

SUPPLEMENTARY MATERIAL

Integrating MUSLE and sediment trap efficiency for oxbow lake service-life estimation, Krueng Keureuto Watershed

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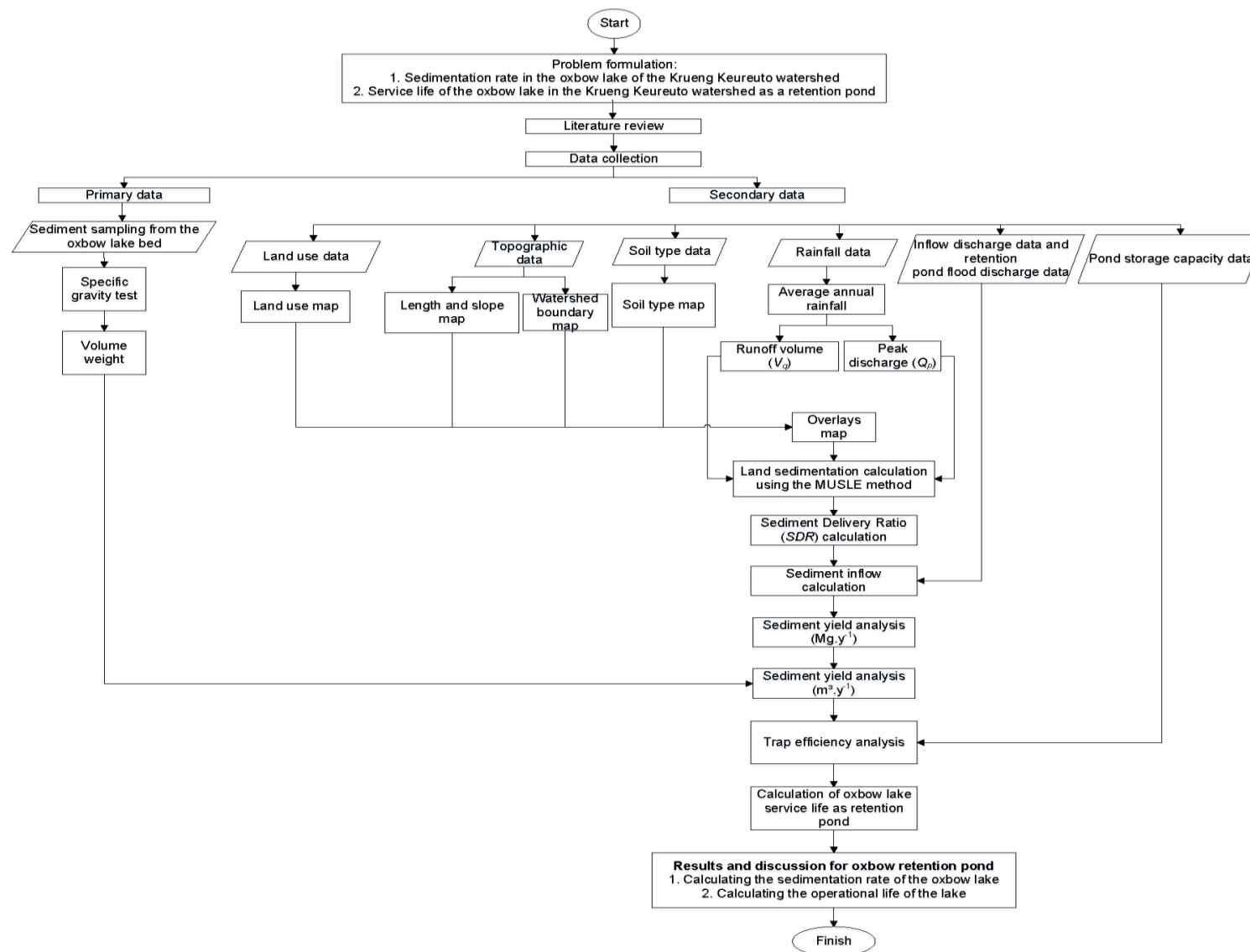


Fig. S1. Research flowchart; source: own elaboration

Table S1. Annual maximum daily rainfall in the oxbow lake catchment area

Year	Maximum yearly rainfall (mm) in			Average
	Keureuto ¹⁾	Jambo Aye ²⁾	Panton Labu ³⁾	
2011	81.52	77.98	103.00	80.53
2012	70.52	66.64	114.00	69.50
2013	59.40	58.36	67.00	59.11
2014	179.43	103.00	86.74	156.33
2015	217.81	108.36	73.50	184.70
2016	72.49	80.00	130.50	74.91
2017	115.91	92.98	60.95	108.90
2018	109.00	80.00	29.56	100.10
2019	114.00	82.00	65.10	104.30
2020	123.00	151.00	79.57	131.22
2021	209.44	100.27	84.32	176.47
2022	54.00	134.00	193.00	78.31
2023	116.00	91.00	100.00	108.49

¹⁾ Polygon area 422.500 km².

²⁾ Polygon area 180.527 km².

³⁾ Polygon area 1.885 km².

Source: own study.

Table S2. Alternating block method (ABM) calculation for 2011–2023

Hour to-	t (h)	It (mm·h ⁻¹)	$t \cdot It$ (mm)	P (mm)	p (%)	Hyetograph	
						(%)	(mm)
2011							
1	4.75	14.91	70.75	70.75	52.28	5.01	4.03
2	9.49	9.39	89.14	18.39	13.59	6.41	5.16
3	14.24	7.17	102.04	12.90	9.53	9.53	7.68
4	18.99	5.92	112.31	10.27	7.59	52.28	42.10
5	23.73	5.10	120.98	8.67	6.41	13.59	10.94
6	28.48	4.51	128.56	7.58	5.60	7.59	6.11
7	33.23	4.07	135.34	6.78	5.01	5.60	4.51
Total				135.34	100.00	100.00	80.53
2012							
1	4.75	12.86	61.06	61.06	52.28	5.01	3.48
2	9.49	8.10	76.93	15.87	13.59	6.41	4.45
3	14.24	6.18	88.06	11.13	9.53	9.53	6.62
4	18.99	5.11	96.93	8.86	7.59	52.28	36.33
5	23.73	4.40	104.41	7.48	6.41	13.59	9.44
6	28.48	3.90	110.95	6.54	5.60	7.59	5.27
7	33.23	3.52	116.80	5.85	5.01	5.60	3.89
Total				116.80	100.00	100.00	69.50

continue Tab. S2

Hour to-	t (h)	It (mm·h ⁻¹)	$t \cdot It$ (mm)	P (mm)	p (%)	Hyetograph	
						(%)	(mm)
2013							
1	4.75	10.94	51.93	51.93	52.28	5.01	2.96
2	9.49	6.89	65.43	13.50	13.59	6.41	3.79
3	14.24	5.26	74.90	9.47	9.53	9.53	5.63
4	18.99	4.34	82.43	7.54	7.59	52.28	30.90
5	23.73	3.74	88.80	6.37	6.41	13.59	8.03
6	28.48	3.31	94.36	5.56	5.60	7.59	4.49
7	33.23	2.99	99.34	4.98	5.01	5.60	3.31
Total				99.34	100.00	100.00	59.11
2014							
1	4.75	28.94	137.34	137.34	52.28	5.01	7.83
2	9.49	18.23	173.04	35.70	13.59	6.41	10.02
3	14.24	13.91	198.08	25.04	9.53	9.53	14.90
4	18.99	11.48	218.02	19.94	7.59	52.28	81.72
5	23.73	9.90	234.85	16.84	6.41	13.59	21.24
6	28.48	8.76	249.57	14.72	5.60	7.59	11.86
7	33.23	7.91	262.72	13.16	5.01	5.60	8.76
Total				262.72	100.00	100.00	156.33
2015							
1	4.75	34.19	162.26	162.26	52.28	5.01	9.25
2	9.49	21.54	204.44	42.18	13.59	6.41	11.84
3	14.24	16.44	234.02	29.59	9.53	9.53	17.60
4	18.99	13.57	257.57	23.55	7.59	52.28	96.55
5	23.73	11.69	277.46	19.89	6.41	13.59	25.10
6	28.48	10.35	294.85	17.39	5.60	7.59	14.02
7	33.23	9.34	310.40	15.55	5.01	5.60	10.35
Total				310.40	100.00	100.00	184.70
2016							
1	4.75	13.87	65.86	65.82	52.28	5.01	3.75
2	9.49	8.74	82.92	17.11	13.59	6.41	4.80
3	14.24	6.67	94.92	12.00	9.53	9.53	7.14
4	18.99	5.50	104.48	9.55	7.59	52.28	39.16
5	23.73	4.74	112.54	8.07	6.41	13.59	10.18
6	28.48	4.20	119.59	7.05	5.60	7.59	5.68
7	33.23	3.79	125.90	6.31	5.01	5.60	4.20
Total				125.90	100.00	100.00	74.92
2017							
1	4.75	20.16	95.67	95.67	52.28	5.01	5.45
2	9.49	12.70	120.54	24.87	13.59	6.41	6.98
3	14.24	9.69	137.98	17.44	9.53	9.53	10.38

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Hour to-	t (h)	It (mm·h ⁻¹)	$t \cdot It$ (mm)	P (mm)	p (%)	Hyetograph	
						(%)	(mm)
4	18.99	8.00	151.87	13.89	7.59	52.28	56.93
5	23.73	6.89	163.60	11.73	6.41	13.59	14.80
6	28.48	6.10	173.85	10.25	5.60	7.59	8.26
7	33.23	5.51	183.01	9.17	5.01	5.60	6.10
Total				183.01	100.00	100.00	108.90
2018							
1	4.75	18.53	87.94	87.94	52.28	5.01	5.01
2	9.49	11.67	110.80	22.86	13.59	6.41	6.41
3	14.24	8.91	126.83	16.03	9.53	9.53	9.54
4	18.99	7.35	139.60	12.77	7.59	52.28	52.33
5	23.73	6.34	150.37	10.78	6.41	13.59	13.60
6	28.48	5.61	159.80	9.42	5.60	7.59	7.60
7	33.23	5.06	168.22	8.43	5.01	5.60	5.61
Total				168.22	100.00	100.00	100.10
2019							
1	4.75	19.30	91.63	91.63	52.28	5.01	5.22
2	9.49	12.16	115.45	23.82	13.59	6.41	6.68
3	14.24	9.28	132.15	16.71	9.53	9.53	9.94
4	18.99	7.66	145.45	13.30	7.59	52.28	54.52
5	23.73	6.60	156.68	11.23	6.41	13.59	14.17
6	28.48	5.85	166.50	9.82	5.60	7.59	7.91
7	33.23	5.28	175.28	8.78	5.01	5.60	5.84
Total				175.28	100.00	100.00	104.30
2020							
1	4.75	24.29	115.28	115.28	52.28	5.01	6.57
2	9.49	15.30	145.25	29.96	13.59	6.41	8.41
3	14.24	11.68	166.27	21.02	9.53	9.53	12.51
4	18.99	9.64	183.00	16.73	7.59	52.28	68.60
5	23.73	8.31	197.13	14.13	6.41	13.59	17.83
6	28.48	7.36	209.48	12.35	5.60	7.59	9.96
7	33.23	6.64	220.53	11.05	5.01	5.60	7.35
Total				220.53	100.00	100.00	131.22
2021							
1	4.75	32.66	155.04	155.04	52.28	5.01	8.84
2	9.49	20.58	195.33	40.30	13.59	6.41	11.31
3	14.24	15.70	223.60	28.27	9.53	9.53	16.82
4	18.99	12.96	246.10	22.50	7.59	52.28	92.25
5	23.73	11.17	265.11	19.00	6.41	13.59	23.98
6	28.48	9.89	281.72	16.61	5.60	7.59	13.39
7	33.23	8.93	296.57	14.85	5.01	5.60	9.88

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Hour to-	t (h)	It (mm·h ⁻¹)	$t \cdot It$ (mm)	P (mm)	p (%)	Hyetograph	
						(%)	(mm)
Total				296.57	100.00	100.00	176.47
2022							
1	4.75	14.49	68.80	68.80	52.28	5.01	3.92
2	9.49	9.13	86.68	17.88	13.59	6.41	5.02
3	14.24	6.97	99.22	12.54	9.53	9.53	7.46
4	18.99	5.75	109.21	9.99	7.59	52.28	40.94
5	23.73	4.96	117.64	8.43	6.41	13.59	10.64
6	28.48	4.39	125.01	7.37	5.60	7.59	5.94
7	33.23	3.96	131.60	6.59	5.01	5.60	4.39
Total				131.60	100.00	100.00	78.31
2023							
1	4.75	20.08	95.31	95.31	52.28	5.01	5.43
2	9.49	12.65	120.09	24.77	13.59	6.41	6.95
3	14.24	9.65	137.46	17.38	9.53	9.53	10.34
4	18.99	7.97	151.30	13.84	7.59	52.28	56.71
5	23.73	6.87	162.98	11.68	6.41	13.59	14.74
6	28.48	6.08	173.19	10.21	5.60	7.59	8.23
7	33.23	5.49	182.33	9.13	5.01	5.60	6.08
Total				182.33	100.00	100.00	108.49

Explanations: t = time (h), It = rainfall intensity for duration t (mm·h⁻¹), P = rainfall depth (mm), p = probability (%).

Source: own study.

Table S3. Excess rainfall hyetograph (ERH) calculations for 2011–2023

Hour to-	t (hour)	ABM rainfall hyetograph	Cumulative ABM rainfall hyetograph	Cumulative abstraction		Cumulative excess rainfall (P_a)	ERH
				I_a	F_a		
				mm			
2011							
1	4.75	4.03	4.03	22.82	0.00	0.00	0.00
2	9.49	5.16	9.19	45.65	0.00	0.00	0.00
3	14.24	7.68	16.87	45.65	0.00	0.00	0.00
4	18.99	42.10	58.97	45.65	11.93	1.39	1.39
5	23.73	10.94	69.91	45.65	20.01	4.26	2.86
6	28.48	6.11	76.02	45.65	23.99	6.39	2.13
7	33.23	4.51	80.53	45.65	26.72	8.17	1.78
2012							
1	4.75	3.48	3.48	22.82	0.00	0.00	0.00
2	9.49	4.45	7.93	45.65	0.00	0.00	0.00
3	14.24	6.62	14.56	45.65	0.00	0.00	0.00
4	18.99	36.33	50.89	45.65	5.01	0.23	0.23

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Hour to-	<i>t</i> (hour)	ABM rainfall hyetograph	Cumulative ABM rainfall hyetograph	Cumulative abstraction		Cumulative excess rainfall (<i>Pa</i>)	ERH
				<i>Ia</i>	<i>Fa</i>		
				mm			
5	23.73	9.44	60.34	45.65	13.01	1.68	1.45
6	28.48	5.27	65.61	45.65	16.99	2.97	1.30
7	33.23	3.89	69.50	45.65	19.73	4.12	1.15
2013							
1	4.75	2.96	2.96	22.82	0.00	0.00	0.00
2	9.49	3.79	6.75	45.65	0.00	0.00	0.00
3	14.24	5.63	12.38	45.65	0.00	0.00	0.00
4	18.99	30.90	43.28	45.65	0.00	0.00	0.00
5	23.73	8.03	51.31	45.65	5.40	0.27	0.27
6	28.48	4.49	55.80	45.65	9.32	0.83	0.56
7	33.23	3.31	59.11	45.65	12.04	1.42	0.59
2014							
1	4.75	7.83	7.83	22.82	0.00	0.00	0.00
2	9.49	10.02	17.85	45.65	0.00	0.00	0.00
3	14.24	14.90	32.75	45.65	0.00	0.00	0.00
4	18.99	81.72	114.47	45.65	42.93	25.89	25.89
5	23.73	21.24	135.71	45.65	50.34	39.73	13.84
6	28.48	11.86	147.57	45.65	53.84	48.09	8.36
7	33.23	8.76	156.33	45.65	56.19	54.50	6.40
2015							
1	4.75	9.25	9.25	22.82	0.00	0.00	0.00
2	9.49	11.84	21.09	45.65	0.00	0.00	0.00
3	14.24	17.60	38.69	45.65	0.00	0.00	0.00
4	18.99	96.55	135.24	45.65	50.19	39.40	39.40
5	23.73	25.10	160.34	45.65	57.20	57.49	18.08
6	28.48	14.02	174.35	45.65	60.49	68.22	10.73
7	33.23	10.35	184.70	45.65	62.68	76.37	8.15
2016							
1	4.75	3.75	3.75	22.82	0.00	0.00	0.00
2	9.49	4.80	8.55	45.65	0.00	0.00	0.00
3	14.24	7.14	15.69	45.65	0.00	0.00	0.00
4	18.99	39.16	54.86	45.65	8.52	0.69	0.69
5	23.73	10.18	65.03	45.65	16.57	2.82	2.13
6	28.48	5.68	70.72	45.65	20.56	4.52	1.70
7	33.23	4.20	74.92	45.65	23.29	5.97	1.46
2017							
1	4.75	5.45	5.45	22.82	0.00	0.00	0.00
2	9.49	6.98	12.43	45.65	0.00	0.00	0.00

continue Tab. S3

Hour to-	<i>t</i> (hour)	ABM rainfall hyetograph	Cumulative ABM rainfall hyetograph	Cumulative abstraction		Cumulative excess rainfall (<i>Pa</i>)	ERH
				<i>Ia</i>	<i>Fa</i>		
				mm			
3	14.24	10.38	22.81	45.65	0.00	0.00	0.00
4	18.99	56.93	79.74	45.65	26.25	7.84	7.84
5	23.73	14.80	94.54	45.65	34.23	14.66	6.82
6	28.48	8.26	102.80	45.65	38.08	19.07	4.41
7	33.23	6.10	108.90	45.65	40.70	22.56	3.49
2018							
1	4.75	5.01	5.01	22.82	0.00	0.00	0.00
2	9.49	6.41	11.43	45.65	0.00	0.00	0.00
3	14.24	9.54	20.97	45.65	0.00	0.00	0.00
4	18.99	52.33	73.30	45.65	22.26	5.39	5.39
5	23.73	13.60	86.90	45.65	30.30	10.95	5.56
6	28.48	7.60	94.49	45.65	34.20	14.64	3.69
7	33.23	5.61	100.10	45.65	36.86	17.59	2.95
2019							
1	4.75	5.22	5.22	22.82	0.00	0.00	0.00
2	9.49	6.68	11.91	45.65	0.00	0.00	0.00
3	14.24	9.94	21.85	45.65	0.00	0.00	0.00
4	18.99	54.52	76.37	45.65	24.21	6.52	6.52
5	23.73	14.17	90.54	45.65	32.22	12.68	6.16
6	28.48	7.91	98.46	45.65	36.10	16.71	4.03
7	33.23	5.84	104.30	45.65	38.74	19.91	3.20
2020							
1	4.75	6.57	6.57	22.82	0.00	0.00	0.00
2	9.49	8.41	14.98	45.65	0.00	0.00	0.00
3	14.24	12.51	27.49	45.65	0.00	0.00	0.00
4	18.99	68.60	96.08	45.65	34.98	15.46	15.46
5	23.73	17.83	113.91	45.65	42.72	25.55	10.09
6	28.48	9.96	123.87	45.65	46.41	31.81	6.26
7	33.23	7.35	131.22	45.65	48.90	36.67	4.86
2021							
1	4.75	8.84	8.84	22.82	0.00	0.00	0.00
2	9.49	11.31	20.15	45.65	0.00	0.00	0.00
3	14.24	16.82	36.97	45.65	0.00	0.00	0.00
4	18.99	92.25	129.22	45.65	48.24	35.33	35.33
5	23.73	23.98	153.20	45.65	55.37	52.18	16.85
6	28.48	13.39	166.59	45.65	58.72	62.23	10.04
7	33.23	9.88	176.47	45.65	60.95	69.88	7.65

continue Tab. S3

Hour to-	t (hour)	ABM rainfall hyetograph	Cumulative ABM rainfall hyetograph	Cumulative abstraction		Cumulative excess rainfall (P_a)	ERH
				I_a	F_a		
		mm					
2022							
1	4.75	3.92	3.92	22.82	0.00	0.00	0.00
2	9.49	5.02	8.94	45.65	0.00	0.00	0.00
3	14.24	7.46	16.40	45.65	0.00	0.00	0.00
4	18.99	40.94	57.34	45.65	10.61	1.09	1.09
5	23.73	10.64	67.98	45.65	18.68	3.66	2.57
6	28.48	5.94	73.92	45.65	22.67	5.62	1.96
7	33.23	4.39	78.31	45.65	25.39	7.27	1.65
2023							
1	4.75	5.43	5.43	22.82	0.00	0.00	0.00
2	9.49	6.95	12.39	45.65	0.00	0.00	0.00
3	14.24	10.34	22.73	45.65	0.00	0.00	0.00
4	18.99	56.71	79.44	45.65	26.07	7.72	7.72
5	23.73	14.74	94.18	45.65	34.05	14.48	6.76
6	28.48	8.23	102.41	45.65	37.91	18.86	4.38
7	33.23	6.08	108.49	45.65	40.53	22.32	3.46

Explanations: ABM = alternating block method, t = time (h), I_a = initial abstraction (mm), F_a = continuous abstraction (mm).

Source: own study.

Table S4. Soil Conservation Service (SCS) method calculation

t_s/Pr	Q/Q_p	t	Q	t_s/Pr	Q/Q_p	t	Q
0.0	0.00	0.00	0.00	1.4	0.75	7.31	18.07
0.1	0.02	0.52	0.36	1.5	0.66	7.83	15.90
0.2	0.08	1.04	1.81	1.6	0.56	8.35	13.49
0.3	0.16	1.57	3.86	1.8	0.42	9.40	10.12
0.4	0.28	2.09	6.75	2.0	0.32	10.44	7.71
0.5	0.43	2.61	10.36	2.2	0.24	11.49	5.78
0.6	0.60	3.13	14.46	2.4	0.18	12.53	4.34
0.7	0.77	3.65	18.56	2.6	0.13	13.58	3.13
0.8	0.89	4.18	21.45	2.8	0.10	14.62	2.36
0.9	0.97	4.70	23.37	3.0	0.08	15.66	1.81
1.0	1.00	5.22	24.10	3.5	0.04	18.27	0.87
1.1	0.98	5.74	23.62	4.0	0.02	20.88	0.43
1.2	0.92	6.27	22.17	4.5	0.01	23.50	0.22
1.3	0.84	6.79	20.24	5.0	0.004	26.11	0.10

Explanations: t_s = time from the beginning of the hydrograph (h), Pr = peak time (h), t_s/Pr = dimensionless time ratio, Q = discharge at time t ($\text{m}^3 \cdot \text{s}^{-1}$), Q_p = flood discharge ($\text{m}^3 \cdot \text{s}^{-1}$), Q/Q_p = dimensionless discharge ratio, t = time on the hydrograph (h).

Source: own study.

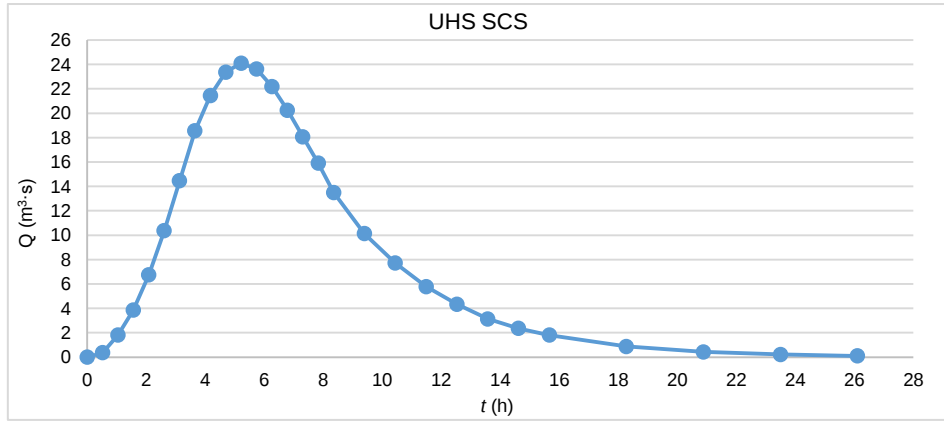


Fig. S2. Soil Conservation Service (SCS) method graph; Q = discharge at time t ($\text{m}^3 \cdot \text{s}^{-1}$); source: own study

Table S5. Recapitulation of peak discharge (Q_p)

Year	Q_p ($\text{m}^3 \cdot \text{s}^{-1}$)
2011	191.49
2012	97.42
2013	33.68
2014	1,277.73
2015	1,792.03
2016	140.57
2017	527.36
2018	410.78
2019	465.26
2020	858.86
2021	1,639.26
2022	170.62
2023	521.74
Amount	8,126.80

Source: own study.

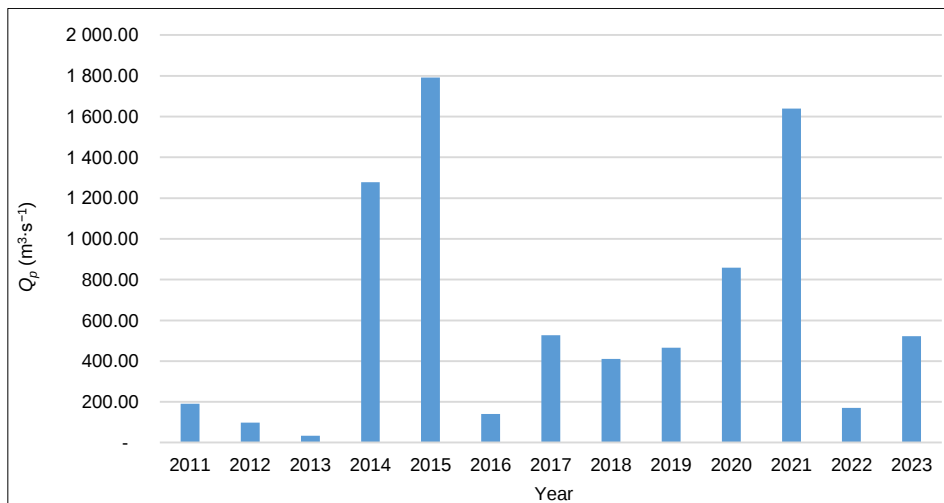


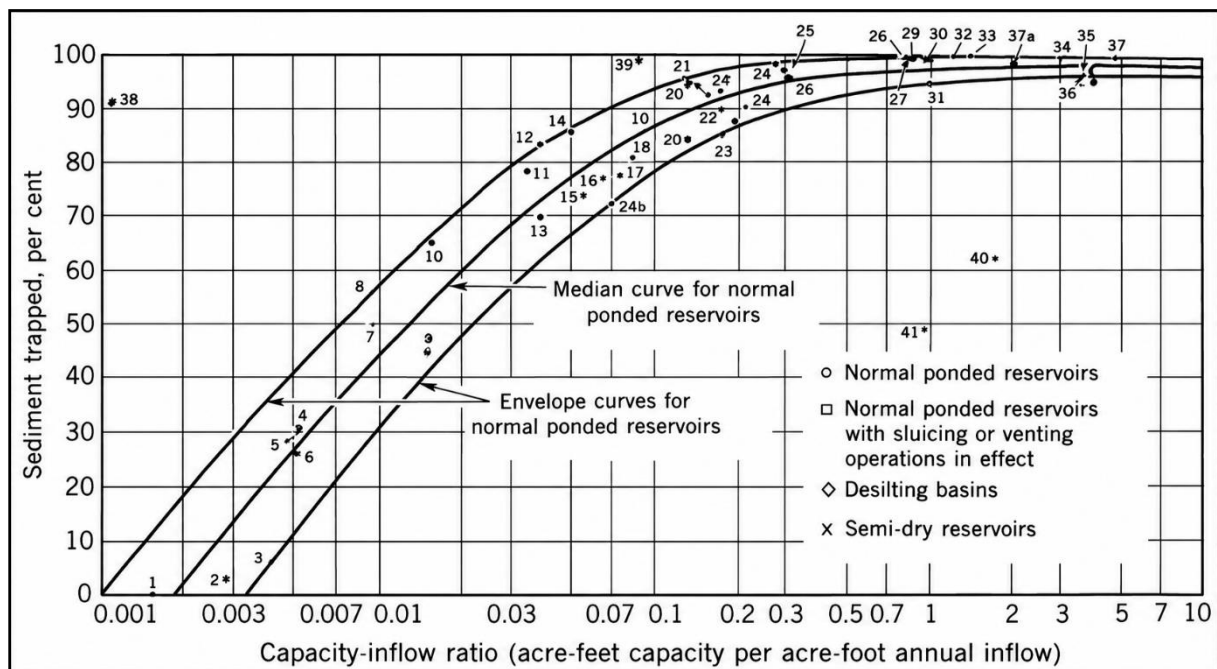
Fig. S3. Recapitulation of peak discharge (Q_p); source: own study

Table S6. Runoff volume (V_q) calculation

Year	P (mm)	V_a (mm)	V_q (m ³)
2011	80.53	0.02	11,724.73
2012	69.50	0.01	8,196.73
2013	59.11	0.01	5,295.70
2014	156.33	0.07	43,540.79
2015	184.70	0.09	57,429.75
2016	74.91	0.02	9,875.72
2017	108.90	0.04	22,387.05
2018	100.10	0.03	18,872.81
2019	104.30	0.03	20,529.54
2020	131.22	0.05	31,942.33
2021	176.47	0.09	53,331.64
2022	78.31	0.02	10,980.05
2023	108.49	0.04	22,220.04

Explanations: V_q is calculated at soil water storage (SWS) = 114.12 mm,
 P = average areal rainfall (mm), V_a = annual runoff volume value (mm).

Source: own study.

**Fig. S4.** Trap efficiency; source: Brune (1953), as cited in Utomo and Febriani (2021, p. 252)

REFERENCES

Utomo, P. and Febriani, P. (2021) "Penentuan tingkat akurasi beberapa metode prediksi efisiensi tangkapan (trap efficiency) sedimen di Waduk Mrica," *Jurnal Rekayasa Sipil (JRS-UNAND)*, 17(3), pp. 248–258. Available at: <https://jrs.ft.unand.ac.id/index.php/jrs/article/view/315/187> (Accessed: November 10, 2025).