

## Supplementary material

*Article*

# **Cropland and Crop Type Classification with Sentinel-1 and Sentinel-2 Time-series using Google Earth Engine for Agricultural Monitoring in Ethiopia**

(please see the three following pages)

## Amhara 2021

Reference data LULC class	Classified data										Total	PA [%]
	TC	GW	CL	BA	WA	SL	SV	FC	TP	YP		
Tree cover (TC)	12	-	-	-	-	3	-	-	-	-	15	80.0
Grassland/Wetland (GW)	-	22	5	-	-	-	2	2	-	-	31	71.0
Cropland (CL)	1	-	200	-	-	4	-	3	1	-	209	95.7
Bare/Built-up (BA)	-	-	-	26	-	-	-	-	-	-	26	100.0
Water (WA)	-	-	-	-	1	-	-	-	-	-	1	100.0
Shrubland (SL)	2	-	15	-	-	55	-	-	-	-	72	76.4
Sparse vegetation (SV)	-	8	1	-	-	3	9	2	-	-	23	39.1
Fallow cropland (FC)	-	-	1	-	-	-	-	36	-	-	37	97.3
Tree plantation (TP)	-	-	-	-	-	1	-	-	13	-	14	92.9
Young plantation (YP)	-	-	-	-	-	-	-	-	-	3	3	100.0
Total	15	30	222	26	1	66	11	43	14	3	431	OA [%]
UA [%]	80.0	73.3	90.1	100.0	100.0	83.3	81.8	83.7	92.9	100.0		87.5

## Benishangul 2021

Reference data LULC class	Classified data										Total	PA [%]
	TC	GW	CL	BA	WA	SL	SV	FC	TP	YP		
Tree cover (TC)	50	-	-	-	-	2	-	-	-	-	52	96.2
Grassland/Wetland (GW)	-	70	17	-	-	7	2	-	-	-	96	72.9
Cropland (CL)	-	17	388	-	-	17	4	2	-	-	428	90.7
Bare/Built-up (BA)	-	-	1	37	-	1	2	-	-	-	41	90.2
Water (WA)	-	-	-	-	2	-	-	-	-	-	2	100.0
Shrubland (SL)	2	5	11	-	-	195	-	-	-	-	213	91.5
Sparse vegetation (SV)	-	1	2	-	-	-	32	2	-	-	37	86.5
Fallow cropland (FC)	-	1	3	1	-	-	-	35	-	-	40	87.5
Tree plantation (TP)	-	-	-	-	-	-	-	-	13	-	13	100.0
Total	52	94	422	38	2	222	40	39	13		922	OA [%]
UA [%]	96.2	74.5	91.9	97.4	100.0	87.8	80.0	89.7	100.0			89.2

## Gambella 2021

Reference data LULC class	Classified data										Total	PA [%]
	TC	GW	CL	BA	WA	SL	FC	MV				
Tree cover (TC)	45	-	-	-	-	5	-	-	-	-	50	90.0
Grassland/Wetland (GW)	-	100	15	-	-	8	1	-	-	-	124	80.6
Cropland (CL)	-	1	512	-	-	9	-	1	-	-	523	97.9
Bare/Built-up (BA)	-	-	1	24	-	-	2	1	-	-	28	85.7
Water (WA)	-	-	-	-	7	-	-	-	-	-	7	100.0
Shrubland (SL)	1	4	33	-	-	139	-	-	-	-	177	78.5
Fallow cropland (FC)	-	-	-	3	-	-	23	-	-	-	26	88.5
Mixed vegetated/bare (MV)	-	2	11	1	-	-	-	11	-	-	25	44.0
Total	46	107	572	28	7	161	26	13			960	OA [%]
UA [%]	97.8	93.5	89.5	85.7	100.0	86.3	88.5	84.6				89.7

## Amhara 2022

Reference data LULC class	Classified data										Total	PA [%]
	TC	GW	CL	BA	WA	SL	SV	FC	TP	YP		
Tree cover (TC)	19	-	-	-	-	2	-	-	2	-	23	82.6
Grassland/Wetland (GW)	2	32	3	-	-	-	-	-	-	-	37	86.5
Cropland (CL)	2	-	212	-	-	5	1	-	-	-	220	96.4
Bare/Built-up (BA)	-	-	-	14	-	-	-	-	-	-	14	100.0
Water (WA)	-	-	-	-	2	-	-	-	-	-	2	100.0
Shrubland (SL)	-	3	7	-	-	64	1	-	-	-	75	85.3
Sparse vegetation (SV)	-	-	3	1	-	8	3	-	-	-	15	20.0
Fallow cropland (FC)	-	-	3	-	-	-	-	7	-	-	10	70.0
Tree plantation (TP)	1	-	1	-	-	-	-	-	20	-	22	90.9
Young plantation (YP)	-	2	-	-	-	-	-	-	-	2	4	50.0
Total	24	37	229	15	2	79	5	7	22	2	422	OA [%]
UA [%]	79.2	86.5	92.6	93.3	100.0	81.0	60.0	100.0	90.9	100.0		88.9

## Benishangul 2022

Reference data LULC class	Classified data										Total	PA [%]
	TC	GW	CL	BA	WA	SL	SV	FC	TP	YP		
Tree cover (TC)	47	1	-	-	-	2	-	-	-	-	50	94.0
Grassland/Wetland (GW)	-	86	10	-	-	4	1	-	2	-	103	83.5
Cropland (CL)	-	16	272	-	-	18	1	2	2	-	311	87.5
Bare/Built-up (BA)	-	1	-	49	-	-	1	-	-	-	51	96.1
Water (WA)	-	-	-	-	1	-	-	-	-	-	1	100.0
Shrubland (SL)	3	4	15	-	-	192	2	-	-	-	216	88.9
Sparse vegetation (SV)	-	10	2	1	-	1	25	-	-	-	39	64.1
Fallow cropland (FC)	-	-	1	-	-	-	-	13	-	-	14	92.9
Tree plantation (TP)	2	-	-	-	-	-	-	-	10	-	12	83.3
Total	52	118	300	50	1	217	30	15	14		797	OA [%]
UA [%]	90.4	72.9	90.7	98.0	100.0	88.5	83.3	86.7	71.4			87.2

## Gambella 2022

Reference data LULC class	Classified data										Total	PA [%]
	TC	GW	CL	BA	WA	SL	SV	FC	TP	MV		
Tree cover (TC)	39	-	1	-	-	5	-	-	-	-	45	86.7
Grassland/Wetland (GW)	-	138	18	-	1	9	2	-	-	-	168	82.1
Cropland (CL)	-	2	402	-	-	28	-	-	-	-	432	93.1
Bare/Built-up (BA)	-	-	-	32	-	-	1	1	-	1	35	91.4
Water (WA)	-	-	-	-	5	-	-	-	-	-	5	100.0
Shrubland (SL)	-	9	39	-	-	240	2	-	-	3	293	81.9
Sparse vegetation (SV)	-	1	6	-	-	-	18	1	-	-	26	69.2
Fallow cropland (FC)	-	-	3	-	-	-	-	5	-	-	8	62.5
Tree plantation (TP)	-	-	-	-	-	-	-	-	6	-	6	100.0
Mixed vegetated/bare (MV)	-	-	5	-	-	3	-	-	-	26	34	76.5
Total	39	150	474	32	6	285	23	7	6	30	1052	OA [%]
UA [%]	100.0	92.0	84.8	100.0	83.3	84.2	78.3	71.4	100.0	86.7		86.6

**Figure S1.** Confusion matrix tables for the LULC classifications for the three study areas Amhara, Benishangul and Gambela for the years 2021 and 2022. The accuracies are given as user's accuracies (UA), producer's accuracies (PA) and overall accuracy (OA).

**Table S1.** Overview of the 33 input data variants tested for random forest crop type classification. The table provides information about variant category (column 1), bands/indices/parameters included as input features (column 2), number of input features (column 3), and overall accuracies retrieved (columns 4–12). The overall accuracies are provided for the six individual classifications, as average for each study area, and as overall mean.

33 Variants			Overall accuracies									
Category	Input features	No. of input features	AMH 2021	AMH 2022	BEN 2021	BEN 2022	GAM 2021	GAM 2022	AMH Average	BEN Average	GAM Average	Overall mean
VI	NDVI	8	0.85	0.73	0.64	0.74	0.83	0.77	0.79	0.69	0.80	0.76
	MSR	8	0.84	0.73	0.65	0.75	0.80	0.76	0.78	0.70	0.78	0.75
	EVI	8	0.86	0.72	0.63	0.74	0.89	0.75	0.79	0.69	0.82	0.76
	EVI2	8	0.84	0.77	0.63	0.74	0.89	0.73	0.80	0.69	0.81	0.77
	SAVI	8	0.85	0.73	0.59	0.72	0.87	0.73	0.79	0.66	0.80	0.75
	GNDVI	8	0.84	0.67	0.61	0.76	0.89	0.73	0.75	0.68	0.81	0.75
	NDRe1	8	0.84	0.66	0.66	0.73	0.85	0.76	0.75	0.70	0.81	0.75
	NDRe2	8	0.81	0.74	0.66	0.73	0.85	0.77	0.78	0.70	0.81	0.76
	ReNDVI	8	0.85	0.73	0.70	0.73	0.83	0.70	0.79	0.71	0.77	0.75
	GNDWI	8	0.80	0.65	0.61	0.79	0.88	0.73	0.73	0.70	0.80	0.74
	NDWI1	8	0.82	0.68	0.63	0.74	0.85	0.70	0.75	0.69	0.78	0.74
	NDWI2	8	0.83	0.69	0.64	0.77	0.84	0.76	0.76	0.70	0.80	0.75
VI combined	EVI2 + NDRe2	16	0.88	0.81	0.70	0.78	0.88	0.77	0.85	0.74	0.83	0.80
	EVI2 + NDRe2 + GNDWI	24	0.89	0.80	0.73	0.81	0.88	0.77	0.84	0.77	0.82	0.81
	EVI2 + NDRe2 + NDWI2	24	0.86	0.77	0.73	0.79	0.89	0.77	0.82	0.76	0.83	0.80
S2	S2 bands	80	0.93	0.82	0.81	0.86	0.88	0.79	0.87	0.83	0.84	0.85
S2 + VI	S2 bands + EVI2	88	0.89	0.81	0.80	0.86	0.88	0.78	0.85	0.83	0.83	0.84
	S2 bands + EVI2 + NDRe2	96	0.92	0.81	0.80	0.87	0.89	0.81	0.87	0.84	0.85	0.85
	S2 bands + EVI2 + NDRe2 + GNDWI	104	0.92	0.80	0.80	0.85	0.90	0.81	0.86	0.83	0.86	0.85
RI	RVI	8	0.63	0.61	0.49	0.58	0.58	0.42	0.62	0.54	0.50	0.55
	Diff	8	0.57	0.61	0.54	0.60	0.67	0.55	0.59	0.57	0.61	0.59
	Ratio	8	0.62	0.64	0.46	0.56	0.59	0.45	0.63	0.51	0.52	0.55
RI combined	RVI + Diff + Ratio	24	0.64	0.65	0.58	0.65	0.63	0.56	0.64	0.62	0.59	0.62
S1	VV + VH	16	0.77	0.66	0.63	0.72	0.77	0.66	0.72	0.67	0.72	0.70
S1 + RI	VV + VH + RVI	24	0.77	0.69	0.61	0.73	0.76	0.68	0.73	0.67	0.72	0.71
	VV + VH + Diff	24	0.75	0.71	0.65	0.77	0.81	0.67	0.73	0.71	0.74	0.73
	VV + VH + Ratio	24	0.75	0.72	0.62	0.73	0.77	0.66	0.74	0.67	0.72	0.71
	VV + VH + RVI + Diff + Ratio	40	0.74	0.70	0.64	0.69	0.80	0.65	0.72	0.66	0.72	0.70
VI + S1 + RI	EVI2 + NDRe2 + VV + VH + Diff	40	0.89	0.82	0.70	0.84	0.80	0.79	0.86	0.77	0.80	0.81
	EVI2 + NDRe2 + GNDWI + VV + VH + Diff	48	0.91	0.80	0.73	0.85	0.82	0.77	0.85	0.79	0.80	0.81
S2 + S1	S2 bands + VV + VH	96	0.91	0.81	0.80	0.87	0.88	0.81	0.86	0.83	0.84	0.85
S2 + S1 + RI	S2 bands + VV + VH + Diff	104	0.90	0.84	0.81	0.86	0.88	0.83	0.87	0.83	0.85	0.85
S2 + VI + S1 + RI	S2 bands + EVI2 + NDRe2 + VV + VH + Diff	120	0.92	0.84	0.82	0.88	0.89	0.85	0.88	0.85	0.87	0.86

## Amhara 2021

Reference data	Classified data											Total	PA [%]
Crop type	1	3	4	5	6	8	10	12	15	18	19		
Maize (1)	24	-	-	-	-	-	1	-	-	-	-	25	96.0
Sunflower (3)	-	19	-	-	-	-	-	-	-	-	-	19	100.0
Sesame (4)	-	-	5	-	-	-	-	-	-	-	-	5	100.0
Mung bean (5)	-	-	-	5	-	-	-	-	-	-	-	5	100.0
Soya bean (6)	1	1	-	-	17	-	-	-	-	-	-	19	89.5
Haricot bean (8)	-	-	-	-	-	5	-	-	-	-	-	5	100.0
Pepper (10)	1	-	-	-	-	-	4	-	-	1	-	6	66.7
Chickpea (12)	2	-	-	-	-	-	-	4	-	-	-	6	66.7
Wheat (15)	-	-	1	1	-	-	-	-	8	-	-	10	80.0
Teff (18)	-	-	-	-	-	-	-	-	-	4	-	4	100.0
Finger Millet (19)	-	-	-	-	-	-	-	-	-	-	6	6	100.0
Total	28	20	6	6	17	5	5	4	8	5	6	110	OA [%]
UA [%]	85.7	95.0	83.3	83.3	100.0	100.0	80.0	100.0	100.0	80.0	100.0		91.8

## Benishangul 2021

Reference data	Classified data								Total	PA [%]
Crop type	1	2	4	6	7	10	18	20		
Maize (1)	32	2	-	-	-	-	-	-	34	94.1
Sorghum (2)	1	35	-	3	-	-	-	-	39	89.7
Sesame (4)	1	1	0	-	-	-	-	-	2	0.0
Soya bean (6)	5	3	-	33	-	3	-	1	45	73.3
Groundnut (7)	1	-	-	-	2	-	-	-	3	66.7
Pepper (10)	1	2	-	2	-	20	-	1	26	76.9
Teff (18)	-	-	-	-	-	-	3	-	3	100.0
Niger seed (20)	-	-	1	-	-	-	-	2	3	66.7
Total	41	43	1	38	2	23	3	4	155	OA [%]
UA [%]	78.0	81.4	0.0	86.8	100.0	87.0	100.0	50.0		81.9

## Gambella 2021

Reference data	Classified data				Total	PA [%]
Crop type	1	2	5	9		
Maize (1)	8	1	1	-	10	80.0
Sorghum (2)	-	3	1	2	6	50.0
Mung bean (5)	-	-	31	-	31	100.0
Cotton (9)	2	-	2	31	35	88.6
Total	10	4	35	33	82	OA [%]
UA [%]	80.0	75.0	88.6	93.9		89.0

## Amhara 2022

Reference data	Classified data											Total	PA [%]
Crop type	1	3	4	5	6	8	10	15	18	19			
Maize (1)	27	-	-	-	1	-	-	1	-	-	-	29	93.1
Sunflower (3)	1	17	-	-	-	-	-	-	-	-	-	18	94.4
Sesame (4)	1	-	3	-	1	-	-	-	-	-	-	5	60.0
Mung bean (5)	-	-	-	5	1	-	-	-	-	-	-	6	83.3
Soya bean (6)	3	-	-	1	22	-	-	-	-	-	-	26	84.6
Haricot bean (8)	1	-	-	-	-	3	-	-	-	-	-	4	75.0
Pepper (10)	2	-	-	1	2	-	0	-	-	-	-	5	0.0
Wheat (15)	1	-	-	-	-	-	-	20	-	-	-	21	95.2
Teff (18)	1	-	-	-	1	-	-	-	3	-	-	5	60.0
Finger Millet (19)	-	-	-	1	-	-	-	-	-	2	-	3	66.7
Total	37	17	3	8	28	3	0	21	3	2		122	OA [%]
UA [%]	73.0	100.0	100.0	62.5	78.6	100.0	-	95.2	100.0	100.0			83.6

## Benishangul 2022

Reference data	Classified data						Total	PA [%]
Crop type	1	2	6	10	18	20		
Maize (1)	23	1	-	2	-	-	26	88.5
Sorghum (2)	2	24	-	-	-	1	27	88.9
Soya bean (6)	-	1	10	-	-	-	11	90.9
Pepper (10)	2	3	-	33	-	-	38	86.8
Teff (18)	-	-	-	2	3	-	5	60.0
Niger seed (20)	-	-	-	-	-	6	6	100.0
Total	27	29	10	37	3	7	113	OA [%]
UA [%]	85.2	82.8	100.0	89.2	100.0	85.7		87.6

## Gambella 2022

Reference data	Classified data							
Crop type	1	2	4	5	6	9	Total	PA [%]
Maize (1)	19	-	-	2	-	-	21	90.5
Sorghum (2)	2	3	-	4	-	-	9	33.3
Sesame (4)	-	-	7	-	-	-	7	100.0
Mung bean (5)	5	-	-	22	-	-	27	81.5
Soya bean (6)	-	-	-	2	12	2	16	75.0
Cotton (9)	-	-	-	-	-	31	31	100.0
Total	26	3	7	30	12	33	111	OA [%]
UA [%]	73.1	100.0	100.0	73.3	100.0	93.9		84.7

**Figure S2.** Confusion matrix tables for the crop type classifications for the three study areas Amhara, Benishangul and Gambella for the years 2021 and 2022. The accuracies are given as user's accuracies (UA), producer's accuracies (PA) and overall accuracy (OA).