Supplementary material

Identification of Potential Surface Water Resources for Inland Aquaculture from Sentinel-2 Images of the Rwenzori Region of Uganda

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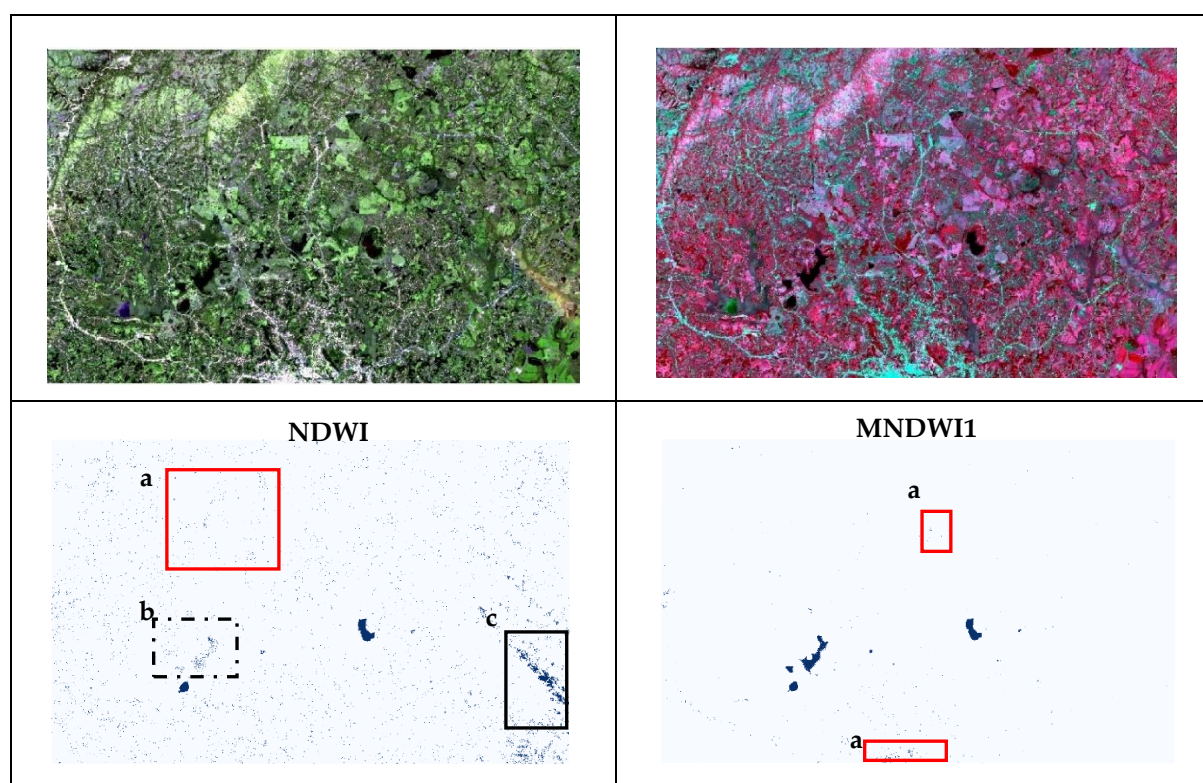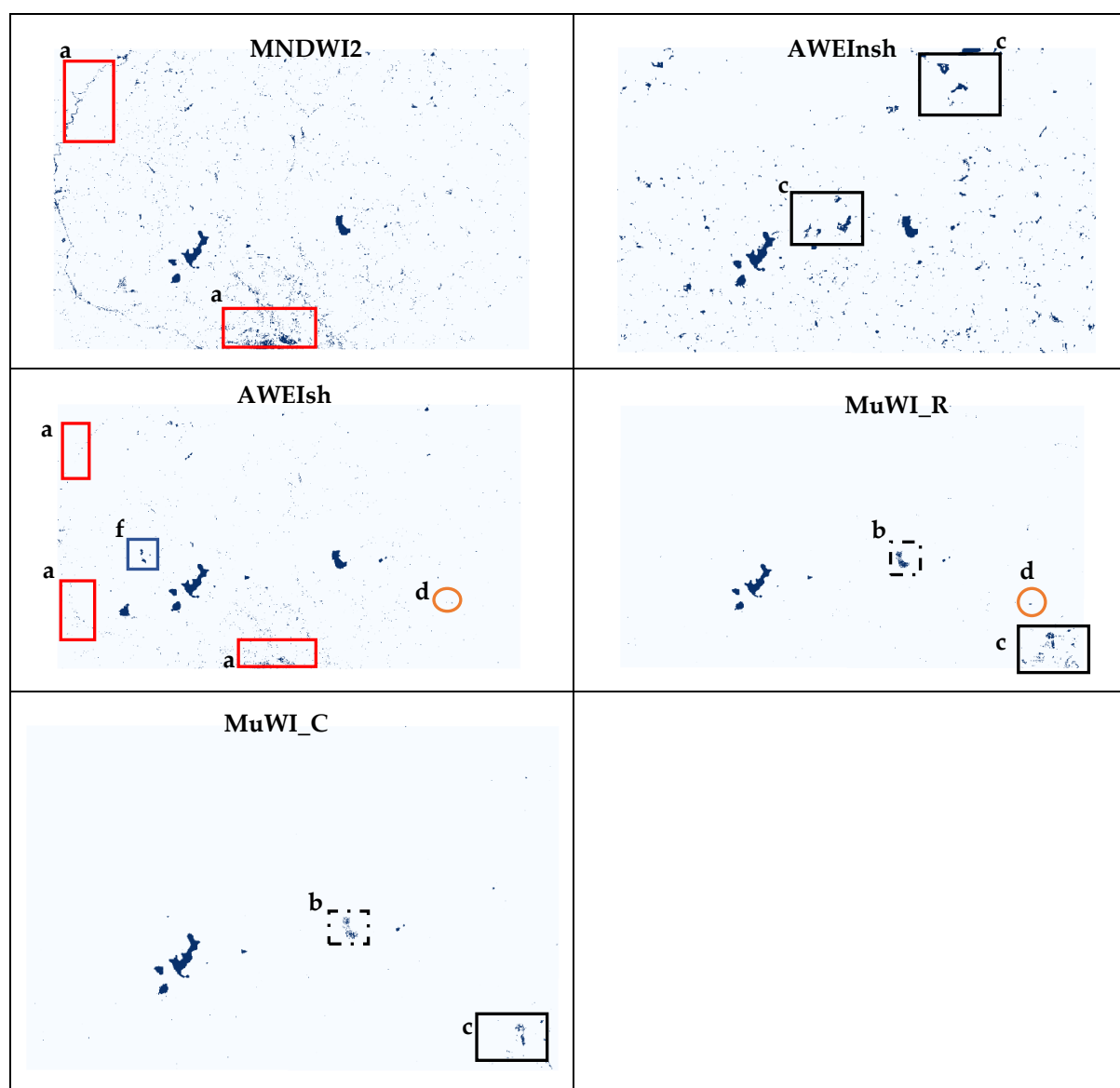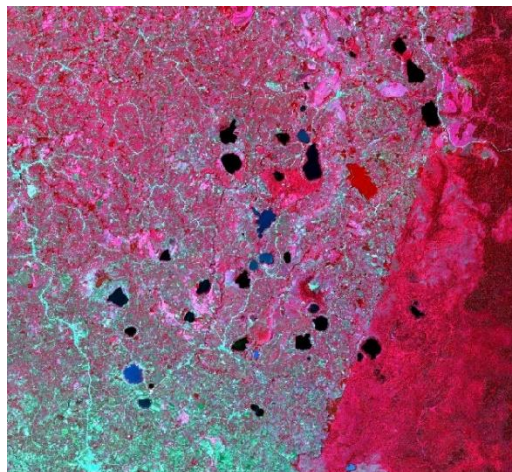
Figure S1. Comparing cases of surface water extraction in site 1. Top left is Sentinel-2 MSI RGB (4,3,2) 10m natural-color image, top right is Sentinel-2 MSI RGB (8,4,3) false-color composite. This is followed by the corresponding water maps as classified by the respective spectral water indices. The red rectangles (a) are built-up areas misclassified as water, dotted black rectangles (b) show blurred waterbodies, black rectangles (c) are vegetated areas (forests and other vegetation) misclassified as water, orange circles (d) shows small ponds (fishponds), while blue rectangles (f) is water in swampy (wetland) areas.
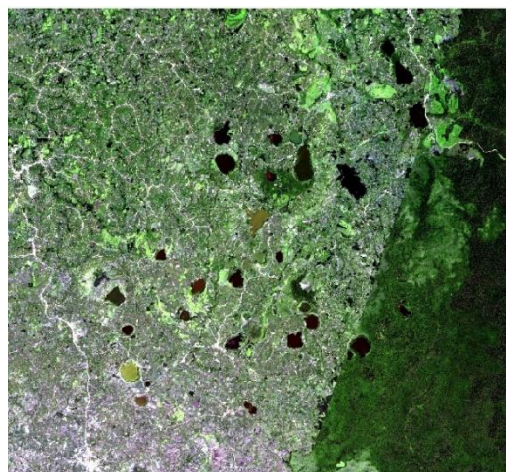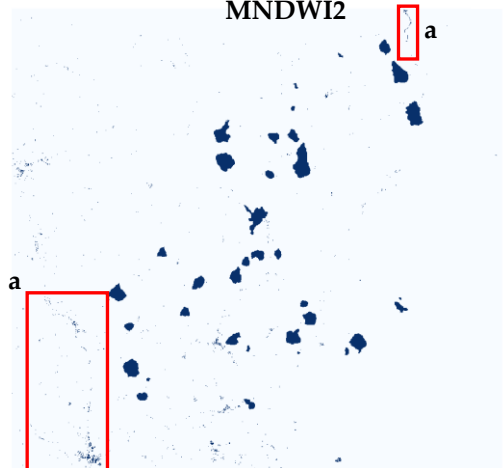
Figure S2. Comparing cases of surface water extraction in site 2. Top left is Sentinel-2 MSI RGB (4,3,2) 10m natural-color image, top right is Sentinel-2 MSI RGB (8,4,3) false-color composite. This is followed by the corresponding water maps as classified by the respective spectral water indices. The red rectangles (a) are built-up areas misclassified as water, dotted black rectangles (b) show blurred waterbodies, black rectangles (c) are vegetated areas (forests and other vegetation) misclassified as water, while (g) are discontinuous portions of narrow rivers.
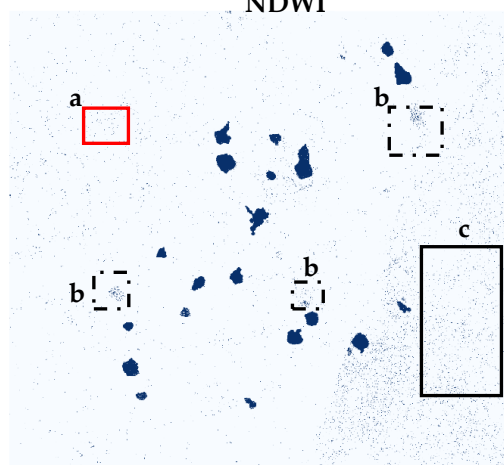
Figure S3. Comparing cases of surface water extraction in site 3. Top left is Sentinel-2 MSI RGB (4,3,2) 10m natural-color image, top right is Sentinel-2 MSI RGB (8,4,3) false-color composite. This is followed by the corresponding water maps as classified by the respective spectral water indices. The red rectangles (a) are built-up areas misclassified as water, black rectangles (c) are vegetated areas (forests and other vegetation) misclassified as water, orange circles (d), while (g) are discontinuous portions of narrow rivers.
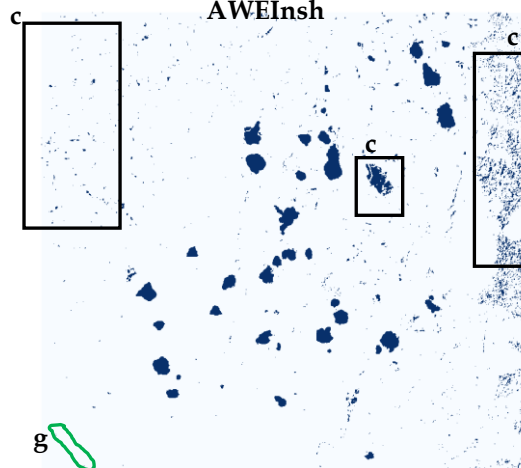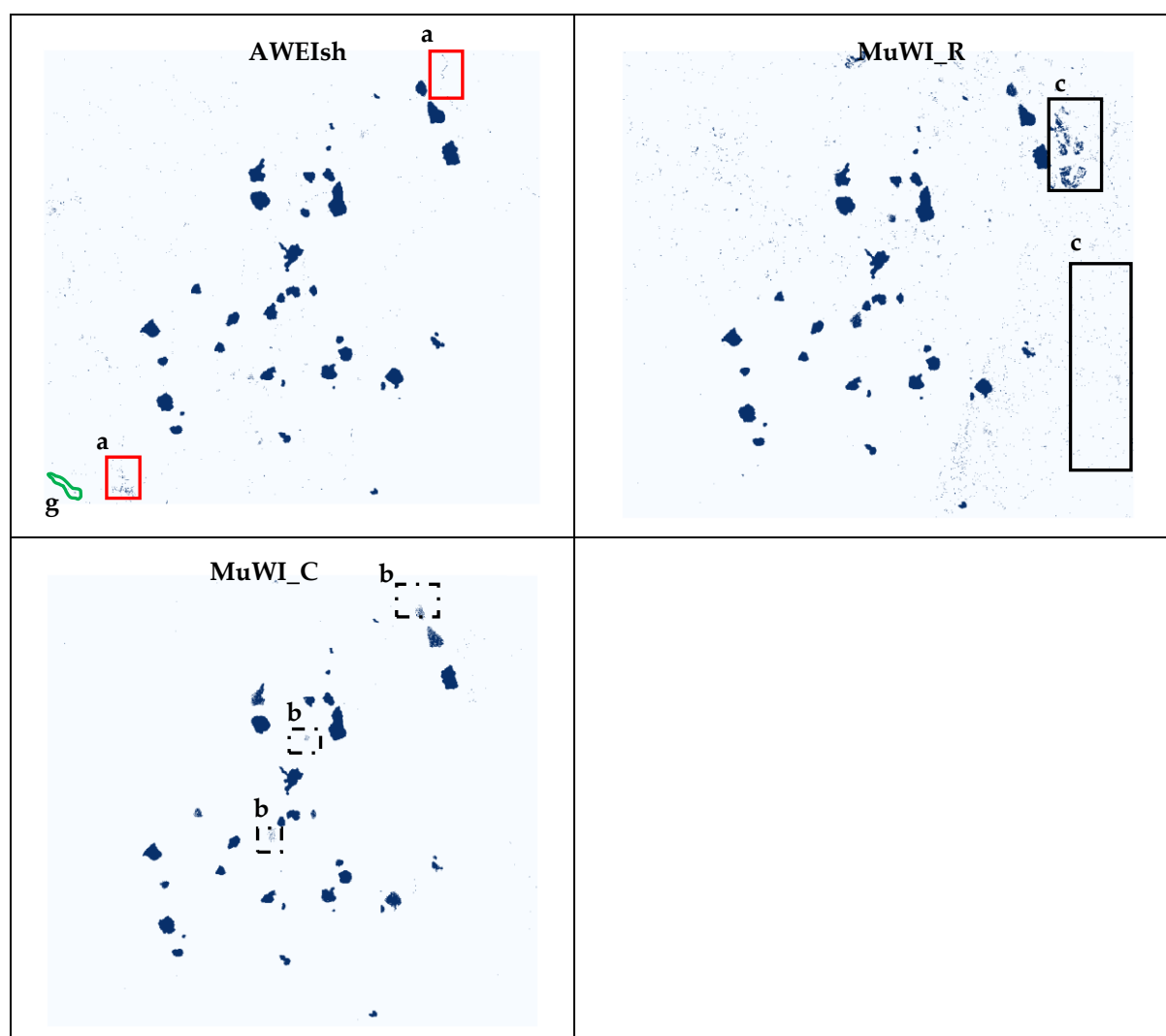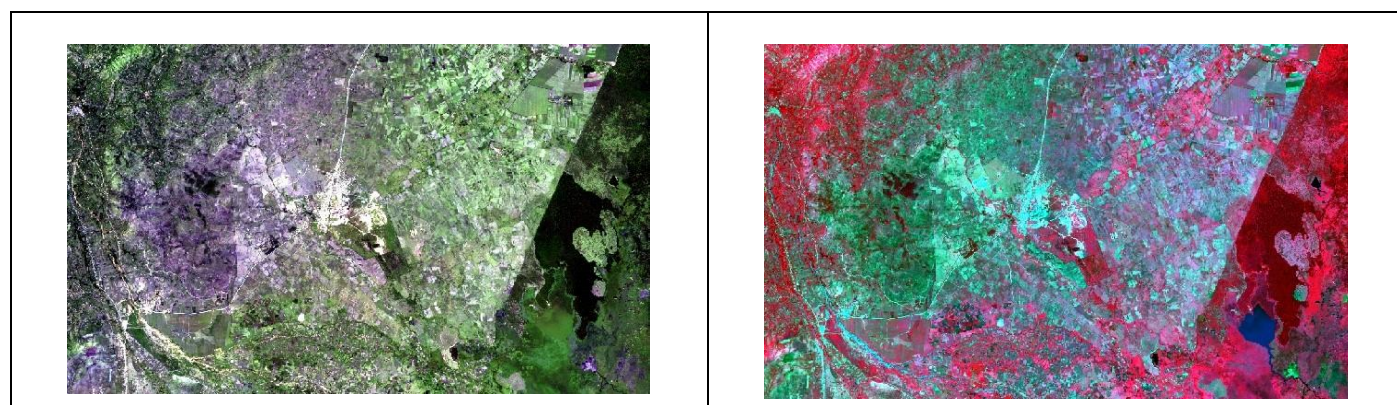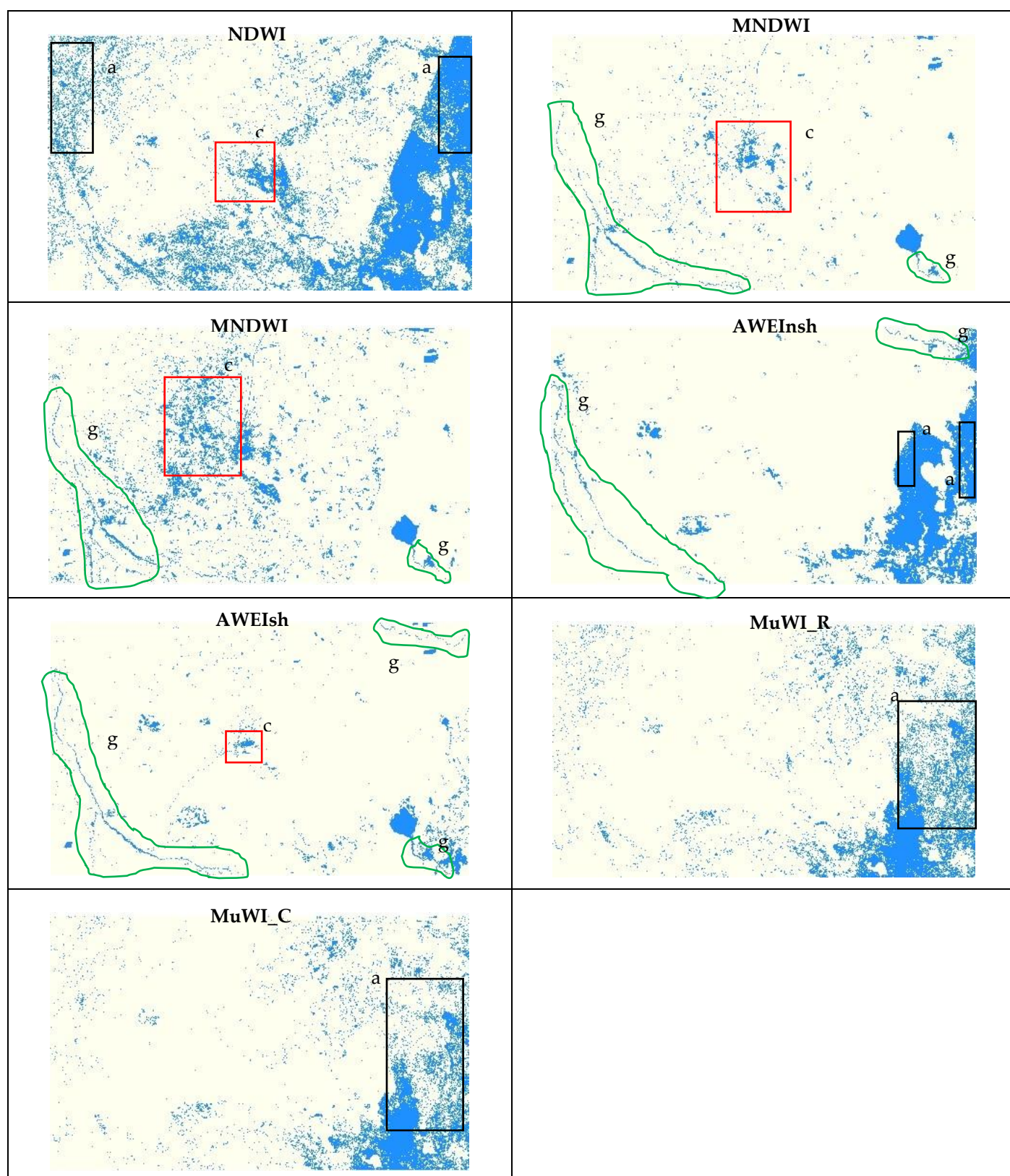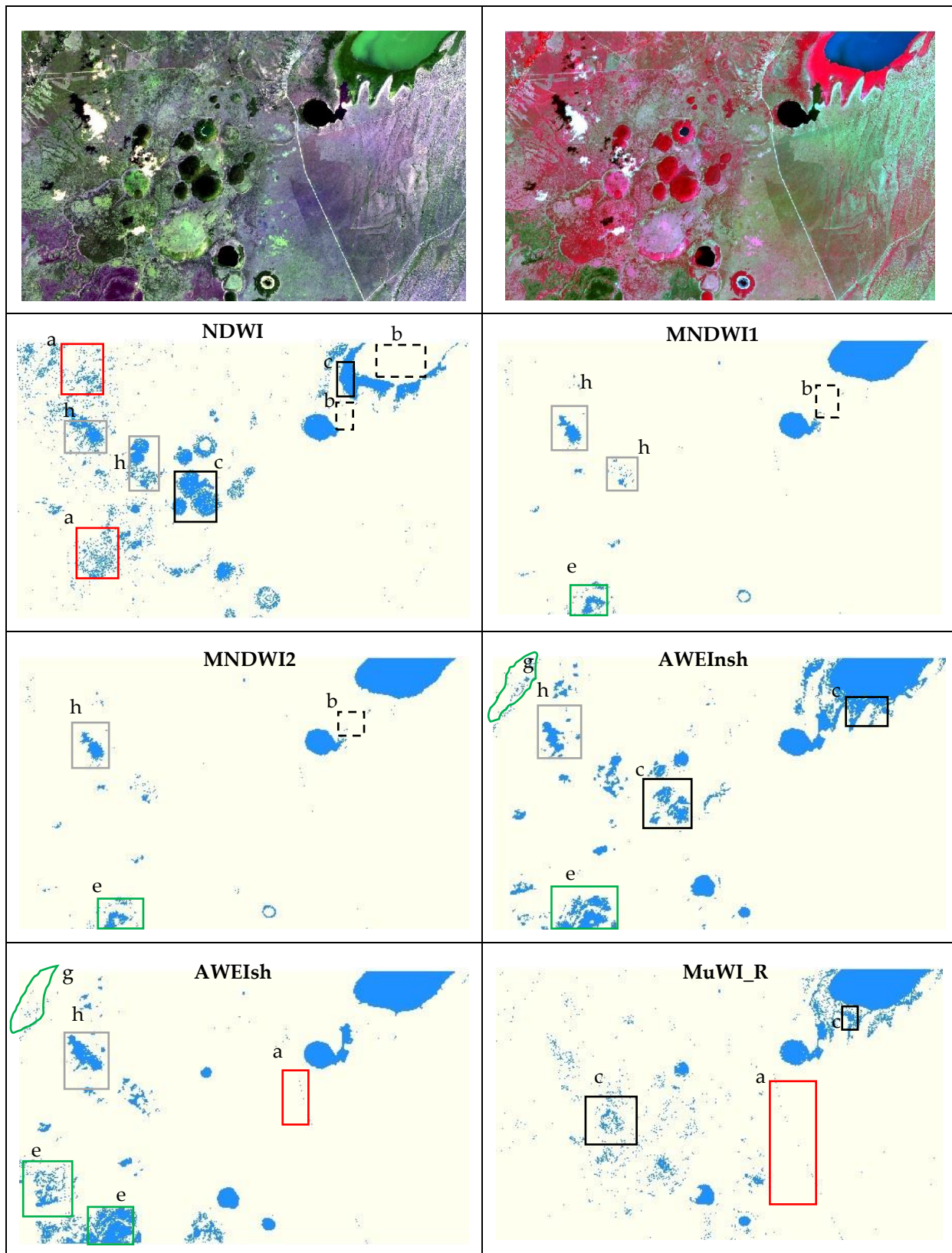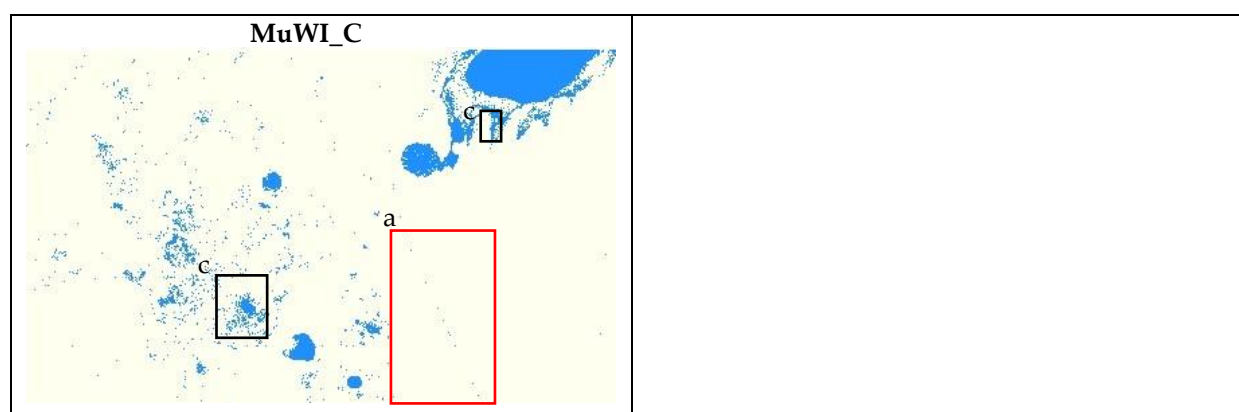
Figure S4. Comparing cases of surface water extraction in site 4. Top left is Sentinel-2 MSI RGB (4,3,2) 10m natural-color image, top right is Sentinel-2 MSI RGB (8,4,3) false-color composite. This is followed by the corresponding water maps as classified by the respective spectral water indices. The red rectangles (a) are built-up areas misclassified as water, dotted black rectangles (b) show blurred waterbodies, black rectangles (c) are vegetated areas (forests and tea estates) misclassified as water, green rectangles (e) is bare ground misclassified as water, while (g) are discontinuous portions of narrow rivers, and grey rectangles (h) clouds/cloud shadows misclassified as water.

Table S5. K-means cluster centers, where the optimum threshold (the center that gave the highest OA and kappa) is highlighted.

Site 1

Cluster center	NDWI	MNDWI1	MNDWI2	AWEIsh	AWEInsh	MuWI_C	MuWI_R
1	-0.27	-0.60	-0.10	-5926.58	-16209.74	2.39	0.08
2	0.14	-0.03	-0.77	-3166.10	-11294.86	7.47	-0.68
3	-0.41	-0.84	-0.36	-4349.30	-12176.02	0.69	2.77
4	-0.24	-0.49	-0.86	-5493.35	-8619.31	-3.07	-0.06
5	-0.21	-0.68	-0.83	-5000.62	-14344.24	1.53	-0.39
6	-0.32	-0.29	-0.72	-6839.84	-13159.25	3.33	0.96
7	-0.07	-0.73	-0.80	73.44	-7050.44	-0.22	0.36
8	-0.18	-0.77	-0.65	-8286.82	-9596.69	19.83	0.54
9	-0.15	-0.81	-0.54	-6359.41	-10458.41	4.54	-0.21
10	-0.12	-0.88	-0.90	-7410.16	-444.37	-1.33	0.21

Site 2

Cluster center	NDWI	MNDWI1	MNDWI2	AWEIsh	AWEInsh	MuWI_C	MuWI_R
1	-0.22	-0.80	-0.69	-2928.46	-11783.30	-2.69	-0.06
2	-0.25	-0.57	-0.90	-5199.38	-270.36	12.17	-0.61
3	-0.15	-0.66	-0.46	-6411.62	-8336.82	3.97	0.24
4	-0.04	-0.76	-0.79	-4740.54	-13910.72	0.66	0.08
5	-0.18	-0.84	-0.74	-5596.51	-10132.42	2.62	-0.22
6	-0.34	-0.43	0.05	276.99	-7201.59	1.59	1.59
7	0.10	-0.11	-0.61	-5986.37	-12700.91	-0.26	-0.38
8	-0.12	0.09	-0.83	-4140.40	-10951.91	7.77	0.42
9	-0.09	-0.88	-0.15	-7658.28	-15888.88	17.76	0.68
10	-0.29	-0.72	-0.86	-6929.70	-9276.21	-1.28	2.61

Site 3

Cluster center	NDWI	MNDWI1	MNDWI2	AWEIsh	AWEInsh	MuWI_C	MuWI_R

1	-0.34	-0.58	-0.81	-2665.28	-16286.55	-0.26	-0.24
2	-0.29	-0.75	-0.66	-5022.17	-18559.13	1.35	0.32
3	-0.13	-0.38	-0.85	-4593.32	-12848.25	3.54	0.00
4	-0.09	-0.67	-0.41	-5394.81	-13819.54	0.53	-0.49
5	-0.16	-0.63	-0.55	881.26	-9000.94	-1.87	-0.66
6	-0.26	-0.51	-0.61	-6182.35	876.09	2.29	-0.36
7	-0.19	-0.79	-0.70	-7837.49	-10494.63	-1.04	-0.12
8	-0.21	-0.71	-0.77	-5761.15	-11801.94	-2.96	0.14
9	-0.05	-0.16	-0.18	-3949.14	-14897.65	5.70	0.61
10	0.24	-0.83	-0.74	-6758.48	-7571.75	18.70	2.72

Site 4

Cluster center	NDWI	MNDWI1	MNDWI2	AWEIsh	AWEInsh	MuWI_C	MuWI_R
1	-0.22	-0.72	-0.76	-127.87	-6280.94	20.63	0.16
2	-0.04	-0.67	-0.70	-1936.92	-953.94	9.37	3.06
3	0.02	-0.49	-0.52	-4496.02	-12050.34	-2.17	-0.29
4	-0.29	-0.63	-0.66	-4835.96	-15416.24	0.14	-0.03
5	-0.16	-0.29	-0.58	1525.60	-14205.73	4.58	-0.40
6	-0.19	-0.55	-0.13	-5178.02	-9030.85	-0.64	-0.51
7	-0.13	-0.59	-0.46	-4069.98	-17050.71	2.25	0.15
8	-0.09	-0.79	-0.32	-6299.19	-13076.04	1.04	-0.65
9	-0.24	-0.11	-0.82	-5562.80	-10825.84	-3.18	-0.17
10	-0.26	-0.42	-0.62	-3141.01	2183.85	-1.39	0.52
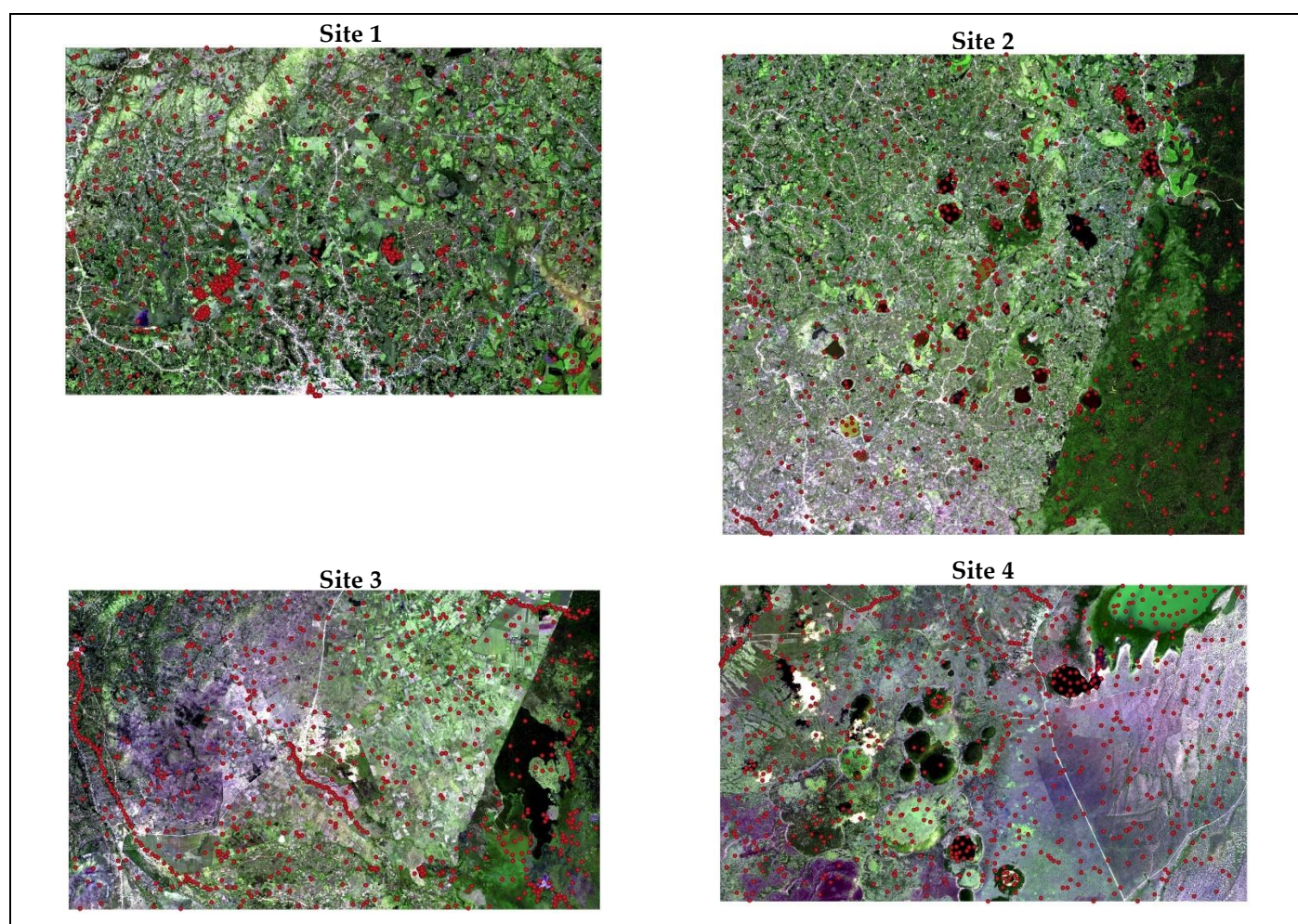
Figure S6. RGB images of the studied sites (1, 2, 3, and 4) with the reference points (red) used for the accuracy analysis.

Table S7. Confusion matrices of the water indices under the respective studied sites of the Rwenzori region.

NDWI Site 1				
	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	529.0	149.0	678.0	78.0
Water	5.0	117.0	122.0	95.9
Sum	534.0	26.,0	800.0	
Producers	99.1	44.0		80.8

MNDWI1 Site 1				
	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	520.0	103.0	623.0	83.5
Water	14.0	163.0	177.0	92.1
Sum	534.0	266.0	800.0	
Producers	97.0	61.3		85.4

MNDWI2 Site 1				
	Reference			

Prediction	Non-water	Water	Sum	Users
Non-water	522.0	103.0	625.0	83.5
Water	12.0	163.0	175.0	93.1
Sum	534.0	266.0	800.0	
Producers	97.8	61.3		85.6

AWEISH Site 1		
Reference		

Prediction	Non-water	Water	Sum	Users
Non-water	522.0	42.0	564.0	92.6
Water	12.0	224.0	236.0	94.9
Sum	534.0	266.0	800.0	
Producers	97.8	84.2		93.2

AWEInSH		
Site 1		
Reference		

Prediction	Non-water	Water	Sum	Users
Non-water	519.0	42.0	561.0	92.5
Water	15.0	224.0	239.0	93.7
Sum	534.0	266.0	800.0	
Producers	97.2	84.2		92.9

MuWI_C		
Site 1		
Reference		

Prediction	Non-water	Water	Sum	Users
Non-water	533.0	107.0	640.0	83.3
Water	1.0	159.0	160.0	99.4
Sum	534.0	266.0	800.0	
Producers	99.8	59.8		86.5

MuWI_R		
Site 1		
Reference		

Prediction	Non-water	Water	Sum	Users
Non-water	529.0	80.0	609.0	86.9
Water	5.0	186.0	191.0	97.4
Sum	534.0	266.0	800.0	
Producers	99.1	69.9		89.4

NDWI Site 2		
Reference		

Prediction	Non-water	Water	Sum	Users
Non-water	516.0	187.0	703.0	73.4
Water	8.0	82.0	90.0	91.1
Sum	524.0	269.0	793.0	

Producers	98.5	30.5		75.4

MNDWI Site 2

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	522.0	156.0	678.0	77.0
Water	2.0	113.0	115.0	98.3
Sum	524.0	269.0	793.0	
Producers	99.6	42.0		80.1

MNDW2 Site 2

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	503.0	126.0	629.0	80.0
Water	21.0	143.0	164.0	87.2
Sum	524.0	269.0	793.0	
Producers	96.0	53.2		81.5

AWEISH Site 2

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	514.0	59.0	573.0	89.7
Water	10.0	210.0	220.0	95.5
Sum	524.0	269.0	793.0	
Producers	98.1	78.1		91.3

AWEInSH Site 2

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	521.0	50.0	571.0	91.2
Water	3.0	219.0	222.0	98.6
Sum	524.0	269.0	793.0	
Producers	99.4	81.4		93.3

MuWI_C Site 2

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	523.0	124.0	647.0	80.8
Water	1.0	145.0	146.0	99.3
Sum	524.0	269.0	793.0	
Producers	99.8	53.9		84.2

MuWI_R Site 2

Reference

Prediction	Non-water	Water	Sum	Users
Non-water	522.0	114.0	636.0	82.1
Water	2.0	155.0	157.0	98.7
Sum	524.0	269.0	793.0	
Producers	99.6	57.0		85.4

NDWI Site 3

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	388.0	77.0	465.0	83.4
Water	117.0	218.0	335.0	65.1
Sum	505.0	295.0	800.0	
Producers	76.8	73.9		75.8

MNDWI1 Site 3

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	459.0	166.0	625.0	73.4
Water	46.0	129.0	175.0	73.7
Sum	505.0	295.0	800.0	
Producers	90.9	43.7		73.5

MNDWI2 Site 3

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	462.0	172.0	634.0	729.0
Water	43.0	123.0	166.0	74.1
Sum	505.0	295.0	800.0	
Producers	91.5	41.7		73.1

AWEISH Site 3

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	489.0	87.0	576.0	84.9
Water	16.0	208,0	224.0	92.9
Sum	505.0	295.0	800.0	
Producers	96.8	70.5		87.0

AWEInSH Site 3

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	466.0	82.0	548.0	85.0
Water	39.0	213.0	252.0	84.5
Sum	505.0	295.0	800.0	
Producers	92.3	72.2		84.9

MuWI_C
Site 3

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	463.0	181.0	644.0	71.9
Water	42.0	114.0	156.0	73.1
Sum	505.0	295.0	800.0	
Producers	91.7	38.6		72.1

MuWI_R
Site 3

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	456.0	181.0	637.0	71.6
Water	49.0	114.0	163.0	69.9
Sum	505.0	295.0	800.0	
Producers	90.3	38.6		71.2

NDWI Site 4

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	592.0	135.0	727.0	81.4
Water	34.0	39.0	73.0	53.4
Sum	626.0	174.0	800.0	
Producers	94.6	22.4		78.9

MNDWI Site 4

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	616.0	110.0	726.0	84.8
Water	10.0	64.0	74.0	86.5
Sum	626.0	174.0	800.0	
Producers	98.4	36.8		85.0

MNDW2 Site 4

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	616.0	113.0	729.0	84.5
Water	10.0	61.0	71.0	85.9
Sum	626.0	174.0	800.0	
Producers	98.4	35.1		84,6

AWEISH Site 4

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	612.0	79.0	691.0	88.6
Water	14.0	65.0	109.0	87.2

Sum	626.0	174.0	800.0	
Producers	97.8	54.6		88.4

AWEInSH
Site 4

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	588.0	57.0	645.0	91.2
Water	38.0	117.0	155.0	75.5
Sum	626.0	174.0	800.0	
Producers	93.9	67.2		88.1

MuWI_C
Site 4

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	601.0	83.0	684.0	87.9
Water	25.0	91.0	116.0	78.4
Sum	626.0	174.0	800.0	
Producers	96.0	52.3		86.5

MuWI_R
Site 4

	Reference			
Prediction	Non-water	Water	Sum	Users
Non-water	610.0	80.0	690.0	88.4
Water	16.0	94.0	110.0	85.5
Sum	626.0	174.0	800.0	
Producers	97.4	54.0		88.0

Table S8. 39 extracted crater lakes by AWEI from site 2 with their approximate area (m²/ha). The crater lakes are arranged according to ascending order in surface area.

	Name	ID	AREA (m2)	Area (ha)
1	Mwitampungu	S39	598.518	0.06
2	not named	S21	5585.664	0.56
3	Kanyabutete	S1	11670.581	1.17
4	Kanyanchu	S38	19150.344	1.92
5	Kanyamukali	S37	22844.808	2.28
6	Nkuruba	S20	29325.209	2.93
7	Nyahira	S24	30423.428	3.04
8	Nyanswiga	S29	33116.578	3.31
9	Wandakara	S35	34713.717	3.47
10	Kanyamansira	S2	45084.799	4.51
11	Kisibendi	S7	48975.157	4.90
12	Kasenda	S3	74412.127	7.44
13	Lugembe	S11	86782.485	8.68

14	Rukwanzi	S33	97256.79	9.73
15	Ndicho	S19	98255.93	9.83
16	Nyamugosani	S28	104848.075	10.48
17	Nyarayabana	S30	114121.349	11.41
18	Nyamugoro	S27	115819.063	11.58
19	Kitere	S8	116211.009	11.62
20	Kyanga	S9	124399.958	12.44
21	Kyerbwato	S10	126571.77	12.66
22	Lyantonde	S12	145535.62	14.55
23	Kifuruka	S6	153214.321	15.32
24	Mbajo	S13	171073.585	17.11
25	Mubiro	S14	189236.222	18.92
26	Nyamirima	S25	192004.259	19.20
27	Wankenzi	S36	198209.382	19.82
28	Rwenjuba	S34	221551.189	22.16
29	Murusi	S16	229918.547	22.99
30	Murigamire	S15	280892.947	28.09
31	Nyamitezi	S26	308760.653	30.88
32	Kerere	S5	331649.906	33.16
33	Ntambi	S22	334196.449	33.42
34	Mwegenyi	S18	340559.604	34.06
35	Nyinabulitwa	S31	388293.517	38.83
36	Katanda	S4	398316.399	39.83
37	Mwamba	S17	431924.014	43.19
38	Nyabikere	S23	456212.561	45.62
39	Nyinambuga	S32	593302.906	59.33