Supplementary Materials

Accuracy of land use and cover mapping acrross time in environmental disaster zones: the case of B1 tailings dam rupture in Brumadinho, Brazil

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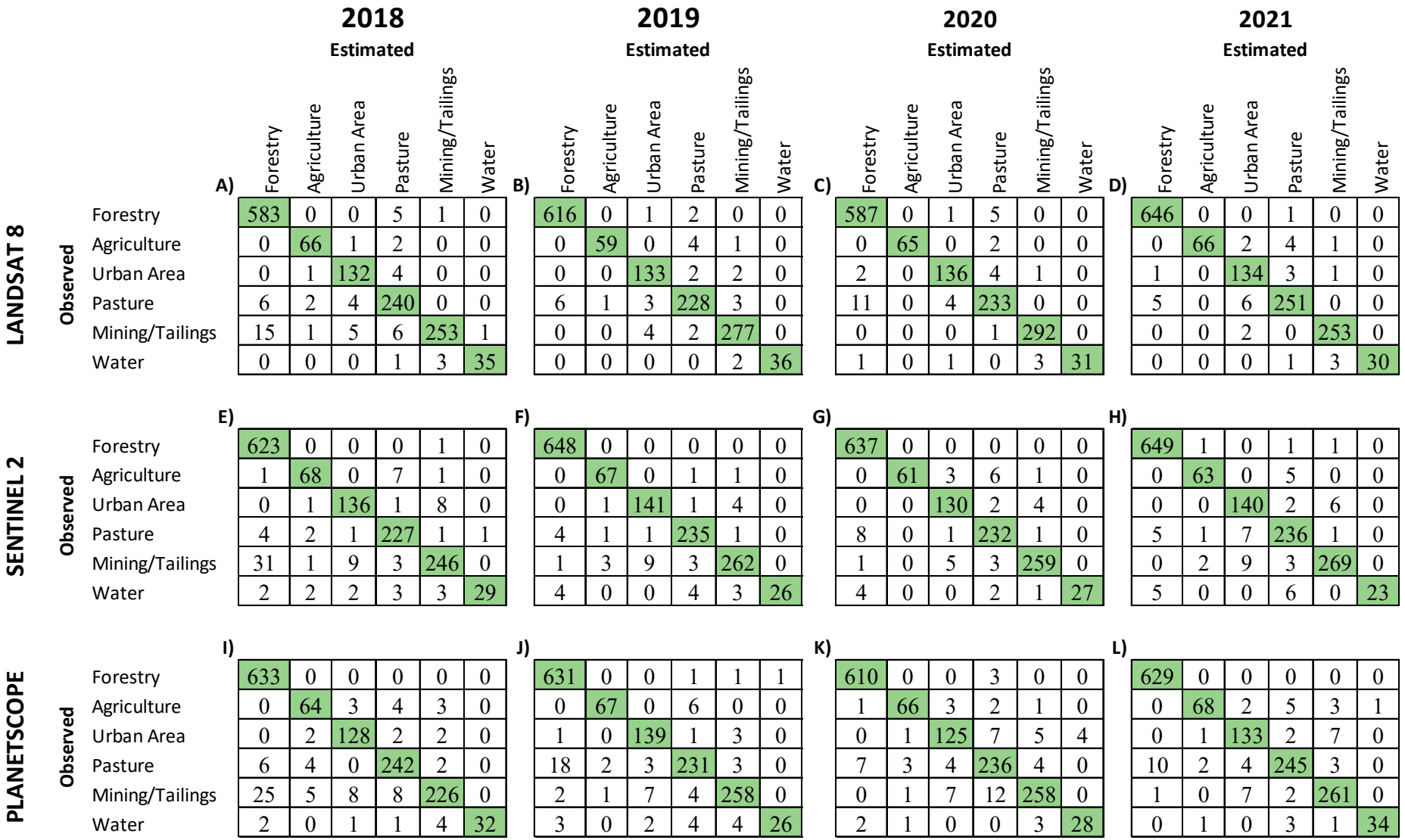
Supplementary Materiais

The forthcoming pages present supplementary tables and figures referred to in the manuscript with title and authors mentioned above.

Figure S1. Confusion Matrices for each class processed on land use and land cover for Landsat8, Sentinel-2 and PlanetScope Satellites



A) 2018	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	583	0	0	5	1	0
Agriculture	0	66	1	2	0	0
Urban Area	0	1	132	4	0	0
Pasture	6	2	4	240	0	0
Mining/Tailings	15	1	5	6	253	1
Water	0	0	0	1	3	35

B) 2019	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	616	0	1	2	0	0
Agriculture	0	59	0	4	1	0
Urban Area	0	0	133	2	2	0
Pasture	6	1	3	228	3	0
Mining/Tailings	0	0	4	2	277	0
Water	0	0	0	0	2	36

C) 2020	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	587	0	1	5	0	0
Agriculture	0	65	0	2	0	0
Urban Area	2	0	136	4	1	0
Pasture	11	0	4	233	0	0
Mining/Tailings	0	0	0	1	292	0
Water	1	0	1	0	3	31

D) 2021	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	646	0	0	1	0	0
Agriculture	0	66	2	4	1	0
Urban Area	1	0	134	3	1	0
Pasture	5	0	6	251	0	0
Mining/Tailings	0	0	2	0	253	0
Water	0	0	0	1	3	30

E)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	623	0	0	0	1	0
Agriculture	1	68	0	7	1	0
Urban Area	0	1	136	1	8	0
Pasture	4	2	1	227	1	1
Mining/Tailings	31	1	9	3	246	0
Water	2	2	2	3	3	29

F)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	648	0	0	0	0	0
Agriculture	0	67	0	1	1	0
Urban Area	0	1	141	1	4	0
Pasture	4	1	1	235	1	0
Mining/Tailings	1	3	9	3	262	0
Water	4	0	0	4	3	26

G)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	637	0	0	0	0	0
Agriculture	0	61	3	6	1	0
Urban Area	0	0	130	2	4	0
Pasture	8	0	1	232	1	0
Mining/Tailings	1	0	5	3	259	0
Water	4	0	0	2	1	27

H)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	649	1	0	1	1	0
Agriculture	0	63	0	5	0	0
Urban Area	0	0	140	2	6	0
Pasture	5	1	7	236	1	0
Mining/Tailings	0	2	9	3	269	0
Water	5	0	0	6	0	23

I)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	633	0	0	0	0	0
Agriculture	0	64	3	4	3	0
Urban Area	0	2	128	2	2	0
Pasture	6	4	0	242	2	0
Mining/Tailings	25	5	8	8	226	0
Water	2	0	1	1	4	32

J)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	631	0	0	1	1	1
Agriculture	0	67	0	6	0	0
Urban Area	1	0	139	1	3	0
Pasture	18	2	3	231	3	0
Mining/Tailings	2	1	7	4	258	0
Water	3	0	2	4	4	26

K)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	610	0	0	3	0	0
Agriculture	1	66	3	2	1	0
Urban Area	0	1	125	7	5	4
Pasture	7	3	4	236	4	0
Mining/Tailings	0	1	7	12	258	0
Water	2	1	0	0	3	28

L)	Forestry	Agriculture	Urban Area	Pasture	Mining/Tailings	Water
Forestry	629	0	0	0	0	0
Agriculture	0	68	2	5	3	1
Urban Area	0	1	133	2	7	0
Pasture	10	2	4	245	3	0
Mining/Tailings	1	0	7	2	261	0
Water	0	1	0	3	1	34

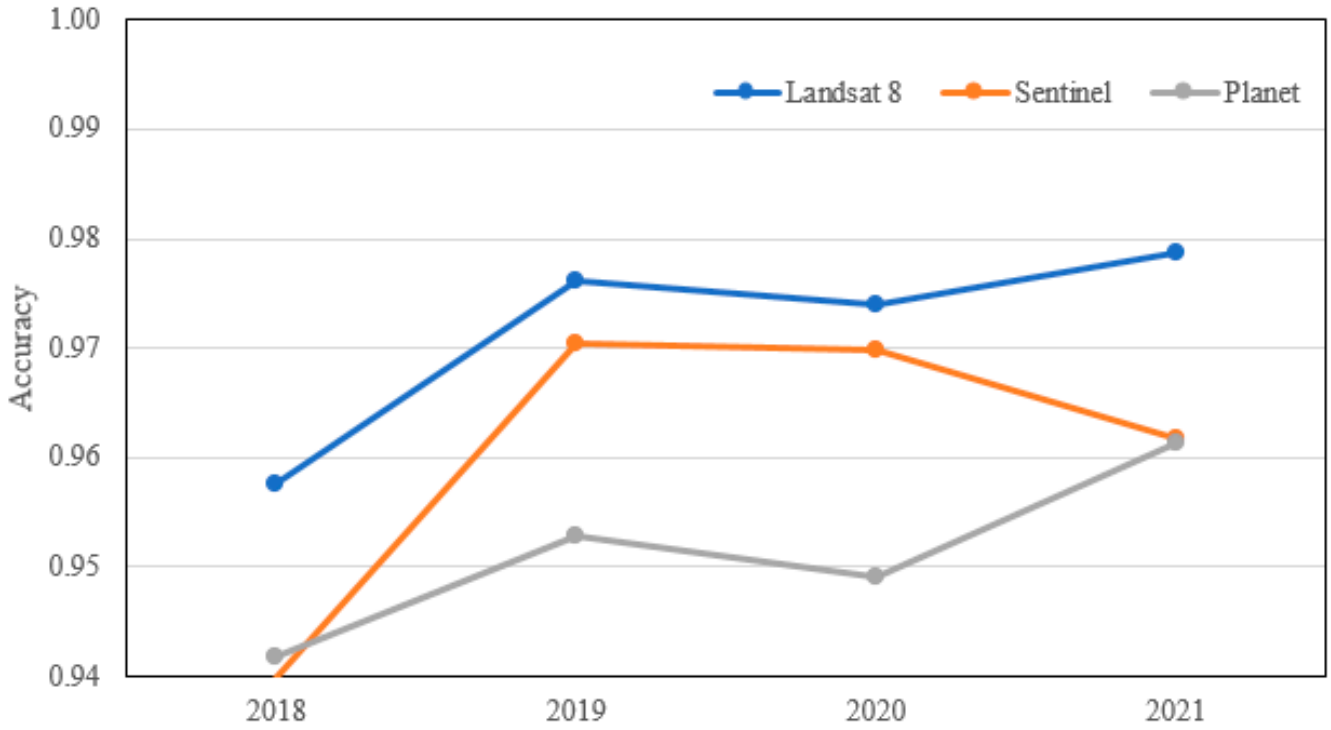


Figure S2. Overall accuracy estimated for Landsat 8 (L8-30 m), Sentinel 2 (S2-10 m) and PlanetScope (p-4.7 m) images for 2018 (before failure) and 2019, 2020 and 2021 (after failure).

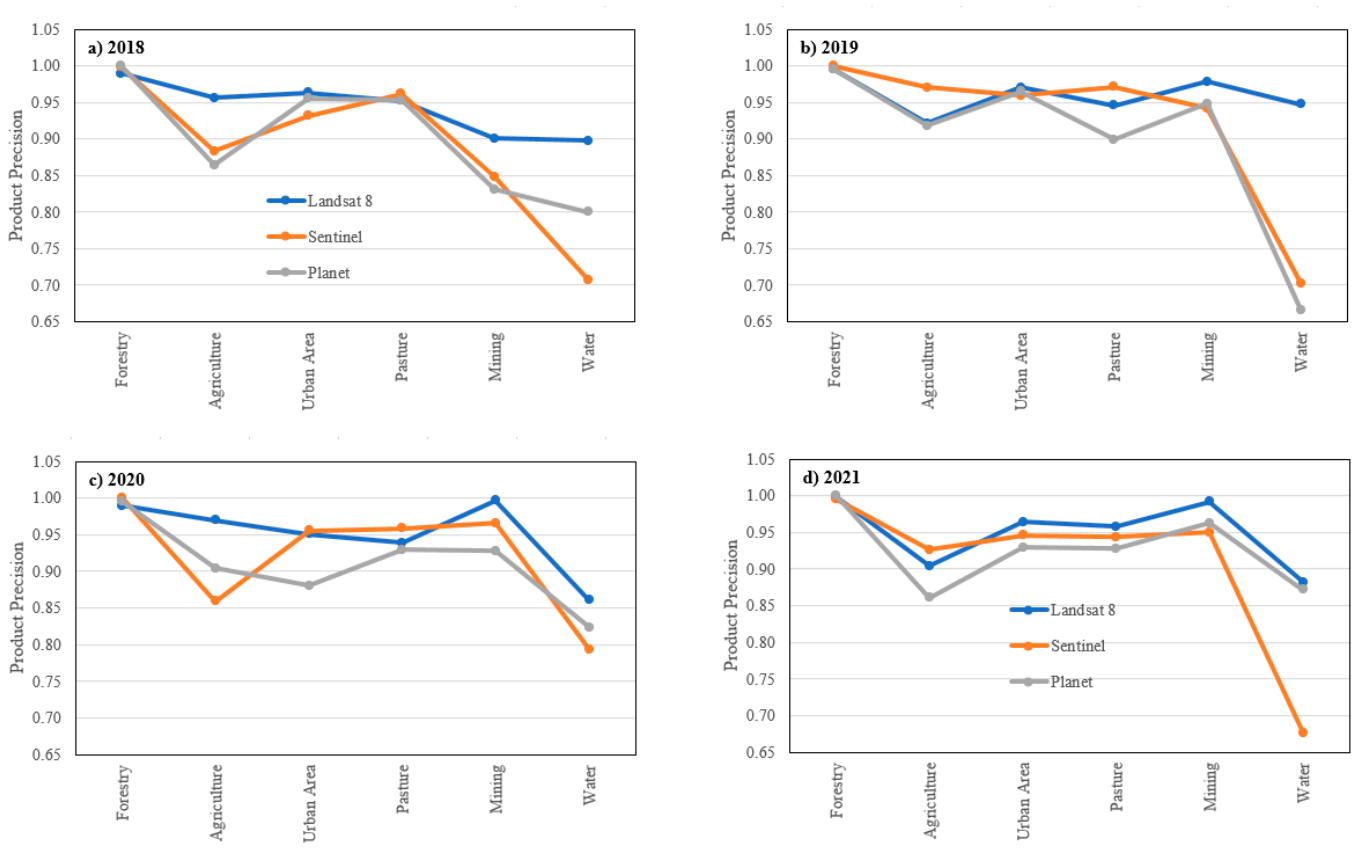


Figure S3. Producer accuracy estimated for Landsat 8, Sentinel 2 and PlanetScope images for 2018 (before failure) and 2019, 2020 and 2021 (after failure).

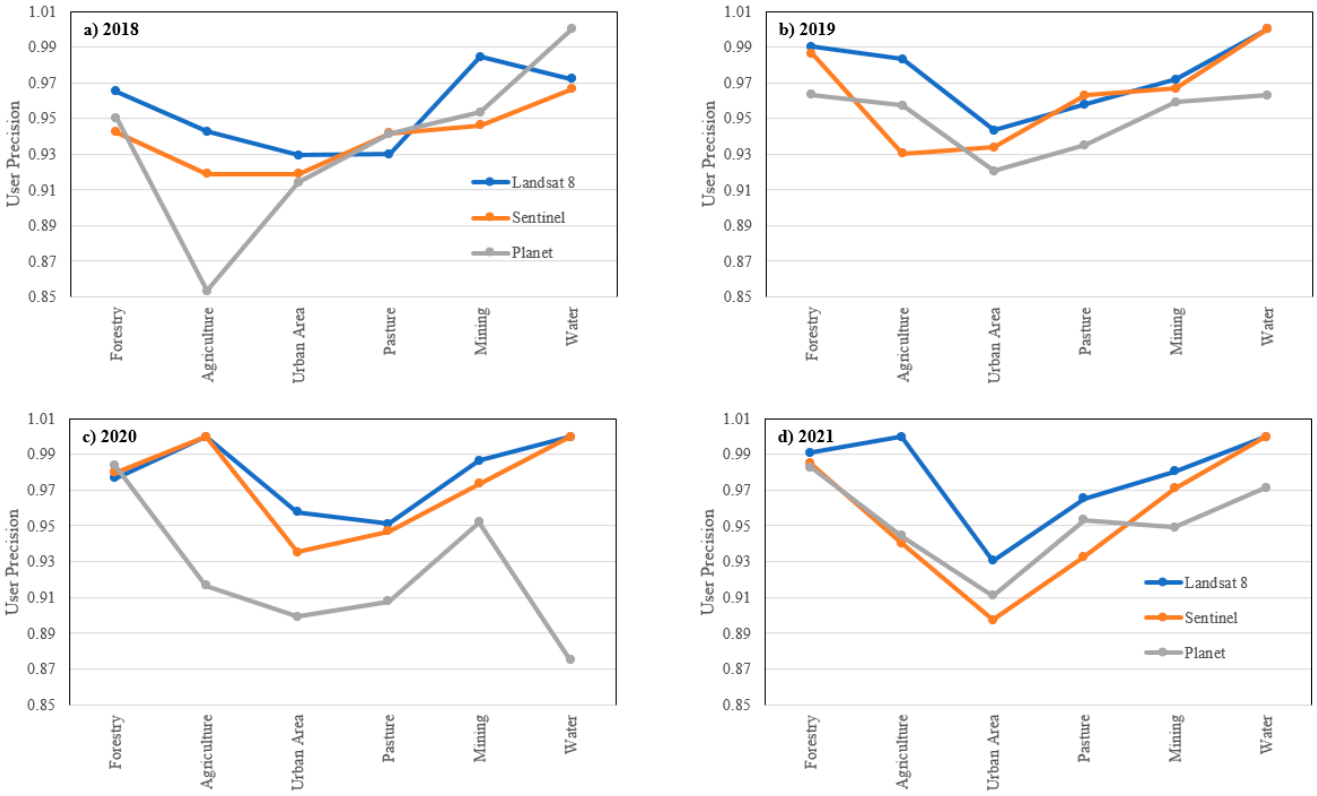


Figure S4. User accuracy estimated for Landsat 8, Sentinel 2 and PlanetScope images for 2018 (before failure) and 2019, 2020 and 2021 (after failure).

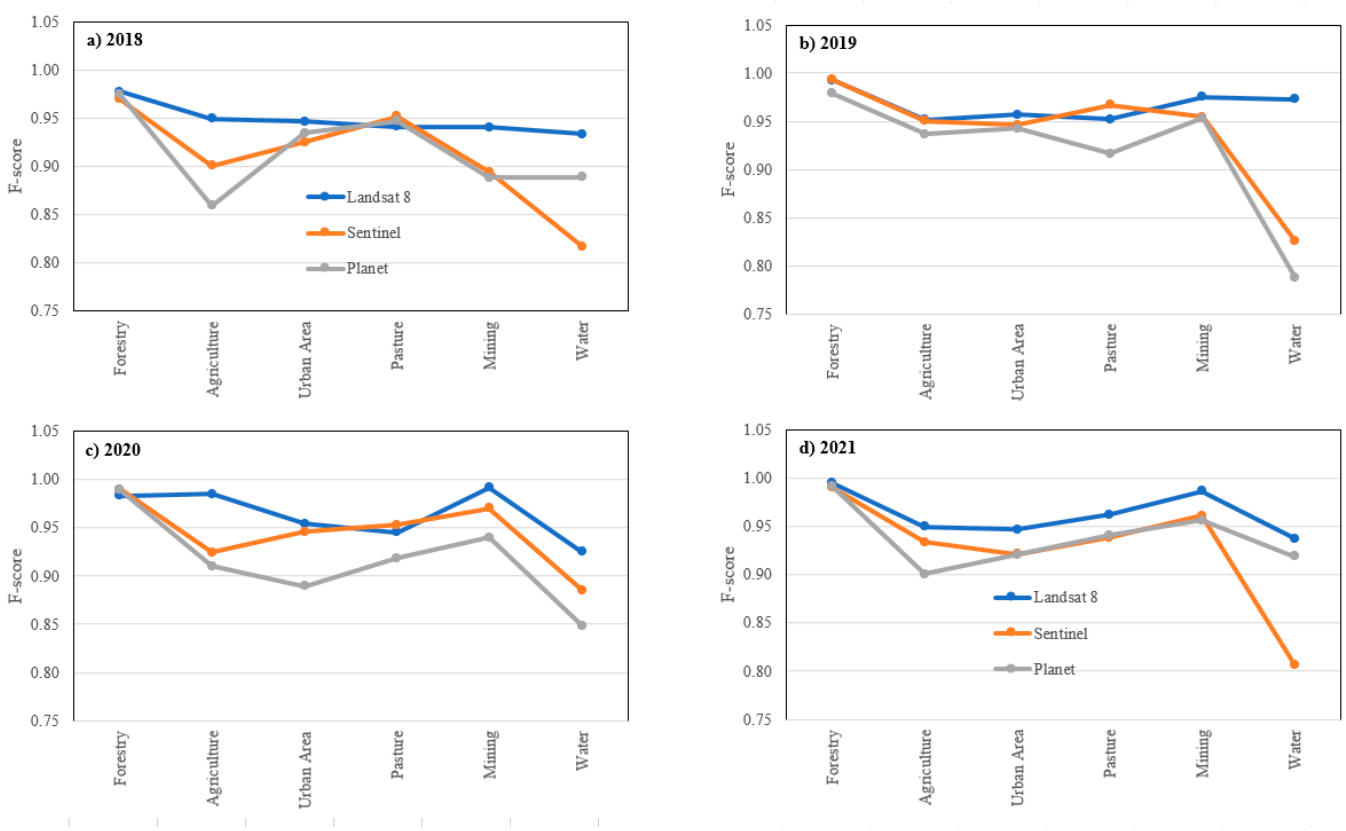


Figure S5. F-score estimated for Landsat 8, Sentinel 2 and PlanetScope images for 2018 (before failure) and 2019, 2020 and 2021 (after failure).

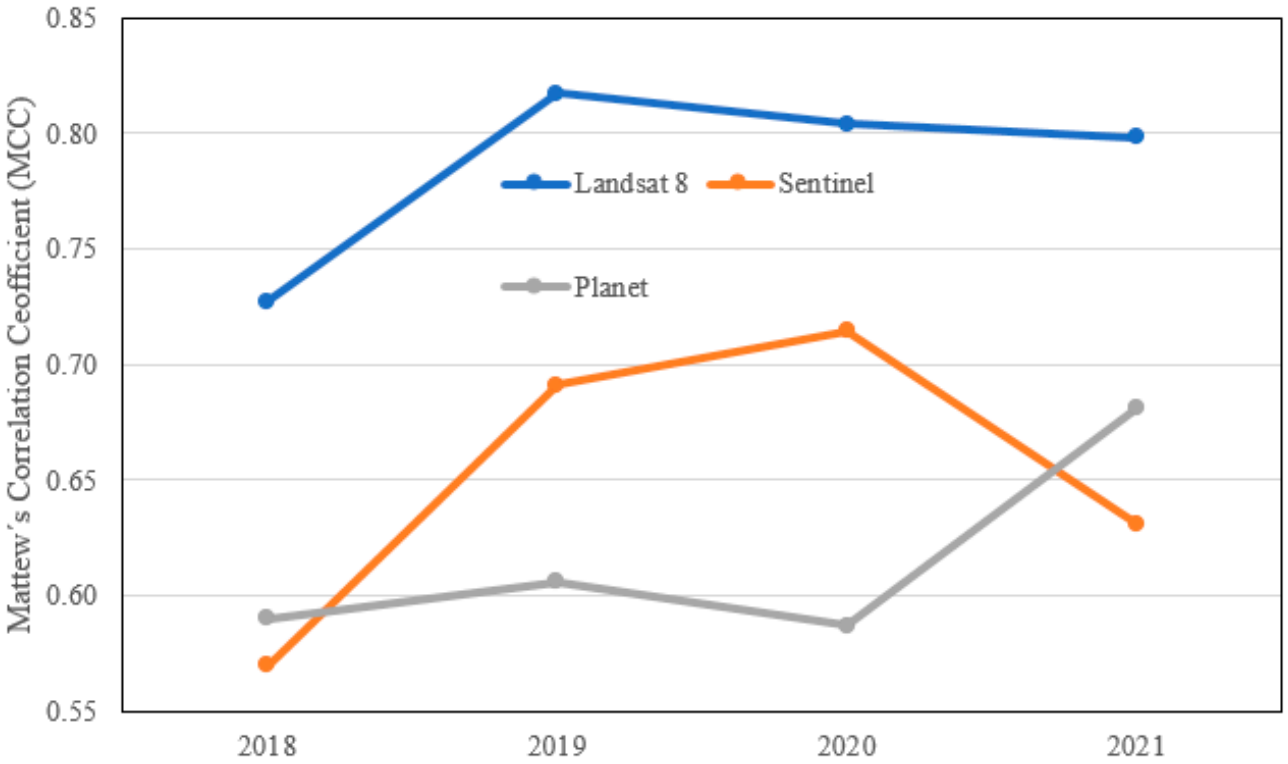


Figure S6. Matthews Correlation Coefficient (MCC) estimated for Landsat 8, Sentinel 2 and PlanetScope images for 2018 (before failure) and 2019, 2020 and 2021 (after failure).

Table S1. Producer (PA) and user accuracy (UA) for each class processed on land use and land cover maps for Landsat8, Sentinel-2 and PlanetScope satellites. 21

Year	Satellite	Forest			Agriculture			Urban Area			Pasture			Mining/Tailings			Water		
		PA	**UA**	**F-Score**	**PA**	**UA**	**F-Score**	**PA**	**UA**	**F-Score**	**PA**	**UA**	**F-Score**	**PA**	**UA**	**F-Score**	**PA**	**UA**	**F-Score**
2018	Landsat 8	0.989	0.965	0.977	0.957	0.943	0.950	0.964	0.929	0.946	0.952	0.930	0.941	0.900	0.984	0.941	0.897	0.972	0.933
	Sentinel-2	0.998	0.943	0.970	0.883	0.919	0.901	0.932	0.919	0.925	0.962	0.942	0.952	0.848	0.946	0.895	0.707	0.967	0.817
	PlanetScope	1.000	0.951	0.975	0.865	0.853	0.859	0.955	0.914	0.934	0.953	0.942	0.947	0.831	0.954	0.888	0.800	1.000	0.889
2019	Landsat 8	0.995	0.990	0.993	0.922	0.983	0.952	0.971	0.943	0.957	0.946	0.958	0.952	0.979	0.972	0.975	0.947	1.000	0.973
	Sentinel-2	1.000	0.986	0.993	0.971	0.931	0.950	0.959	0.934	0.946	0.971	0.963	0.967	0.942	0.967	0.954	0.703	1.000	0.825
	PlanetScope	0.995	0.963	0.979	0.918	0.957	0.937	0.965	0.921	0.942	0.899	0.943	0.920	0.949	0.959	0.954	0.703	0.963	0.812
2020	Landsat 8	0.989	0.977	0.983	0.970	1.000	0.985	0.951	0.958	0.954	0.939	0.951	0.945	0.997	0.986	0.992	0.861	1.000	0.925
	Sentinel-2	1.000	0.980	0.990	0.859	1.000	0.924	0.956	0.935	0.945	0.959	0.947	0.953	0.966	0.974	0.970	0.794	1.000	0.885
	Landsat 8	0.998	0.991	0.995	0.904	1.000	0.950	0.964	0.931	0.947	0.958	0.965	0.962	0.992	0.981	0.986	0.882	1.000	0.938
2021	Sentinel-2	0.995	0.985	0.990	0.926	0.940	0.933	0.946	0.897	0.921	0.944	0.933	0.938	0.951	0.971	0.961	0.676	1.000	0.807
	PlanetScope	1.000	0.983	0.991	0.861	0.944	0.901	0.930	0.911	0.920	0.928	0.953	0.940	0.963	0.949	0.956	0.872	0.971	0.919
	Landsat 8	0.794	0.785	0.790	0.751	0.785	0.767	0.770	0.752	0.761	0.759	0.761	0.760	0.774	0.785	0.779	0.717	0.794	0.754
Means	Sentinel-2	0.998	0.974	0.986	0.910	0.948	0.927	0.948	0.921	0.934	0.959	0.946	0.953	0.927	0.965	0.945	0.720	0.992	0.834
	PlanetScope	0.998	0.970	0.984	0.887	0.918	0.902	0.939	0.911	0.925	0.928	0.937	0.931	0.918	0.954	0.935	0.800	0.984	0.881
	Overall Average	0.996	0.975	0.985	0.912	0.949	0.929	0.950	0.924	0.937	0.945	0.945	0.945	0.937	0.966	0.951	0.806	0.989	0.886

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Table S2. Diagnosis of land use and land cover based on Landsat 8 images, before and after failure. Authors archive, 2022.

LAND USE AND LAND COVER - LANDSAT 8 SATELLITE						
2018 (Before Failure)						
Class	**Ferro-Carvão Stream Watershed**		**Failure Area**		**Outside Failure Area**	
	Area (Km²)	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**
Forest	17.477	52.53	1.200	37.41	16.277	54.14
Agriculture	0.698	2.10	0.079	2.46	0.619	2.06
Urban Area	2.146	6.45	0.189	5.89	1.957	6.51
Pasture	7.835	23.55	0.631	19.67	7.204	23.96
Mining/Tailings	4.880	14.67	1.039	32.39	3.841	12.77
Water	0.234	0.70	0.070	2.18	0.164	0.55
Total Area	33.270	100.00	3.208	100.00	30.062	100.00
2019 (After Failure)						
Class	**Ferro-Carvão Stream Watershed**		**Failure Area**		**Outside Failure Area**	
	Area (Km²)	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**
Forest	16.557	49.77	0.051	1.59	16.506	54.91
Agriculture	0.743	2.23	0.072	2.24	0.671	2.23
Urban Area	2.078	6.25	0.093	2.90	1.985	6.60
Pasture	7.899	23.74	0.170	5.30	7.729	25.71
Mining/Tailings	5.824	17.51	2.796	87.16	3.028	10.07
Water	0.169	0.510	0.026	0.81	0.143	0.48
Total Area	33.270	100.00	3.208	100.00	30.062	100.00
2020 (After Failure)						
Class	**Ferro-Carvão Stream Watershed**		**Failure Area**		**Outside Failure Area**	
	Area (Km²)	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**
Forest	16.994	51.08	0.082	2.56	16.912	56.26
Agriculture	0.695	2.09	0.032	1.00	0.663	2.20
Urban Area	2.439	7.33	0.248	7.73	2.191	7.29
Pasture	6.449	19.38	0.272	8.48	6.177	20.55
Mining/Tailings	6.534	19.64	2.534	78.99	4.000	13.31
Water	0.159	0.48	0.040	1.25	0.119	0.39
Total Area	33.270	100.00	3.208	100.00	30.062	100.00

2021 (After Failure)						
Class	Ferro-Carvão Stream Watershed		Failure Area		Outside Failure Area	
	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)
Forest	16.804	50.49	0.112	3.49	16.692	55.52
Agriculture	0.597	1.80	0.064	2.00	0.533	1.77
Urban Area	2.275	6.84	0.267	8.32	2.008	6.68
Pasture	7.727	23.23	0.493	15.37	7.234	24.06
Mining/tailings	5.668	17.04	2.238	69.76	3.430	11.41
Water	0.199	0.60	0.034	1.06	0.165	0.55
Total Area	33.270	100.00	3.208	100.00	30.062	100.00

Table S3. Diagnosis of land use and land cover based on Sentinel-2 images, before and after failure. Authors` collection, 2022.

LAND USE AND LAND COVER – SENTINAL-2 SATELLITE						
2018 (Before Failure)						
Class	Ferro- Carvão Stream Watershed		Failure Area		Outside Failure Area	
	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)
Forest	17.583	52.85	1.411	43.98	16.172	53.80
Agriculture	1.428	4.29	0.151	4.71	1.277	4.25
Urban Area	1.947	5.85	0.269	8.39	1.678	5.58
Pasture	7.429	22.33	0.700	21.82	6.729	22.38
Mining/Tailings	4.667	14.03	0.659	20.54	4.008	13.33
Water	0.216	0.65	0.018	0.56	0.198	0.66
Total Area	33.270	100.000	3.208	100.000	30.062	100.000
2019 (After Failure)						
Class	Ferro-Carvão Stream Watershed		Failure Area		Outside Failure Area	
	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)
Forest	17.216	51.75	0.182	5.67	17.034	56.66
Agriculture	1.421	4.27	0.095	2.96	1.326	4.41
Urban Area	1.895	5.70	0.213	6.64	1.682	5.60
Pasture	6.691	20.11	0.108	3.37	6.583	21.89
Mining/Tailings	5.514	16.57	2.557	79.68	2.957	9.84
Water	0.533	1.60	0.053	1.68	0.480	1.60
Total Area	33.270	100.000	3.208	100.000	30.062	100.000

2020 (After Failure)						
Class	Ferro-Carvão Stream watershed		Failure Area		Outside Failure Area	
	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)
Forest	16.697	50.19	0.213	6.64	16.484	54.83
Agriculture	0.866	2.60	0.075	2.34	0.791	2.63
Urban Area	2.168	6.52	0.397	12.38	1.771	5.89
Pasture	6.621	19.90	0.455	14.18	6.166	20.51
Mining/ Tailings	6.554	19.70	2.056	64.09	4.498	14.96
Water	0.364	1.09	0.012	0.37	0.352	1.17
Total Area	33.270	100.000	3.208	100.000	30.062	100.000
2021 (After Failure						
Class	Ferro-Carvão Stream Watershed		Failure Area		Outside Failure Area	
	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)
Forest	16.776	50.42	0.301	9.38	16.475	54.80
Agriculture	1.737	5.22	0.294	9.16	1.443	4.80
Urban Area	2.176	6.54	0.302	9.41	1.874	6.23
Pasture	6.653	20.00	0.361	11.25	6.292	20.93
Mining/ Tailings	5.806	17.45	1.945	60.63	3.861	12.84
Water	0.122	0.37	0.005	0.16	0.117	0.39
Total Area	33.270	100.000	3.208	100.000	30.062	100.000

Table S4. Diagnosis of land use and land cover based on PlanetScope images, before and after failure. Authors collection, 2022.

LAND USE AND LAND COVER – PLANETSCOPE SATELLITE						
2018 (Before Failure)						
Class	Ferro-Carvão Stream Wastewater		Failure Area		Outside Failure Area	
	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)	Area (Km²)	Percentage (%)
Forest	18.271	54.92	1.435	44.73	16.836	56.00
Agriculture	0.997	3.00	0.124	3.87	0.873	2.91
Urban Area	1.516	4.56	0.194	6.05	1.322	4.40
Pasture	7.325	22.02	0.783	24.41	6.542	21.76
Mining/ Tailings	4.856	14.60	0.641	19.98	4.215	14.02
Water	0.305	0.92	0.031	0.97	0.274	0.91
Total Area	33.270	100.000	3.208	100.000	30.062	100.000

2019 (After Failure)						
Class	**Ferro-Carvão Stream Watershed**		**Failure Area**		**Outside Failure Area**	
	Area (Km²)	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**
Forest	18.614	55.95	0.297	9.26	18.317	60.93
Agriculture	1.000	3.01	0.123	3.83	0.877	2.92
Urban Area	1.531	4.60	0.262	8.17	1.269	4.22
Pasture	5.296	15.92	0.356	11.10	4.940	16.43
Mining/Tailings	6.472	19.45	2.140	66.71	4.332	14.41
Water	0.357	1.07	0.030	0.94	0.327	1.09
Total Area	33.270	100.000	3.208	100.000	30.062	100.000
2020 (After Failure)						
Class	**Ferro-Carvão Stream Watershed**		**Failure Area**		**Failure Area**	
	Area (Km²)	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**
Forest	16.684	50.15	0.176	5.49	16.508	54.91
Agriculture	0.830	2.49	0.064	2.00	0.766	2.55
Urban Area	1.811	5.44	0.382	11.91	1.429	4.75
Pasture	7.399	22.24	0.799	24.91	6.600	21.96
Mining/ Tailings	6.218	18.69	1.775	55.33	4.443	14.78
Water	0.328	0.990	0.012	0.37	0.316	1.05
Total Area	33.270	100.000	3.208	100.000	30.062	100.000
2021 (After Failure)						
Class	**Ferro-Carvão Stream Watershed**		**Failure Area**		**Failure Area**	
	Area (Km²)	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**	**Area (Km²)**	**Percentage (%)**
Forest	16.814	50.54	0.215	6.70	16.640	55.35
Agriculture	1.516	4.56	0.176	5.49	1.382	4.60
Urban Area	2.205	6.630	0.495	15.43	1.751	5.82
Pasture	6.904	20.75	0.611	19.05	6.334	21.07
Mining/ Tailings	5.408	16.25	1.693	52.77	3.550	11.81
Water	0.423	1.27	0.018	0.56	0.405	1.35
Total Area	33.270	100.000	3.208	100.00	30.062	100.000

Table S5. Simplified diagnosis of the difference in land use and land cover area based on Landsat 8 images, before and after failure.

Changes in land use and land cover using the Landsat 8 satellite				
2018-2019				
Ferro-Carvão Stream Watershed				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	17.477	16.557	(-) 0.920	2.77
Agriculture	0.698	0.743	(+) 0.045	0.14
Urban Area	2.146	2.078	(-) 0.068	0.20
Pasture	7.835	7.899	(+) 0.064	0.19
Mining/Tailings	4.880	5.824	(+) 0.944	2.84
Water	0.234	0.169	(-) 0.065	0.20
Total Area	33.270	33.270		
Failure Area				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	1.200	0.051	(-) 1.149	35.82
Agriculture	0.079	0.072	(-) 0.007	0.22
Urban Area	0.189	0.093	(-) 0.096	2.99
Pasture	0.631	0.170	(-) 0.461	14.37
Mining/Tailings	1.039	2.796	(+) 1.757	54.77
Water	0.070	0.026	(-) 0.044	1.37
Total Area	3.208	3.208		
Outside Failure Area				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.277	16.506	(+) 0.229	7.14
Agriculture	0.619	0.671	(+) 0.052	1.62
Urban Area	1.957	1.985	(+) 0.028	0.87
Pasture	7.204	7.729	(+) 0.525	16.37
Mining/Tailings	3.841	3.028	(-) 0.813	25.34
Water	0.164	0.143	(-) 0.021	0.65
Total Area	30.062	30.062		
2019-2020				
Ferro-Carvão Stream Watershed				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.557	16.994	(+) 0.437	1.31
Agriculture	0.743	0.695	(-) 0.048	0.14
Urban Area	2.078	2.439	(+) 0.362	1.09
Pasture	7.899	6.449	(-) 1.450	4.36
Mining/Tailings	5.824	6.534	(+) 0.710	2.13
Water	0.169	0.159	(-) 0.010	0.03
Total Area	33.27	33.27		
Failure Area				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	0.051	0.082	(+) 0.031	0.97
Agriculture	0.072	0.032	(-) 0.040	1.25
Urban Area	0.093	0.248	(+) 0.155	4.83
Pasture	0.17	0.272	(-) 0.102	3.18
Mining/Tailings	2.796	2.534	(-) 0.262	8.17
Water	0.026	0.04	(+) 0.014	0.44
Total Area	3.208	3.208		

Ferro-Carvão Stream Watershed				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.506	16.912	(+) 0.406	12.66
Agriculture	0.671	0.663	(-) 0.008	0.25
Urban Area	1.985	2.191	(+) 0.206	6.42
Pasture	7.729	6.177	(-) 1.552	48.38
Mining/Tailings	3,028	4.000	(+) 0.972	30.30
Water	0.143	0.119	(-) 0.024	0.75
Total Area	30.062	30.062		

2020-2021				
Ferro-Carvão Stream Watershed				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.994	16.804	(-) 0.190	0.57
Agriculture	0.695	0.597	(-) 0.098	0.29
Urban Area	2.439	2.275	(-) 0.165	0.50
Pasture	6.449	7.727	(+) 1.278	3.84
Mining/Tailings	6.534	5.668	(-) 0.866	2.60
Water	0.159	0.199	(+) 0.040	0.12
Total Area	33.27	33.27		
Failure Area				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	0.082	0.112	(+) 0.029	0.90
Agriculture	0.032	0.064	(+) 0.032	1.00
Urban Area	0.248	0.267	(+) 0.019	0.59
Pasture	0.272	0.493	(+) 0.221	6.89
Mining/Tailings	2.534	2.238	(-) 0.296	9.23
Water	0.04	0.034	(-) 0.006	0.19
Total Area	3.208	3.208		
Outside failure Area				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.912	16.692	(-) 0.220	6.86
Agriculture	0.663	0.533	(-) 0.130	4.05
Urban Area	2.191	2.008	(-) 0.183	5.70
Pasture	6.177	7.234	(+) 1.057	32.95
Mining/Tailings	4.000	3.43	(-) 0.570	17.77
Water	0.119	0.165	(+) 0.046	1.43
Total Area	30.062	30.062		

Table S6. Simplified diagnosis of the difference in land use and land cover area based on Sentinel-2 images, before and after failure.

Changes in simplified land use and land cover using the Sentinel -2 satellite				
2018-2019				
Ferro-Carvão Stream Watershed				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	17.583	17.216	(-) 0.367	1.10
Agriculture	1.428	1.421	(-) 0.007	0.02
Urban Area	1.947	1.895	(-) 0.052	0.16
Pasture	7.429	6.691	(-) 0.739	2.22
Mining/Tailings	4.667	5.514	(+) 0.847	2.55
Water	0.216	0.533	(+) 0.317	0.95
Total Area	33.270	33.270		
Failure Area				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	1.411	0.182	(-) 1.229	38.31
Agriculture	0.151	0.095	(-) 0.056	1.75
Urban Area	0.269	0.213	(-) 0.056	1.75
Pasture	0.700	0.108	(-) 0.592	18.45
Mining/Tailings	0.659	2.557	(-) 1.898	59.16
Water	0.018	0.053	(-) 0.036	1.12
Total Area	3.208	3.208		
Outside Failure Area				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.172	17.034	(+) 0.862	26.87
Agriculture	1.277	1.326	(+) 0.049	1.53
Urban Area	1.678	1.682	(+) 0.004	0.12
Pasture	6.729	6.583	(-) 0.146	4.55
Mining/Tailings	4.008	2.957	(-) 1.051	32.76
Water	0.198	0.480	(+) 0.282	8.79
Total Area	30.062	30.062		
2019-2020				
Ferro-Carvão Stream Watershed				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	17.216	16.697	(-) 0.519	1.56
Agriculture	1.421	0.866	(-) 0.555	1.67
Urban Area	1.895	2.168	(+) 0.273	0.82
Pasture	6.691	6.621	(-) 0.069	0.21
Mining/Tailings	5.514	6.554	(+) 1.040	3.13
Water	0.533	0.364	(-) 0.169	0.51
Total Area	33.270	33.270		
Failure Area				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	0.182	0.213	(+) 0.031	0.97
Agriculture	0.095	0.075	(-) 0.020	0.62
Urban Area	0.213	0.397	(+) 0.184	5.74
Pasture	0.108	0.455	(+) 0.347	10.82
Mining/Tailings	2.557	2.056	(-) 0.501	15.62
Water	0.053	0.012	(-) 0.042	1.31
Total Area	3.208	3.208		

Outside Failure Area				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	17.034	16.484	(-) 0.550	17.14
Agriculture	1.326	0.791	(-) 0.535	16.68
Urban Area	1.682	1.771	(+) 0.089	2.77
Pasture	6.583	6.166	(-) 0.417	13.00
Mining/Tailings	2.957	4.498	(+) 1.541	48.04
Water	0.480	0.352	(-) 0.128	3.99
Total Area	30.062	30.062		
2020-2021				
Ferro-Carvão Stream Watershed				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.697	16.776	(+) 0.079	0.24
Agriculture	0.866	1.737	(+) 0.871	2.62
Urban Area	2.168	2.176	(+) 0.008	0.02
Pasture	6.621	6.653	(+) 0.032	0.10
Mining/Tailings	6.554	5.806	(-) 0.748	2.25
Water	0.364	0.122	(-) 0.242	0.73
Total Area	33.270	33.270		
Failure Area				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	0.213	0.301	(+) 0.088	2.74
Agriculture	0.075	0.294	(+) 0.219	6.83
Urban Area	0.397	0.302	(-) 0.095	2.96
Pasture	0.455	0.361	(-) 0.094	2.93
Mining/Tailings	2.056	1.945	(-) 0.111	3.46
Water	0.012	0.005	(-) 0.007	0.22
Total Area	3.208	3.208		
Outside Failure Area				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.484	16.475	(-) 0.009	0.28
Agriculture	0.791	1.443	(+) 0.652	20.32
Urban Area	1.771	1.874	(+) 0.103	3.21
Pasture	6.166	6.292	(+) 0.126	3.93
Mining/Tailings	4.498	3.861	(-) 0.637	19.86
Water	0.352	0.117	(-) 0.235	7.33
Total Area	30.062	30.062		

Table S7. Simplified diagnosis of the difference in land use and land cover area based on PlanetScope images, before and after failure

Changes in simplified land use and land cover using the PlanetScope satellite				
2018-2019				
Ferro-Carvão Stream Watershed				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	18.271	18.614	(+) 0.343	1.03
Agriculture	0.997	1.000	(+) 0.003	0.01
Urban Area	1.516	1.531	(+) 0.015	0.05
Pasture	7.325	5.296	(-) 2.029	6.10
Mining/Tailings	4.856	6.472	(+) 1.616	4.86
Water	0.305	0.357	(+) 0.052	0.16
Total Area	33.270	33.270		
Failure Area				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	1.435	0.297	(-) 1.138	35.47
Agriculture	0.124	0.123	(-) 0.001	0.03
Urban Area	0.194	0.262	(+) 0.068	2.12
Pasture	0.783	0.356	(-) 0.427	13.31
Mining/Tailings	0.641	2.140	(+) 1.499	46.73
Water	0.031	0.030	(-) 0.001	0.03
Total Area	3.208	3.208		
Outside Failure Area				
Class	**2018 (Km²)**	**2019 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.836	18.317	(+) 1.481	4.93
Agriculture	0.873	0.877	(+) 0.004	0.01
Urban Area	1.322	1.269	(-) 0.053	0.18
Pasture	6.542	4.940	(-) 1.602	5.33
Mining/Tailings	4.215	4.332	(+) 0.117	0.39
Water	0.274	0.327	(+) 0.053	0.18
Total Area	30.062	30.062		
2019-2020				
Ferro-Carvão Stream Watershed				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	18.614	16.684	(-) 1.930	5.80
Agriculture	1.000	0.830	(-) 0.170	0.51
Urban Area	1.531	1.811	(+) 0.280	0.84
Pasture	5.296	7.399	(+) 2.103	6.32
Mining/Tailings	6.472	6.218	(-) 0.254	0.76
Water	0.357	0.328	(-) 0.029	0.09
Total	33.270	33.270		
Failure Area				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	0.297	0.176	(-) 0.121	3.77
Agriculture	0.123	0.064	(-) 0.059	1.84
Urban Area	0.262	0.382	(+) 0.120	3.74
Pasture	0.356	0.799	(+) 0.443	13.81
Mining/Tailings	2.140	1.775	(-) 0.365	11.38
Water	0.030	0.012	(-) 0.018	0.56
Total Area	3.208	3.208		

Outside Failure Area				
Class	**2019 (Km²)**	**2020 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	18.317	16.508	(-) 1.809	6.02
Agriculture	0.877	0.766	(-) 0.111	0.37
Urban Area	1.269	1.429	(+) 0.160	0.53
Pasture	4.940	6.600	(+) 1.660	5.52
Mining/Tailings	4.332	4.443	(+) 0.111	0.37
Water	0.327	0.316	(-) 0.011	0.04
Total Area	30.062	30.062		
2020-2021				
Ferro-Carvão Stream Watershed				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.684	16.814	(+) 0.130	0.39
Agriculture	0.830	1.516	(+) 0.686	2.06
Urban Area	1.811	2.205	(+) 0.394	1.18
Pasture	7.399	6.904	(-) 0.495	1.49
Mining/Tailings	6.218	5.408	(-) 0.810	2.43
Water	0.328	0.423	(+) 0.095	0.29
Total Area	33.270	33.270		
Failure Area				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	0.176	0.215	(+) 0.039	1.22
Agriculture	0.064	0.176	(+) 0.112	3.49
Urban Area	0.382	0.495	(+) 0.113	3.52
Pasture	0.799	0.611	(-) 0.188	5.86
Mining/Tailings	1.775	1.693	(-) 0.082	2.56
Water	0.012	0.018	(+) 0.006	0.19
Total Area	3.208	3.208		
Outside Failure Area				
Class	**2020 (Km²)**	**2021 (Km²)**	**Changes (Km²)**	**Percentage (%)**
Forest	16.508	16.640	(+) 0.132	0.44
Agriculture	0.766	1.382	(+) 0.616	2.05
Urban Area	1.429	1.751	(+) 0.322	1.07
Pasture	6.600	6.334	(-) 0.266	0.88
Mining/Tailings	4.443	3.550	(-) 0.893	2.97
Water	0.316	0.405	(+) 0.089	0.30
Total Area	30.062	30.062		