

Supplementary material

Table: Landslide events, casualties reported in the study area since 2005 [1]

Location	Description	Event	Fatalities	Source
Hattian	Massive Rock Slide	2005 KEQ	595	[1,2]
Phal Jhelum Valley	Burial in Landslide	2005 KEQ	250	[2]
Chal pani (10 km from Muzaffarabad)	Bus buried by Rock Fall	2005 KEQ	13	[2]
Chela Bandi, Muzaffarabad	Persons were killed in landsliding	July 23, 2006	13	News report [3]
Doonga Kas (7 km from Muzaffarabad)	Young deputy commissioner of district Neelum, was killed by a landslide	February 28, 2013 and September 25, 2016	17	
Lahorgali, Muzaffarabad	jeep was buried beneath the landslide	March 21, 2014	02	News Paper
Sarli Sacha Sharqi village (41 km from Muzaffarabad)	Rock fall hit around half dozen houses	March 19, 2016	06	News Paper
Danna-Sahotar	113 houses destroyed	February 2016		News Paper
Kohala landslide along Kohala road	Road was destroyed and remained closed for 4 days	March 27, 2014		News Paper
Kulian landslide	Kohala road has been blocked for 1day	March 2016	01	News Paper
Chela Bandi, Muzaffarabad	Neelum road has been blocked	February 04, 2021		News Paper
Makri landslide, Muzaffarabad	01 house completely destroyed	February 27, 2021		News Paper
Kulian Bazar landslide	Road damaged	March 28, 2020		News Paper
Ghori landslide along Neelum Valley road	Road damage	July 30, 2021		News Paper

Table: Pairwise comparison matrix scale after Saaty, 2008.

Pair-wise comparison 9-point rating scale

Importance	Definition	Explanation
1	Equal importance	Contribution to objective is equal
3	Moderate importance	Attribute is slightly favored over another
5	Strong importance	Attribute is strongly favored over another
7	Very strong importance	Attribute is very strongly favored over another
9	Extreme importance	Evidence favoring one attribute is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed

Causative factor	Roads	Class	Area, Km ²	No. of landslides	W ⁺	W ⁻	Contrast	Weight
Slope	Neelum Valley	0–10	16.01	1	–2.71	0.17	–2.88	–2.71
		11–20	14.66	6	–0.79	0.09	–0.89	–0.79
		21–30	23.76	11	–0.67	0.14	–0.81	–0.67
		31–40	30.69	40	0.46	–0.26	0.73	0.46
		41–50	15.10	28	0.88	–0.24	1.12	0.88
		51–60	2.58	2	–0.12	0.00	–0.12	0.19
		61–70	0.34	1	1.50	–0.01	1.51	0.12
		>70	0.02	0	0.00	0.00	0.00	–2.70
	Jhelum Valley	0–10	13.02	0	0.00	0.00	0.00	–0.45
		11–20	10.90	4	–0.88	0.18	–1.05	–0.28
		21–30	11.61	12	0.23	–0.09	0.32	0.45
		31–40	7.53	17	1.16	–0.44	1.60	1.16
		41–50	1.98	4	1.02	–0.07	1.09	1.02
		51–60	0.32	1	1.61	–0.02	1.63	1.61
		> 60	0.03	0	0.00	0.00	0.00	–0.45
	Kohala road	0–10	9.36	1	–2.11	0.15	–2.26	–2.11
		11–20	16.50	8	–0.56	0.14	–0.70	–0.56
		21–30	23.01	30	0.52	–0.43	0.95	0.52
		31–40	12.85	10	–0.05	0.01	–0.06	–0.04
		41–50	2.92	4	0.58	–0.04	0.62	–0.06
		51–60	0.31	0	0.00	0.00	0.00	–0.12
		>60	0.02	0	0.00	0.00	0.00	–0.12
Aspect	Neelum Valley	N	18.54	11	–0.40	0.07	–0.48	–0.40
		NE	12.42	6	–0.62	0.06	–0.69	–0.62
		E	12.23	19	0.67	–0.12	0.79	0.67
		SE	13.15	16	0.38	–0.07	0.45	0.38
		S	12.80	16	0.41	–0.07	0.49	0.41
		SW	12.33	12	0.13	–0.02	0.15	–0.09
		W	9.15	5	–0.49	0.04	–0.53	–0.09
		NW	12.52	4	–1.05	0.09	–1.14	–1.05
	Jhelum Valley	N	10.24	7	–0.22	0.06	–0.28	0.31
		NE	9.02	12	0.52	–0.17	0.69	0.52
		E	3.71	5	0.53	–0.06	0.59	0.12
		SE	2.07	3	0.62	–0.04	0.66	0.02
		S	6.27	3	–0.60	0.07	–0.67	0.01
		SW	7.64	4	–0.50	0.08	–0.58	0.12
		W	3.70	1	–1.19	0.06	–1.26	–0.12
		NW	2.72	3	0.30	–0.02	0.33	0.09
	Kohala road	N	7.49	1	–1.88	0.11	–2.00	–1.88
		NE	9.82	6	–0.31	0.05	–0.36	0.90
		E	9.39	7	–0.10	0.02	–0.11	0.10
		SE	4.94	4	–0.01	0.00	–0.01	0.03
		S	7.04	3	–0.69	0.06	–0.75	0.11
		SW	11.26	11	0.20	–0.05	0.24	0.20
		W	9.45	12	0.49	–0.11	0.60	0.49
		NW	5.59	9	0.77	–0.10	0.88	0.77

Elevation	Neelum Valley	621–771	18.05	14	–0.12	0.02	–0.14	–0.03
		772–921	23.22	40	0.79	–0.37	1.16	0.79
		922–1,071	25.99	27	0.21	–0.08	0.28	–0.03
		1,072–1,221	18.74	3	–1.76	0.18	–1.94	–1.76
		1,222–1,371	9.97	3	–1.11	0.07	–1.19	–1.11
		1,372–1,521	4.47	2	–0.70	0.02	–0.73	–0.03
		1,522–1,671	1.95	0	0.00	0.00	0.00	–0.03
		1,672–1,821	0.42	0	0.00	0.00	0.00	–0.03
		1,822–1,971	0.24	0	0.00	0.00	0.00	–0.03
		>1,971	0.11	0	0.00	0.00	0.00	–0.03
	Jhelum	632	0.15	0	0.00	0.00	0	–2.39
	Valley road	633–732	10.38	11	0.26	–0.09	0.35	1.39
		733–832	15.13	12	–0.06	0.03	–0.09	1.12
		833–932	9.30	6	–0.28	0.06	–0.34	0.33
		933–1,032	5.19	6	0.36	–0.05	0.41	0.39
		1,033–1,132	2.90	3	0.23	–0.02	0.25	0.21
		1,133–1,232	1.40	0	0.00	0.00	0	–2.39
		1,233–1,332	0.63	0	0.00	0.00	0	–2.39
		>1,332	0.30	0	0.00	0.00	0	–2.39
	Kohala road	537–687	24.05	36	0.68	–0.72	1.40	0.68
		688–837	26.70	11	–0.73	0.33	–1.05	–0.73
		838–987	11.64	6	–0.49	0.08	–0.58	–0.49
		988–1,137	2.44	0	0.00	0.00	0	–3.98
		>1,137	0.15	0	0.00	0.00	0	–3.98
Curvature	Neelum	Concave	40.98	43	0.22	–0.17	0.38	0.22
	Valley road	Convex	62.24	46	–0.17	0.22	–0.38	–0.17
	Jhelum	Concave	9.90	13	0.50	–0.19	0.69	0.50
	Valley road	Convex	35.49	25	–0.19	0.50	–0.69	–0.19
	Kohala road	Concave	25.16	20	–0.03	0.02	–0.05	1.42
		Convex	39.82	33	0.02	–0.03	0.05	1.32
Landcover	Neelum	Water Bodies	5.16	1	–1.56	0.04	–1.61	–1.56
	Valley road	Forest	28.82	9	–1.07	0.24	–1.32	–1.07
		Grass Land	38.45	19	–0.59	0.25	–0.84	–0.59
		Barren Land	12.83	49	1.88	–0.71	2.59	1.88
		Urban Land	17.63	11	–0.35	0.06	–0.41	–0.38
	Jhelum	Water Bodies	3.50	2	–0.41	0.03	–0.44	0.06
	Valley road	Forest	18.64	11	–0.38	0.21	–0.59	–0.38
		Grass Land	9.04	7	–0.09	0.02	–0.11	0.06
		Barren Land	7.07	16	1.16	–0.41	1.57	1.16
		Urban Land	7.05	2	–1.14	0.13	–1.27	–1.14
	Kohala road	Water Bodies	10.58	2	–1.53	0.15	–1.68	–1.53
		Forest	3.35	1	–1.06	0.04	–1.10	0.28
		Grass Land	16.50	12	–0.13	0.04	–0.17	0.18
		Barren Land	10.28	22	1.12	–0.39	1.51	1.12
		Urban Land	24.11	16	–0.23	0.12	–0.34	0.38
Distance to roads	Neelum	50	5.75	32	2.59	–0.42	3.01	2.59
	Valley road	100	5.54	7	0.43	–0.03	0.46	0.01
		150	5.39	3	–0.47	0.02	–0.49	0.03
		200	5.30	4	–0.14	0.01	–0.15	0.02
		>200	81.38	43	–0.52	1.03	–1.56	–0.52
		50	2.18	9	2.04	–0.24	2.28	2.04

Distance to Faults	Jhelum	100	2.19	2	0.10	−0.01	0.10	0.02
	Valley road	150	2.20	4	0.89	−0.07	0.96	0.89
	Kohala road	200	2.21	1	−0.65	0.03	−0.68	0.02
		>200	36.71	22	−0.36	0.89	−1.25	−0.36
		50	3.36	20	2.80	−0.45	3.26	2.80
		100	3.29	4	0.45	−0.03	0.47	0.01
		150	3.29	7	1.11	−0.10	1.21	1.11
		200	3.27	1	−1.03	0.04	−1.07	0.01
		>200	51.78	21	−0.74	1.28	−2.02	−0.74
	Neelum	100	3.28	1	−1.10	0.02	−1.12	−0.87
	Valley road	200	3.20	2	−0.35	0.01	−0.36	−0.67
	300	3.16	1	−1.06	0.02	−1.08	−0.58	
	400	3.12	1	−1.05	0.02	−1.07	−0.77	
	500	3.01	1	−1.01	0.02	−1.03	−0.87	
	>500	87.38	83	0.11	−0.87	0.98	0.11	
	Jhelum	100	3.76	1	−1.21	0.07	−1.27	−0.01
	Valley road	200	3.75	1	−1.20	0.07	−1.27	−0.01
	300	3.85	3	−0.08	0.01	−0.09	−0.21	
	400	3.76	2	−0.49	0.04	−0.52	−0.11	
	500	3.61	4	0.31	−0.03	0.34	0.11	
	>500	26.66	27	0.21	−0.38	0.59	0.21	
	Kohala road	100	6.72	8	0.42	−0.06	0.48	0.53
	200	6.51	2	−1.03	0.07	−1.10	0.27	
	300	6.29	6	0.18	−0.02	0.20	0.03	
	400	5.92	6	0.24	−0.03	0.27	0.02	
	500	5.54	5	0.11	−0.01	0.12	0.01	
	>500	34.18	26	−0.07	0.08	−0.15	−1.03	
Distance to Streams	Neelum	50	18.00	15	−0.04	0.01	−0.04	0.57
Valley road	100	15.05	24	0.70	−0.17	0.87	0.70	
150	14.58	15	0.20	−0.04	0.23	0.07		
200	12.75	16	0.42	−0.07	0.49	0.42		
>200	42.98	19	−0.71	0.33	−1.04	−0.71		
Jhelum	50	8.06	10	0.44	−0.12	0.56	0.44	
Valley road	100	7.27	9	0.44	−0.10	0.54	0.42	
150	6.18	6	0.16	−0.03	0.19	0.16		
200	5.42	1	−1.58	0.11	−1.69	−1.58		
>200	18.56	12	−0.28	0.16	−0.44	0.16		
Kohala road	50	10.79	18	0.81	−0.25	1.06	0.81	
100	9.80	7	−0.14	0.02	−0.17	−0.58		
150	8.93	9	0.23	−0.04	0.27	−0.38		
200	8.07	8	0.21	−0.03	0.25	−0.08		
>200	27.38	11	−0.75	0.35	−1.10	−0.75		
Geology	Neelum	Murree Fm	59.29	40	−0.26	0.28	−0.55	−0.26
Valley road	Abbotabad Fm	0.98	2	1.00	−0.01	1.02	−0.23	
Surficial Deposits	13.23	5	−0.88	0.09	−0.96	−0.88		
Hazara Fm	14.02	20	0.57	−0.12	0.69	0.57		
Muzaffarabad Fm	5.35	16	1.51	−0.16	1.67	1.51		
Stream channel	0.32	0	0.00	0.00	0.00	−0.03		
Deposits	Palaeocene–Eocene	1.49	1	−0.27	0.00	−0.27	−0.02	
		1.48	0	0.00	0.00	0.00	−0.01	

TWI	Jhelum Valley road	Noseri Granite							
		Gneisses							
		Panjal Meta	2.29	2	0.02	0.00	0.02	−0.23	
		Sediments							
		Panjal Volcanics	3.08	1	−1.03	0.02	−1.05	−0.01	
		Tanol Fm	1.81	2	0.27	−0.01	0.28	−0.02	
		Quaternery Deposits	18.63	6	−1.01	0.39	−1.40	−1.01	
		Kamlial Formation	6.85	8	0.37	−0.08	0.45	−0.07	
		Murree Formation	19.68	24	0.42	−0.46	0.88	0.42	
		Hazara Formation	0.34	0	0.00	0.00	0.00	−0.07	
		Kohala road	Nagri Formation	16.97	22	0.52	−0.25	0.77	0.52
		Murree Formation	34.84	23	−0.23	0.22	−0.45	−0.23	
	Hazara Formation	13.17	8	−0.32	0.07	−0.39	0.07		
	Neelum	<7	20.91	20	0.11	−0.03	0.15	−0.04	
	Valley road	7–10	54.71	53	0.13	−0.16	0.29	0.13	
	10–13	17.57	12	−0.25	0.05	−0.30	−0.03		
	>13	10.03	4	−0.82	0.06	−0.88	−0.82		
	Jhelum	<7	5.75	8	0.57	−0.11	0.68	−0.05	
	Valley road	7–10	23.79	22	0.11	−0.13	0.24	0.57	
	10–13	10.22	8	−0.07	0.02	−0.09	0.17		
	>13	5.63	0	0.00	0.00	0.00	−0.09		
	Kohala road	<7	10.06	8	−0.03	0.00	−0.03	0.09	
	7–10	34.84	35	0.23	−0.34	0.56	0.23		
	10–13	13.26	8	−0.32	0.07	−0.40	0.09		
	>13	6.81	2	−1.08	0.08	−1.16	−1.08		
	NDVI	Neelum	−0.1–0.09	5.45	10	0.87	−0.07	0.94	0.87
		Valley road	0.09–0.2	20.15	51	1.28	−0.68	1.95	1.28
		0.2–0.3	54.27	24	−0.72	0.49	−1.20	−0.72	
0.3–1		23.12	4	−1.68	0.23	−1.91	−1.68		
Jhelum		< 0	16.86	12	−0.18	0.09	−0.27	0.09	
Valley road		0–0.5	19.70	10	−0.54	0.29	−0.83	−0.54	
0.5–1		8.76	16	0.89	−0.36	1.25	0.89		
Kohala road		−0.06–0.09	2.47	1	−0.74	0.02	−0.77	−0.16	
0.09–0.2		6.34	12	0.97	−0.17	1.13	0.97		
0.2–0.3		35.44	33	0.14	−0.20	0.34	−0.16		
0.3–0.5		20.65	7	−0.93	0.27	−1.20	−0.93		

References

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