

Supplementary Material

Flood Hazard Assessment for the Tori Levee Breach of the Indus River Basin, Pakistan

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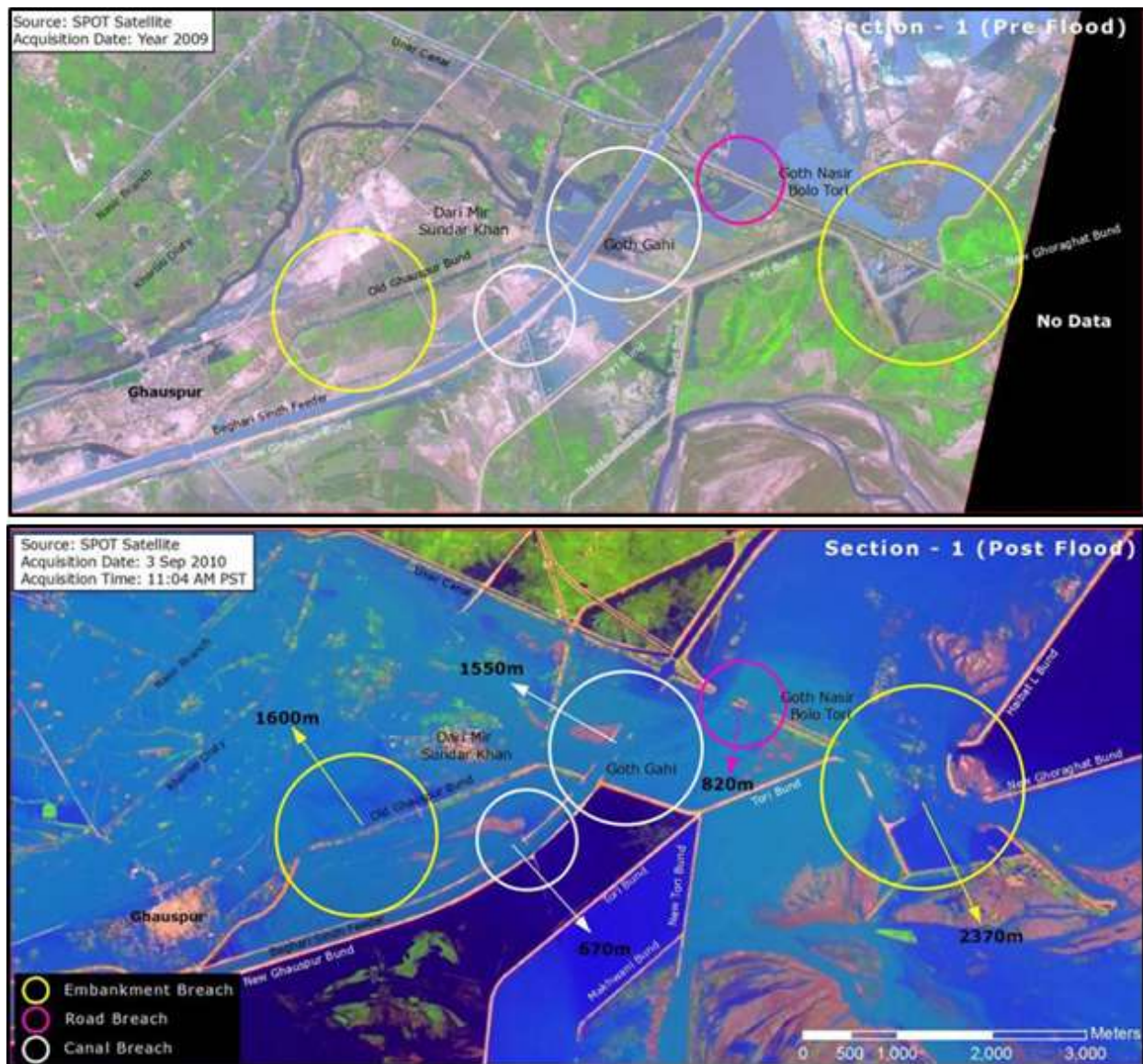


Figure S1. Pre-flood (top), post-flood or breached (bottom) situation of Tori Levee images obtained from SPOT.

Storage Area Connection Breach Data

SA Connection: ConEscape ↓ ↑ Delete this Breach ... Delete all Breaches ...

☒ **Breach This Structure**

Breach Method: User Entered Data

Center Station: 1400

Final Bottom Width: 1000

Final Bottom Elevation: 69.13

Left Side Slope: 80

Right Side Slope: 80

Breach Weir Coef: 1.8

Breach Formation Time (hrs): 168

Failure Mode: Overtopping

Piping Coefficient: 0.5

Initial Piping Elev:

Trigger Failure at: WS Elev

Starting WS: 71.34

Breach Plot | Breach Progression | **Simplified Physical** | Breach Repair (optional) | Parameter Calculator

Input Data

Top of Dam Elevation (m): 72 Breach Bottom Elevation (m): 69.13

Pool Elevation at Failure (m): 71.34 Pool Volume at Failure (1000 m3): 33900000

Failure mode: Overtopping

MacDonald

Dam Crest Width (m): 1400 Slope of US Dam Face Z1 (H:V): 80

Earth Fill Type: Non-homogeneous or Rockfill Slope of DS Dam Face Z2 (H:V): 80

Xu Zhang (and Von Thun)

Dam Type: Dam with corewall Dam Erodibility: Medium

Method	Breach Bottom Width (m)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	1369	0.5	5.38	Select
Frehlich (1995)	718	1.4	374.75	Select
Frehlich (2008)	855	1	359.61	Select
Von Thun & Gilete	59	0.5	0.29	Select
Xu & Zhang	182	7.48	167.55 *	Select

* Note: the breach development time from the Xu Zhang equation includes more of the initial erosion period and post erosion than what is used in the HEC-RAS breach formation time.

Figure S2. Estimation of dam crest width using Xu and Zhang method for Tori Levee breach.

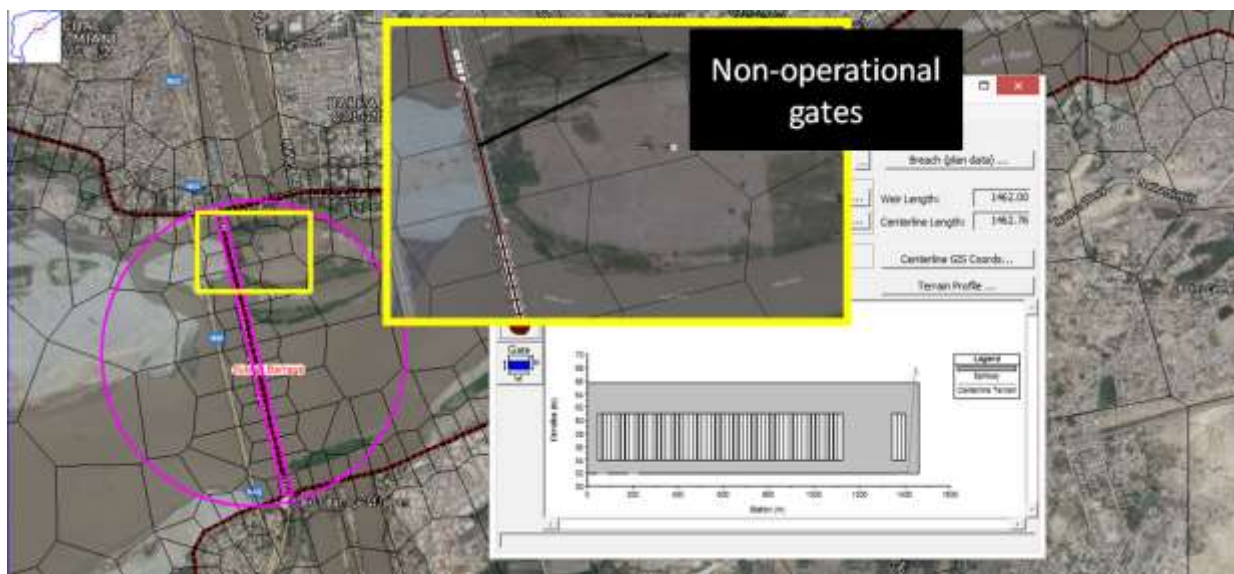
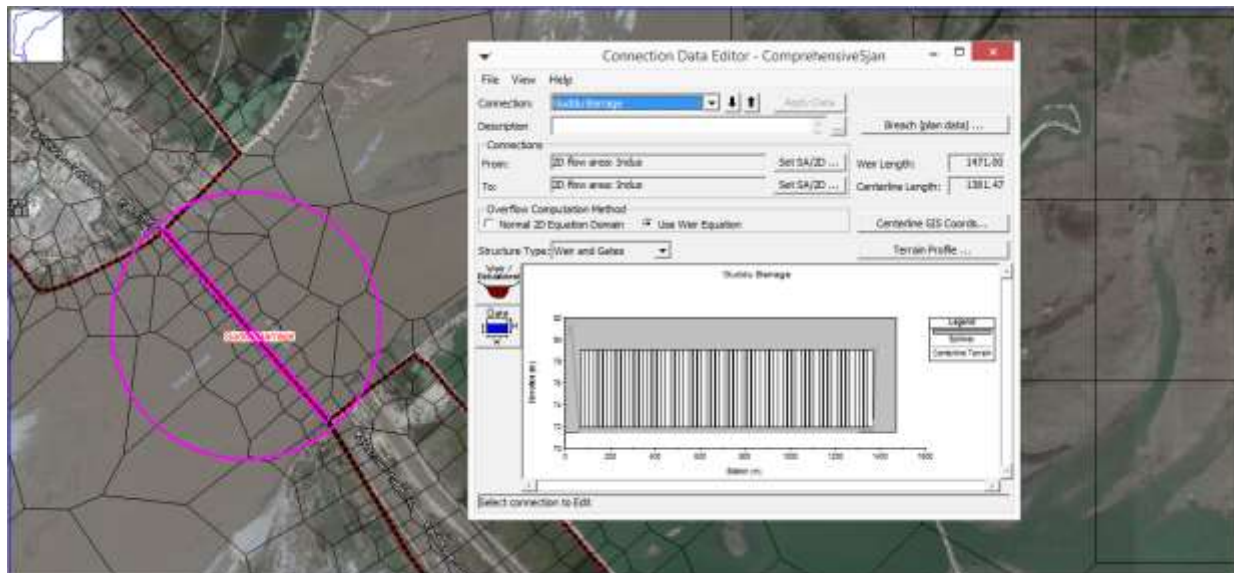


Figure S3. Design of Guddu Barrage structure in HEC-RAS. Upper Figure shows the modelling of gates at Guddu Barrage, low Figure shows operational and non-operational gates at Guddu Barrage.

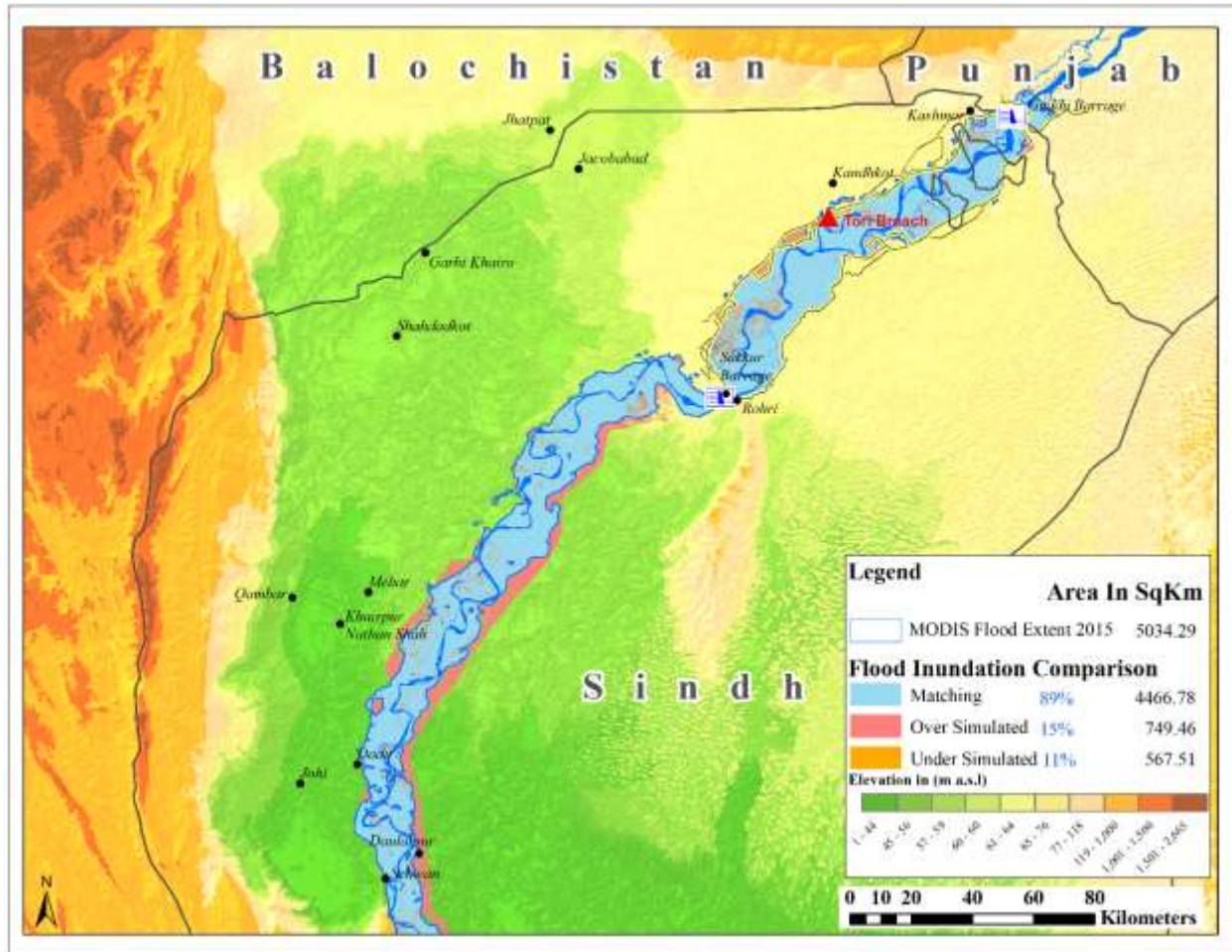


Figure S4. The validation of HEC-RAS model for maximum flood inundation comparison of 2015 flood map by comparing remotely sensed and simulated flood extents.

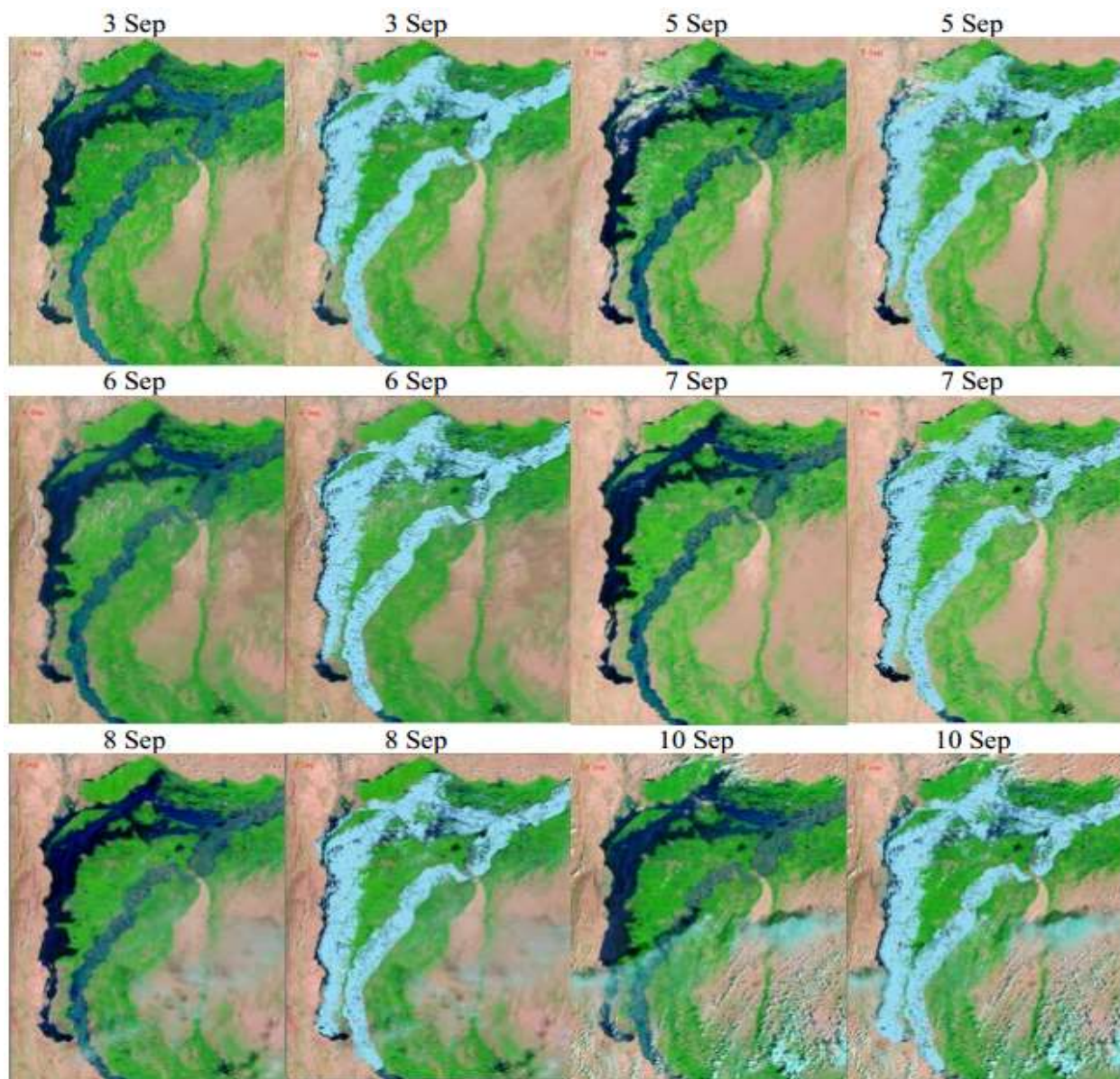


Figure S5. Sample comparison of flood extent in flood plain between MODIS daily images and simulated by HEC-RAS model during 03 to 12 September 2010 flood.

Table S1. Comparison of daily observed and simulated flood extents based on MODIS images of the 2010 flood event.

Date	MODIS Flood Extent	Simulated Flood Extent	Matching Area “M”	Over Simulated “O”	Under Simulate “U”	Matching Area	Over Simulation	Under Simulation	Measure of Fit “F”
Area in km ²						Percentage			
10-Aug	5136.0	5914.9	4190.7	1724.1	945.2	82%	34%	18%	61%
11-Aug	5421.4	6197.9	4463.5	1734.5	957.9	82%	32%	18%	62%
12-Aug	5426.0	6467.9	4086.0	2381.9	1339.9	75%	44%	25%	52%
13-Aug	6719.5	6768.6	5359.9	1408.7	1359.6	80%	21%	20%	66%
17-Aug	7180.5	7992.8	6165.3	1827.5	1015.1	86%	25%	14%	68%
18-Aug	4816.6	8307.0	3787.7	4519.3	1029.0	79%	94%	21%	41%
20-Aug	7468.6	8891.1	5907.5	2983.6	1561.1	79%	40%	21%	57%
22-Aug	9542.5	9504.9	7877.7	1627.2	1664.8	83%	17%	17%	71%
23-Aug	10099.6	9782.7	8366.6	1416.1	1733.1	83%	14%	17%	73%
27-Aug	11172.4	10950.7	9179.3	1771.4	1993.1	82%	16%	18%	71%
29-Aug	10168.4	11376.8	8614.5	2781.1	1553.9	85%	27%	15%	67%
3-Sep	11828.3	12071.5	9189.5	2882.0	2638.8	78%	24%	22%	62%
5-Sep	11063.5	12169.8	8403.8	3766.0	2659.7	76%	34%	24%	57%
6-Sep	11355.6	12216.9	8608.6	3608.4	2747.0	76%	32%	24%	58%
7-Sep	10912.9	12230.5	8300.9	3929.6	2612.0	76%	36%	24%	56%
8-Sep	10775.4	12251.1	8010.0	4241.0	2765.4	74%	39%	26%	53%
10-Sep	11376.5	12103.9	8330.7	3773.2	3045.7	73%	33%	27%	55%
12-Sep	11690.6	11923.7	8386.0	3537.7	3304.6	72%	30%	28%	55%
13-Sep	11755.6	11829.9	8357.5	3472.4	3398.0	71%	30%	29%	55%
15-Sep	9108.1	11591.0	6566.9	5024.2	2541.3	72%	55%	28%	46%
16-Sep	9350.4	11447.8	6645.7	4802.1	2704.7	71%	51%	29%	47%
17-Sep	9180.2	11289.5	6349.7	4939.8	2830.5	69%	54%	31%	45%
18-Sep	11755.6	11122.1	7880.6	3241.5	3875.0	67%	28%	33%	53%
19-Sep	11837.8	10953.7	7811.5	3142.2	4016.9	66%	27%	34%	52%
21-Sep	12034.6	10614.2	7746.0	2868.3	4288.6	64%	24%	36%	52%
22-Sep	11909.1	10422.9	7560.6	2862.4	4348.6	63%	24%	37%	51%
Average Percent						76%	34%	24%	57%