









SUPPLEMENTARY MATERIAL

Random forest-based prediction of flash flood susceptibility under land use dynamics in East Java Watershed

Entin Hidayah*¹⁾ , Jojok Widodo Soetjipto¹⁾ , Juliastuti Juliastuti²⁾ ,
Azmeri Azmeri³⁾ , Alexander Agung Santoso Gunawan⁴⁾ , Joko Widodo⁵⁾ ,
Josaphat Tetuko Sri Sumantyo⁶⁾ , Afif Amiluddin⁷⁾ 

- ¹⁾ Universitas Jember, Faculty of Engineering, Civil Engineering Department, Jl. Kalimantan No. 37, Tegalboto Sumbang, Kec. Sumbang, Kabupaten Jember, Jawa Timur 68121, Indonesia
- ²⁾ Bina Nusantara University, Faculty of Engineering, Civil Engineering Department, Jl. K. H. Syahdan No. 9, Kemanggis, 11480 Palmerah Jakarta, Indonesia
- ³⁾ Faculty of Engineering, Universitas Syiah Kuala, Syech Abdur-Rauf No. 7 Darussalam, 23111, Banda Aceh, Indonesia
- ⁴⁾ Bina Nusantara University, Computer Science Department, School of Computer Science, Jl Kebon Jeruk Raya no 27, 11530 Jakarta Barat, Indonesia
- ⁵⁾ National Research and Innovation Agency (BRIN), Research Center for Geoinformatics, Gedung B.J. Habibie, Jl. M.H. Thamrin No. 8, Jakarta, 10340, Indonesia
- ⁶⁾ Chiba University, Center for Environmental Remote Sensing, 1-33 Yayoi-cho, Inage-ku, 263-8522 Chiba-shi, Japan
- ⁷⁾ Universitas Mochammad Sroedji, Faculty of Engineering, Civil Engineering Department, Jalan Sriwijaya No. 32, Sumbang District, 68121 Jember, Indonesia

* Corresponding author

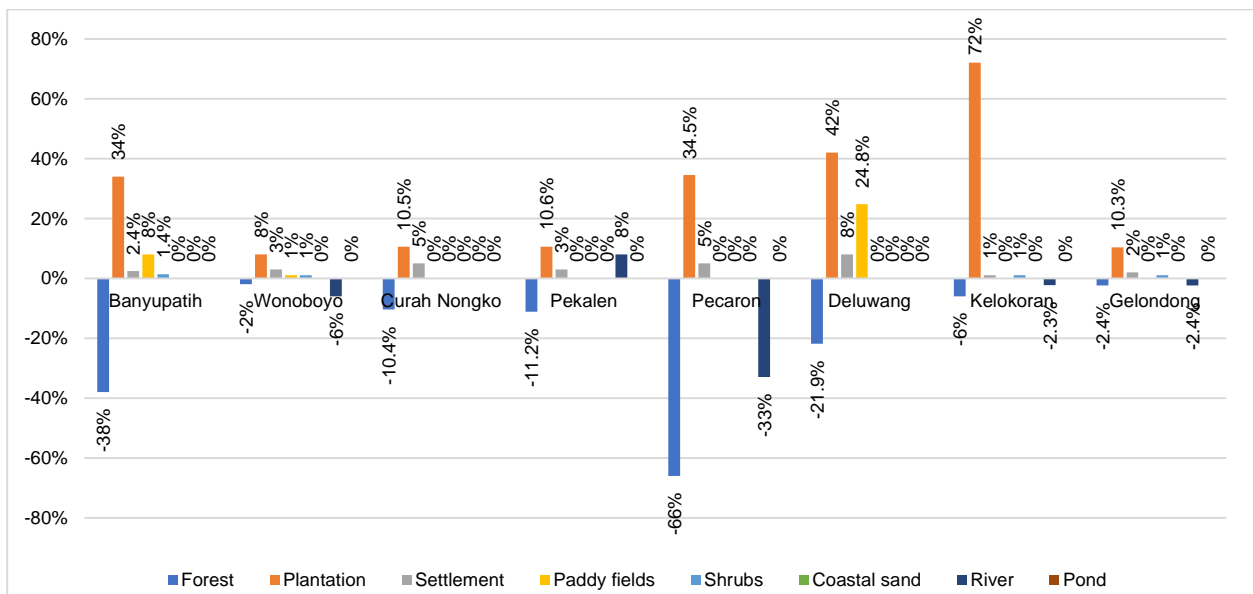


Fig. S1. Land cover changes from 2000–2020; source: own study

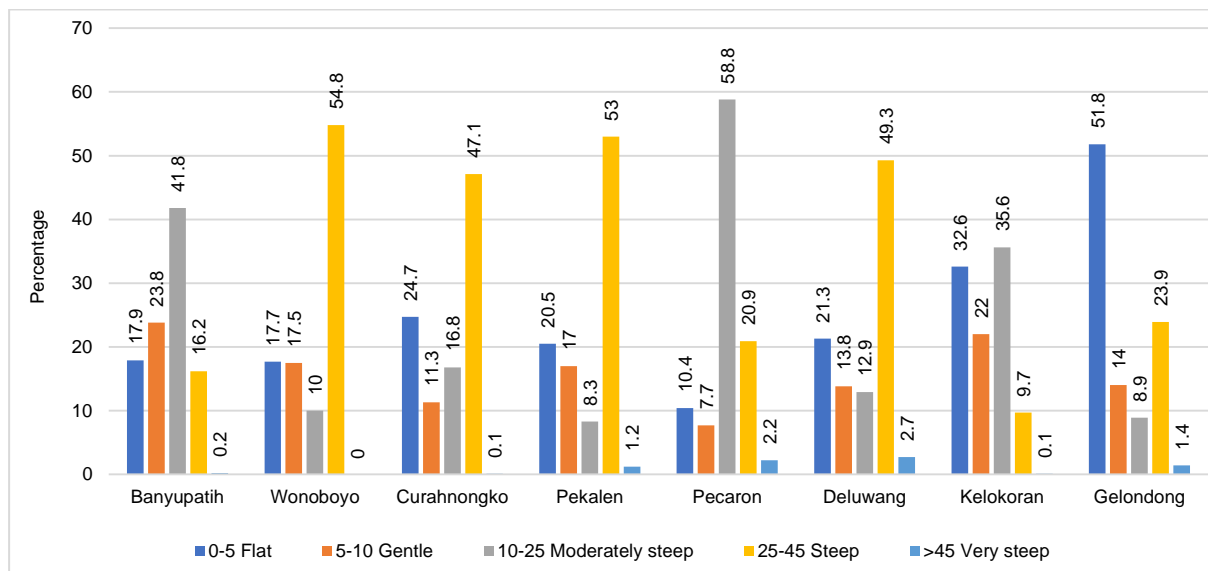


Fig. S2. Slope factor at eight watersheds; source: own study

Table S1. Event-based rainfall data corresponding with field-based photographic documentation for Banyuputih watershed (Bondowoso Regency)

Location	Elevation	Day	Rainfall depth (mm) on			
			12 th Dec 2019	14 th Mar 2020	1 st -2 nd Feb 2023	4 th Apr 2023
Sumber Rejo	972 m a.s.l.	D - 2	14	4	82	2
		D - 1	3	64	4	35
		D	58	62	18	48
		total	75	130	104	85

Explanations: D = the day of the flood event, while D - 1 and D - 2 one and two days before the flood event, respectively.

Source: Public work East Java Province, Indonesia.

Table S2. Event-based rainfall data corresponding with field-based photographic documentation for Wonoboyo watershed (Bondowoso Regency)

Location	Elevation	Day	Rainfall depth (mm) on					
			16 th Jan 2008	31 st Jan 2016	29 th Jan 2017	27 th Jan 2018	29 th Jan 2019	31 st Oct 2020
Blonjong	112 m a.s.l.	D - 2	75	0	23	7	0	0
		D - 1	7	44	0	67	22	0
		D	27	15	96	190	74	55
		total	109	59	119	264	96	55
Wonoboyo	112 m a.s.l.	D - 2	75	0	0	9	18	0
		D - 1	7	50	0	18	17	0
		D	27	150	100	120	50	80
		total	109	200	100	147	85	80

Explanations: D = the day of the flood event, while D - 1 and D - 2 one and two days before the flood event, respectively.

Source: Public work East Java Province, Indonesia.

Table S3. Event-based rainfall data corresponding with field-based photographic documentation for Curah Nongko watershed (Jember Regency)

Location	Elevation	Day	Rainfall depth (mm) on				
			8 th Mar 2012	2 nd Apr 2017	19 th Mar 2019	19 th Jan 2021	23 rd Dec 2024
Sanerejo	36 m a.s.l.	D – 2	0	0	0	53	0
		D – 1	36	11	87	32	53
		D	107	41	32	31	155
		total	143	52	119	116	208

Explanations: D = the day of the flood event, while D – 1 and D – 2 one and two days before the flood event, respectively.

Source: Public work East Java Province, Indonesia.

Table S4. Event-based rainfall data corresponding with field-based photographic documentation for Pecaron watershed (Situbondo Regency)

Location	Elevation	Day	Rainfall depth (mm) on		
			14 th Feb-2021	20 th Apr 2022	24 th Dec 2022
Kalitapen Jeru	104 m a.s.l.	D – 2	23	0	0
		D – 1	3	0	0
		D	79	6	40
		total	105	6	40
Botolinggo Glendengan	104 m a.s.l.	D – 2	0	0	0
		D – 1	76	0	0
		D	4	65	99
		total	80	65	99

Explanations: D = the day of the flood event, while D – 1 and D – 2 one and two days before the flood event, respectively.

Source: Public work East Java Province, Indonesia.

Table S5. Event-based rainfall data corresponding with field-based photographic documentation for Pekalen watershed (Probolinggo Regency)

Location	Elevation	Day	Rainfall depth (mm) on	
			11 th Dec 2018	1 st Nov 2020
Tiris	687 m a.s.l.	D – 2	13	12
		D – 1	0	11
		D	232	185
		total	245	208
Pajarakan	687 m a.s.l.	D – 2	0	0
		D – 1	7	0
		D	2	97
		total	9	97

Explanations: D = the day of the flood event, while D – 1 and D – 2 one and two days before the flood event, respectively.

Source: Public work East Java Province, Indonesia.

Table S6. Event-based rainfall data corresponding with field-based photographic documentation for Deluwang watershed (Situbondo Regency)

Location	Elevation	Day	Rainfall depth (mm) on	
			31 st Jan 2016	6 th Apr 2020
Buduan	36 m a.s.l.	D – 2	2	0
		D – 1	67	3
		D	43	87
		total	112	90
Jatisari Wringin		D – 2	0	0
		D – 1	37	0
		D	0	97
		total	37	97
Jatibanteng		D – 2	2	27
		D – 1	68	5
		D	21	3
		total	91	35

Explanations: D = the day of the flood event, while D – 1 and D – 2 one and two days before the flood event, respectively.

Source: Public work East Java Province, Indonesia.

Table S7. Event-based rainfall data corresponding with field-based photographic documentation for Glondong watershed (Banyuwangi Regency)

Location	Elevation	Day	Rainfall depth (mm) on	
			25 th Nov 2018	22 nd Sep 2020
Rogojampi	134 m a.s.l.	D – 2	103	47
		D – 1	30	9
		D	72	6
		total	205	62

Explanations: D = the day of the flood event, while D – 1 and D – 2 one and two days before the flood event, respectively.

Source: Public work East Java Province, Indonesia.

Table S8. Analysed factors' multicollinearity

Factor	Plan C.	Prof C.	Slope	<i>TPI</i>	<i>TWI</i>	<i>NDVI</i>	<i>R. Dens.</i>	Conv.	Aspect	Land use
Plan C.	1.000	-0.306	0.027	0.194	0.499	-0.004	-0.027	0.428	0.017	-0.009
Prof C.	-0.306	1.000	-0.010	-0.250	0.222	0.001	0.049	0.232	0.023	0.044
Slope	0.027	-0.010	1.000	0.147	-0.597	0.162	-0.258	0.129	0.233	-0.622
<i>TPI</i>	0.194	-0.250	0.147	1.000	-0.332	0.079	-0.334	0.341	-0.095	-0.173
<i>TWI</i>	-0.499	0.222	-0.597	-0.332	1.000	-0.119	0.199	-0.454	-0.141	0.370
<i>NDVI</i>	-0.004	0.001	0.162	0.079	-0.119	1.0000	-0.049	0.068	-0.097	-0.186
<i>R. Dens.</i>	-0.027	0.049	-0.258	-0.334	0.199	-0.049	1.000	-0.104	-0.054	0.157
Conv.	0.428	-0.232	0.129	0.341	-0.454	0.068	-0.104	1.000	0.089	-0.075
Aspect	0.017	0.020	0.233	-0.095	-0.141	-0.097	-0.054	0.089	1.000	-0.128
Land use	-0.009	0.044	-0.622	-0.173	0.370	-0.186	0.157	-0.075	-0.128	1.000

Explanations: Plan C. = plan curvature, Prof C. = profile curvature, *TPI* = topographic position index, *TWI* = topographic wetness index, *NDVI* = normalised difference vegetation index, *R. Dens.* = river density, Conv. = convergence.

Source: own study.

Table S9. Potential areas of flash floods range from high to very high and model performance

Watershed	Flash flood area (%)	Training			Testing		
		<i>ROC</i>	<i>RMSE</i>	corrected classified (%)	<i>ROC</i>	<i>RMSE</i>	corrected classified (%)
Gelondong	54	0.92	0.03	99.89	0.89	0.04	95.88
Deluwang	50	0.94	0.02	99.94	0.96	0.12	98.45
Wonobojo	46	0.95	0.11	98.68	0.89	0.05	95.87
Pecaron	46	0.96	0.07	99.35	0.95	0.09	94.04
Banyuputih	43	0.87	0.04	99.77	0.83	0.03	98.21
Curah Nongko	41	0.99	0.06	99.53	0.91	0.09	99.25
Pekalen	36	0.98	0.06	99.57	0.96	0.05	96.37
Kelokoran	31	0.94	0.02	99.95	0.88	0.02	99.94

Explanations: *ROC* = receiver operating characteristic, *RMSE* = root square mean error.

Source: own study.