

Appendix 2. LULC Imagery and Classification Details

A2.1. Imagery Availability

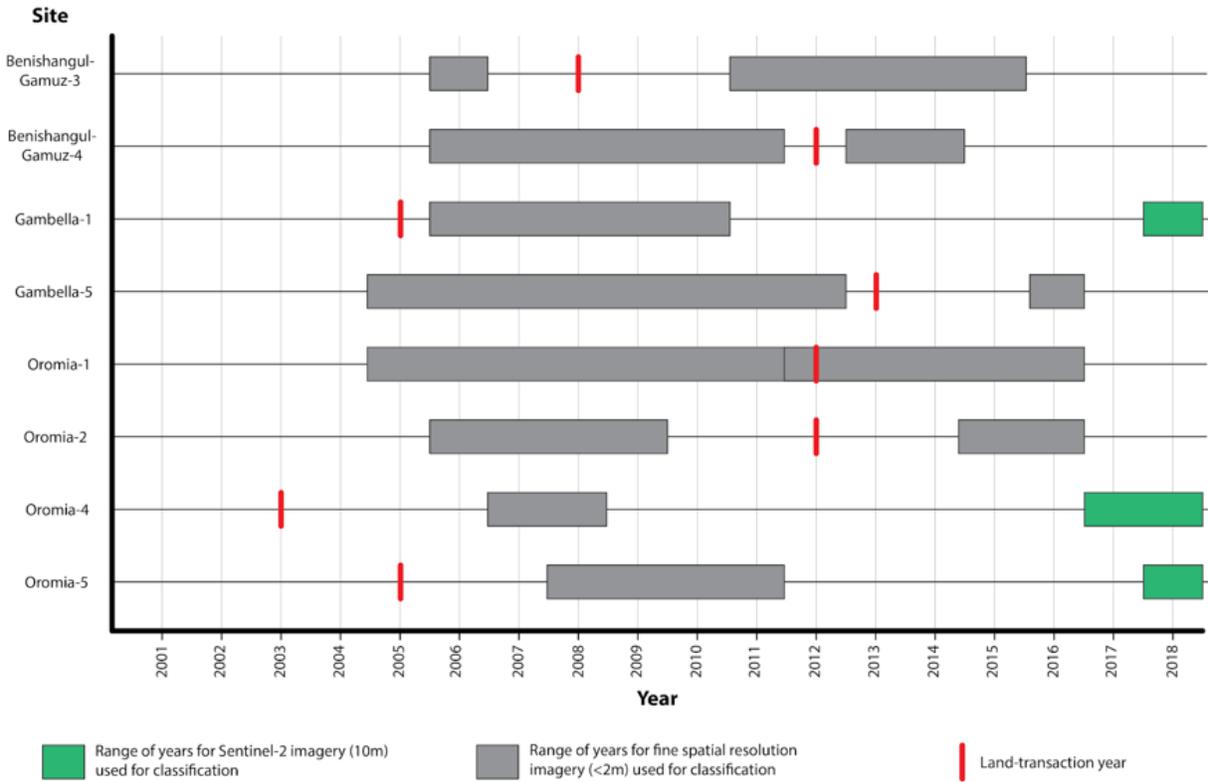


Fig. A2.1: Dates of satellite imagery in relation to the LSLT implementation years

A2.2. LULC Classification Process

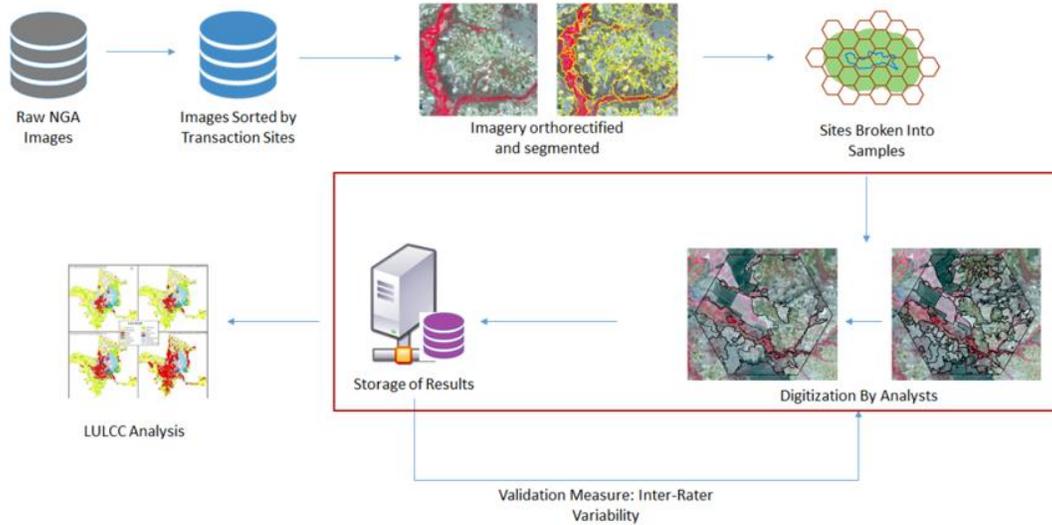


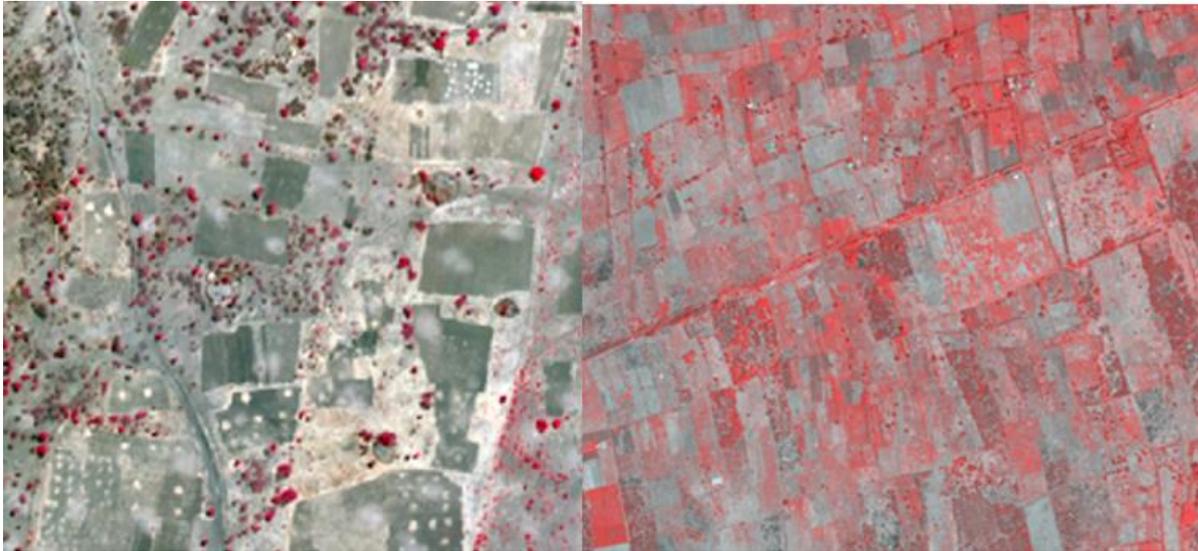
Fig. A2.2: Image classification pipeline.

1. Raw Images: 30,643 images, dating from 2004-2011, obtained from: IKONOS (1-4m); GeoEye-1 (0.5 - 2m); WorldView-1, 2, and 3 (0.3-2m); and Sentinel-2 (10m)
2. Sort by Site: sorted to each site (BG3, BG4, GM1, GM2, OR1, OR2, OR4, and OR5), then by Treatment or Control, and then by Pre- or Post- transaction date. Resulting in 4 sets of images per site (e.g. BG3-Treatment-Pre, BG3-Treatment-Post, BG3-Control-Pre, BG3-Control-Post)
3. Segmentation - an object based classification was used to partition the landscape into polygons by distinct spectral and textural characteristics
4. Data Organization - to help keep assign and keep track of analysts' progress, a hexagon grid (each hex = 15 km²) was overlaid on each site. A geodatabase was created for each site as well.
5. ArcGIS: In Arc, analysts edited the attribute tables to assign a LULC to each polygon created in the Segmentation (3) process. If adjacent polygons appeared to be the same they were combined using the Merge tool. After an entire site was completed, any polygons that were split when gridding the sites into hexagons were merged if of the same LULC.
6. Analyst Classification - User and Producer's Accuracy was used to evaluate the agreement between raters of each LULC. Each rater was asked to classify the same set of three hexagons (that each contained all LULC types/choices). Then, the Tabulate Intersection tool was used to identify areas of disagreement in LULC assignment between raters. User's and Producer's matrices were computed in Excel to find percent agreement between individual raters and individual classes (Appendix D)
7. Classified Site - For each site, Treatment and Control, Pre- and Post- classifications were overlaid and the Tabulate Intersection tool was used again to find the transition of LULC types from before and after a transaction date.

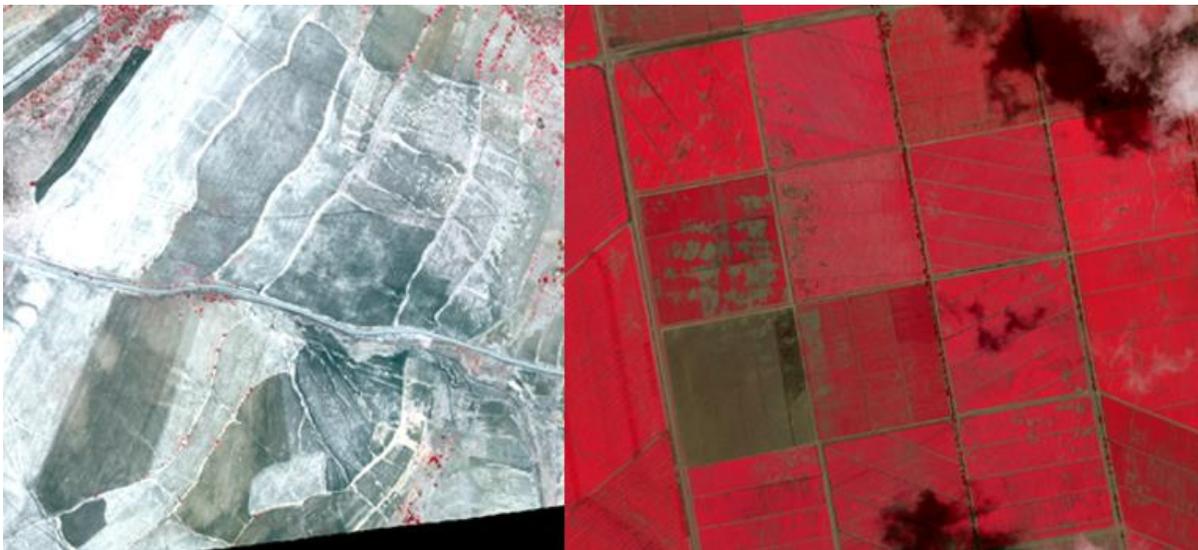
A2.3: LULC Examples

Descriptions and examples were used to train analysts. We note that the examples presented here are from Tanzania (another country in our project), but they demonstrate the relevant LULC characteristics.

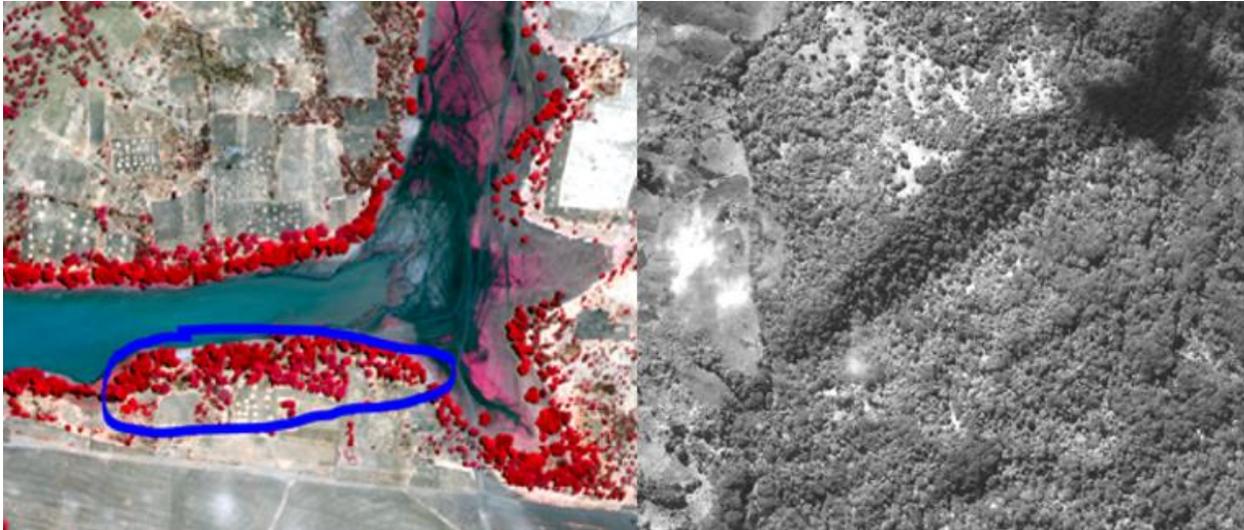
Smallholder Agriculture - cultivated areas (<10ha) with a mosaic of different subsistence crops (primarily cereals), fallow area, and cycle of crop maturity; some settlements and sparse tree cover.



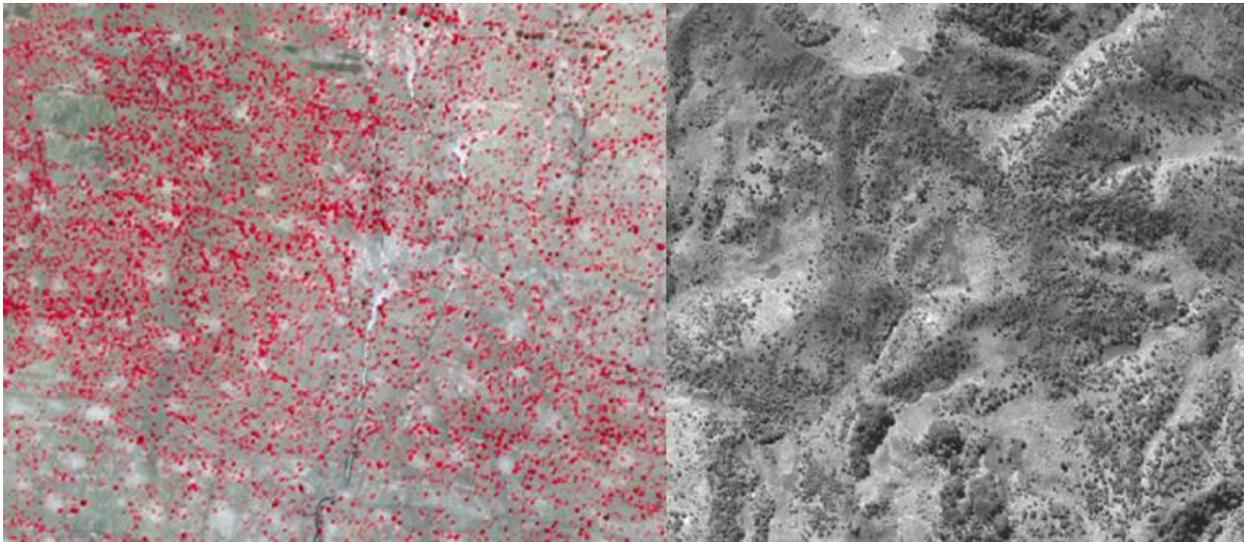
Intensive Agriculture - cultivated fields (>10ha) with vegetation pattern indicating uniform planting (monocrop) and harvest cycles; may include tree crops and is clearly visible from satellite imagery.



Forest - Densely forested area with 70–100% closed canopy cover



Woodland/Shrubland - mixed area of small trees, short bushes, shrubs and open grassland; 10-70% ground coverage, small trees (<10%)



Bare/Exposed Soil - land with very sparse grass or completely no vegetation cover.



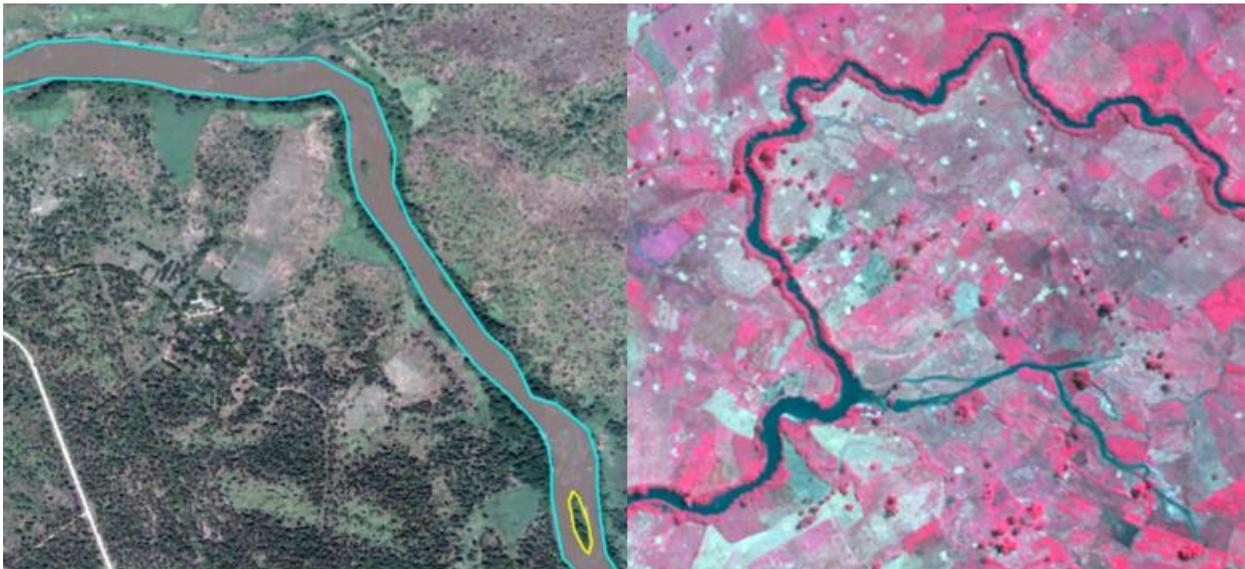
Rural Settlement - natural and impermeable surfaces, including roads and dense housing.



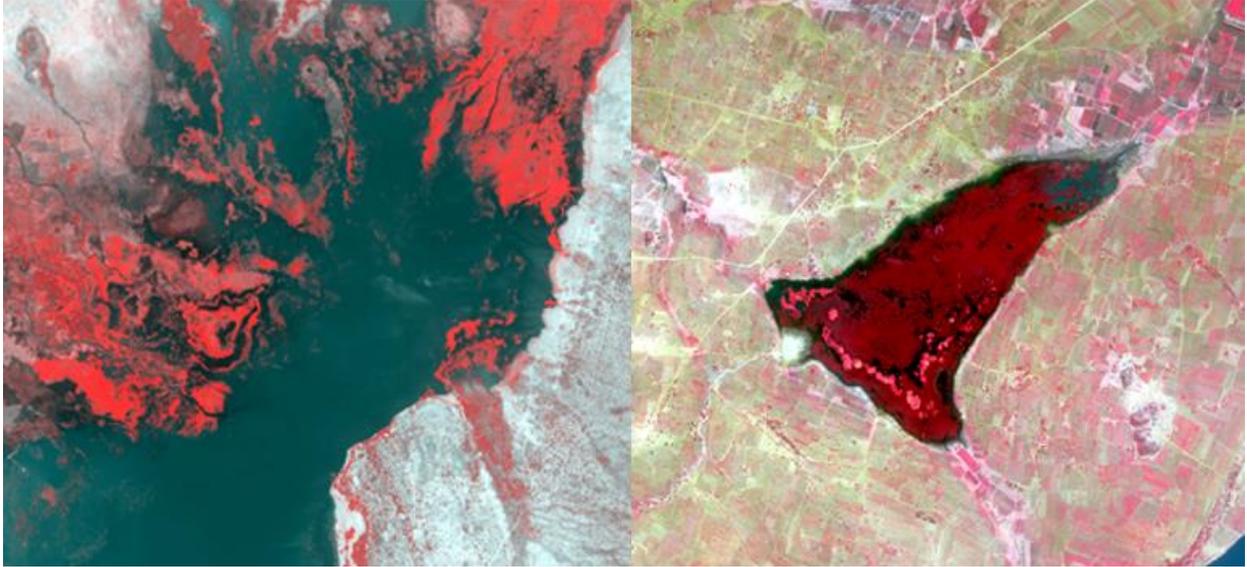
Development - major roads and urban or industrial infrastructure with a minimum mapping unit of 30 meters.



Water - natural and artificial water bodies; river, lakes and reservoirs.



Wetland - swampy and waterlogged in the wet season (June-August), dry in the dry season (December - February)



A2.4. Inter-Rater Reliability

We conducted an inter-rater reliability test to account for work completed by multiple analysts. We divided the sites into sets of 15km² hexagons and asked each analyst to independently classify the same three areas to compare their LULC decisions. User's and Producer's Accuracy was calculated to assess agreement between individual raters and each LULC. Agreement between analysts ranged from 53 – 69%.

Table A2.1: Rater agreement

Rater	Percent agreement
XW	52.7
PN	56.4
NC	61.2
DW	59.9
CL	60.0
AB	69.4

Table A2.2: Inter-rater class agreement

LULC Class	IRR (%)	Aggregated class	IRR (%)
Smallholder agriculture	80.7	Smallholder	80.7
Rural settlement	n/a		
Large-scale agriculture	55.4	Large-scale agriculture	55.4
Forest	73.9	Forest	73.9
Woodland/ shrubland	78.9	Woodland/ shrubland	78.9
Bare/exposed soil	19.6	Bare/exposed soil	19.6
Development	81.7	Other	36.9
Water	4.6		
Wetland	n/a		