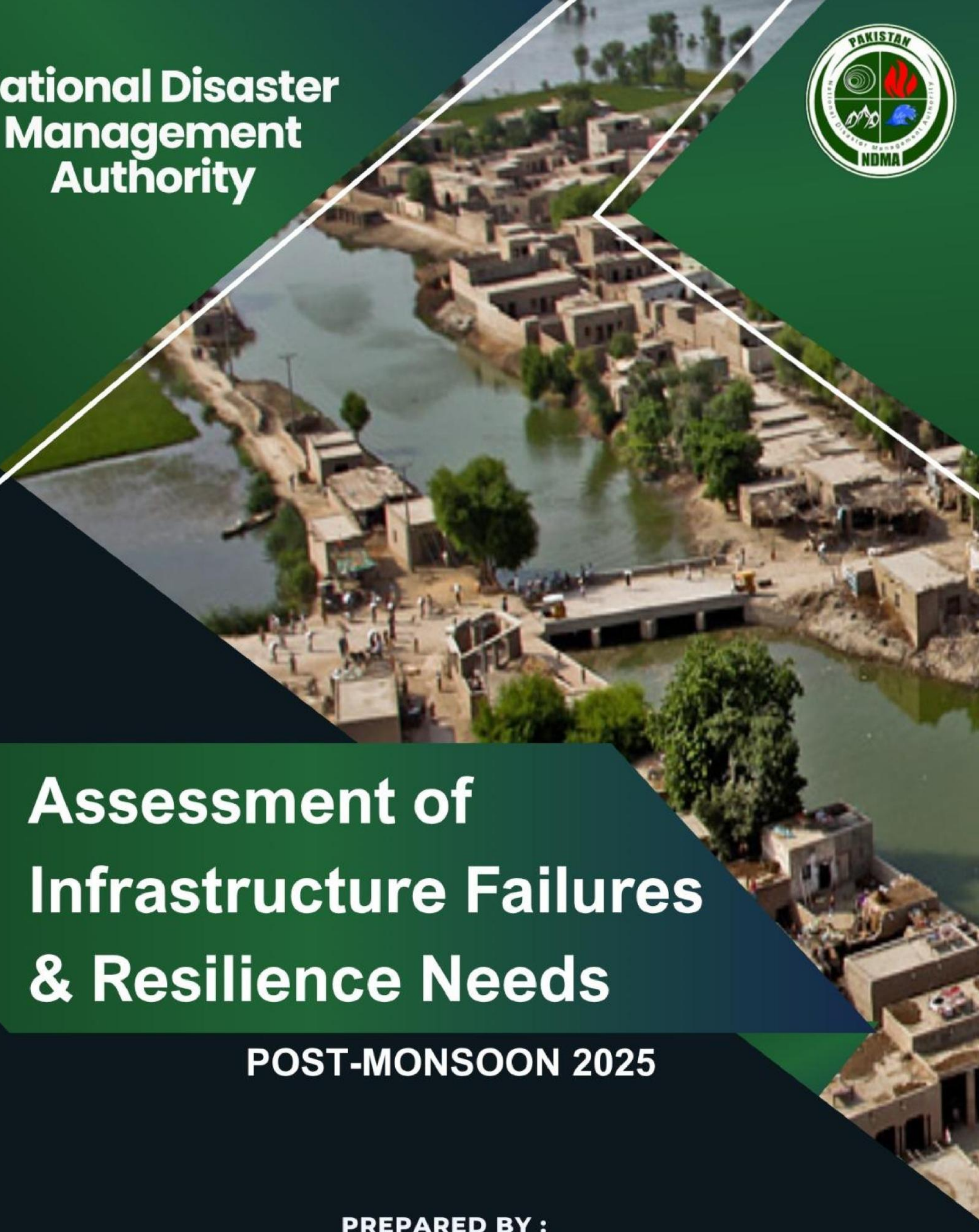
National Disaster Management Authority



Assessment of Infrastructure Failures & Resilience Needs

POST-MONSOON 2025

PREPARED BY :

INFRASTRUCTURE ADVISORY & PROJECT DEVELOPMENT

Acknowledgement

The Infrastructure Advisory and Project Development (IA&PD) Wing of the NDMA is pleased to present the post-Monsoon 2025 Infrastructure Damage Report. This report documents the extent of infrastructure damages, analyzes the underlying causes of failure, and provides recommendations to help mitigate such impacts during future monsoon seasons.

We gratefully acknowledge the efforts of PDMAs, GBDMA, and SDMA for their timely provision of infrastructure damage data, which formed the foundation of this report. The IA&PD Wing also extends its appreciation to the Operations Wing and Provincial Coordination Cell of the NDMA for their valuable support and for supplying essential information required for the report's preparation.

Preface

The Monsoon 2025 season brought significant hydrometeorological challenges across Pakistan, resulting in widespread infrastructure damages and disruptions. In response, the National Disaster Management Authority (NDMA), through its Infrastructure Assessment and Planning Division (IA & PD), conducted a comprehensive post-monsoon evaluation to assess the extent and nature of these impacts across all provinces and regions.

This report presents a consolidated analysis of damages, underlying causes of infrastructure failures, and key recommendations for building resilience in future reconstruction and planning efforts.

NDMA remains committed to fostering resilience through evidence-based planning and climate-adaptive infrastructure development. It is hoped that this report will contribute meaningfully to informed decision-making and to strengthening Pakistan’s preparedness and response to future monsoon events.

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1. Introduction

The Monsoon 2025 season posed severe hydrometeorological challenges across Pakistan, resulting in extensive infrastructure damage, disruption of essential services, and notable economic setbacks. Prolonged and intense rainfall, accompanied by localized flash floods and riverine overflows, caused significant impacts on road networks, bridges, communication systems, energy supply, and public service facilities nationwide.

The northern and southern regions experienced the most pronounced effects, where topography, fragile slopes, and inadequate drainage systems amplified flood and landslide risks. In several districts, unplanned construction in hazard-prone zones, combined with poor maintenance of stormwater infrastructure, further intensified the scale of destruction and displacement. These events once again underscored Pakistan's increasing vulnerability to climate-induced disasters and the urgent need for resilient development practices.

In response, the National Disaster Management Authority (NDMA) compiled a comprehensive post-monsoon report to evaluate the extent of damages across all provinces and administrative territories, including Azad Jammu & Kashmir (AJK) and Gilgit-Baltistan (GB).

The purpose of this report is to provide an analytical overview of the infrastructure impacts of Monsoon 2025, highlighting key trends, vulnerabilities, and underlying causes of failure. It serves as a foundation for informed recovery, rehabilitation, and reconstruction planning.

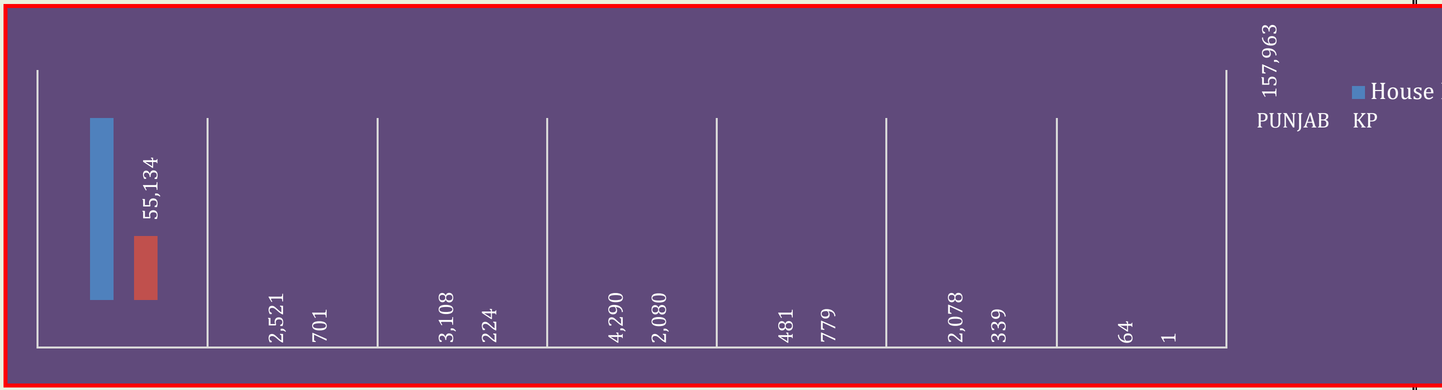
Through this assessment, NDMA emphasizes the importance of integrating resilience into infrastructure planning, strengthening institutional coordination, and adopting climateadaptive engineering standards to safeguard communities and sustain national development gains against recurring monsoon hazards.

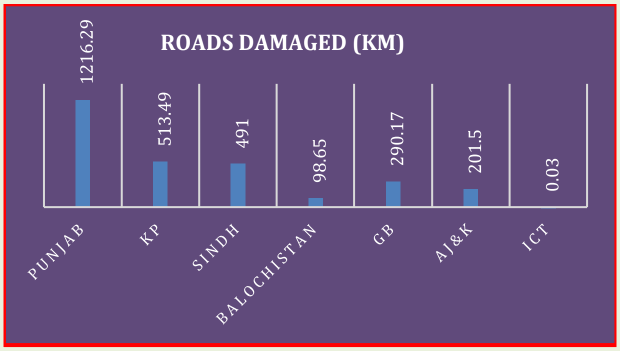
2. Summary of Infrastructure Damages

The summary table and graph below presents the infrastructure damages incurred across Pakistan during the Monsoon 2025 season.

Table 1: Summary of Infrastructure Damages Across Pakistan During Monsoon 2025

Province	Roads (km)	Bridges	House Damage		
			Partial	Full	Total
Punjab	1216.29	462	157,963	55,134	**213,097**
KP	513.49	52	2,521	701	**3,222**
Sindh	491	66	3,108	224	**3,332**
Balochistan	98.65	3	4,290	2,080	**6,370**
GB	290.17	92	481	779	**1,260**
AJ&K	201.5	112	2,078	339	**2,417**
ICT	0.03	3	64	1	**65**
Grand Total	**2811.13**	**790**	**170,505**	**59,258**	**229,763**





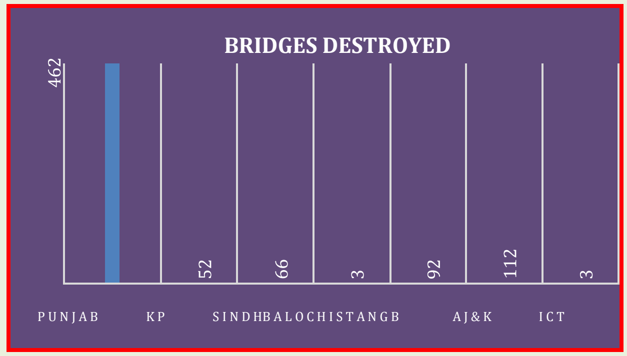


Figure 1. Summary of Infrastructure Damages Across Pakistan During Monsoon 2025

3. District-Level Provincial Infrastructure Damage

This section outlines the infrastructure damages recorded across various districts within the provinces of Pakistan during the Monsoon 2025 season.

3.1 Khyber Pakhtunkhwa

3.1.1 Summary of Damages

A comprehensive summary of infrastructure damages across various districts of Khyber Pakhtunkhwa is presented in the table below.

Table 2: District-Wise Summary of House Damages in Khyber Pakhtunkhwa (Monsoon 2025)

Sr.	District	House Damage			Sr.	District	House Damage		
		Partial	Full	Total			Partial	Full	Total
1	Abbottabad	38	3	41	19	Malakand	16	2	18
2	Bajaur	38	11	49	20	Mansehra	55	50	105
3	Bannu	8	1	9	21	Mardan	23	5	28
4	Battagram	28	4	32	22	Mohmand	87	37	124
5	Buner	921	454	1375	23	North Waziristan	17	8	25
6	Charsadda	54	10	64	24	Nowshera	52	2	54

7	Dera Ismail Khan	90	29	119	25	Orakzai	1	3	4
8	Hangu	12	1	13	26	Peshawar	2	2	4
9	Haripur	20	3	23	27	Shangla	215	182	397
10	Karak	40	0	40	28	South Waziristan (L)	19	10	29
11	Khyber	70	21	91	29	South Waziristan (U)	5	9	14
12	Kohat	9	21	30	30	Swabi	59	26	85
13	Kohistan Kolai Pallas	1	1	2	31	Swat	494	55	549
14	Kurram	22	37	59	32	Tank	46	13	59
15	Lakki Marwat	14	3	17	33	Torghar	24	1	25
16	Lower Chitral	12	5	17	34	Upper Chitral	14	14	28
17	Lower Dir	57	3	60	35	Upper Dir	7	6	13
18	Lower Kohistan	1	0	1	36	Upper Kohistan	10	45	55

Table 3: District-Wise Summary of Road Damages in Khyber Pakhtunkhwa (Monsoon 2025)

Sr.	District	Roads (km)	Sr.	District	Roads (km)
1	Abbottabad	33.65	15	Malakand	7.25
2	Bajaur	23.6	16	Mansehra	276.38
3	Battagram	80.25	17	Mardan	13.22
4	Buner	118.28	18	Nowshera	20.76
5	Charsadda	0.4	19	Shangla	45.9
6	Dera Ismail Khan	1.1	20	South Waziristan Lower	8
7	Haripur	45.68	21	South Waziristan Upper	1.8
8	Karak	27.77	22	Swabi	92.59
9	Khyber	49.7	23	Swat	54.09
10	Kohat	1.5	24	Tank	6.9
11	Kurram	10.02	25	Torghar	28.87

12	Lower Dir	40.56	26	Upper Dir	120.74
13	Lower Kohistan	26.3	27	Upper Kohistan	7.5
14	Lower Chitral	145.7	28	Upper Chitral	9.37

Table 4: District-Wise Summary of Bridge Damages in Khyber Pakhtunkhwa (Monsoon 2025)

Sr.	District	Bridges	Sr.	District	Bridges
1	Abbottabad	4	10	Mardan	17
2	Bajaur	2	11	Nowshera	1
3	Buner	4	12	Shangla	3
4	Dera Ismail Khan	1	13	South Waziristan Lower	1
5	Haripur	3	14	South Waziristan Upper	8
6	Kurram	3	15	Swabi	7
7	Lower Dir	5	16	Swat	14
8	Malakand	1	17	Upper Dir	7
9	Mansehra	4	18	Upper Kohistan	4

3.1.2 Spatial Overview of Damages

The spatial distribution maps illustrate the varying extent of house damages across districts of Khyber Pakhtunkhwa during the Monsoon 2025 season. The maps indicate significant differences in damage intensity, with certain districts experiencing severe destruction while others reported relatively minor impacts. The red color denotes districts with more than 51 damaged houses, while yellow indicates those with 31 to 50 damages. Dark blue represents districts reporting 16 to 30 damaged houses, and light blue reflects areas with 1 to 15 damages. Overall, the visualization provides a clear depiction of the uneven impact of monsoon-induced damages across the province, emphasizing the importance of targeted preparedness, risk reduction, and recovery measures.

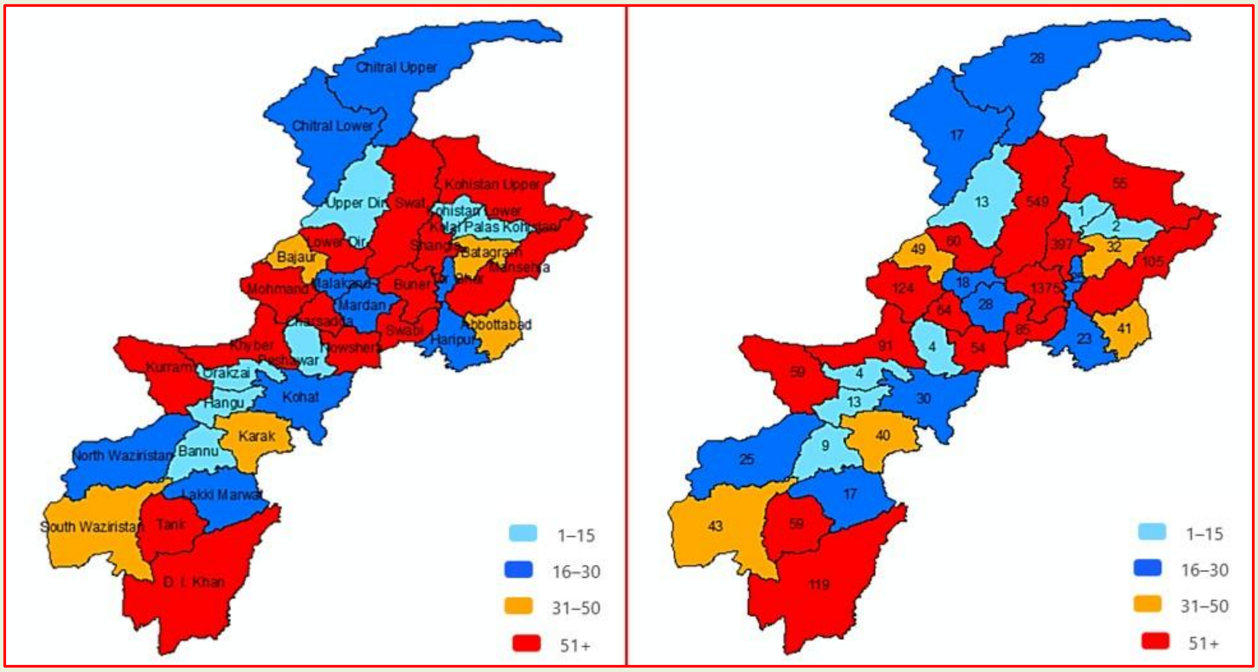


Figure 2: Spatial Distribution of House Damages Across Districts of Khyber Pakhtunkhwa

3.1.3 Incident Details

During the Monsoon 2025 season, Khyber Pakhtunkhwa witnessed multiple localized yet severe weather-induced events including flash flooding, landslides, and structural collapses. These incidents underscore the province's exposure to complex hydrometeorological hazards, especially in mountainous and semi-hilly terrains. The following cases provide a situational overview of the nature and diversity of impacts reported during monsoon 2025.

3.1.3.1 Flash Flooding in Swabi (2nd July 2025)

A flash flooding event struck parts of Swabi District, resulting in significant deterioration of binding materials and erosion at infrastructure bases. The forceful water flow eroded the supporting soil around small retaining walls and culverts, destabilizing foundations and threatening adjacent structures.

Figure 3: Structural Erosion and Material Degradation in Swabi Following Flash Flood

3.1.3.2 House Damage in Chitral (21st July 2025)

In Chitral District, intense flash floods led to house collapse and uprooting of trees, accompanied by extensive water seepage into residential structures. This incident highlighted the compounded effects of flash flooding in mountainous settlements.

Figure 4: Ground Instability and Vegetation Uprooting in Chitral

3.1.3.3 Road Blockage in Lower Kohistan (19th July 2025)

A major landslide in Lower Kohistan caused road blockages along key inter-district routes. The event was attributed to slope instability induced by persistent rainfall and loose geological formations. This incident underscores the vulnerability of the province's mountainous road infrastructure to recurring monsoon-induced landslides.

Figure 5: Rainfall-Induced Slope Instability and Road Blockage in Lower Kohistan

3.1.3.4 Roof Collapse in Mansehra (22nd July 2025)

In Mansehra District, excessive rainfall led to water accumulation on rooftops, triggering structural failure and roof collapse in several houses. The incident reinforced the need for improved roofing materials and drainage systems, particularly in semi-urban and rural areas with non-engineered construction practices.

Figure 6: Roof Collapse Due to Rainwater Accumulation

3.1.3.5 Flash Flood in Swat (15th August 2025)

Heavy monsoon downpours in Swat District caused a flash flood, leading to extensive road blockages and the submergence of low-lying areas. The event exposed the lack of adequate drainage systems, as accumulated runoff overwhelmed local channels and roadways. This disrupted vehicular movement and isolated several adjoining communities.

Figure 7: Severe Urban Flooding Due to Inadequate Drainage Infrastructure

3.1.3.6 Road Erosion and Instability in Swat (18th August 2025)

Just days later, another flood event on 18th August 2025 in Swat resulted in severe road erosion due to soil saturation and instability. Prolonged waterlogging weakened the road base, leading to partial collapses and posing hazards for transport and relief operations. This recurrence underscored the persistent threat of slope and soil failures in the northern highlands during sustained rainfall.

Figure 8: Flash Flood-Induced Inundation Due to Inadequate Urban Drainage

3.1.3.7 Structural Damage in D.I. Khan (24th August 2025)

In Dera Ismail Khan, intense rainfall led to the collapse of multiple houses, revealing major concerns regarding structural integrity in vulnerable settlements. The incident caused displacement of affected households and significant property losses.

Figure 9: Structural Collapse of Houses

3.1.3.8 Electrical Infrastructure Damage in D.I. Khan (24th August 2025)

Concurrent to the heavy rains, strong winds toppled electrical poles, leading to temporary power outages in several urban and semi-urban areas. The damage was linked to the lack of bracing and structural reinforcement in electrical infrastructure, further emphasizing the cascading impact of monsoon-induced weather conditions on critical lifelines.

Figure 10: Failure of Unbraced Electrical Pole Infrastructure

3.2 Punjab

3.2.1 Summary of Damages

A comprehensive summary of infrastructure damages across various districts of Punjab is presented in the table below.

Table 5: District-Wise Summary of House Damages in Punjab (Monsoon 2025)

Sr.	District	House Damage			Sr.	District	House Damage		
		Partial	Full	Total			Partial	Full	Total
1	Attock	1	0	1	15	Multan	3	0	3
2	Bahawalnagar	4	0	4	16	Murree	6		6
3	Chakwal	2	0	2	17	Nankana Sahib	3	0	3
4	Chiniot	5	0	5	18	Narowal	4	0	4
5	Faisalabad	41	0	41	19	Okara	20	0	20
6	Gujranwala	7	0	7	20	Pakpattan	5	0	5
7	Gujrat	2	0	2	21	Rahim Yar Khan	1	0	1
8	Hafizabad	1	0	1	22	Rajanpur	1	0	1
9	Jhelum	34	0	34	23	Rawalpindi	2	0	2
10	Kasur	20	0	20	24	Sahiwal	11	0	11
11	Khushab	0	3	3	25	Sargodha	2	0	2
12	Lahore	31	1	32	26	Sheikhupura	25	0	25
13	Layyah	0	0	0	27	Sialkot	1	0	1
14	Mandi Bahauddin	1	0	1	28	Wazirabad	1	0	1

Table 6: District-Wise Summary of Road Damages in Punjab (Monsoon 2025)

Sr.	District	Roads (km)	Sr.	District	Roads (km)
1	Bahawalnagar	41	12	Muzaffargarh	183
2	Bahawalpur	121	13	Nankana Sahib	1
3	Chiniot	16	14	Narowal	31
4	Faisalabad	17	15	Okara	5
5	Gujrat	4	16	Pakpattan	56
6	Jhang	300	17	Rahim Yar Khan	20

7	Kasur	19	18	Rajanpur	5
8	Khanewal	68	19	Sahiwal	4
9	Lahore	1	20	Sialkot	3
10	Lodhran	17	21	Toba Tek Singh	32
11	Multan	259	22	Vehari	4

3.2.2 Spatial Overview of Damages

The spatial distribution maps illustrate the extent and pattern of house damages across various districts of Punjab during the Monsoon 2025 season. The maps highlight significant spatial variations in the level of destruction, with certain districts witnessing extensive structural damages, while others reported comparatively minor impacts. Overall, the figures emphasize the urgent need for region-specific disaster preparedness, improved housing resilience, and the strengthening of early warning and recovery mechanisms to minimize future monsoon impacts in Punjab.

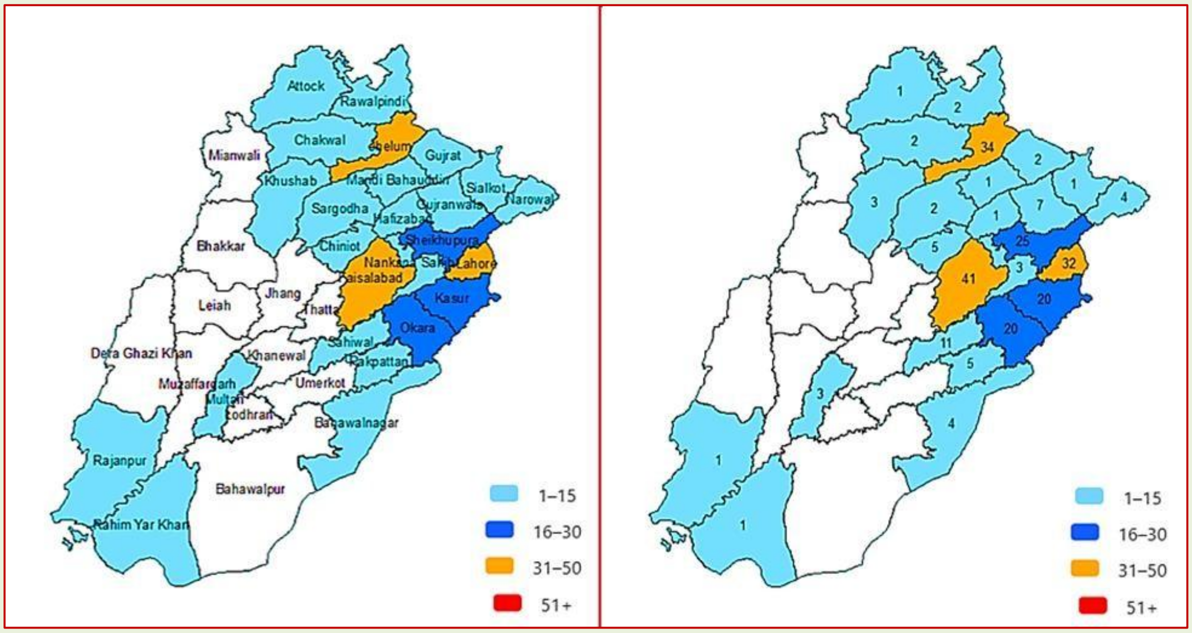


Figure 11: Spatial Distribution of House Damages Across Districts of Punjab

3.2.3 Incident Details

During the Monsoon 2025 season, several districts of Punjab experienced significant infrastructure and housing damages due to heavy rainfall, urban flooding, and poor drainage management. The widespread impacts reflected both natural vulnerabilities and man-made deficiencies across multiple locations.

3.2.3.1 Water Accumulation on Motorway (Chakri – 17th July 2025)

Heavy rainfall led to severe water accumulation along the Chakri section of the Motorway, resulting in traffic disruption and partial closure of road segments. The primary cause was identified as the blockage of the drainage network, which prevented effective runoff management. This event underscores the urgent need for routine maintenance and regular desilting of stormwater channels along major transport corridors.

Figure 12: Flooding and Water Accumulation on Motorway Due to Blocked Drainage Network

3.2.3.2 Houses Damaged in Sargodha (17th July 2025)

In Sargodha, continuous rainfall caused the collapse of residential structures, revealing critical weaknesses in local construction practices. The use of substandard building materials and the lack of proper reinforcement were major contributing factors. These findings call for stricter enforcement of building codes and quality control measures, particularly in flood-prone rural settlements.

Figure 13: Structural Collapse of Residential Houses in Sargodha Due to Poor Construction Practices

3.2.3.3 House Collapse in Rawalpindi (24th July 2025)

In Rawalpindi, flooding led to the collapse of a residential house, primarily due to foundation settlement and soil erosion. The incident highlights the vulnerability of lowlying urban areas where unplanned drainage and weak soil conditions exacerbate the effects of heavy rainfall. Improved geotechnical assessment and flood-resilient construction practices are required to mitigate similar future losses.

Figure 14: Structural Failure of Residential Building Due to Foundation Settlement and Erosion

3.2.3.4 Roof Collapse in Muzaffargarh (25th July 2025)

In Muzaffargarh, intense rainfall caused the collapse of a roof, attributed to water ponding and insufficient roof drainage systems. The event reveals the recurring issue of poor design and maintenance in residential roofing structures. Incorporating roof slope standards, effective drainage outlets, and regular inspections could significantly reduce such risks.

Figure 15: Roof Collapse in Muzaffargarh Due to Water Ponding and Inadequate Drainage

3.2.3.5 Flooding at Kartarpur Corridor, Narowal (27th August 2025)

The Kartarpur Corridor in Narowal experienced severe flooding as a result of poor drainage design and insufficient runoff management. The inundation affected access routes and religious infrastructure, hampering mobility and emergency response. The event emphasizes the necessity for incorporating hydrological assessments and floodproof design features in sensitive and high-footfall public facilities.

Figure 16: Flooding at Kartarpur Corridor, Narowal Due to Inadequate Drainage Infrastructure

3.2.3.6 Flood-Induced Road Erosion and Collapse in Multan (18th Sept 2025)

One of the most significant infrastructural failures occurred along the M-5 Multan Motorway, where intense flooding resulted in road erosion and partial collapse of the motorway embankment. The incident revealed underlying vulnerabilities linked to inadequate slope protection, soil compaction issues, and weak embankment stabilization. The scale of damage disrupted inter-district connectivity and underscored the urgent requirement for engineering interventions such as reinforced retaining structures, improved drainage outlets, and flood-resilient pavement materials.

Figure 17: Flood-Induced Erosion and Embankment Collapse on M-5 Motorway, Multan

3.3 Balochistan

3.3.1 Summary of Damages

A comprehensive summary of infrastructure damages across various districts of Balochistan is presented in the table below.

Table 7: District-Wise Summary of House Damages in Balochistan (Monsoon 2025)

Sr.	District	House Damage			Sr.	District	House Damage		
		Partial	Full	Total			Partial	Full	Total
1	Awaran	100	32	132	11	Lasbella	126	30	156
2	Barkan	134	16	150	12	Loralai		1	1
3	Dera Bugti	60	10	70	13	Musakhail	648	356	1004
4	Harnai		9	9	14	Qilla Saifullah	69	13	82
5	Hub	1029	1151	2180	15	Sherani	4	5	9
6	Jhal Magsi	1029	979	2008	16	Surab	98	219	317
7	Kachhi	84	29	113	17	Washuk	0	0	0
8	Kalat	10	3	13	18	Zhob	8		8

9	Khuzdar	183	19	202	19	Ziarat	7	8	15
10	Kohlu		28	28					

Table 8: District-Wise Summary of Road Damages in Balochistan (Monsoon 2025)

Sr.	District	Roads (km)
1	Hub	30
2	Jhal Magsi	35
3	Kachhi	12
4	Kalat	60
5	Lasbella	3
6	Sherani	10
7	Surab	14

Table 9: District-Wise Summary of Bridge Damages in Balochistan (Monsoon 2025)

Sr.	District	Bridges
1	Jhal Magsi	19
2	Kachhi	2
3	Khuzdar	1
4	Sherani	4

3.3.2 Spatial Overview of Damages

The spatial distribution maps illustrate the extent of house damages across various districts of Balochistan during the Monsoon 2025 season. The maps show significant disparities in the level of destruction, with some districts experiencing extensive structural damage, while others recorded relatively minor impacts. This spatial variation highlights the complex interaction between environmental and infrastructural factors that determine the scale of monsoon-induced damages across Balochistan. The visualization offers valuable insights into the province’s exposure to extreme weather events, particularly in areas prone to flash floods and inadequate drainage systems.

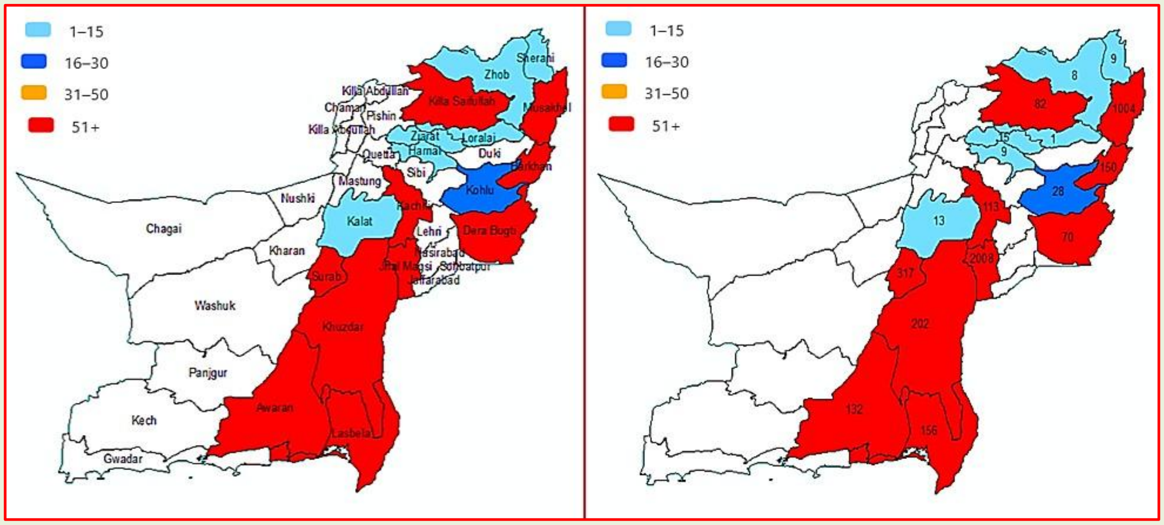


Figure 18: Spatial Distribution of House Damages Across Districts of Balochistan

3.3.3 Incident Details

During the Monsoon 2025 season, several districts of Balochistan experienced severe flooding and extensive infrastructure damage due to intense and prolonged rainfall. Rural and urban areas alike faced significant disruptions, with road networks, bridges, and housing structures being heavily affected. The situation was further intensified by the region’s rugged terrain, limited drainage infrastructure, and delayed emergency response.

3.3.3.1 Houses Damage – Musakhail (24th August 2025)

In Musakhail, intense and sustained rainfall on 24th August 2025 resulted in the complete collapse of one residential unit and partial structural damages to more than 30 adjoining houses. The affected structures predominantly comprised earthen and unreinforced masonry materials with inadequate foundations and poor load-bearing capacity. Prolonged moisture infiltration led to the weakening of wall integrity and subsequent localized failures. The incident highlights the high vulnerability of non-engineered construction to hydro-meteorological stresses and reinforces the necessity for promoting resilient building practices, proper drainage planning, and structural reinforcement in flood-prone rural settlements.

Figure 19: House Damage in Musakhail due to Intense Rainfall

3.3.3.2 Roof Collapse – Harnai (18th August 2025)

In Harnai, intense rainfall on 18th August 2025 caused the collapse of a residential roof structure. The failure occurred primarily due to the saturation of mud-based roofing materials and the absence of adequate load distribution supports. Field inspection indicated that excessive moisture penetration led to the disintegration of binding materials and subsequent collapse under self-weight. The incident underscores the structural vulnerability of non-engineered housing units to heavy precipitation events and emphasizes the urgent requirement for introducing reinforced roofing systems, improved drainage around foundations, and adherence to resilient construction standards in rural settlements.

Figure 20: Roof Collapse in Harnai due to Intense Rainfall

3.3.3.3 Roof and Solar Infrastructure Damages – Surab (6th July 2025)

In Surab, a windstorm accompanied by heavy rainfall on 6th July 2025 caused the collapse of residential roof structures and significant damage to solar energy installations. The affected buildings were primarily non-engineered, utilizing wooden trusses and mud plaster, which failed under combined wind pressure and moisture ingress. Several rooftop solar panels and ground-mounted photovoltaic units were dislodged or tilted due to inadequate anchoring and soil erosion around foundations. The incident illustrates the compounded vulnerability of both traditional housing and renewable energy infrastructure to extreme weather conditions, emphasizing the requirement for improved structural anchorage, wind-resistant roofing systems, and climate-resilient solar installations in hazard-prone regions.

Figure 21: Roof and Solar Infrastructure Damage in Surab due to Heavy Rainfall

3.3.3.4 Solar Infrastructure Damage – Surab (9th July 2025)

In Surab, heavy rainfall on 9th July 2025 caused extensive damage to solar power infrastructure installed in exposed terrain. Several photovoltaic (PV) panels were displaced, detached, or structurally compromised due to inadequate mounting strength, poor anchoring systems, and soil erosion around support frames. Continuous surface runoff and water accumulation weakened the base stability of steel structures, leading to tilting and mechanical failure of the mounting assemblies.

Figure 22: Solar Infrastructure Damage due to Heavy Rainfall

3.3.3.5 Roof Collapse – Muslim Bagh (5th July 2025)

In Muslim Bagh, a severe windstorm accompanied by heavy rainfall on 5th July 2025 resulted in the collapse of a metal-sheet roof structure. The structural failure was primarily attributed to excessive wind uplift forces acting on inadequately braced trusses and weak anchoring of corrugated sheets. The combination of high wind velocity and accumulated rainwater increased the dead load, leading to progressive deformation and eventual collapse. Field observations indicated substandard welding joints and insufficient lateral bracing, which further contributed to the instability of the roofing frame.

Figure 23: Roof Collapse in Muslim Bagh due to Heavy Rainfall

3.3.3.6 Bridge Washed Away – Lasbela (1st July 2025)

In Lasbela, a severe flash flood on 1st July 2025 resulted in the complete collapse and washing away of a concrete bridge structure. The incident was caused by an abrupt rise in floodwater discharge and high-velocity flow that exceeded the bridge's hydraulic design capacity. Scouring around the abutments and piers undermined the foundation stability, leading to structural failure and detachment of the deck slab. Field observations revealed inadequate flood protection works, insufficient freeboard clearance, and erosion of the approach embankments.

Figure 24: Bridge Washed Away in Lasbela due to Severe Flashflood

3.4 Sindh

3.4.1 Summary of Damages

A comprehensive summary of infrastructure damages across various districts of Sindh is presented in the table below.

Table 10: District-Wise Summary of House Damages in Sindh (Monsoon 2025)

Sr.	District	House Damage			Sr.	District	House Damage		
		Kacha	Pakka	Total			Kacha	Pakka	Total
1	Badin	53		53	9	Malir	16	17	33
2	Dadu	896	196	1092	10	Mirpurkhas		2	2
3	Ghotki	80		80	11	Sanghar	1		1
4	Hyderabad	350	5	355	12	South Karachi		2	2
5	Jamshero	340	190	530	13	Sujawal	517		517
6	Keamari	25		25	14	Tando Allahyar		1	1
7	Khairpur	30	5	35	15	Tando Muhammad Khan	485	26	511
8	Larkana	95		95					

Table 11: District-Wise Summary of Road Damages in Sindh (Monsoon 2025)

Sr.	District	Roads (km)
1	Central Karachi	32
2	Dadu	108
3	East Karachi	25
4	Hyderabad	32
5	Jamshero	65
6	Keamari	35
7	Korangi	15
8	Malir	18
9	South Karachi	20
10	Sujawal	7
11	Tando Allahyar	50
12	Tando Muhammad Khan	5
13	West Karachi	79

Table 12: District-Wise Summary of Bridges and Culverts Damages in Sindh (Monsoon 2025)

Sr.	District	Bridges and Culverts
1	Dadu	45
2	Hyderabad	3
3	Jamshero	2
4	Sujawal	10
5	Tando Muhammad Khan	6

3.4.2 Spatial Overview of Damages

The spatial distribution maps illustrate the extent of house damages across various districts of Sindh during the Monsoon 2025 season. The maps reveal significant variations in the severity of impacts, with some districts experiencing extensive structural damages, while others reported comparatively lesser effects. The visualization provides useful insights into the areas most affected by flooding and water accumulation, particularly in low-lying and densely populated zones. Overall, the maps underscore the importance of enhancing disaster preparedness, strengthening housing resilience, and implementing targeted risk reduction and recovery measures to minimize future monsoon impacts in Sindh.

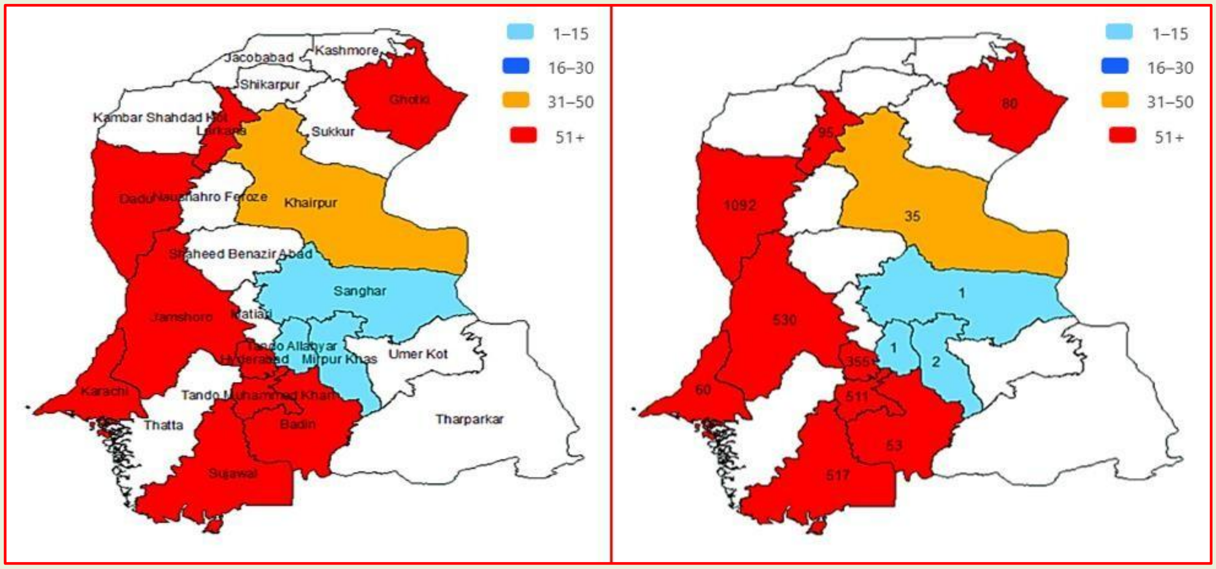


Figure 25: Spatial Distribution of House Damages Across Districts of Sindh

3.4.3 Incident Details

During the Monsoon 2025 season, multiple districts across Sindh experienced severe flooding and infrastructure damage caused by persistent heavy rainfall and overflow from major rivers (Indus) and drainage channels. Urban centers such as Karachi and Hyderabad faced extensive waterlogging, traffic disruptions, and property losses, while rural areas suffered large-scale damage to crops, roads, and housing. The impacts were intensified by inadequate drainage systems, encroachment on natural waterways, and delayed mitigation measures, underscoring both environmental vulnerabilities and systemic planning deficiencies across the province.

3.4.3.1 Urban Flooding – Karachi (19th August 2025)

In Karachi, intense and prolonged rainfall on 19th August 2025 resulted in severe urban flooding, leading to widespread disruption of transportation networks, power outages, and damage to vehicles and public infrastructure. The existing drainage system was overwhelmed due to high rainfall intensity, inadequate stormwater management, and obstruction of natural outflow channels by encroachments and solid waste accumulation. Several major thoroughfares and underpasses remained inundated for extended periods, severely affecting urban mobility and emergency response operations. The event underscores critical deficiencies in urban flood management infrastructure and emphasizes the urgent requirement for upgrading drainage capacity, enforcing building and land-use regulations, and integrating sustainable urban flood resilience planning within municipal systems.

Figure 26: Urban Flooding in Karachi due to Intense and Prolonged Rainfall

3.4.3.2 Building Collapse – Karachi (20th August 2025)

In Karachi, heavy and persistent rainfall on 20th August 2025 led to the collapse of a residential building located in a low-lying urban area. Continuous rainfall caused significant waterlogging around the foundation, resulting in soil saturation, reduced bearing capacity, and progressive structural settlement. The building’s load-bearing masonry walls and roof system, already weakened by poor construction practices and inadequate maintenance, ultimately failed under accumulated stresses. The incident underscores the critical need for enforcing urban building codes, conducting routine structural safety inspections, and implementing improved foundation and drainage designs to enhance resilience of residential infrastructure in flood-prone areas.

Figure 27: Building Collapse in Karachi due to Heavy and Persistent Rainfall

3.4.3.3 Water Ponding – Sukkur (8th September 2025)

In Sukkur, heavy rainfall on 8th September 2025 resulted in extensive water ponding across several low-lying urban areas. The incident was primarily caused by poor surface drainage, silted stormwater channels, and accumulation of solid waste obstructing natural and man-made outflow paths. Prolonged standing water led to localized flooding, road surface deterioration, and restricted access to residential and commercial zones. Field assessments indicated inadequate maintenance of municipal drainage infrastructure and the absence of proper runoff management systems. The event highlights the urgent need for systematic urban drainage rehabilitation, regular de-silting of channels, enforcement of solid waste disposal regulations, and the integration of climate-resilient stormwater management strategies in city planning to reduce future flood risks.

Figure 28: Water Ponding in Sukkur due to Heavy Rainfall

3.4.3.4 Urban Flooding – Malir, Karachi (10th September 2025)

On 10th September 2025, intense monsoon rainfall triggered severe urban flooding in multiple areas of Malir District, Karachi. The incident was primarily attributed to the overflow of local drainage channels and inadequate stormwater management systems. Rapid runoff from surrounding elevated areas accumulated along residential corridors and under-construction zones, submerging roadways and low-lying settlements. Field reports indicated partial damage to boundary walls, foundations of ongoing construction, and interruption to local mobility. Poorly maintained drainage infrastructure and unregulated urban expansion further intensified inundation impacts. The event highlights the critical need for upgrading Karachi’s stormwater drainage network, enforcing land-use regulations, and integrating flood-resilient design standards in urban infrastructure to mitigate future monsoon-induced flooding risks.

Figure 29: Urban Flooding in Malir, Karachi due to Intense Monsoon Rainfall

3.4.3.5 Roof Collapse – Lyari, Karachi, Sindh (11th September 2025)

On 11th September 2025, a roof collapse incident occurred in the Lyari area of Karachi following continuous heavy rainfall during the ongoing monsoon spell. The sustained precipitation caused structural weakening of mud and brick houses in densely populated localities, leading to the partial collapse of several residential structures. The incident resulted in injuries to residents and damage to household assets. Field assessments indicated that poor construction quality, inadequate drainage around building foundations, and prolonged moisture exposure were major contributing factors. Emergency response teams from the Sindh Rescue Service and local administration promptly reached the site for debris clearance and assistance to the affected families. This event underscores the urgent requirement for enforcing structural safety standards, retrofitting vulnerable housing, and improving urban drainage in high-density settlements like Lyari to minimize future monsoon-related casualties.

Figure 30: Roof Collapse in Lyari, Karachi due to Heavy Rainfall

3.4.3.6 Mud and Thatch House Damage – Thatta (29th August 2025)

On 29th August 2024, flash flooding triggered by intense monsoon rainfall caused extensive damage to several mud and thatch houses in Thatta district. The sudden rise in water levels, following heavy downpours in surrounding catchments, inundated lowlying settlements and weakened the structural integrity of traditional housing units. Many homes constructed with local materials such as mud, reeds, and bamboo were partially or completely destroyed, displacing multiple families. Preliminary field assessments revealed that inadequate drainage, encroachments on natural waterways, and poor housing resilience were key factors contributing to the destruction. Emergency response teams facilitated immediate evacuation, provided temporary shelters, and assisted in debris clearance and relief distribution. This event highlights the pressing need for improved flood management infrastructure, enforcement of land-use planning regulations, and the promotion of resilient housing designs in flood-prone districts like Thatta to mitigate future monsoon-induced damages.

Figure 31: Mud and Thatch House Damage due to Flash Flooding Triggered by Intense Monsoon Rainfall

3.5 Gilgit Baltistan

3.5.1 Summary of Damages

A comprehensive summary of infrastructure damages across various districts of Gilgit Baltistan is presented in the table below.

Table 13: District-Wise Summary of House Damages in Gilgit Baltistan (Monsoon 2025)

Sr.	District	House Damage		
		Partial	Full	Total
1	Astore	19	4	23
2	Diamer	81	396	477
3	Ghanche	17	37	54
4	Ghizer	160	278	438
5	Gilgit	42	41	83
6	Hunza	1	14	15
7	Kharmang	16	15	31
8	Nagar	1	3	4
9	Shiger	20	22	42
10	Skardu	28	28	56

Table 14: District-Wise Summary of Bridge Damages in Gilgit Baltistan (Monsoon 2025)

Sr.	District	Bridges
1	Astore	2
2	Diamer	34
3	Ghanche	1
4	Ghizer	8
5	Gilgit	8
6	Hunza	2
7	Kharmang	2
8	Nagar	2

9	Shiger	2

3.5.2 Spatial Overview of Damages

The spatial distribution maps depict the extent of house damages across the districts of Gilgit Baltistan during the Monsoon 2025 season. The maps reveal notable variations in damage intensity, with some districts facing considerable destruction while others experienced limited impacts. Overall, the visualization highlights the uneven impact of monsoon-related damages across the region, underscoring the need for focused preparedness, risk mitigation, and recovery interventions.

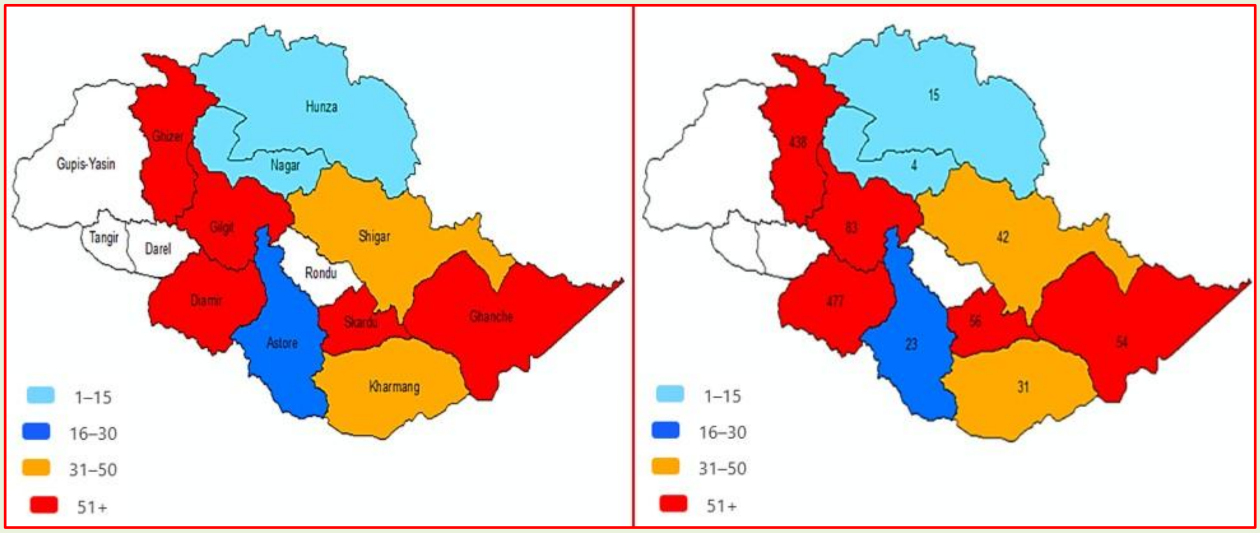


Figure 32: Spatial Distribution of House Damages Across Districts of Gilgit-Baltistan

3.5.3 Incident Details

During the Monsoon 2025 season, Gilgit Baltistan experienced a series of high-impact hydrometeorological events that caused significant damage to critical infrastructure, including roads, bridges, and riverbanks. The region’s mountainous terrain, coupled with intense rainfall episodes, glacial lake outburst floods (GLOFs), and cloud bursts, led to severe localized disasters. These incidents not only disrupted connectivity and mobility but also highlighted critical vulnerabilities in existing engineering designs and slope stabilization practices. The following subsections summarize the major incidents reported across Gilgit Baltistan during monsoon 2025, outlining their causes, impacts, and key lessons for resilient infrastructure planning.

3.5.3.1 Road Damaged at Brundubar Nullah, Hunza (16th July 2025)

A major road section at Brundubar Nullah, Hunza was severely damaged due to intense water flow during the monsoon rains. The primary cause was identified as inadequate design, where the road infrastructure lacked flood resilience. The event highlights the need for climate-responsive road engineering that considers higher rainfall intensity and changing hydrological behavior in mountainous terrain.

Figure 33: Road Damage at Brundubar Nullah, Hunza – Result of Inadequate Design

3.5.3.2 Riverbank Erosion and GLOF at Shishper (20th July 2025)

At Shishper, a Glacial Lake Outburst Flood (GLOF) on 20th July 2025 led to widespread riverbank erosion, destabilizing adjacent land and infrastructure. The erosion was primarily driven by soil saturation and instability, triggered by the sudden influx of glacial water. This incident underscores the necessity of continuous monitoring of glacial lakes and implementing protective embankments to minimize erosion risks in vulnerable valleys.

Figure 34: Riverbank Erosion and Slope Failure at Shishper Following GLOF Event

3.5.3.3 Bridge Damaged at Babusar–Chilas (21st July 2025)

A bridge near Babusar–Chilas was damaged following a cloud burst on 21st July 2025. The structural failure was linked to design deficiencies based on outdated return period calculations, which underestimated the magnitude of extreme rainfall events. This incident reflects the urgent requirement for revising engineering design standards to integrate updated hydrological data and climate projections.

Figure 35: Bridge Collapse at Babusar–Chilas Following Cloud Burst

3.5.3.4 Landslide at Babusar–Chilas (21st July 2025)

Another event in the Babusar–Chilas area on the same date involved a landslide triggered by heavy rainfall, resulting in road blockages and damage to nearby assets. The absence of retaining structures and proper slope stabilization measures exacerbated the impact.

This highlights the importance of incorporating retaining walls, drainage systems, and vegetation cover in high-risk slope areas to enhance resilience against rainfall-induced landslides.

Figure 36: Rainfall-Induced Landslide and Infrastructure Damage at Babusar–Chilas

3.5.3.5 Collapse of Multiple Houses in Gilgit (16th August 2025)

On 16th August 2025, a flash flood in Gilgit resulted in the collapse of multiple houses, leading to widespread loss of shelter and property. The primary contributing factor was the use of substandard construction materials and inadequate adherence to safety and quality standards. This event highlights the urgent need for enforcement of resilient construction practices, particularly in vulnerable riverine settlements. Strengthening local construction guidelines, conducting safety audits, and providing training to masons and local builders are essential steps to mitigate such structural failures in future flood scenarios.

Figure 37: Structural Collapse of Residential Houses in Gilgit Following Flash Flood

3.6 Azad Jammu and Kashmir

3.6.1 Summary of Damages

A comprehensive summary of infrastructure damages across various districts of Azad Jammu and Kashmir is presented in the table below.

Table 15: District-Wise Summary of House Damages in AJ&K (Monsoon 2025)

Sr.	District	House Damage		
		Partial	Full	Total
1	Bagh	109	28	137
2	Bhimber	90	5	95
3	Haveli	456	34	490
4	Jhelum Valley	124	21	145
5	Kotli	320	26	346
6	Mirpur	14	6	20
7	Muzaffarabad	82	43	125
8	Neelum	8	3	11
9	Poonch	403	103	506
10	Sudhnoti	472	70	542

Table 16: District-Wise Summary of Bridge Damages in AJ&K (Monsoon 2025)

Sr.	District	Bridges
1	Bagh	13
2	Bhimber	1
3	Haveli	2
4	Jhelum Valley	10
5	Kotli	33
6	Mirpur	8

7	Muzaffarabad	13
8	Neelum	14
9	Poonch	14
10	Sudhnoti	4

3.6.2 Spatial Overview of Damages

The spatial distribution maps illustrate the extent of house damages across the districts of Azad Jammu and Kashmir (AJK) during the Monsoon 2025 season. The maps reveal considerable variation in the severity of impacts, with some districts experiencing widespread structural damages, while others reported relatively minor effects.The visualization provides valuable insight into the uneven distribution of impacts, highlighting the regions most affected by heavy rainfall and landslide-prone conditions. Overall, the figures emphasize the importance of enhancing disaster preparedness, improving structural resilience, and adopting targeted risk reduction and recovery measures to mitigate the effects of future monsoon events in AJK.

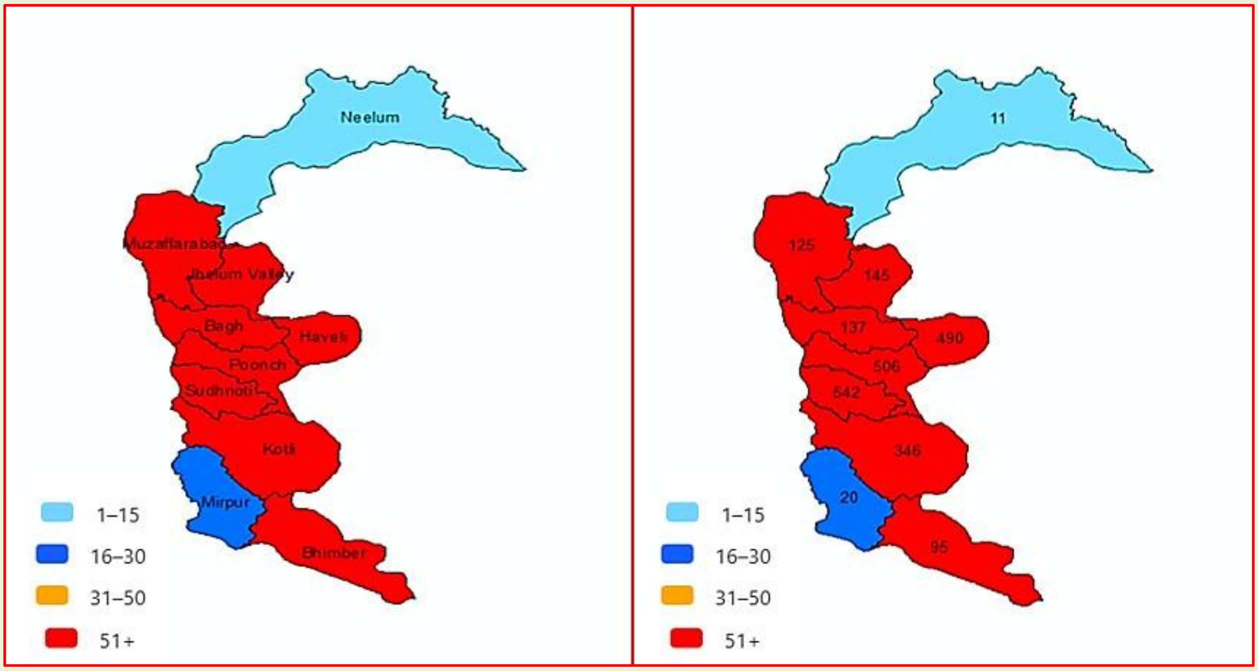


Figure 38: Spatial Distribution of House Damages Across Districts of Azad Jammu & Kashmir

3.6.3 Incident Details

During Monsoon 2025, Azad Jammu & Kashmir (AJK) experienced severe rainfall, flash floods, and landslides that caused widespread damage to infrastructure, housing, and transportation networks. The following incidents highlight key areas affected across multiple districts, underscoring the region's vulnerability to slope instability, poor construction practices, and inadequate drainage management.

3.6.3.1 Road Blockage – Pallandri (16th July 2025)

A major landslide in Pallandri led to road blockage, disrupting connectivity and isolating several local communities. The primary cause was identified as loose rocky slopes combined with a lack of slope stabilization measures, which made the terrain highly susceptible to collapse under heavy rainfall.

Figure 39: Landslide-Induced Road Blockage in Pallandri Due to Unstable Rocky Slopes

3.6.3.2 Flash Flood – Neelum (21st July 2025)

Severe flash flooding occurred in Neelum District, inundating low-lying areas and damaging roadside settlements. The event highlighted the risk of construction in floodplain zones, where poor planning and the absence of protective embankments exacerbated the impact of floodwaters.

Figure 40: Flash Flood Impact in Neelum Due to Construction within Floodplain Areas

3.6.3.3 Roof Collapse – Sudhnoti (18th July 2025)

In Sudhnoti, intense and prolonged rainfall caused several roof collapses, particularly in structures made of weak construction materials with poor structural design. The incident revealed critical shortcomings in compliance with building standards and highlighted the urgent need for reinforced roofing systems.

Figure 41: Structural Collapse of Residential Buildings in Sudhnoti Due to Weak Design and Materials

3.6.3.4 House Collapse – Muzaffarabad (22nd July 2025)

Landslides triggered by continuous rainfall caused significant damage in Muzaffarabad, including the collapse of multiple houses. The damage was linked to poor site selection, with homes built on unstable slopes without geotechnical assessment or adequate foundation stabilization.

Figure 42: Structural Collapse of a Residential Unit in Muzaffarabad Due to Poor Site Selection

3.6.3.5 Bridge Damage – Neelum (14th August 2025)

Flooding in Neelum resulted in structural failure of a key bridge, disrupting transportation links between localities. The incident pointed to inadequate design standards and the need for flood-resilient infrastructure capable of withstanding high water flow and sediment pressure.

Figure 43: Bridge Collapse in Neelum Due to Flood-Induced Structural Failure

3.6.3.6 Landslide – Sudhnoti (19th August 2025)

A series of landslides in Sudhnoti further hampered mobility and safety in the region. The main contributing factor was the lack of retaining structures along vulnerable slopes, which failed to support the terrain during periods of heavy rainfall.

Figure 44: Landslide in Sudhnoti Triggered by Heavy Rainfall and Absence of Retaining Structures

3.6.3.7 Road Erosion – Bagh (14th August 2025)

In Bagh, riverbank and road erosion caused by monsoon floods compromised the stability of vital road networks. The absence of riverbank stabilization measures allowed the floodwaters to undercut embankments, resulting in partial road washouts and accessibility challenges.

Figure 45: Road and Riverbank Erosion in Bagh Due to Absence of Stabilization Measures

3.6.3.8 House Damage – Mirpur (19th August 2025)

In Mirpur, several houses suffered partial or complete collapse due to heavy rainfall. Investigations revealed the damage was exacerbated by aged infrastructure and lack of maintenance, emphasizing the need for retrofitting and periodic inspection of older structures.

Figure 46: Structural Failure of an Aged Residential Unit in Mirpur Due to Lack of Maintenance

4. Causes of Failure

This section describes the key factors contributing to the failure of residential and communication infrastructure.

4.1 Residential Infrastructure

The post-monsoon damage assessment revealed that a considerable proportion of residential infrastructure failures during Monsoon 2025 resulted from structural deficiencies, inappropriate site selection, and poor construction practices. These failures were further aggravated by sustained rainfall, flash flooding, and subsequent waterlogging in vulnerable areas. The following analysis identifies the major engineering and planning shortcomings that contributed to widespread housing damages across multiple districts.

4.1.1 Poor Site Selection

A significant number of residential structures were found to be located in flood-prone zones, particularly along riverbeds, nullahs, and low-lying depressions with inadequate natural drainage. Settlements established in these areas were directly exposed to surface runoff and prolonged inundation during peak monsoon activity. This pattern of unregulated development demonstrates the absence of comprehensive land-use planning and enforcement of zoning regulations at the local level. The high water table and poor drainage characteristics of these areas led to persistent waterlogging, which severely compromised the load-bearing capacity of foundation soils, eventually resulting in partial or complete structural failures.

4.1.2 Inadequate Foundation Design

Field investigations indicated that a majority of damaged houses employed shallow foundation systems constructed without consideration of site-specific soil conditions. The lack of geotechnical assessment or engineering supervision led to the use of weak and moisture-sensitive soil strata as bearing layers. Under prolonged saturation, these layers experienced significant loss of shear strength, triggering settlement, tilting, or cracking of superstructures. The absence of proper foundation reinforcement and inadequate footing depth, particularly in single-storey masonry dwellings, amplified vulnerability during sustained monsoon events.

4.1.3 Foundation Soil Erosion

Prolonged floodwater exposure and unlined drainage channels caused progressive scouring and erosion of foundation soils. Houses situated near watercourses or along eroded embankments were especially prone to foundation soil erosion, where the removal of subsoil beneath the structure led to partial collapse. This phenomenon was prevalent in both urban fringe settlements and rural communities where drainage systems remain underdeveloped. Such erosion not only undermined the stability of the foundations but also induced tilting and separation of structural elements, rendering the buildings unsafe for habitation even after floodwaters receded.

Figure 47: Structural Instability Caused by Foundation Soil Erosion

4.1.4 Blocked Drainage Systems

Inadequate surface and sub-surface drainage infrastructure emerged as another major cause of structural failure. Blocked or undersized drains, combined with poor site grading, resulted in the accumulation of standing water around building perimeters. Continuous waterlogging accelerated the degradation of foundations, facilitated seepage through walls, and weakened structural joints. The problem was further intensified by debris accumulation, lack of maintenance, and unplanned urban extensions that obstructed natural water paths. The assessment emphasizes that ensuring effective stormwater drainage systems at both community and household levels is critical to reducing future damage potential.

Figure 48: Waterlogging Around Residential Structures Due to Blocked Drainage Systems

4.1.5 Ground Movement and Differential Settlement

Several affected areas experienced significant ground movement due to saturationinduced slope instability, particularly in hilly and mountainous terrain. This movement often led to horizontal displacement and settlement of residential structures. Differential settlement, caused by uneven soil consolidation beneath foundations, resulted in visible cracking, tilting, and in some cases, partial collapse of houses.

These issues underline the necessity of incorporating geotechnical studies and slopestability assessments into future construction planning.

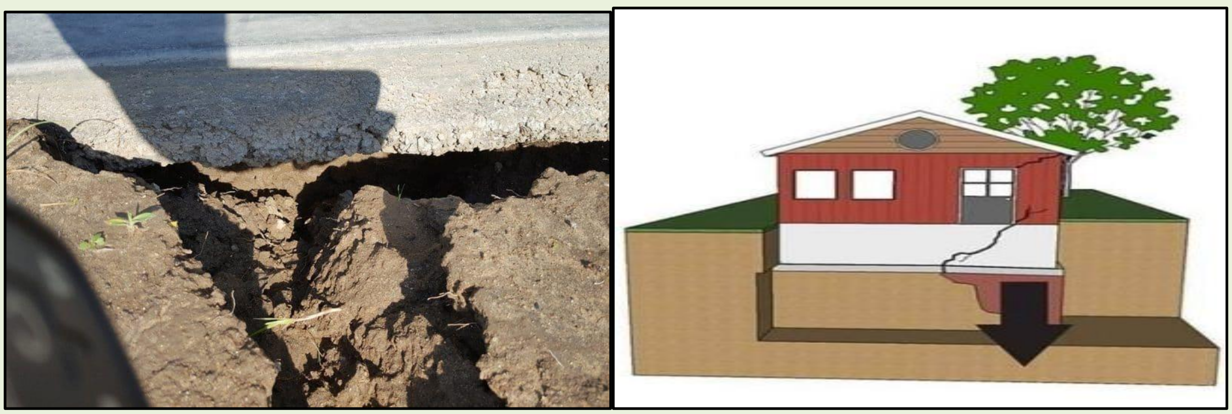


Figure 49: Left-Ground Movement and Right-Differential Settlement

4.1.6 Substandard Construction Materials

A recurring theme in the field observations was the widespread use of low-quality, nonengineered materials. Many rural and peri-urban houses were constructed using unreinforced brick masonry, mud mortar, or loosely compacted earthen blocks. Such materials lack the tensile strength and water resistance required to endure prolonged exposure to moisture and hydraulic pressure. As a result, structural elements deteriorated rapidly when subjected to sustained rainfall and flooding. Cracking, spalling, and joint failures were commonly observed, rendering structures non-repairable in many cases. The absence of standardized building codes, limited technical oversight, and cost-driven shortcuts further exacerbated this condition.

4.1.7 Lack of Proper Drainage

The absence of functional stormwater drainage systems around residential settlements was a primary factor contributing to building damage. Without adequate channels for runoff, rainwater accumulated around structures, resulting in ponding and hydrostatic pressure against walls. Continuous seepage into foundations weakened building bases and caused cracking in structural elements.

4.1.8 Soil Settlement

Sustained rainfall led to high soil saturation, significantly reducing the ground's bearing capacity. The softened subsoil beneath foundations caused differential settlement, leading to wall cracking and in some cases partial collapse of structures. Houses built on soft alluvial soils or un-engineered fill were especially prone to such settlement-related failures during the monsoon period.

Figure 50: Ground Cracking and Structural Instability Due to Soil Settlement

4.1.9 Encroachments on Natural Waterways

Unregulated construction along natural drainage paths and floodplains exacerbated flood impacts. These encroachments obstructed natural water flow, creating backflow and concentrated hydraulic pressure against residential structures. The diversion of runoff into populated areas intensified erosion and flooding, leading to greater structural damage and foundation instability.

4.1.10 Inadequate Drainage Planning

Improper drainage planning, including insufficient slope design and lack of runoff management channels, allowed stormwater to stagnate near building foundations. The resulting prolonged exposure to moisture caused wall seepage, material deterioration, and weakening of substructures. Many settlements lacked coordinated municipal drainage layouts, further amplifying local flooding effects.

Figure 51: Water Accumulation and Structural Deterioration Due to Inadequate Drainage Planning

4.1.11 Foundation Failure and Structural Cracking

The combined influence of poor drainage, soil instability, and waterlogging triggered widespread foundation failures. Structural inspections revealed prominent wall cracks, floor settlement, and in some instances, complete structural failure due to compromised load-bearing capacity. Areas affected by prolonged submersion or recurring seepage showed accelerated structural degradation.

Figure 52: Foundation Failure and Structural Cracking Caused by Poor Drainage and Soil Instability

4.2 Communication Infrastructure

The Monsoon 2025 events exposed significant vulnerabilities in Pakistan's communication infrastructure, particularly in road networks, culverts, causeways, and bridges. Multiple structural failures were recorded across various provinces, primarily resulting from hydrological stresses, design inadequacies, and insufficient maintenance of drainage systems. The observed damages were not isolated but reflected systemic weaknesses in design standards, river training works, and slope protection measures.

4.2.1 Design and Structural Deficiencies

A number of bridge and culvert failures were traced back to design limitations. In several instances, structures were unable to withstand high transverse and torsional stresses induced by peak monsoon flows. The lack of consideration for combined load conditions—bending, shear, and bearing—led to premature distress in superstructures and girders. The inadequacy of structural redundancy and poor detailing further exacerbated vulnerability during prolonged submersion and high-velocity flow conditions.

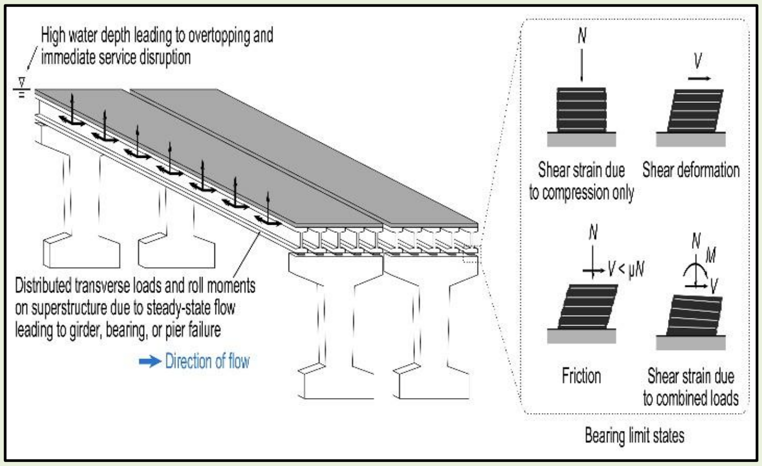


Figure 53: Structural Behavior and Failure Mechanisms Due to Design Deficiencies in Bridge Systems

4.2.2 Poor Drainage and Undersized Structures

In numerous sites, undersized drainage structures such as culverts and causeways were found insufficient to accommodate peak flood discharges. This led to overtopping, structural choking, and the redirection of floodwaters onto adjacent embankments and road surfaces. Blocked drainage channels and silted waterways compounded the issue, causing prolonged inundation and accelerated deterioration of pavement and subgrade layers. The lack of routine inspection and debris clearance was a recurring deficiency.

Figure 54: Urban Flooding Resulting from Poor Drainage and Undersized Hydraulic Structures

4.2.3 Inadequate River Training Works

Failures of bridge piers and abutments were closely linked with inadequate river training and protection works. The absence of guide bunds, stone spurs, and embankment reinforcement allowed river currents to erode supporting foundations. This pier and abutment scouring phenomenon was particularly evident at sites in Havelian (Khyber Pakhtunkhwa) and similar riverine crossings, where intense flow velocities undercut bridge supports, resulting in partial collapses and structural instability.

Figure 55: Structural Failures Due to Inadequate River Training and Scouring at Bridge Piers and Abutments

4.2.4 Slope Instability and Poor Site Conditions

In mountainous and hilly regions, slope instability emerged as a major cause of road and bridge failures. Roads constructed on steep embankments without protective measures—such as retaining walls, gabion works, or stone pitching—were prone to washouts and landslides during heavy rainfall. The combination of weak geological formations and uncontrolled runoff significantly increased the frequency of embankment failures, cutting off critical communication links during the monsoon period.

4.2.5 Sedimentation and Debris Load

Heavy siltation, boulders, and tree debris transported by monsoon floods caused extensive clogging of culverts and drainage channels. This sediment and debris accumulation obstructed water flow, increasing hydrostatic pressure on structures and leading to the collapse of culvert wing walls and damage to bridge piers. In several districts, the blockage of hydraulic channels diverted floodwater onto road surfaces, worsening erosion and transport disruption.

Figure 56: Structural Impacts of Sedimentation and Debris Load on Bridge and Culvert Systems

4.2.6 Soil Erosion and Landslide Impacts

Persistent rainfall triggered soil erosion and slope failures, particularly along unprotected embankments and mountainous road sections. Erosion undermined bridge abutments and road foundations, while landslide debris buried road corridors and drainage systems.

These erosive processes not only disrupted connectivity but also increased the maintenance burden and risk of future structural instability.

Figure 57: Road and Infrastructure Damage Caused by Soil Erosion and Landslide Deposition

4.2.7 Aging Infrastructure and Design Deficiencies

A substantial portion of Pakistan's rural bridges and road networks remain outdated and under-designed for current hydrological and hydraulic loads. Many structures were constructed decades ago without accounting for the increased rainfall intensity and sediment load patterns now being experienced. The lack of modern design standards, reinforced materials, and hydrological modeling has rendered these assets particularly vulnerable during extreme weather events.

4.2.8 Unregulated Sand and Gravel Mining

Uncontrolled extraction of sand and gravel from riverbeds near bridge foundations has exacerbated scouring and weakened structural supports. This practice has lowered riverbed levels, exposed foundations, and accelerated the rate of erosion around critical infrastructure elements. The degradation of natural river channels due to mining has further intensified the vulnerability of bridges and culverts to flood-induced failure.

Figure 58: Unregulated river sand mining: a tale of survival, profit, and environmental loss

Figure 59: Accumulated sand from unregulated extraction activities, indicating unsustainable mining practices

5. Recommendations

This section outlines key recommendations to enhance infrastructure resilience and prevent future failures.

5.1 Residential Infrastructure

The widespread damage to residential structures during Monsoon 2025 revealed persistent weaknesses in building design, material quality, and construction practices across flood- and landslide-prone regions. To enhance resilience and minimize future monsoon-related housing losses, the following technical and structural measures are recommended for implementation at both community and policy levels.

5.1.1 Structural and Material Improvements

- **Cementitious and Bituminous Waterproofing** Application of cement-based waterproofing and bituminous coatings is essential to reduce water ingress into walls and foundations. These materials significantly enhance the durability of masonry structures under prolonged rainfall and high groundwater conditions.

Figure 60: Application of Cementitious Waterproofing for Enhanced Structural Durability

- **Pre-Cast and Pre-Fabricated Construction**

  Promotion of pre-cast or pre-fabricated housing systems should be prioritized to enable faster, standardized, and flood-resilient construction. These methods minimize on-site curing and improve the structural integrity of dwellings during adverse weather.

Figure 61: Pre-Cast Structural Systems for Rapid and Resilient Construction

- **Reinforced Load Distribution Systems**

  Introducing band beams and vertical columns in masonry construction can effectively distribute seismic and hydrological stresses. This measure is particularly beneficial in hilly terrain and flood-affected districts where unreinforced masonry structures are highly vulnerable.

Figure 62: Reinforced Band Beams and Columns for Load Distribution in Masonry Structures

- **Structural Crack Restoration**

  The use of epoxy injection techniques for repairing cracks can help restore structural continuity and prevent progressive damage in partially affected houses. This low-cost rehabilitation approach extends the life of existing housing stock.

Figure 63: Epoxy Injection for Structural Crack Rehabilitation

5.1.2 Design and Elevation Measures

- **Pitched or Sloped Roofs**

  Adoption of sloped or pitched roofing systems is recommended to facilitate drainage and prevent rainwater accumulation. This design adaptation substantially reduces seepage and material degradation.

Figure 64: Sloped and Pitched Roofing Systems for Improved Rainwater Drainage

- **Reinforcement of Traditional Structures**
  Strengthening adobe and timber-based houses with additional reinforcement materials such as wire mesh or bamboo framing can enhance structural resistance against water stagnation and lateral loads.

Figure 65: Reinforcement of Traditional Housing Structures Using Timber and Masonry Techniques

- **Elevated Housing in Flood-Prone Areas**
  In low-lying floodplains, residential structures should be constructed on raised plinths or stilts to minimize direct exposure to inundation. Elevated housing reduces asset loss and displacement during recurrent flooding.

Figure 66: Elevated Housing on Stilts for Flood-Resilient Construction in Low-Lying Areas

- **Use of CGI Sheet Roofing**
  Lightweight corrugated galvanized iron (CGI) sheets offer a durable, cost-effective, and easily replaceable roofing solution suitable for rural and semi-urban areas. These roofs improve runoff efficiency and provide better resistance to storm-related impacts.

5.2 Communication Infrastructure

The Monsoon 2025 season caused extensive damage to Pakistan's communication infrastructure, including roads, bridges, and culverts, primarily due to slope failures, scouring, and inadequate drainage capacity. Strengthening these lifeline networks requires both engineering interventions and regular maintenance to ensure system resilience against future hydrometeorological events.

5.2.1 Slope Stabilization and Erosion Control

To prevent embankment failure and landslide-induced blockages, it is essential to adopt robust slope protection techniques:

- **Construction of Retaining Walls, Soil Nailing, and Ground Anchoring**

  These measures should be implemented along steep road corridors and embankments to stabilize loose soil layers and prevent slope slippages. Ground anchor walls are particularly effective in areas with weak strata or high rainfall exposure.

Figure 67: Slope Stabilization Techniques – Construction of a Retaining Wall (left) and Application of Soil Nailing (right) for Slope Reinforcement.

- **Riprap Bracing and Shotcreting on Riverbanks and Slopes**

  The use of riprap stone pitching and concrete shotcreting should be expanded along river-adjacent roads and bridge approaches to resist erosion and enhance slope durability.

Figure 68: Ground Anchor Wall with Riprap and Shotcrete Slope Stabilization

- **Improvement of Stormwater Drainage Systems**
  Regular maintenance and de-silting of roadside and bridge drainage networks are necessary to prevent waterlogging, surface erosion, and structural degradation of transport corridors.

5.2.2 Hydraulic and Structural Capacity Enhancement

The hydraulic performance and structural integrity of bridges and culverts require systematic upgrades to withstand monsoon-induced discharges:

- **Construction of Adequately Designed Culverts and Aqueducts**
  All new culverts and aqueducts should be designed with sufficient hydraulic capacity to accommodate peak flood flows. Existing structures with inadequate discharge capacity must be retrofitted to avoid overtopping and road washouts.

Figure 69: Culverts and Aqueducts for Hydraulic Capacity Enhancement

- **Scour Protection at Bridge Piers and Abutments**
  Installation of concrete block armoring or gabion mattresses around bridge piers is recommended to prevent foundation scouring, undermining, and potential collapse during high-velocity flows.

Figure 70: Scour Protection Using Concrete Block Armoring Around Bridge Piers

- **Integrated Slope and Drainage Design for Roads**
  Road alignment in hilly and flood-prone areas should incorporate slope stabilization elements and engineered drainage systems to reduce surface runoff concentration and minimize structural stress during heavy rainfall.

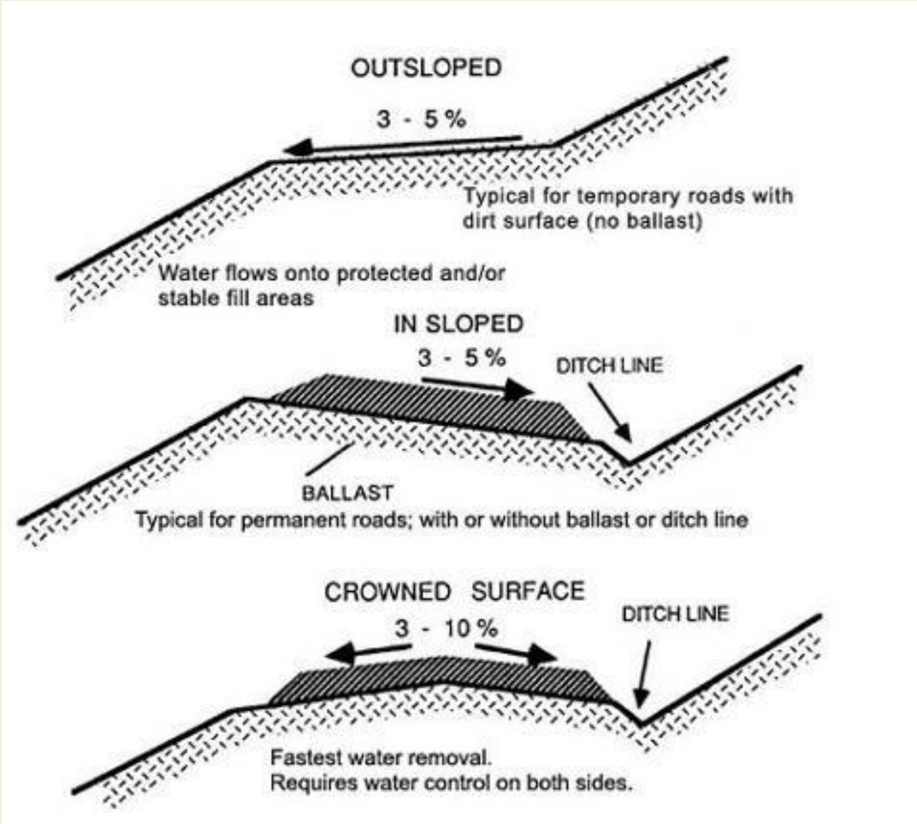


Figure 71: Types of Road Surface Slopes for Effective Drainage Control

6. Conclusion

The Monsoon 2025 season in Pakistan once again highlighted the country's high exposure to hydrometeorological hazards and the resulting vulnerability of its built environment. The nationwide post-monsoon assessment conducted by the National Disaster Management Authority (NDMA) provides a clear and data-driven understanding of the magnitude, distribution, and nature of infrastructure damages across all provinces and regions. This report not only serves as an evaluative document but also as a critical policy instrument for guiding future planning, mitigation, and reconstruction strategies.

The assessment reveals that while the intensity of the monsoon events varied geographically, the underlying causes of infrastructure failure were largely systemic—stemming from inadequate design standards, poor maintenance regimes, nonengineered construction practices, and unregulated land use in hazard-prone zones. The widespread damage to roads, bridges, and housing structures across Khyber Pakhtunkhwa, Gilgit-Baltistan, Azad Jammu & Kashmir, Punjab, Sindh, and Balochistan underscores the urgent need to integrate resilience thinking into every stage of infrastructure development.

The analysis further emphasizes that climate change is intensifying the scale and frequency of extreme rainfall events, requiring immediate adaptation in both design and policy. Hydrological and geotechnical assessments must become mandatory components of project feasibility studies, particularly for public infrastructure in high-risk zones. Moreover, the enforcement of provincial and national building codes must be strengthened to ensure that residential and public structures adhere to minimum safety standards. Strengthening local governance, promoting community awareness, and building technical capacity among local engineers and masons will play a decisive role in reducing recurrent losses.

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