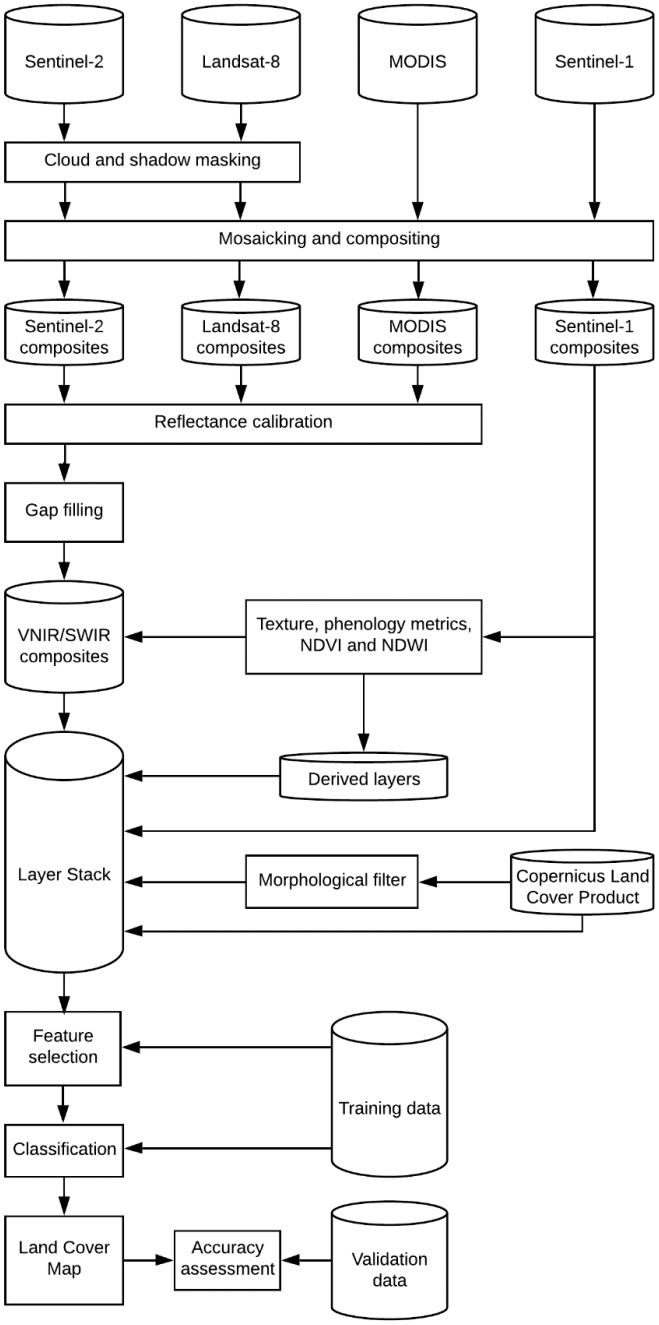
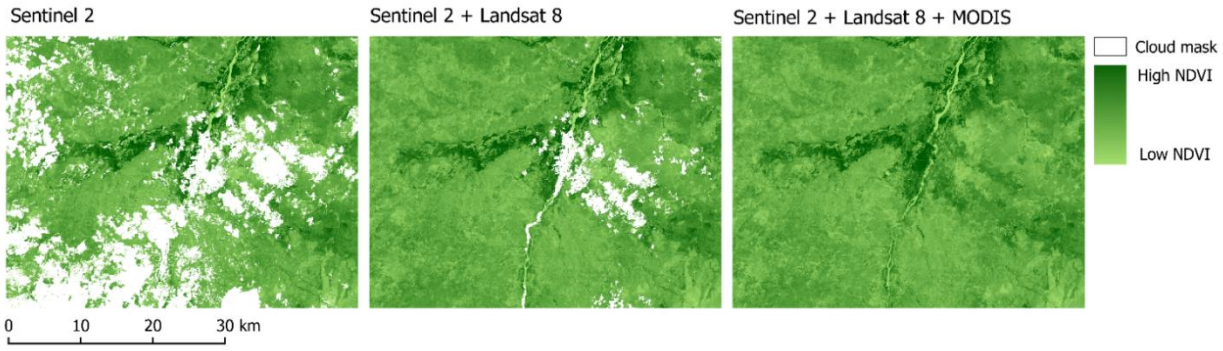
SUPPLEMENTARY FIGURES

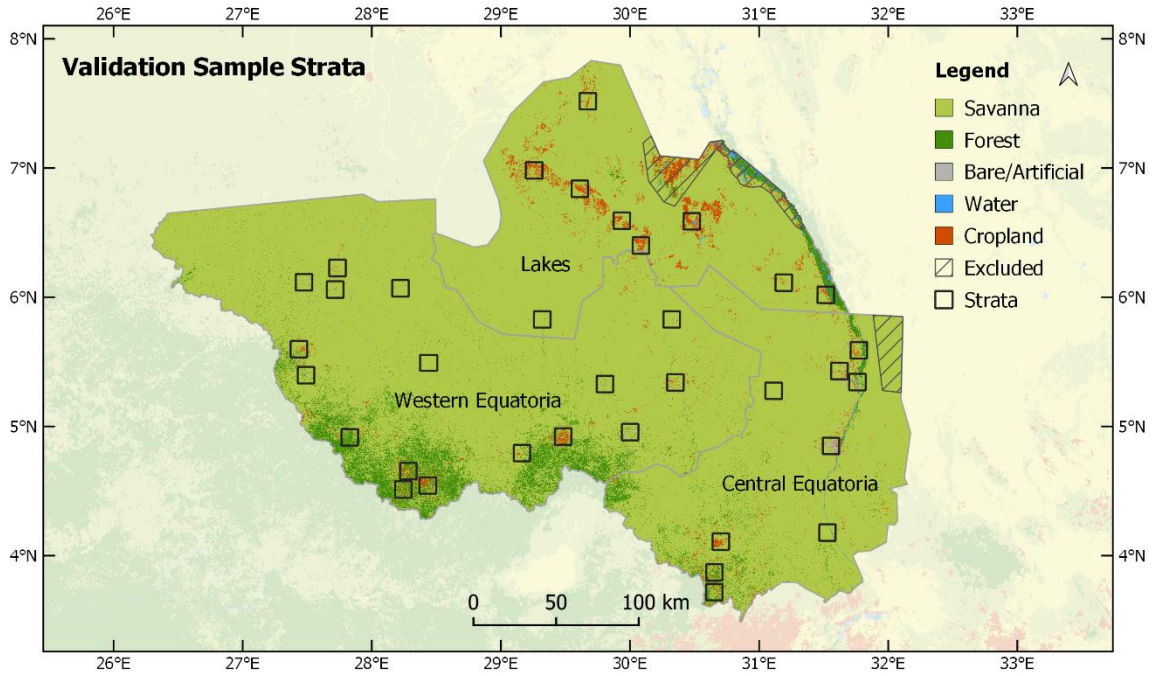
Supplementary Figure 1 | Image classification flowchart.



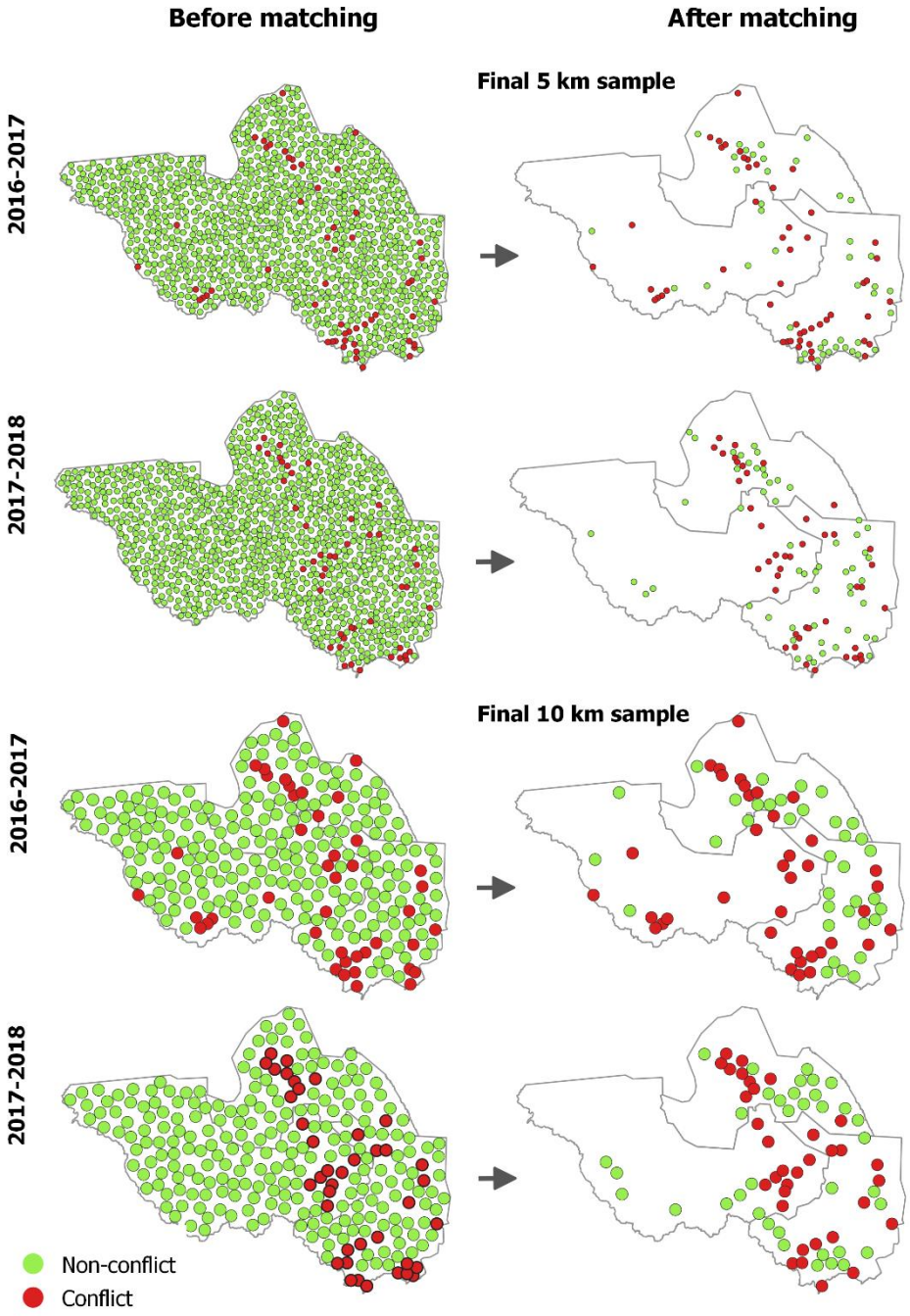
Supplementary Figure 2 | Example of cloud and shadow gap filling for the January 2017 composite with the fusion of Sentinel-2, Landsat-8, and MODIS imagery.



Supplementary Figure 3 | Map showing validation sample strata.



Supplementary Figure 4 | Geographical representation of the conflict and non-conflict samples before and after propensity score matching.



SUPPLEMENTARY TABLES

Supplementary Table 1 | Satellite imagery used in this study.

Product	Satellites	Temporal resolution	Spatial resolution	Selected bands	Level of correction
Sentinel-1 SAR, IW	Sentinel-1A and -1B	6 days	10 m	VV and VH	GRD
Sentinel-2 MSI, L1A	Sentinel-2A and -2B	5 days	10-20 m	VNIR and SWIR	TOA
Landsat-8 Tier 1	Landsat-8	16 days	30 m	VNIR and SWIR	TOA
MYD13Q1	Aqua	16 days	250-500 m	VNIR and SWIR	BOA
MOD13Q1	Terra	16 days	250-500 m	VNIR and SWIR	BOA

Supplementary Table 2 | Summary of features used for image classification.

Feature	Count
Blue	13
Red	13
NIR	13
SWIR	13
NDVI	13
NDWI	13
VV	12
VH	12
Entropy	12
Inertia	12
NDVI Amp.	1
NDVI Max	1
NDVI Min	1
NDVI Std.	1
VV Amp.	1
VV Max	1
VV Min	1
VV Std.	1
COP[1]	1
COP Morph.	1
Total	**136**

[1] Copernicus Land Cover Product

Supplementary Table 3 | Contribution of optical satellite products to create satellite image mosaics. Example for 2017.

Month	Sentinel-2	Landsat-8	MODIS
January	98.9	1.1	0
February	97.3	2.2	0.5
March	86.5	4.0	9.5
April	91.5	4.9	3.6
May	85.8	12.0	2.3
June	91.5	6.3	2.3
July	96.9	1.2	1.9
August	96.7	0.1	3.2
September	99.6	0.3	0.1
October	97.3	0.1	2.6
November	99.5	0.5	0
December	99.8	0.2	0

Supplementary Table 4 | Training samples distributed across land-cover classes and years.

Class	2016	2017	2018	Combined
Cropland	593	566	569	1,728
Savanna	1,691	1,691	1,691	5,073
Forest	153	153	153	459
Bare	165	165	165	495
Grassland	244	244	244	732
Water	51	51	51	153
Artificial	49	49	49	147
Total	2,946	2,919	2,922	8,687

Supplementary Table 5 | Land-cover class catalog.

Class	Definition
Cropland	Cropland was defined as an agricultural plot, which was used actively for planting the field crops, such as sorghum, maize and millet. Often crop fields have distinctive tilled soil and vegetation signals.
Savanna	Savanna was defined as land occupied with grassland, bushes and sparse trees. Savanna differed from the grassland class based on the higher density of shrubs and trees but lower than forest.
Forest	Forest was defined as land occupied with trees and dense bushes that remained green throughout the dry season.
Bare	Bare was defined as an exposed surface, including bare soil, dirt roads and rocks.
Grassland	Grassland was defined as land occupied with herbaceous vegetation and only a few bushes.
Water	Water represented permanent water objects for the entire year.
Artificial	Artificial was defined as any impervious surface, including paved roads and buildings.

Supplementary Table 6 | Confusion matrix and accuracy assessment for 2016.

2016	Savanna	Forest	Bare	Water	Cropland	Total
Savanna	420	26	4	0	23	473
Forest	17	162	0	1	0	180
Bare	2	0	56	0	0	58
Water	2	0	0	18	0	20
Cropland	91	3	17	0	158	269
Total	532	191	77	19	181	1,000
Initial accuracy						
PA	0.79	0.85	0.73	0.95	0.87	
UA	0.89	0.90	0.97	0.90	0.59	
OA	0.81					
Adjusted accuracy						
PA	0.98	0.46	0.20	0.84	0.24	
UA	0.89	0.90	0.97	0.90	0.59	
OA	0.88					
Area estimates in hectares						
Initial	15,059,541	782,900	40,310	25,414	389,792	
Adjusted	13,581,843	1,536,755	190,907	27,222	961,230	
Std. error	219,613	158,979	63,745	4,688	149,551	

Note: Reference values are represented vertically and classification values are represented horizontally.

Supplementary Table 7 | Confusion matrix and accuracy assessment for 2017.

2017	Savanna	Forest	Bare	Water	Cropland	Total
Savanna	341	8	12	0	15	376
Forest	37	178	0	0	2	217
Bare	1	0	48	0	1	50
Water	0	1	0	19	0	20
Cropland	101	2	16	0	218	337
Total	480	189	76	19	236	1,000
Initial accuracy						
PA	0.71	0.94	0.63	1.00	0.92	
UA	0.91	0.82	0.96	0.95	0.65	
OA	0.80					
Adjusted accuracy						
PA	0.98	0.71	0.06	1.00	0.27	
UA	0.91	0.82	0.96	0.95	0.65	
OA	0.90					
Area estimates in hectares						
Initial	14,934,699	951,997	31,077	29,679	350,505	
Adjusted	13,812,492	1,102,225	523,114	28,195	831,931	
Std. error	225,572	114,056	135,625	1,484	151,340	

Supplementary Table 8 | Confusion matrix and accuracy assessment for 2018.

2018	Savanna	Forest	Bare	Water	Cropland	Total
Savanna	405	10	6	0	21	442
Forest	50	181	0	3	2	236
Bare	4	0	57	0	1	62
Water	1	0	0	16	0	17
Cropland	68	2	13	0	160	243
Total	528	193	76	19	184	1,000
Initial accuracy						
PA	0.77	0.94	0.75	0.84	0.87	
UA	0.92	0.77	0.92	0.94	0.66	
OA	0.82					
Adjusted accuracy						
PA	0.98	0.69	0.17	0.63	0.22	
UA	0.92	0.77	0.92	0.94	0.66	
OA	0.90					
Area estimates in hectares						
Initial	14,953,839	971,014	48,781	22,648	301,676	
Adjusted	13,996,669	1,085,523	263,979	33,659	918,126	
Std. error	199,107	109,237	82,534	7,220	151,874	

Note: Reference values are represented vertically and classification values are represented horizontally.

Supplemental Table 9 | Description of conflict types used in this study from the Armed Conflict Location and Event Data Project (ACLED) dataset.

Event type	Sub-events/description	Status
Battles	Armed clashes Non-state actor overtakes territory Government regains territory	Included
Violence against civilians	Attack Sexual violence Abduction/forced disappearance	Included
Explosions/Remote violence	Shelling, artillery or missile attack	Included
Protests	Peaceful protest Protest with excessive force against protestors	Excluded
Riots	Violent demonstration Mob violence	Excluded
Strategic development	Agreements between conflicting parties Change of territories Change of activities Looting/property destruction Other strategic developments	Excluded

Supplemental Table 10 | Diagnostics for the logistic regression models.

Variables	Coefficient	Std. error	Z-Value	VIF	P-Value	Sig.[1]
5 km sample						
Intercept	-1.17	0.28	-4.27	n/a	1.98E-05	***
Distance to settlement	-4.51E-05	1.50E-05	-3.00	1.16	2.69E-03	**
Population density	1.68	0.38	4.39	1.04	1.12E-05	***
Distance to road	-4.52E-04	8.11E-05	-5.58	1.13	2.44E-08	***
Null deviance	811.52	df = 2114				
Residual deviance	585.72	df = 2111				
AIC	593.72					
R^2	0.19					
AUC	89.90%					
10 km sample						
Intercept	3.85E-02	0.40	0.10	n/a	0.92	
Distance to settlement	-4.63E-05	1.79E-05	-2.58	1.19	9.82E-03	**
Population density	2.19	0.67	3.27	1.06	1.08E-03	**
Distance to road	-3.08E-04	7.29E-05	-4.22	1.19	2.42E-05	***
Null deviance	458.67	df = 525				
Residual deviance	310.16	df = 522				
AIC	318.16					
R^2	0.35					
AUC	88.96%					

[1] Significance: *** = $p < 0.001$, ** = $p < 0.01$.

Supplemental Table 11 | Covariate and propensity score sample balance before and after matching.

	Conflict and non-conflict sample means				T-Test for the difference in means				
	Conflict	**Non-conflict**	**Diff.**	**Std. Diff.**	**T-Value**	**DF**	**P-Value**	**Sig.**[1]	**Balance Improvemen**
5 km sample									
All data									
Propensity score	0.21	0.04	0.17	1.20	n/a	n/a	n/a		n/a
Population density	0.41	0.19	0.22	0.73	-7.31	103.62	5.93E-11	***	n/a
Distance to road	1,911.88	12,257.87	-10,345.99	-2.47	20.26	221.10	2.20E-16	***	n/a
Distance to settlement	9,601.31	27,732.26	-18,130.96	-1.8	16.39	148.63	2.20E-16	***	n/a
Matched data									
Propensity score	0.20	0.19	0.01	0.05	n/a	n/a	n/a	n/a	95.83
Population density	0.39	0.45	-0.06	-0.21	1.42	186.19	0.16		71.19
Distance to road	1,950.09	2,226.95	-276.86	-0.07	0.45	193.98	0.65		97.32
Distance to settlement	9,792.18	10,041.12	-248.94	-0.02	0.18	189.33	0.85		98.63
10 km sample									
All data									
Propensity score	0.43	0.11	0.32	1.40	n/a	n/a	n/a	n/a	n/a
Population density	0.39	0.18	0.21	0.73	-6.51	90.49	4.04E-09	***	n/a
Distance to road	2,845.64	12,972.67	-10,127.03	-2.27	12.81	375.93	2.20E-16	***	n/a
Distance to settlement	11,326.81	29,568.96	-18,242.15	-1.84	12.37	243.88	2.20E-16	***	n/a
Matched data									
Propensity score	0.38	0.33	0.04	0.19	n/a	n/a	n/a	n/a	86.342
Population density	0.30	0.31	-3.63E-03	-1.25E-02	0.11	138.03	0.91		98.288
Distance to road	3,041.65	3,604.77	-563.12	-0.13	0.70	143.39	0.49		94.439
Distance to settlement	11,889.36	12,201.44	-312.08	-3.14E-02	0.22	121.22	0.83		98.289

Supplementary Table 12 | Sample distribution after propensity score matching—original, matched, and outside of common support.

	5-km sample		10-km sample	
	Conflict	**Non-conflict**	**Conflict**	**Non-conflict**
Original	101	2014	83	443
Matched	98	98	73	73
Outside area of common support	3	99	10	21

Supplementary Table 13 | Proportion of crops, crop energy, and yields in South Sudan.

The proportion of crops per state (%)

Crop	Central Equatoria	Western Equatoria	Lakes	Kcal/kg	Yield kg/ha (2014-2016)
Sorghum	24.7	12.4	33.7	3,290	963.8
Maize	18.3	27.9	5.3	3,640	560.4
Rice	1	5.8	0	3,560	3720
Finger millet	1	5.7	1.1	3,308	803.7
Pearl millet	0.9	0.2	5.9	3,308	803.7
Groundnuts	25.4	13.9	27.5	6,070	600
Cassava	11.6	17.4	3.5	1,600	15,000-17,000
Beans	2.7	2.6	0	3,370	3,073
Sesame	3.6	5.1	8.2	5,670	315.5
Other crops	10.7	8.9	14.7		
Source	WFP/FAO, 2019	WFP/FAO, 2019	WFP/FAO, 2019		FAOSTAT 2020, WFP/FAO, 2019

Notes. Other crops include sunflower, okra, green gram, cowpeas, yam, and sweet potatoes. Yields for rice was available for 2011 (FAOSTAT, 2020). Average yields for cassava were 15,000 kg/ha in Central Equatoria, 17,000 kg/ha in Western Equatoria, and 17,000 kg/ha in Lakes.