked-roads-hamper-afghanistan-quake-relief-un

Dawn News Urdu. (2025). پہاڑوں سے پتھر گرنے کا خوف، افغان زلزلہ متاثرین کا گھروں کو جانے سے انکار [Fear of rockfalls: Afghan earthquake survivors refuse to return to homes]. Dawn News Urdu. https://www.dawnnews.tv/news/1268790

Doebrich, J. L., & Wahl, R. R. (2006). Geologic and mineral resource map of Afghanistan (U.S. Geological Survey Open File Report No. 2006 1038 [Version 2]) [Map]. U.S. Department of the Interior, U.S. Geological Survey; Afghanistan Head Office of Geodesy & Cartography; U.S. Trade and Development Agency; U.S. Agency for International Development. Retrieved from https://pubs.usgs.gov/of/2006/1038/

Ellis-Petersen, H., & Agencies. (2025). Third earthquake hits Afghanistan as death toll rises above 2,200. The Guardian. https://www.theguardian.com/world/2025/sep/04/third-earthquake-hits-afghanistan-as-death-toll-rises

Esteban, H., Broughton, M., Hashmi, Z., Zadran, S., Zwak, Q., & Miyamoto, K. (2022). 2022 Southeast Afghanistan Earthquake Build Back Safer Practical Training Program: IOM Provision of Engineering Design Services – Afghanistan Post-Earthquake Technical Assistance Program. Miyamoto International, Inc. https://s3.eu-north-1.amazonaws.com/cdn.sheltercluster.org/public/docs/Miyamoto_Afghanistan%20Post-Earthquake%20Technical%20Assistance%20Program_BBS%20Pr....pdf?VersionId=ryTrlhuuSsmUwEMzLyWDL3wPE6HahNNM

Faryad, S. W., Collett, S., Petterson, M., & Sergeev, S. A. (2013). Magmatism and metamorphism linked to the accretion of continental blocks south of the Hindu Kush, Afghanistan. Lithos, 175-176, 302-314. https://doi.org/10.1016/j.lithos.2013.04.016

GFZ (German Research Centre for Geosciences). (2025). Background information on the Afghanistan earthquake, 31 August 2025. https://www.gfz.de/sektion/seismologie/ueberblick/detailseite-sektionsnews/hintergrund-information-zum-beben-in-afghanistan-vom-31-august-2025

Gilmour, M., 2020. Local Architecture Review: Key findings on vernacular shelter designs, materials, and local building practices in Afghanistan. REACH Initiative, Shelter Cluster Afghanistan, UNHCR

Government of the Islamic Republic of Afghanistan. (2012). Afghan structural code (ASC). Government of the Islamic Republic of Afghanistan.

Hallet, S.I., Samizay, R. (1980), Traditional Architecture of Afghanistan. New York and London: Garland STPM Press.

Haziq, D., & Kiyotaka, M. (2017). Afghanistan building codes (ABC): Focused on comparative analysis and the viability of enforcement. Proceedings of the Architectural Engineering Conference, Oklahoma City, United States, 11-13 April. https://docs.openquake.org/global_risk_model/south_asia/exposure/design_regulations.html

Health Resources and Services Availability System (HeRAMS). (2024). Geographic Presentation of Health Facilities. https://dashboard.whe-him.org/index.php/herams/

Hesari, S.H. (2006), Traditional Housing & Settlement in Central Afghanistan-Haza'raja't - A Socio-cultural & Spatial Study. PhD thesis - Aalborg Universitetsforlag. doi: 10.5278/vbn.phd.engsci.00002

Hubbard, J. and Bradley, K., 2025. Updates on the deadly Afghanistan earthquake. Earthquake Insights. https://earthquakeinsights.substack.com/p/updates-on-the-deadly-afghanistan

IJCRT, 2020. Traditional Housing of Afghanistan. International Journal of Creative Research Thoughts.

International Organization for Migration IOM (2025a). Flash Update #2– Earthquake in Eastern Afghanistan (Kunar, Nangarhar, Laghman). IOM Afghanistan.

International Organization for Migration IOM (2025b). Afghanistan Climate Vulnerability Assessment.

Instagram user [islamicreliefau]. (2025, Sep 10). Islamic Relief is on the ground delivering crucial aid. Instagram. https://www.instagram.com/p/DOaqdqzkZmk/?img_index=3

International Committee of the Red Cross (ICRC). (2025a). Afghanistan: ICRC team reaches remote communities affected by earthquake in Kunar. https://www.icrc.org/en/article/afghanistan-icrc-reaches-remote-earthquake-affected-communities

International Committee of the Red Cross. (2025b). Afghanistan: One month of helping people affected by Kunar earthquake. International Committee of the Red Cross. https://www.icrc.org/en/article/afghanistan-one-month-kunar-earthquake

Hasht-E Subh. (2025). FAO: Farmers and Livestock in Eastern Afghanistan Face Rising Threats After Earthquake.

Janjua, H., & Ellis-Petersen, H. (2025). At least 800 dead after magnitude-6 earthquake hits eastern Afghanistan. The Guardian. https://www.theguardian.com/world/2025/sep/01/afghanistan-earthquake-near-jalalabad-magnitude-6-quake-pakistan-border

JICA, 2014. The Study on Disaster Risk Management in the Islamic Republic of Afghanistan. Japan International Cooperation Agency.

Johnson, K., Villani, M., Bayliss, K., Brooks, C., Chandrasekhar, S., Chartier, T., Chen, Y., Garcia-Pelaez, J., Gee, R., Styron, R., Rood, A., Simionato, M., Pagani M. (2023). Global Earthquake Model (GEM) Seismic Hazard Map (version 2023.1 - June 2023), DOI: https://doi.org/10.5281/zenodo.8409647

Kamal, A.S.M.M., Hossain, F., Ahmed, B., Rahman, B.M.Z. & Sammonds, P. (2023). Assessing the effectiveness of landslide slope stability by analysing structural mitigation measures and community risk perception. Nat Hazards 117, 2393–2418. https://doi.org/10.1007/s11069-023-05947-6

Karapınar, I.S., Özbay, A.E.Ö., Kutlu, Z.N., Yazgan, A.U. & Kılıç, I.E. (2025). Seismic vulnerability analysis incorporating local site amplification effects in shallow, varying bedrock depths. Nat Hazards 121, 16013–16032. https://doi.org/10.1007/s11069-025-07417-7

Kast, S., Singh, A., Meguro, K., Miyamoto, H.K. (2024). Housing Lessons Post-2022 Afghanistan Earthquake. In: Meraj, G., Hashimoto, S., Kumar, P. (eds) Navigating Natural Hazards in Mountainous Topographies. Disaster Risk Reduction. Springer, Cham. https://doi.org/10.1007/978-3-031-65862-4_5

Kawoosa, V. M., & Arranz, A. (2025). Deadly earthquake in Afghanistan. Reuters. https://www.reuters.com/graphics/AFGHANISTAN-QUAKE/byvrenowmpe/

KIT Royal Tropical Institute (2019). Afghanistan Health Survey 2018.

Langenbach, R. (2000). Intuition from the Past: What We Can Learn from Traditional Construction in Seismic Areas. Proc. of the Conference “Earthquake Safe”, Istanbul

Lazecký, M., Spaans, K., González, P. J., Maghsoudi, Y., Morishita, Y., Albino, F., ... & Wright, T. J. (2020). LiCSAR: An automatic InSAR tool for measuring and monitoring tectonic and volcanic activity. Remote Sensing, 12(15), 2430.

Medi, H. & Fedelle, S.F., 2021. Distinctive Aspects of Vernacular Architecture of Wakhan Valley. Space Ontology International Journal

Ministry of Public Health (2024). 50-Bed Hospital Opens in Nangarhar for Earthquake Victims Without Guardians. https://moph.gov.af/en/50-bed-hospital-opens-nangarhar-earthquake-victims-without-guardians

Mishra, O. (2020) Seismic Microzonation Study of South Asian Cities and Its Implications to Urban Risk Resiliency under Climate Change Scenario. International Journal of Geosciences, 11, 197-237. https://doi.org/10.4236/ijg.2020.114012

Miyamoto International. (2025a). UPDATE: Damage Assessment of the M6.0 Earthquake in Kunar, Afghanistan. Miyamoto International. https://miyamotointernational.com/update-damage-assessment-of-the-m6-0-earthquake-in-kunar-afghanistan/

Miyamoto International. (2025b). Seismic Training in Herat: Strengthening Local Housing Resilience. https://miyamotointernational.com/seismic-training-in-herat-strengthening-local-housing-resilience/

Miyamoto International. (2025c). 2022 Southeast Afghanistan Earthquake: Rapid Technical Field Assessment Report. https://miyamotointernational.com/technical-papers/2022-southeast-afghanistan-earthquake-rapid-technical-field-assessment-report/

Mohammadi, M., & Fujimi, T. (2021). Impact of retrofitting work on vulnerability reduction of local buildings in Kabul, Afghanistan. Jàmbá: Journal of Disaster Risk Studies, 13(1), a1062. https://doi.org/10.4102/jamba.v13i1.1062

Nemat, A., 2018. Traditional Architecture and Seismic Risk in Afghanistan. Kabul: Kabul University Press.

Office for the Coordination of Humanitarian Affairs (OCHA) (2002). Afghanistan Earthquake: OCHA Situation Report No. 2. ReliefWeb. https://reliefweb.int/report/afghanistan/afghanistan-earthquake-ocha-situation-report-no-2-2

Office for the Coordination of Humanitarian Affairs (OCHA). (2025a). Eastern Region Earthquake Emergency Response Plan Afghanistan: Immediate Humanitarian Response Needs September 2025 – December 2025. Office for the Coordination of Humanitarian Affairs. https://fscluster.org/sites/default/files/2025-09/AFG_Eastern_Region_Earthquake_Emergency_Response_Plan_v01_LR.pdf

United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (2025b). Afghanistan: Eastern Region Earthquake Response, Situation Update No. 8.

Oliver, P (ed) (1997). Encyclopedia of Vernacular Architecture of the World. Cambridge University Press.

Ortega, J., Vasconcelos, G. and Correia, M. (2014) “An overview of seismic strengthening techniques traditionally applied in vernacular architecture” 9th International Masonry Conference, Guimarães (Portugal)

Overture Maps Foundation. 2025. Overture Maps Dataset (Buildings). Contains data from © OpenStreetMap contributors and Microsoft Corporation. Retrieved from https://overturemaps.org. Accessed 6/10/2025.

Patel, D. (2024). The Behaviour of Mixed Timber-Masonry Structures. SAHC

Pesaresi, M., Schiavina, M., Politis, P., Freire, S., Krasnodębska, K., Uhl, J. H., Carioli, A., Corbane, C., Dijkstra, L., Florio, P., Friedrich, H. K., Gao, J., Leyk, S., Lu, L., Maffenini, L., Mari-Rivero, I., Melchiorri, M., Syrris, V., Van Den Hoek, J., Kemper, T. (2024). Advances on the Global Human Settlement Layer by joint assessment of Earth Observation and population survey data. International Journal of Digital Earth, 17(1), 2390454.

RedR UK (2024) Cultural Heritage and Earthquake Resilience in Afghanistan. Available at: https://redr.org.uk/news_story/earthquakes-resilience-afghanistan (Accessed: 31 October 2025).

Reuters. (2025). UN Afghanistan coordinator says damaged roads are biggest challenge after deadly quake. https://www.reuters.com/world/asia-pacific/un-afghanistan-coordinator-says-damaged-roads-are-biggest-challenge-after-deadly-2025-09-02/

Saffi, M. H. (2007). Groundwater resources at risk in Afghanistan (Report No. 555). https://doi.org/10.13140/RG.2.1.4465.7128.

Hallet, S. I., Samizay, R. (1975). “Nuristan’s cliff-hangers” Afghanistan Journal 2/2, pp. 65-72.

Shamim, S. (2025). Deadly earthquake hits Afghanistan: What we know so far. Al Jazeera. Retrieved from https://www.aljazeera.com/news/2025/9/1/deadly-earthquake-hits-afghanistan-what-we-know-so-far

Shirzaei, M., Daqiq, M. T., Lucy, J., Werth, S., Sharma, R., Velasco, M. J., Matin, M., & Madani, K. (2025). Afghanistan’s August 2025 earthquake reveals the cost of international isolation, UN scientists warn. United Nations University Institute for Water, Environment and Health (UNU-INWEH). https://doi.org/10.53328/INR25MSIR002

Shnizai, Z., Talebian, M., Valkanotis, S., & Walker, R. (2022). Multiple factors make Afghan communities vulnerable to earthquakes. UNESCO Iran. https://unescoiran.com/multiple-factors-make-afghan-communities-vulnerable-to-earthquakes/

Shnizai, Z., & Walker, R. (2024). Detailed Active Fault Map of the Spin Ghar Fault System and Related Seismicity in Eastern Afghanistan. тектоніка, 2(1), 132-156. https://doi.org/10.55575/tektonika2024.2.1.49

Shroder, J. F., Schettler, M. J., & Weihs, B. J. (2011). Loess failure in northeast Afghanistan. Physics and Chemistry of the Earth, Parts A/B/C, 36(16), 1287–1299. https://doi.org/10.1016/j.pce.2011.03.001

Simmon, R. (2002). Earthquake hits Hindu Kush, Afghanistan. NASA Earth Observatory. https://www.earthobservatory.nasa.gov/images/2316/earthquake-hits-hindu-kush-afghanistan

Slawin, W. A. (1984). Geological map of Afghanistan [Map]. U.S. Geological Survey.

Spense, R. and Coburn, A. (1992) Strengthening Buildings of Stone Masonry to Resist Earthquakes, Meccanica 27: 213-221

South Asian Desk. (2025). Temporary Classrooms Afghanistan 2025: Aid for Kunar Quake Victims. https://southasiandesk.com/temporary-classrooms-afghanistan/17/09/2025/

Szabo, A., Barfield, T.J. (1991), Afghanistan - An Atlas of Indigenous Domestic Architecture. Austin: University of Texas Press

Tareq. (2025). Why did Kunar earthquake result in widespread destruction, human tragedy? The Kabul Times. https://thekabultimes.com/why-did-kunar-earthquake-result-in-widespread-destruction-human-tragedy

The Food and Agriculture Organization (FAO) (2025). Rebuilding in earthquake-hit Afghanistan. https://www.fao.org/newsroom/story/rebuilding-in-earthquake-hit-Afghanistan/en

The Guardian (2025a). Third earthquake hits Afghanistan as death toll rises above 2,200 (accessed on 5 September 2025). Available from https://www.theguardian.com/world/2025/sep/04/third-earthquake-hits-afghanistan-as-death-toll-rises

The Guardian (2025b). Afghanistan death toll passes 1,400 as second earthquake strikes (accessed on 5 September 2025). Available from https://www.theguardian.com/world/2025/sep/02/afghanistan-earthquake-taliban-appeals-for-international-aid-as-rescue-teams-search-for-survivors

The Guardian. (2025c). “All I have left is this cloth”: Afghan quake survivors still waiting for help.https://www.theguardian.com/global-development/2025/sep/05/afghanistan-earthquake-survivors-aid-relief-kunar

Touzi, R., Lopes, A., Bruniquel, J., & Vachon, P. W. (2002). Coherence estimation for SAR imagery. IEEE transactions on geoscience and remote sensing, 37(1), 135-149.

Turner, B., Jenkins, J., Turner, R., Parker, A., Sinclair, A., Davies, S., Hayes, G. P., Villaseñor, A., Dart, R. L., Tarr, A. C., Furlong, K. P., & Benz, H. M. (2013). Seismicity of the Earth 1900-2010: Himalaya and vicinity (USGS Open-File Report 2010-1083-J). U.S. Geological Survey. https://doi.org/10.3133/ofr20101083J

UNDP, 2023. What is Vernacular Architecture, and How Can It Help Afghanistan? United Nations Development Programme.

UNDP (2024) Building Homes While Preserving Knowledge and Heritage Following Afghanistan’s Earthquakes. Available at: https://www.undp.org/afghanistan/blog/building-homes-while-preserving-knowledge-and-heritage-following-afghanistans-earthquakes (Accessed: 31 October 2025).

UNDP (2025a). Afghanistan Earthquake: Understanding the Impact. https://geosmart.undp.org/arcgis/apps/experiencebuilder/experience/?_gl=1%2A13mncqi%2A_ga%2AMTYzNTQwODIwNy4xNzYwNzg2NjQy%2A_ga_PBF14M9C6G%2AczE3NjA3ODY2NDIkbzEkZzAkdDE3NjA3ODY2NDMkajU5JGwwJGgw&block_id=layout_0_block_8&id=c52c1fb3937546e18dc67e24806b030c&page=Page

United Nations Development Programme (UNDP). (2025b). CB Assessments and Digital Solutions Team. Afghanistan Earthquake: Understanding the Impact.

United Nations Development Programme (UNDP). (2025c). Afghanistan earthquake 2025. UNDP Asia-Pacific. https://www.undp.org/asia-pacific/afghanistan-earthquake-2025

UNESCO-UNDP India (2007). Manual for restoration and retrofitting of rural structures in Kashmir: how to reduce vulnerability of existing structures in earthquake affected areas of Jammu and Kashmir. UNESCO Office New Delhi, UNDP India.

UNESCO (2016). Towards resilient non-engineered construction guide for risk-informed policy making. UNESCO.

UN-Habitat, 2011. Post-Conflict Reconstruction Guidelines for Afghanistan. United Nations Human Settlements Programme.

UN-Habitat, 2017. Afghanistan Housing Profile. United Nations Human Settlements Programme.

UN-Habitat, 2023. Afghanistan Urban Profile Update. United Nations Human Settlements Programme.

UNICEF. (2025a). Eastern Region Earthquake Update – The third week. UNICEF Afghanistan. https://www.unicef.org/afghanistan/documents/eastern-region-earthquake-update-third-week

UNICEF. (2025b). Eastern Region Earthquake Response Plan – September 2025 to March 2026. UNICEF Afghanistan. https://www.unicef.org/afghanistan/media/12501/file/UNICEF%20Afghanistan%20Earthquarke%20Response%20Plan%20Sep%202025%20to%20Mar%202026.pdf.pdf

United Nations Population Fund (UNFPA). (2025). Flash Update on the Earthquake in Nangarhar, Afghanistan (August 31-2 September 2025) (accessed on 5 September 2025). Available from https://www.unfpa.org/resources/flash-update-earthquake-nangarhar-afghanistan-august-31-%E2%80%94-2-september-2025

United Nations University (UNU). (2025a). Damage Assessment of Afghanistan's August 2025 Earthquake. https://collections.unu.edu/eserv/UNU:10335/UNU_INWEH_INCIDENT_BRIEF_Afg_Earthquake_2025.pdf

United Nations University (UNU). (2025b). Afghanistan's August 2025 Earthquake Reveals the Cost of International Isolation, UN Scientists Warn. https://unu.edu/inweh/news/afghanistans-august-2025 -earthquake-reveals-cost-international-isolation-un-scientists

U.S. Geological Survey (2023). M 6.5 - 2023 Hindu Kush Region Earthquake. https://earthquake.usgs.gov/earthquakes/eventpage/us7000jln7

USGS (2025a). M 6.0 - 37 km WSW of Asadābād, Afghanistan (accessed on 5 September 2025). Available from https://earthquake.usgs.gov/earthquakes/eventpage/us7000qsvj/executive

USGS. (2025b). USGS shakemap (accessed on 5 September 2025). Available from https://en.wikipedia.org/wiki/File:2025-08-31_Asad%C4%81b%C4%81d,_Afghanistan_M6_earthquake_shakemap_(USGS).jpg

USGS (2025c). Prompt Assessment of Global Earthquakes for Response (PAGER) (accessed on 5 September 2025). Available from https://en.wikipedia.org/wiki/PAGER

Vintzileou, E. (2008). Effect of timber ties on the behavior of historic masonry. Journal of Structural Engineering, 134(6), 961-972.

Waseem, M., Lateef, A., Ahmad, I., Ahmed, W. (2019). Seismic hazard assessment of Afghanistan. Journal of Seismology 23(2):217-242. DOI: 10.1007/s10950-018-9802-5

WHE. (2024). Health Emergency Risk Assessment. Available at https://dashboard.whe-him.org/index.php/2022/09/17/health-emergency-risk-assessment-hera-earthquake-risk-level/

Wheeler, R. L., Bufe, C. G., Johnson, M. L., & Dart, R. L. (2005). Seismotectonic Map of Afghanistan, with annotated bibliography (USGS Open-File Rep. 2005–1264). U.S. Geological Survey. https://pubs.usgs.gov/of/2005/1264/pdf/OFR-1264.pdf

World Bank, 2020. Afghanistan Building Resilience Report. Washington, D.C.: World Bank Group.

World Bank, 2023a. Afghanistan Energy Access Statistics. Washington, D.C.: World Bank Group.

World Bank (2023b). Water Emergency Relief Project (P179311)

World Bank (2023c). Trans-Hindukush Road Connectivity Project (P145347)

World Bank, 2025a. Afghanistan Urban Development Outlook. Washington, D.C.: World Bank Group.

World Bank. (2025b). Global Rapid Post-Disaster Damage Estimation (GRADE) report – Eastern Afghanistan Earthquake August 31, 2025. Washington, D.C.: World Bank Group.

WHO. (2025a). Earthquake in Eastern Afghanistan: WHO Situation report no. 8. WHO Health Organization. https://www.emro.who.int/images/stories/afghanistan/afghanistan-earthquake-sitatuion-report-8-9-september-2025.pdf?

WHO. (2025b). WHO Emergency Health Response to the Eastern Afghanistan Earthquake. https://www.emro.who.int/images/stories/afghanistan/WHO-Emergency-Health-Response-to-the-Eastern-Afghanistan-Earthquake-September-2025-March-2026.pdf

WHO. (2025c). WHO Health Cluster. Afghanistan: Humanitarian Mobile Health and Nutrition Teams (MHNTs) Supported by Health Cluster Partners. Available at https://reliefweb.int/map/afghanistan/afghanistan-humanitarian-mobile-health-and-nutrition-teams-mhnts-supported-health-cluster-partners-september-2025?_gl=1*138qcux*_ga*ODAxMjg0OTE4LjE3NjMxNDQxNjk.*_ga_E60ZNX2F68*czE3NjQxMDc5MjMkbzQkZzAkdDE3NjQxMDc5MjMkajYwJGwwJGgw

WHO. (2025d). Afghanistan Earthquake: WHO Situation report no. 13. https://reliefweb.int/report/afghanistan/afghanistan-earthquake-who-situation-report-no-13-2-oct-2025

Xekalakis, G., Christou, P., Pitilakis, D., & Kyriakides, N. (2023). Quantitative Contribution of Timber Ring Beams in the Dynamic Response of Adobe Masonry Structures. CivilEng, 4(4), 1182–1197. https://doi.org/10.3390/civileng4040065

Xinhua. (2025). Eastern Afghanistan earthquake death toll rises to 1,124, 3,251 injured. Xinhua. https://english.news.cn/asiapacific/20250902/17f58de93ca14f2a807146995b75a9cf/c.html

Yawar MY, Hassib S, Greenfield C (2025). Afghanistan airdrops commandos to rescue quake survivors, UN warns food may run out. Reuter (accessed on 5 September 2025). Available from https://www.reuters.com/business/environment/afghanistan-airdrops-commandos-rescue-quake-survivors-un-warns-food-may-run-out-2025-09-03/

Yeats, R. S., & Madden, C. (2003). Damage from the Nahrin, Afghanistan, earthquake of 25 March 2002. Seismological Research Letters, 74(3), 305-311. https://doi.org/10.1785/gssrl.74.3.305

Yun, S. H., Hudnut, K., Owen, S., Webb, F., Simons, M., Sacco, P., ... & Coletta, A. (2015). Rapid damage mapping for the 2015 M w 7.8 Gorkha earthquake using synthetic aperture radar data from COSMO–SkyMed and ALOS-2 Satellites. Seismological Research Letters, 86(6), 1549-1556.

Zahir, A. (2025). Hope fades for survivors days after deadly Afghanistan earthquake. The Sun. https://thesun.my/world-news/hope-fades-for-survivors-days-after-deadly-afghanistan-earthquake-GP14820464

Appendix A: SAR coherence image processing

SAR images are co-registered using the GAMMA Remote Sensing software following the pipeline presented in Lazecký et al. (2020). Interferometric coherence is estimated at an interval of 12 days for descending frames over the study area for the period 18-03-2025 until 02-09-2025. See e.g. Touzi et al. (2002) for a thorough explanation of coherence estimation calculations. Interferometric coherence from 17x5 pixel windows was estimated, corresponding roughly to 60-meters ground distance in both dimensions. The coherence estimation results are geocoded to a grid with approximately 30m by 30m square pixels. The geocoded coherence images were used to create a timeseries of coherence for each pixel.

For each built-up pixel, the pre-event coherence measurements were retrieved in a 3x3 pixel window centred on the pixel of interest. A beta distribution to these pre-event data was fitted. The percentile *P* in the beta distribution was computed that the observed co-event coherence corresponds to. The damage proxy value is then *1-P*, such that higher values correspond to more changed areas. The damage proxy value ranges from 0 to 1.

It is important to consider that SAR coherence change may also be caused by factors other than building damage. (Partially) vegetated areas are characterised by varying coherence, for example. Whilst the use of time series data (rather than a classic two-image difference approach) may help increase confidence in the interpretation of coherence change as building damage, it should be noted that SAR coherence change approaches are less reliable in areas with abundant vegetation, such as the remote mountain villages.

Appendix B-1: Details of Surveyed Buildings

Three villages (Shomaash [34.74749N 70.74789E], Ghaziabaad [34.71639N 70.7618E], and Patang [34.63029N 70.79769E]) were investigated in Zone 1 and Zone 2 of the earthquake by a reconnaissance team (Figure B.1). At least 10 buildings were visited for each case. Figure B.2 shows population clusters and earthquake intensity in the visited regions.

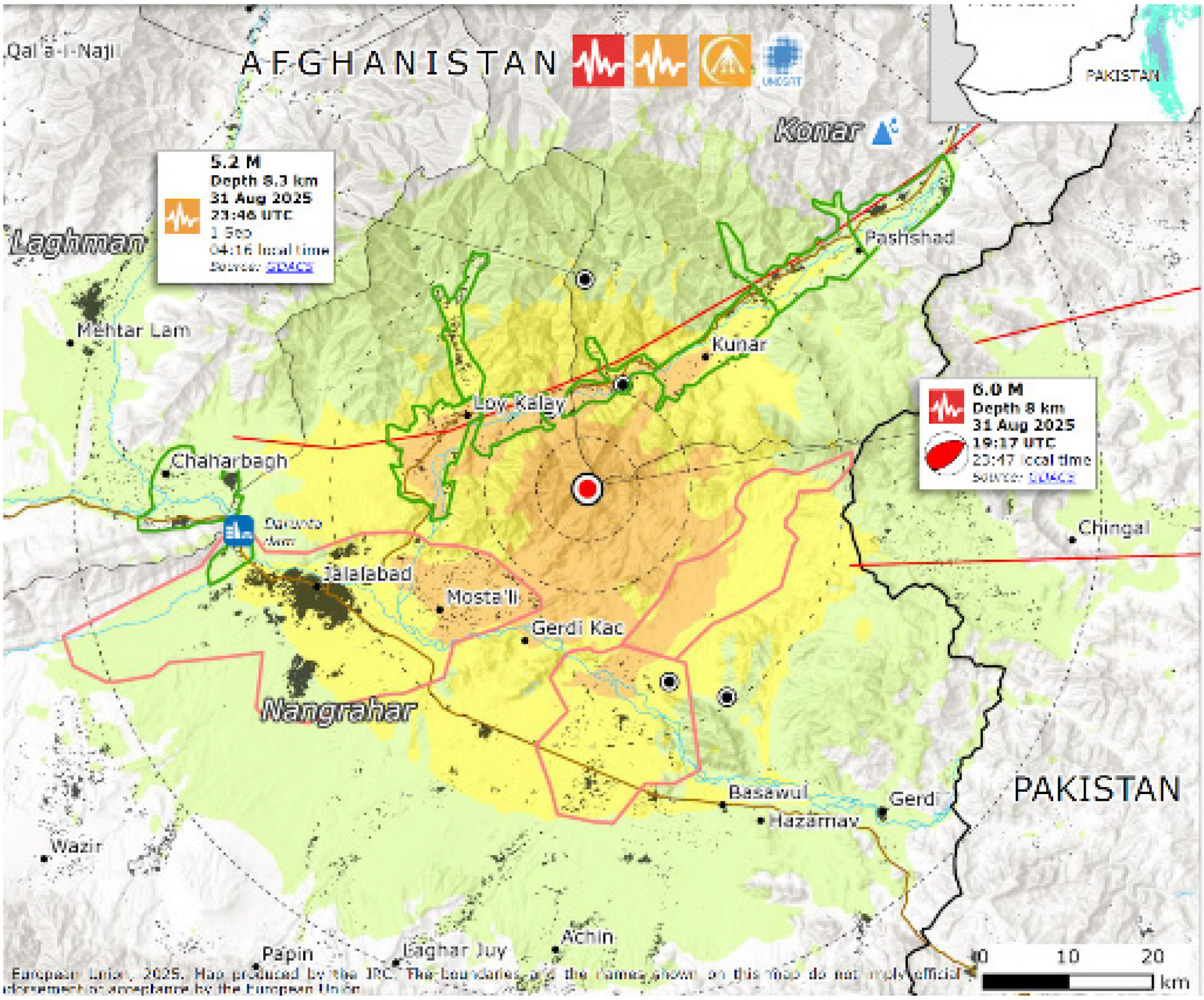


Figure B.1: Map of earthquake affected area

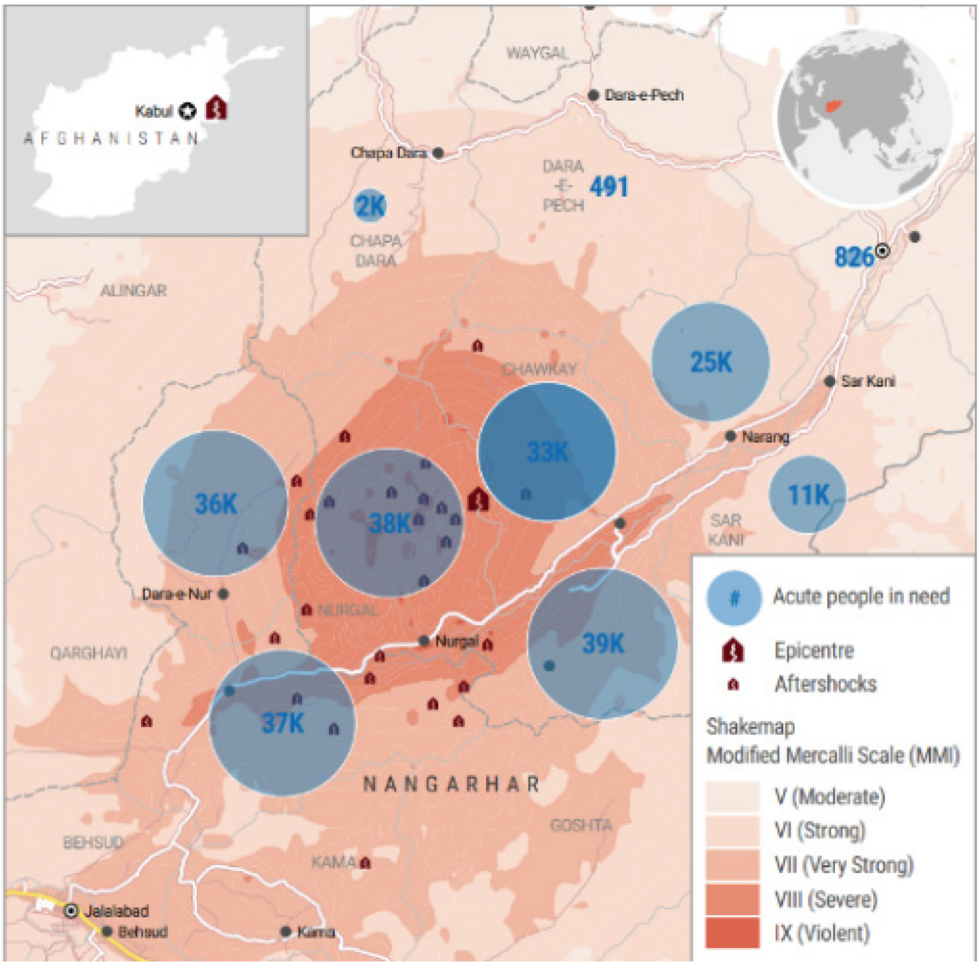


Figure B.2: Number of residents per cluster and intensity of earthquake

Appendix B-2: Stone Masonry (Figure B.3)

Location: Shomaash village

Items	**Descriptions**
Construction typology	Stone Masonry
Location	Orange (VII) Very strong shaking zone
Room sizes	4 m x 5 m
Roof height	2.7 m or 2.8 m
Wall thickness	50 cm max
EQ measure	Wooden cribs used in some houses
Door sizes	0.8 m x 1.8 m
Number of rooms in a house	3 rooms (minimum)
Number of windows in a room	1 (max 2)
Window size	1.5 m x 1.5 m
Footprint of an average house	120 m^2
Number of stories	Terraced houses up to 3 stories max
Foundation materials	Dry stones
Wall materials	Dry stone masonry
Roof materials	From bottom to top: wooden cribs, small pieces of wood, bushes, mud (Ghora gill), soft soil, plastic sheet, Kaagil (soil+ straw) 20 cm. The roof of one house is the terrace of the yard or balcony for the second house in the upper part. This chain of terraces continues to up to 5 or 6 houses.
Floor materials	Earthen floor
Door/window materials	Wooden (Oak tree or Spindle tree)

Figure B.3: Earthquake damaged stone masonry buildings in Kunar

Appendix B-3: Stone and Cob Walls (Figure B.4)

Location: Ghaziabaad village (also known as Wadeir)

Items	Descriptions
Construction typology	Stone masonry plus cob walls
Location	Yellow (VI) Strong shaking zone
Room sizes	4 m x 5 m and 4 m x 6 m
Roof height	2.7 m or 2.8 m
Wall thickness	60 cm
EQ measure	Not observed or evidenced
Door sizes	0.8 m x 1.8 m
Number of rooms in a house	3 rooms (minimum)
Number of windows in a room	1 (max 2)
Window size	1.5 m x 1.5 m
Footprint of an average house	200 m^2
Number of storeys	Terraced houses up to 4 stories
Foundation materials	Dry stone masonry
Wall materials	Dry stone masonry or stone masonry with mud mortar in the lower storeys and cob walls in the upper floors
Roof materials	From bottom to top: wooden cribs, small pieces of wood, bushes, mud (Ghora gill), soft soil, plastic sheet, Kaagil (soil+ straw)
Floor materials	Earthen floor
Door/window materials	Wooden (Oak tree or Spindle tree)

Figure B.4: Earthquake damaged buildings in Kunar with stone and cob walls

Appendix B-4: Cob walls (Pakhsa) (Figure B.5)

Location: Patang village

Items	**Descriptions**
Construction typology	Cob walls (Pakhsa) (+ adobe walls)
Location	Yellow (VI) Strong shaking zone but in flat lands
Room sizes	4 m x 5 m and 4 m x 6 m
Roof height	2.7 m or 2.8 m
Wall thickness	60 cm
EQ measure	Not observed or evidenced
Door sizes	0.9 m x 1.9 m
Number of rooms in a house	4 rooms (minimum)
Number of windows in a room	1 (max 2)
Window size	1.7 m x 1.7 m, 1.7 m x 2 m
Footprint of an average house	200 - 250 m^2
Number of storeys	Mostly single storeyed houses in flat areas however in some areas there more than two storeys high buildings
Foundation materials	Dry stone masonry
Wall materials	Cob walls also known as Pakhsa walls
Roof materials	From bottom to top: Wooden cribs, small pieces of wood, bushes, mud (Ghora gill), soft soil, plastic sheet, Kaagil (soil+ straw) In some areas, an I-beam is used as main beam and the weaker orthogonal wooden beams are supported by the I-beam
Floor materials	- Cement floor (PCC- Plain Concrete Course) - Earthen floor
Door/window materials	Wooden (Oak tree or Spindle tree)

Figure B.5: Earthen structure affected by earthquake