



A generic Remote Sensing approach for large-scale Land cover and Land use systems mapping

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EMBRAPA

INPE



INTRODUCTION

PROJECT in support of GEOGLAM



PROGRAM in support of GEOABC



TOSCA AGRIZONE



COMMON SCIENTIFIC OBJECTIVE

Develop methodologies to improve the monitoring **agricultural systems** at a large-scale



GLOBAL CHALLENGE

Increase production in a sustainable way

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Develop methodologies to improve the monitoring **agricultural systems** at a large-scale



Explore the potential of RS techniques

Localization and characterization



- Production
- Agricultural land expansion
- Intensification of management practices
- ...

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Localization and characterization

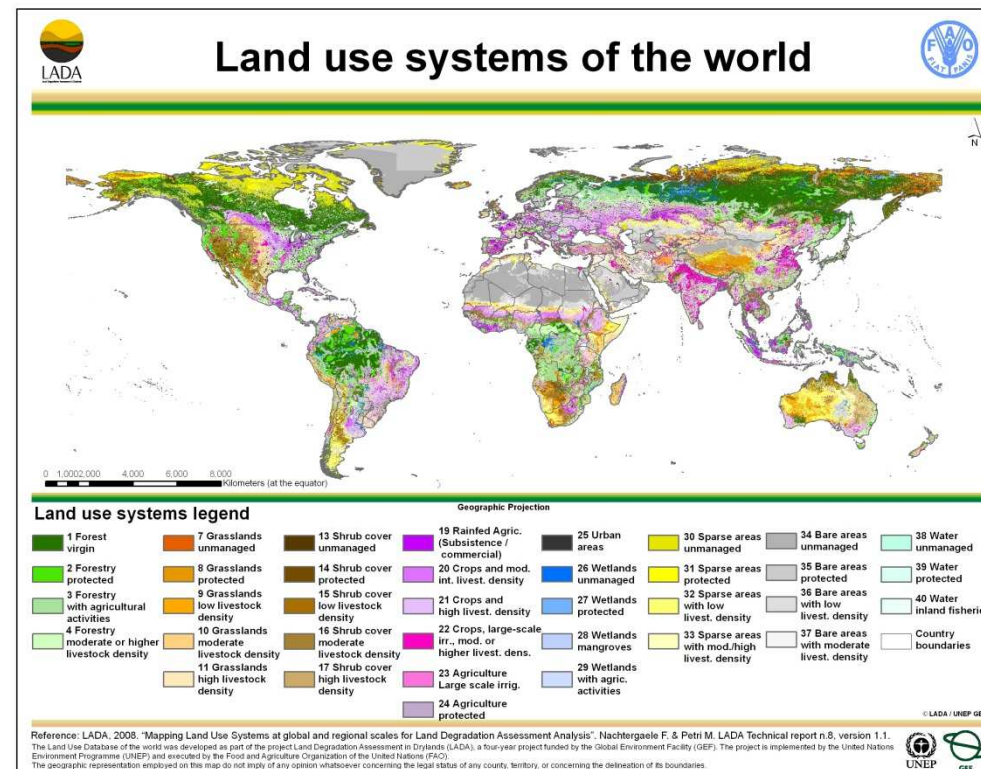


**AGRICULTURAL LAND USE
SYSTEMS MAPPING**

INTRODUCTION

Land use system mapping involves:

The delineation of relatively homogeneous areas of land, referred to as **land units**, that are directly linked to a specific type of **land use** (Driessen & Konijn, 1992; FAO, 1993)

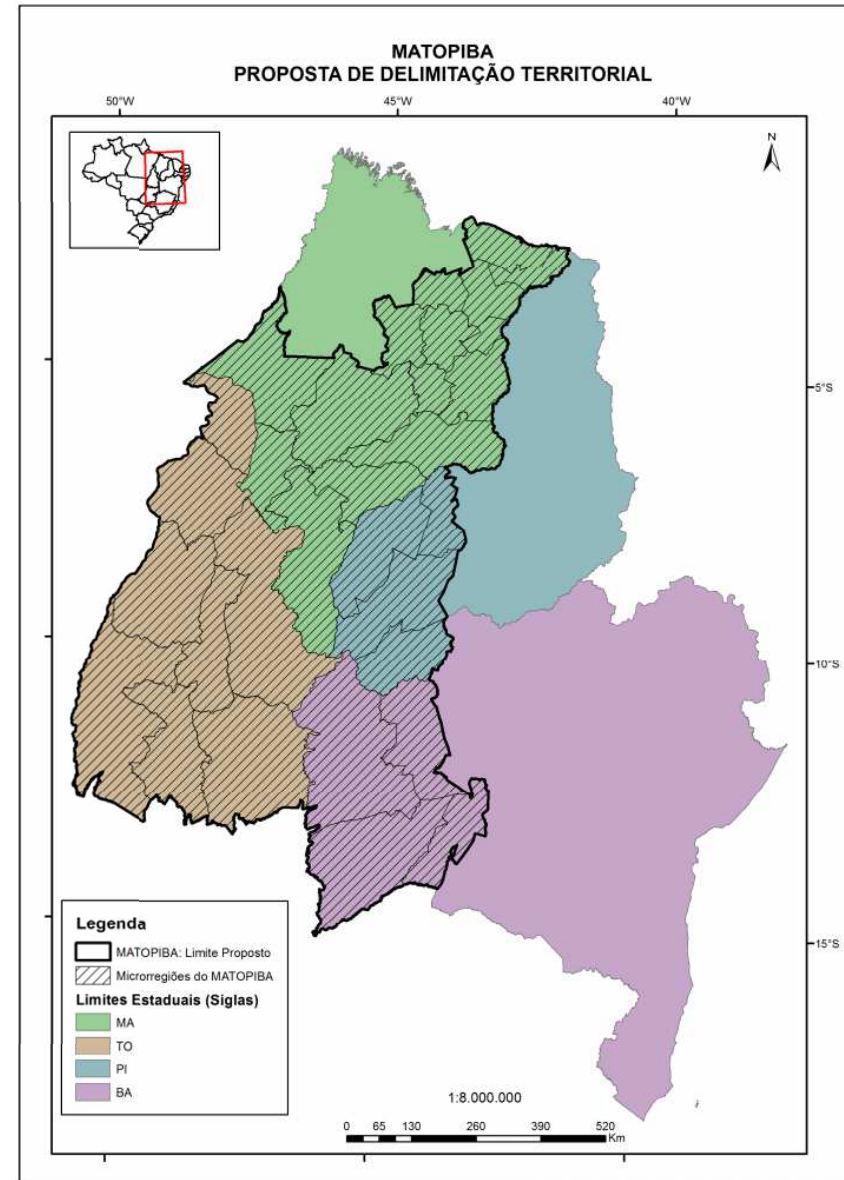


OBJECTIVE

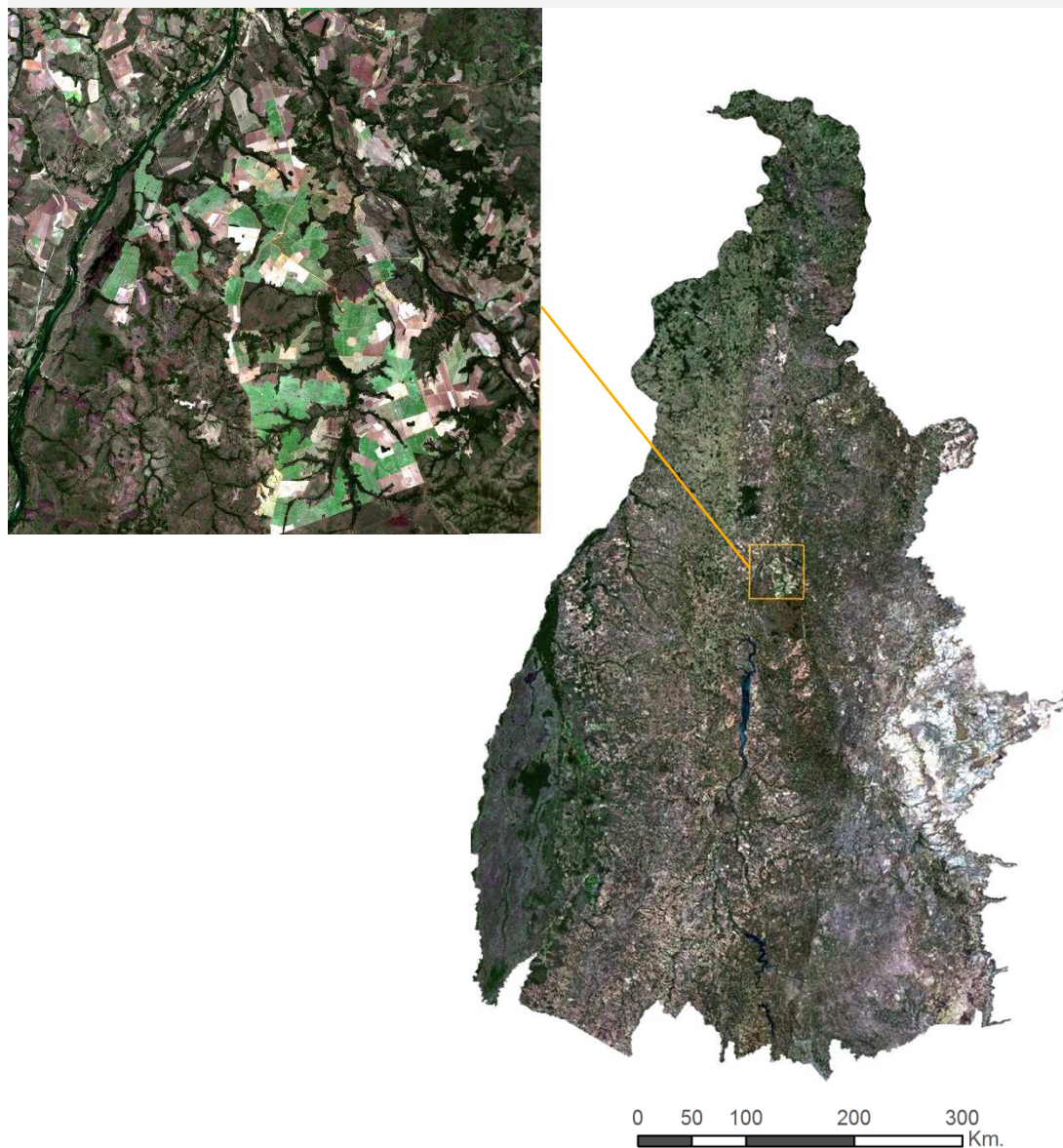
Develop a **multi-level** approach based on **GEOBIA** and **vegetation index time series** analysis for large-scale mapping of agricultural land use systems

STUDY SITE

TOCANTINS, Brazil



STUDY SITE



Area : 277,621 km²

Field size : mostly large (~ 100 ha.)

Main cropping systems :

- Soybean/Cereal double-crop
- Rice/Soybean double-crop
- Soybean monoculture
- Sugarcane monoculture

Main agricultural practices :

- Mechanical seeding, fertilization, pesticide application and harvest
- Dominance of zero-tillage systems

Landsat 8 2015 mosaic – 30m spatial res.

MULTI-LEVEL APPROACH

REGIONAL LEVEL

Delimit homogeneous land units
in terms of phenological patterns

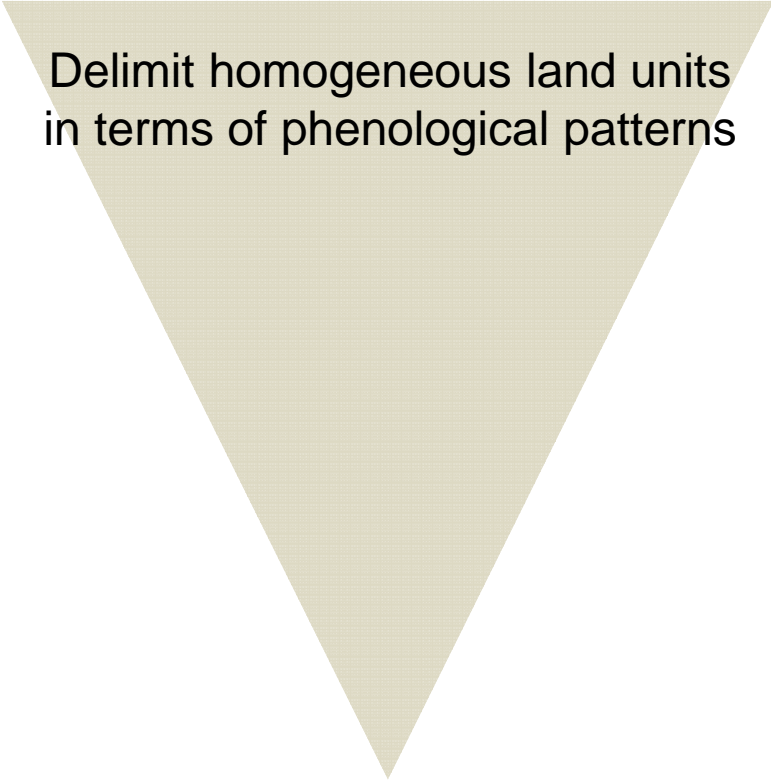
Identification of agricultural land use systems
through spatial analysis

Annual cropland
+
Cropping systems classification

FIELD LEVEL



REGIONAL LEVEL



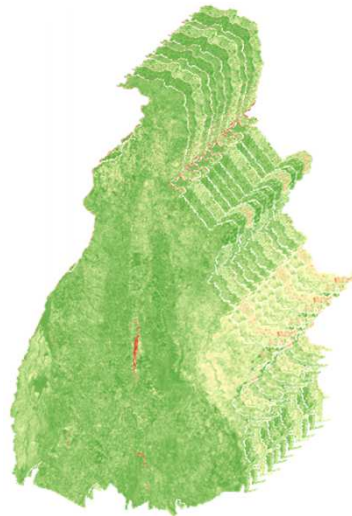
Delimit homogeneous land units
in terms of phenological patterns

METHODS > Regional level Land units delineation

DATA

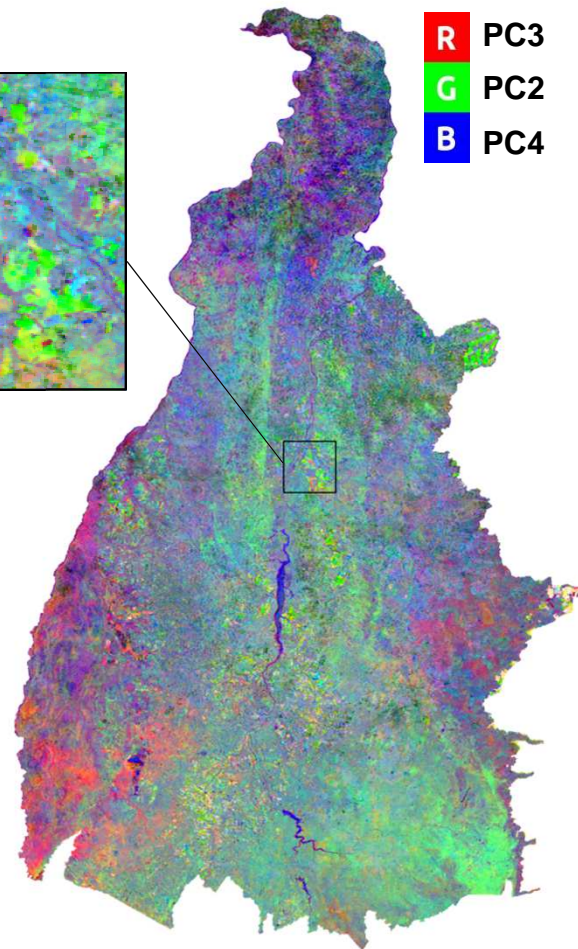
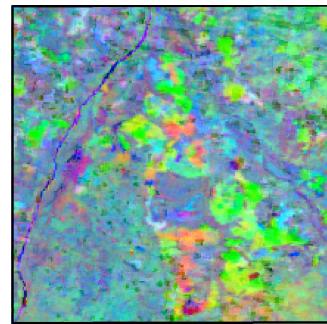
MODIS NDVI 16-days
composites annual time series

Oct 2014 – Sep 2015
23 composite images
250m spatial resolution



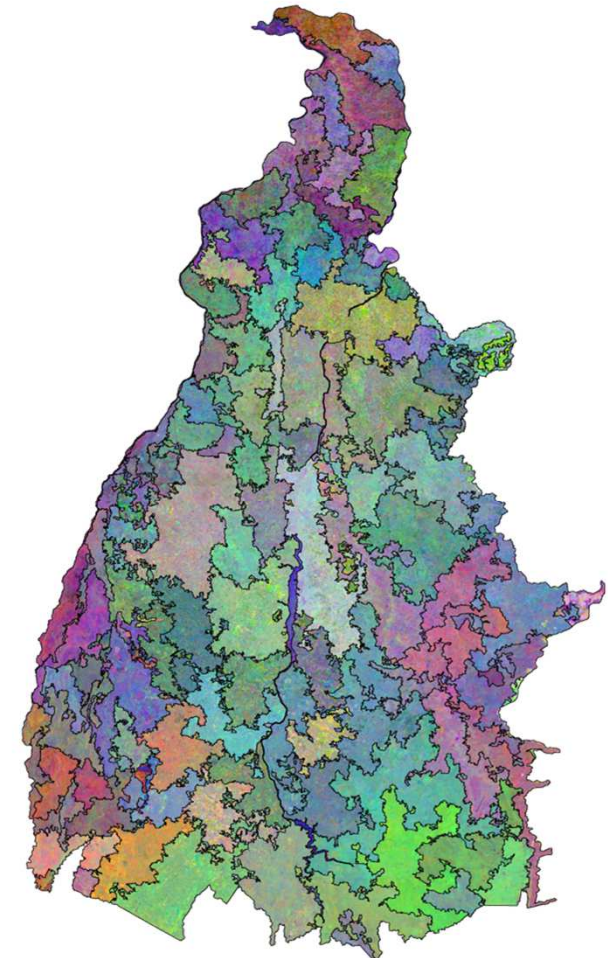
PROCESSING

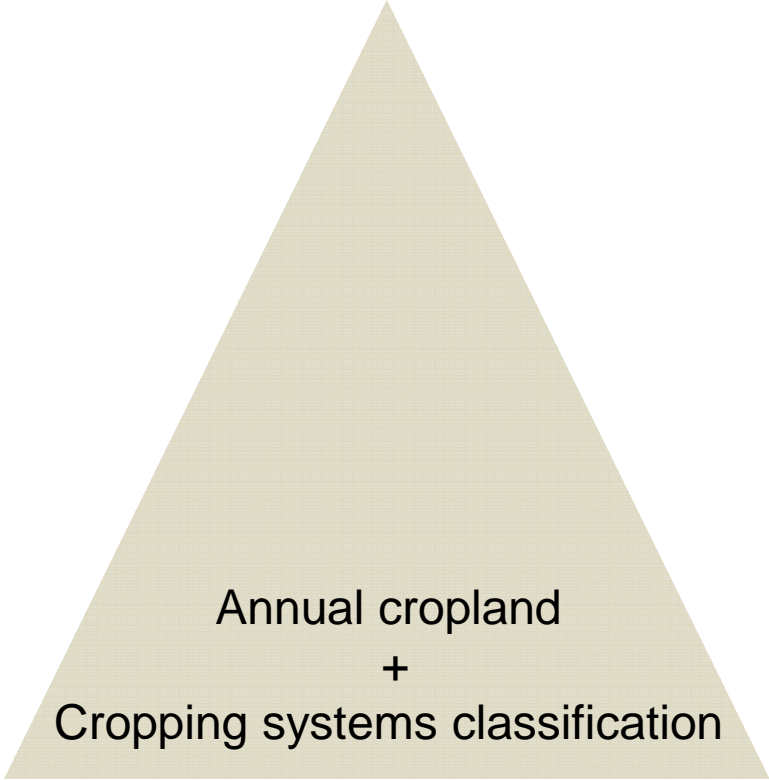
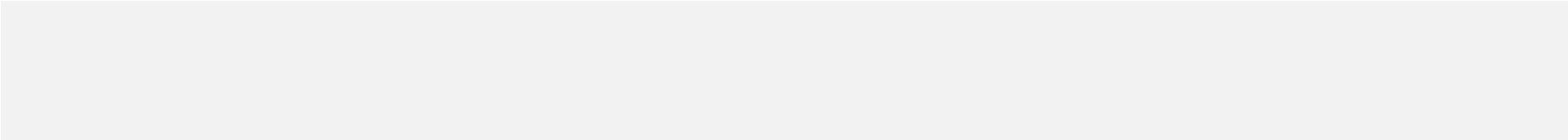
Principal Component Analysis (PCA)
Radiometric features = PC2 – PC20



RESULT

Multiresolution segmentation
eCognition Developer 9.0





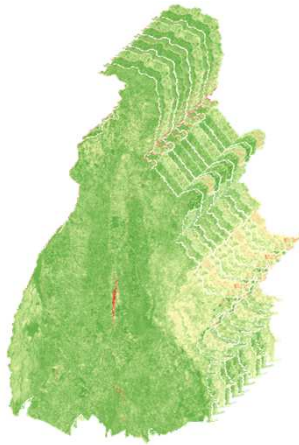
Annual cropland
+
Cropping systems classification

FIELD LEVEL

METHODS > Field Level Classification

DATA

MODIS NDVI
annual time series



Landsat 8 mosaic
30m spatial res.

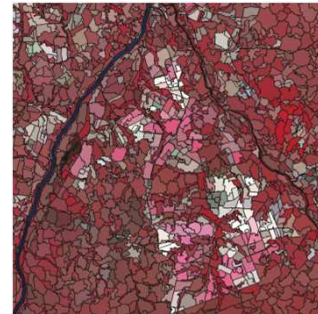


PROCESSING

OBIA + Unsupervised Classification

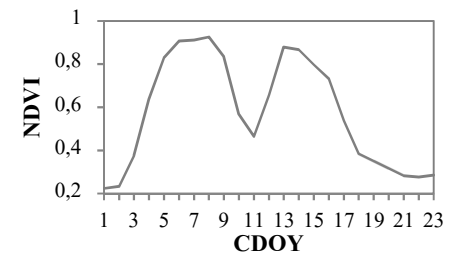
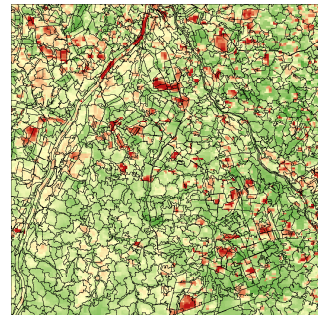
1

HSR
SEGMENTATION
(187741 objects)



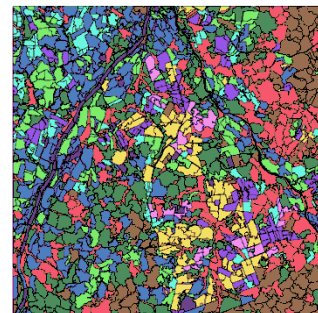
2

MEDIAN TEMPORAL
NDVI PROFILE
PER OBJECT
(23 composite images)



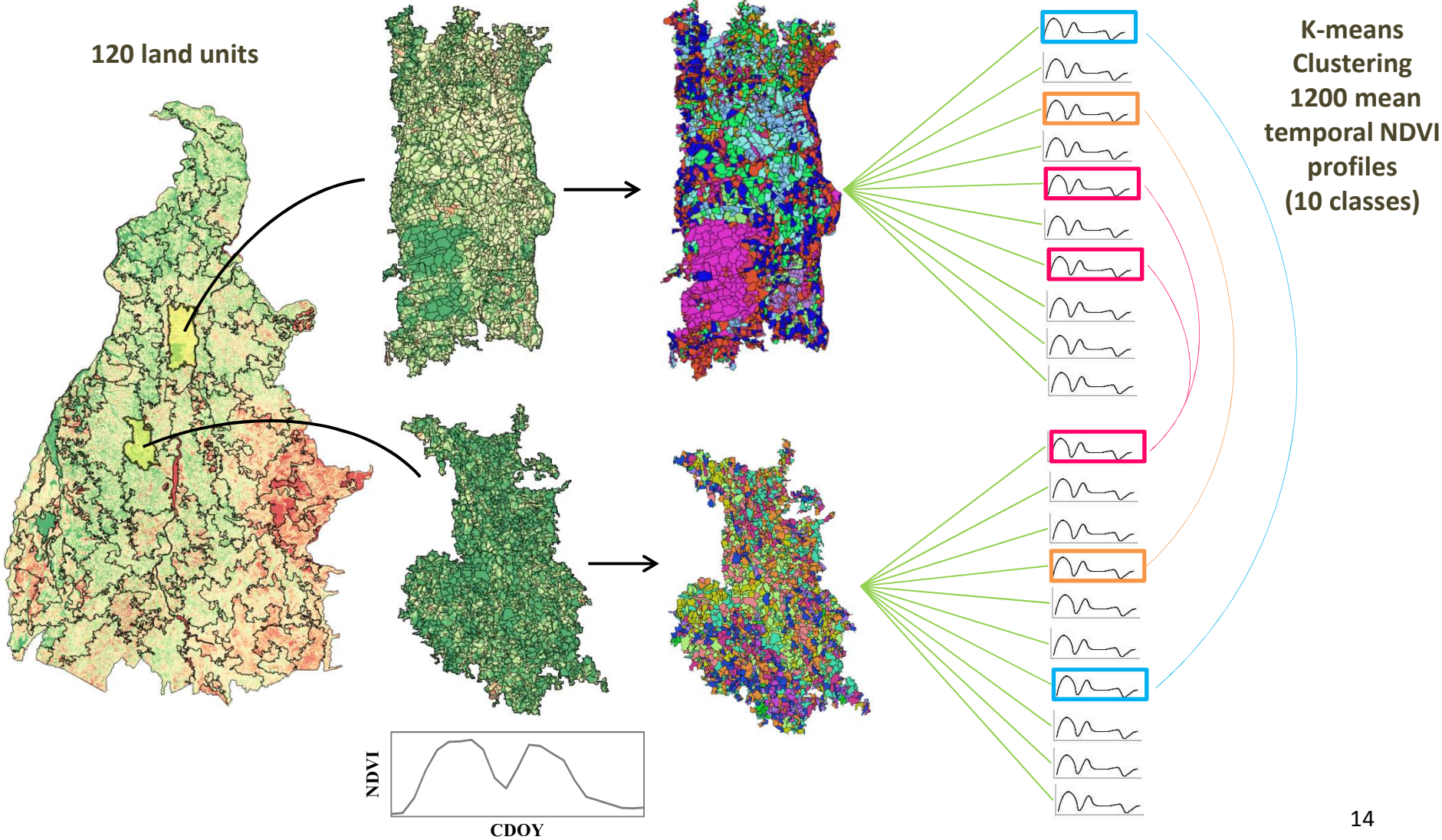
3

UNSUPERVISED
CLASSIFICATION



METHODS > Field Level classification

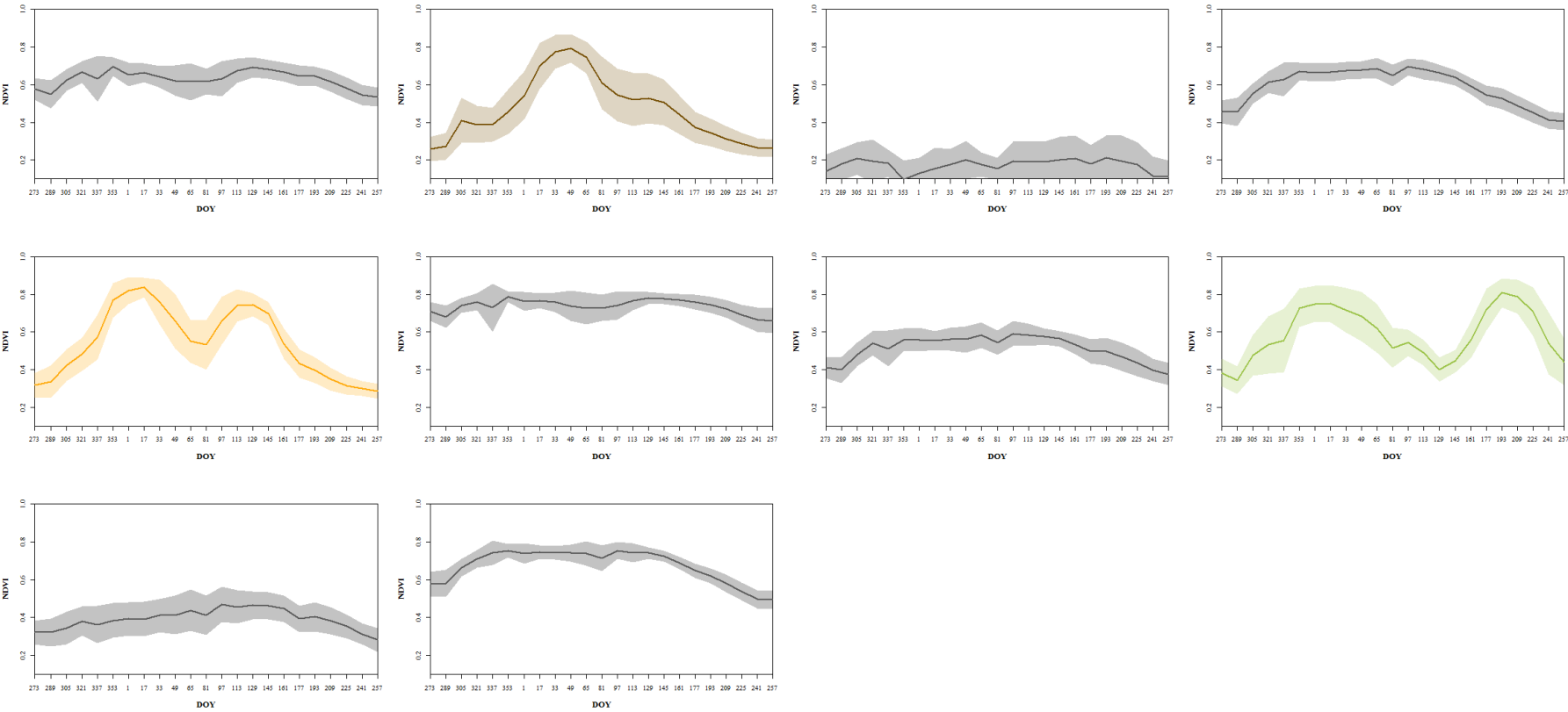
3 UNSUPERVISED CLASSIFICATION



METHODS > Field Level classification

RESULTS

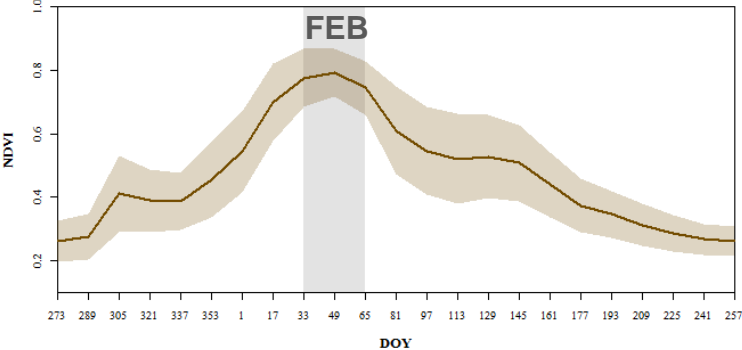
NDVI temporal profile analysis of final classes



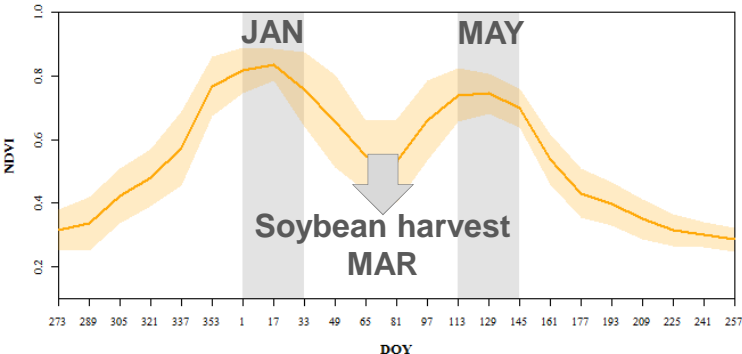
METHODS > Field Level classification



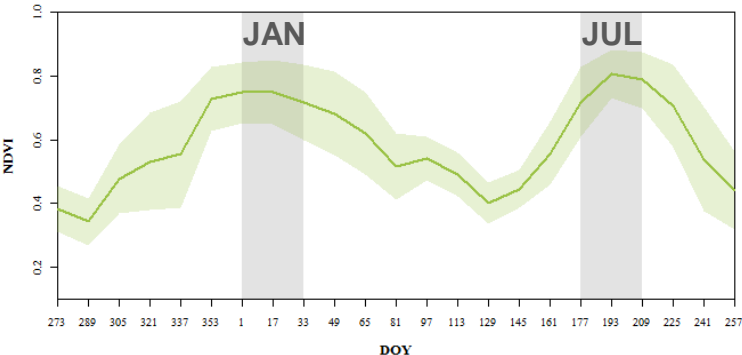
Soybean single cropping system



Soybean-cereal double cropping system

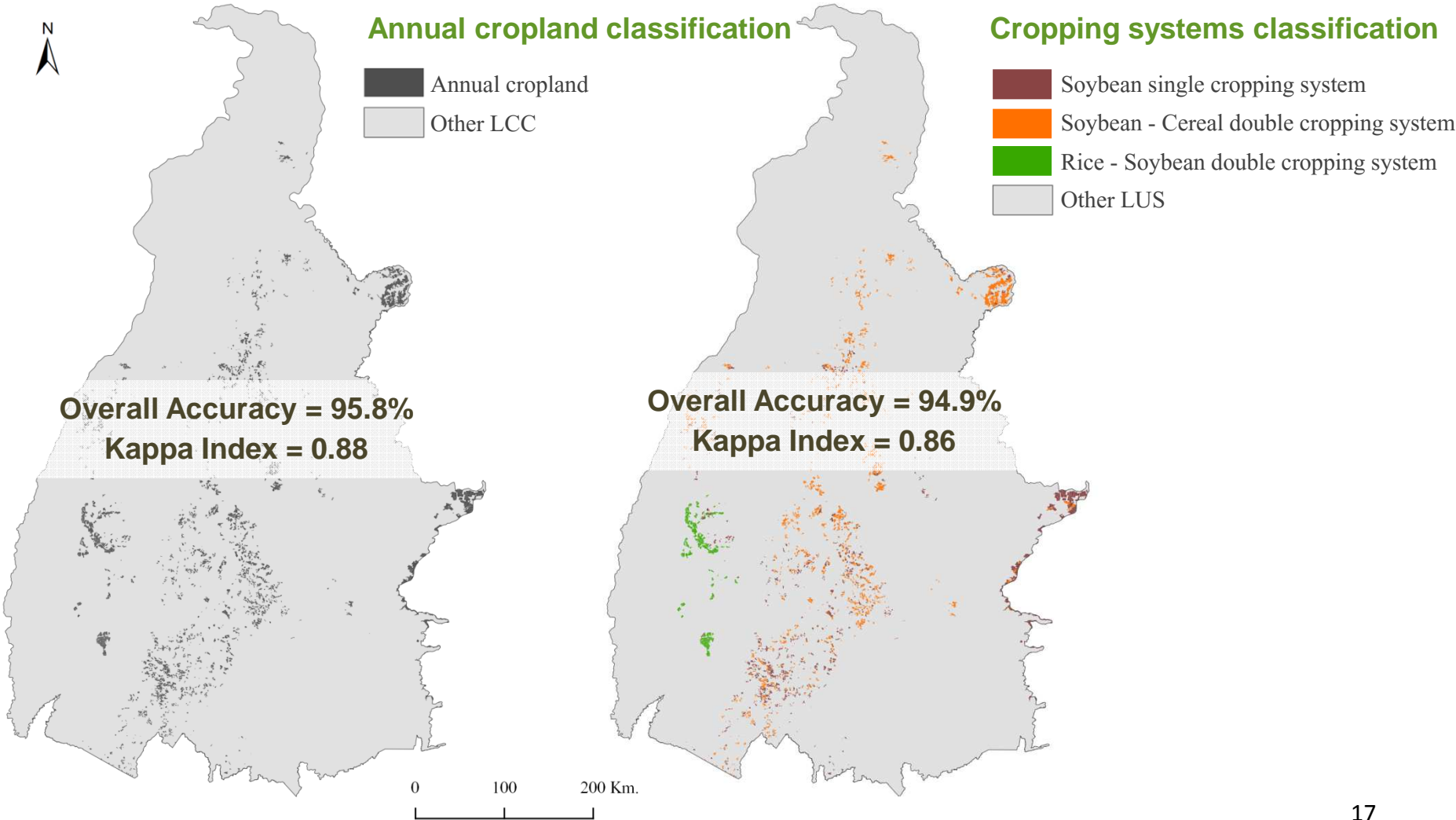


Rice-Soybean double cropping system





RESULTS



REGIONAL LEVEL

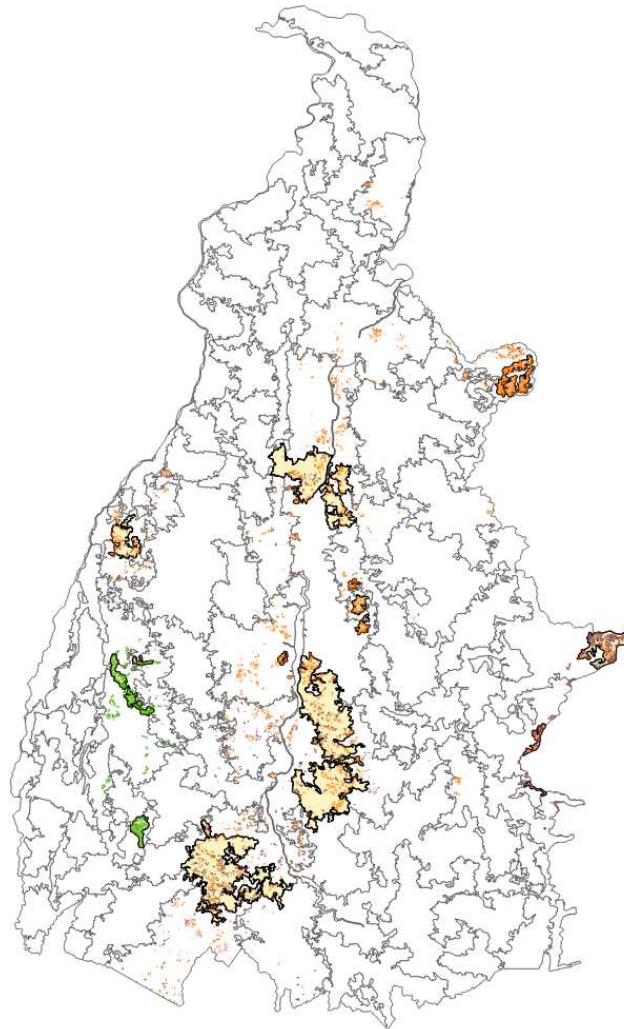
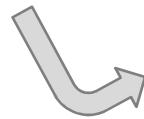
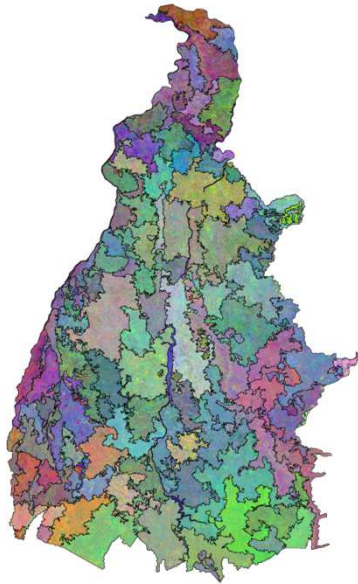
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FIELD LEVEL

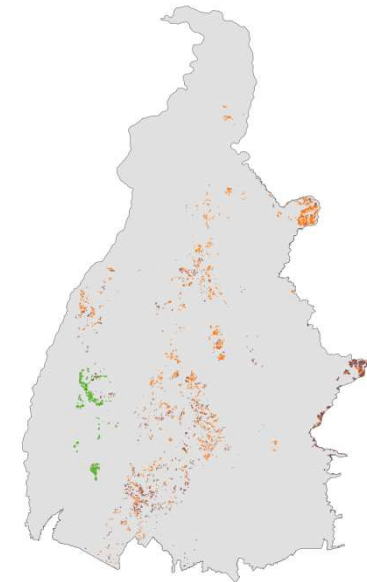
Identification of Agricultural LUS



REGIONAL LEVEL



FIELD LEVEL



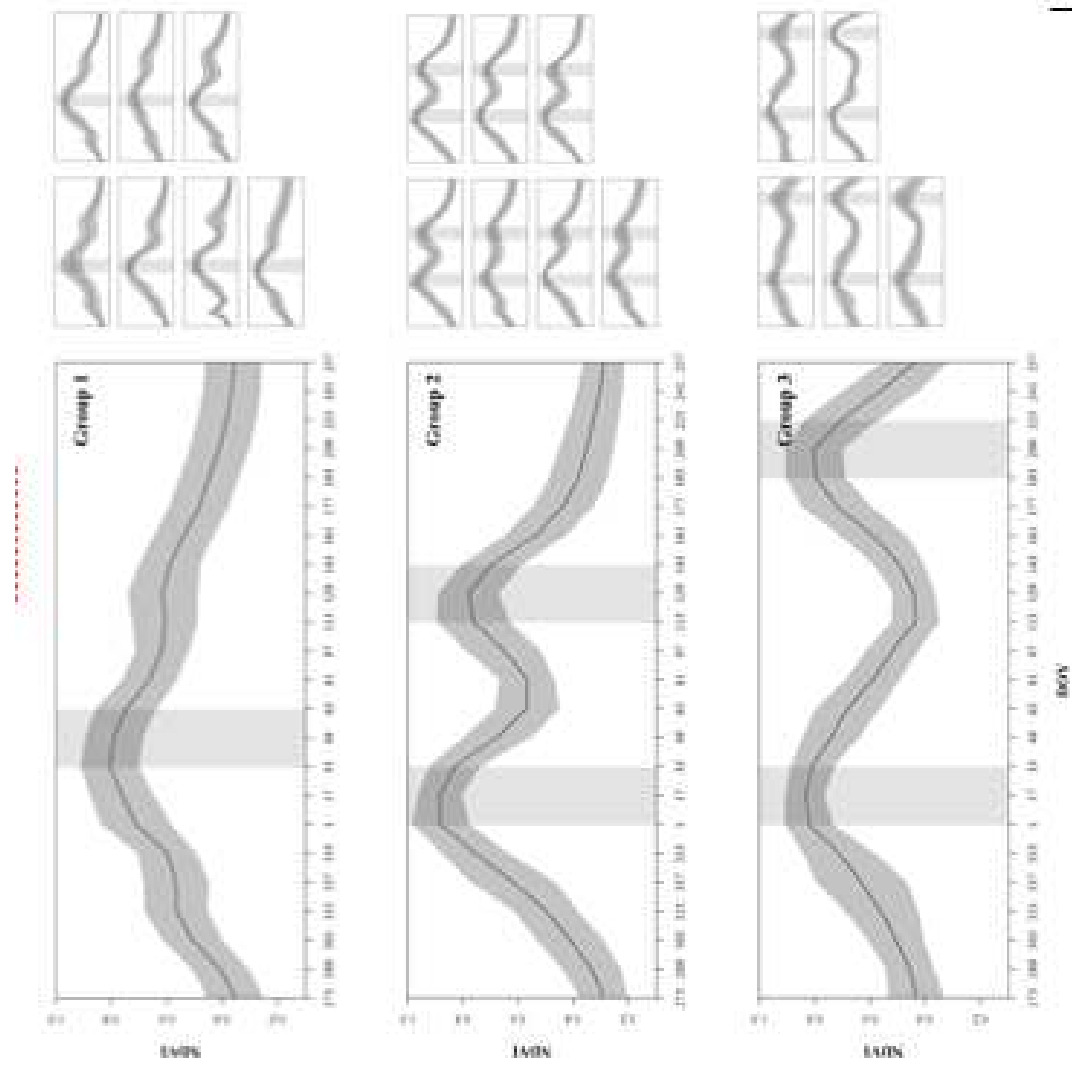
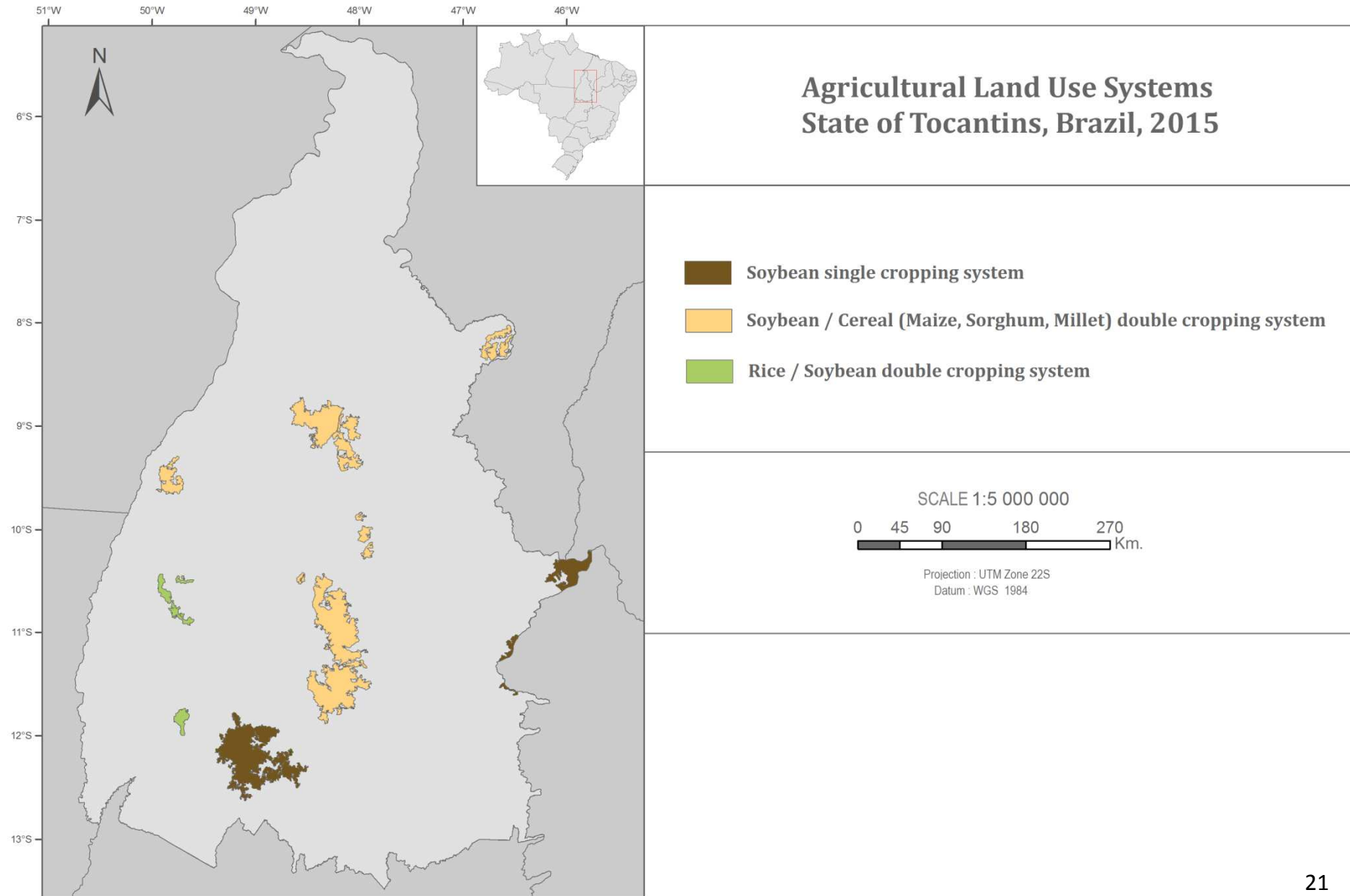
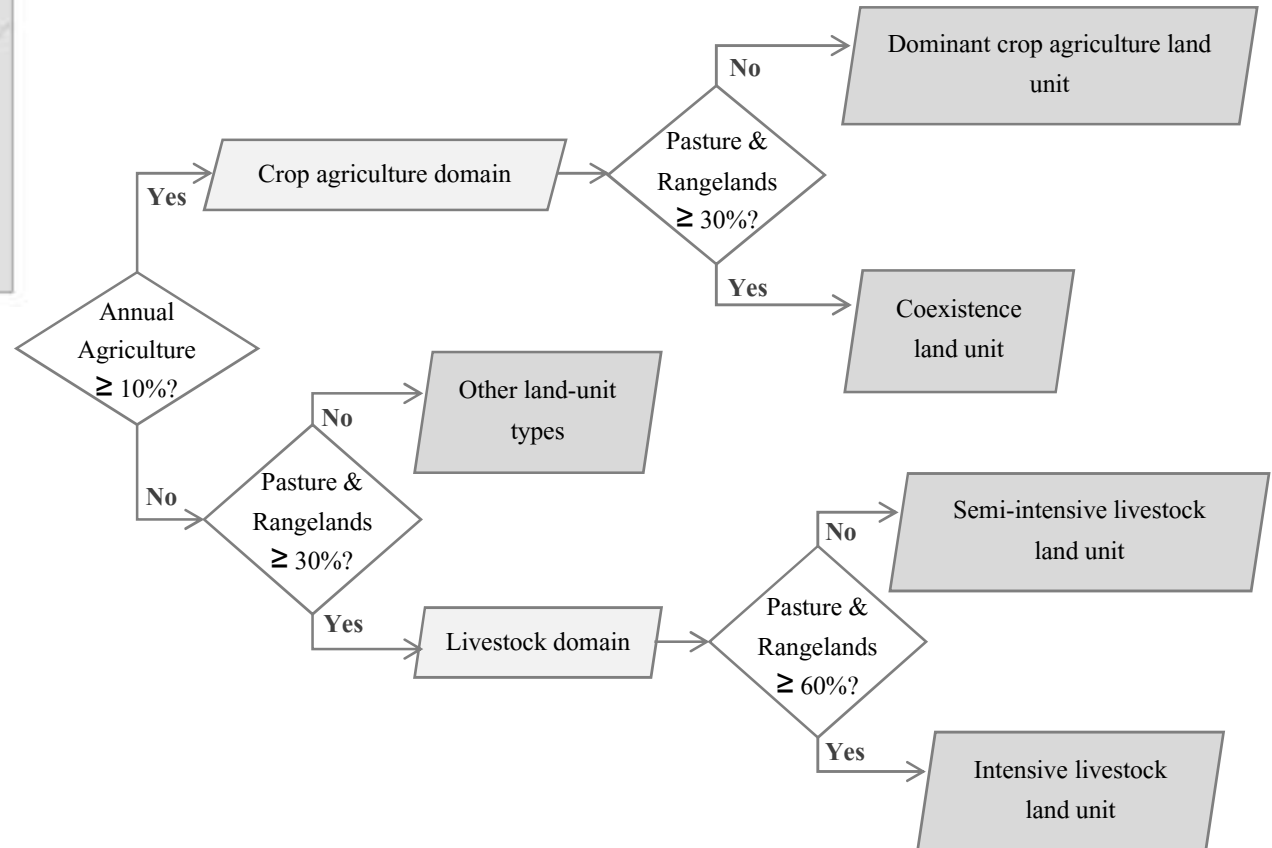
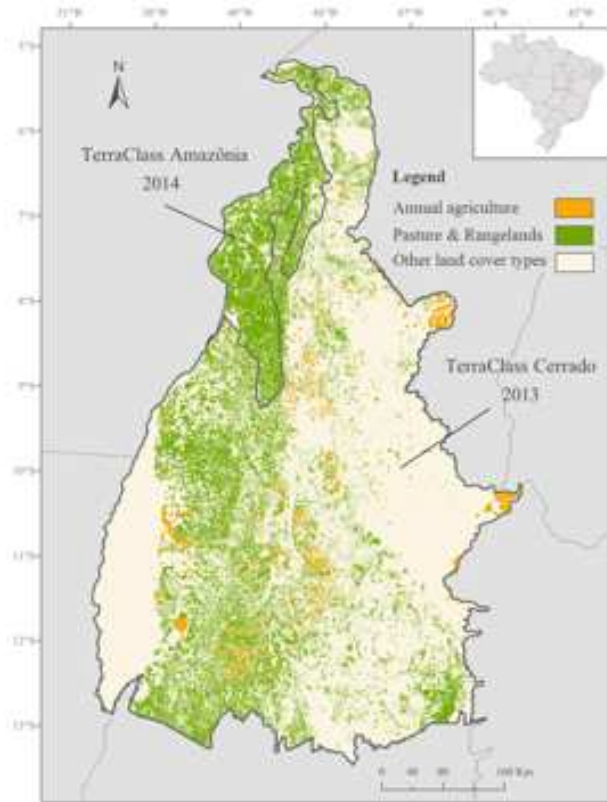


Figure 7. The temporal NDVI profiles plots of the 22 crop agriculture domain land units. The plots show the mean (solid black curve) and the standard deviation (shaded dark grey curve) of the NDVI pixel values inside the annual agriculture TerraClass mask for each land unit against the day of the year (DOY). A representative land-unit profile for each of the three phenological pattern groups

FINAL RESULTS



TERRAClass Amazonia et Cerrado



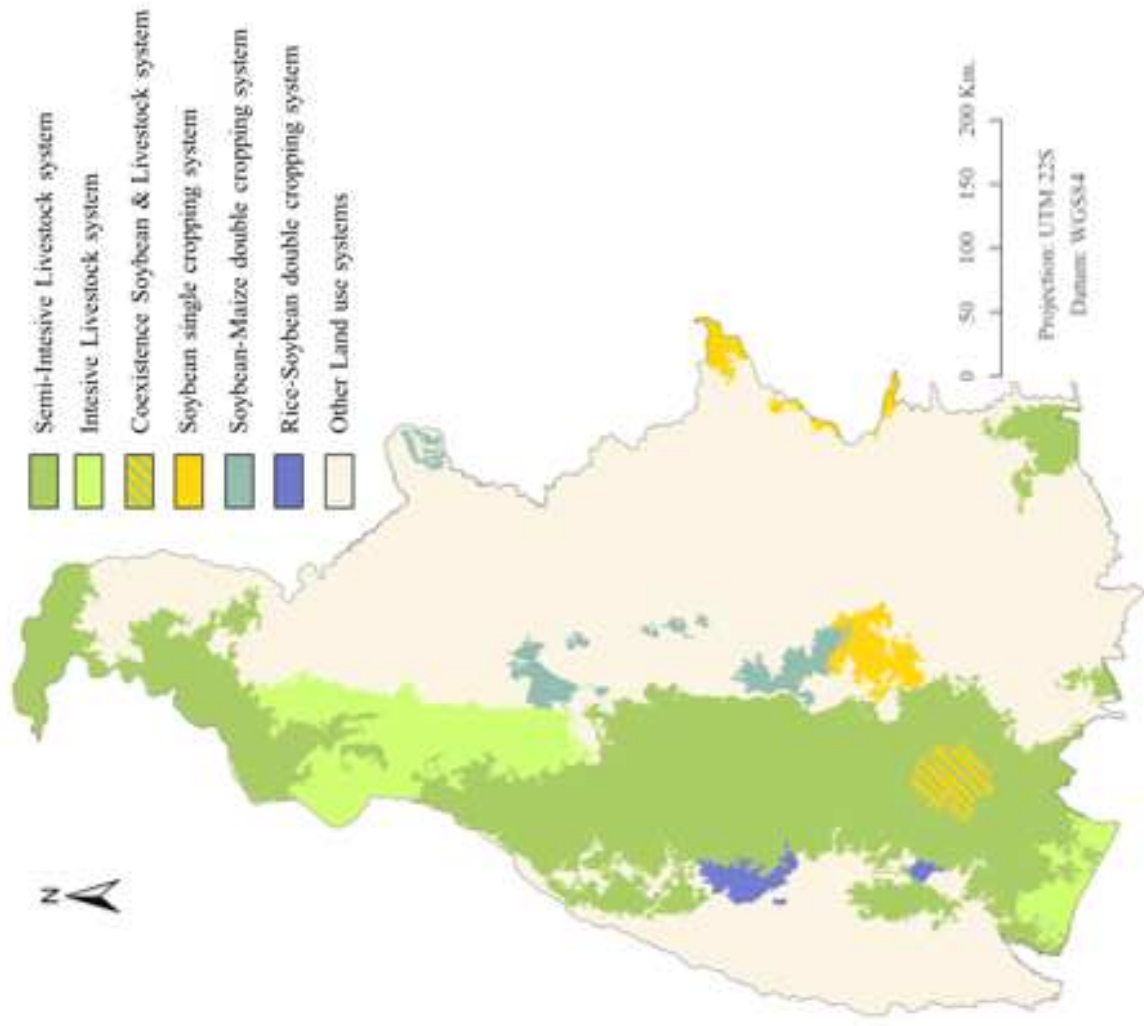


Figure 8. Map of the main agricultural land-use systems (ALUS) of the Tocantins state in the 2013-2014 growing season.

ONGOING WORK

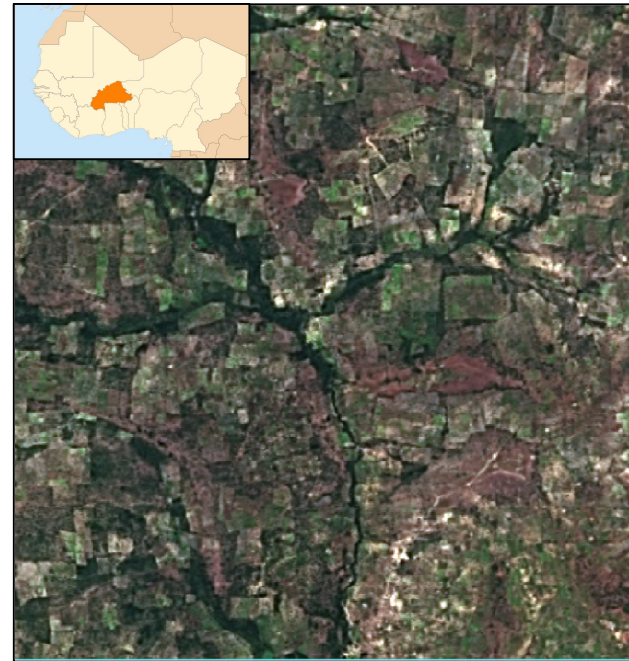
Reproducibility tests:

- 2016 Tocantins
- Burkina Faso

Tocantins



Burkina Faso



0 1 2 Kilometers

Landsat 8 PXS
Spatial resolution = 15m



THANK YOU

ACKNOWLEDGEMENTS

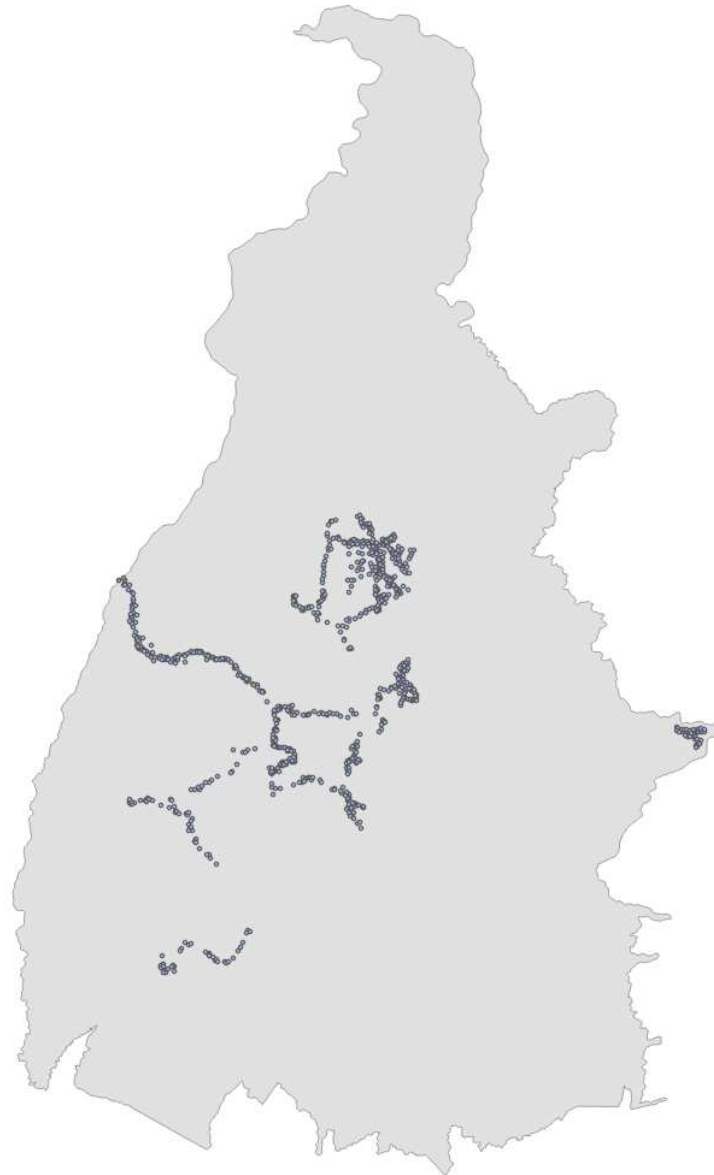


EXTRAS

IN SITU DATA COLLECTION

DB LULC – October 2015

| LULC Class | No. of points TO |
|----------------------------------|------------------|
| Annual cropland | 193 |
| Soybean single cropping | 38 |
| Soybean – Cereal double cropping | 133 |
| Rice- Soybean double cropping | 22 |
| Other LCC | 653 |
| Grassland and meadows | 242 |
| Fallows | 28 |
| Perennial crops | 67 |
| Shrubland | 128 |
| Forest | 65 |
| Build-up Surface | 30 |
| Bare soil | 12 |
| Water bodies | 15 |
| TOTAL | 900 |



CONFUSION MATRIX

Annual cropland classification

| | | Reference | | TOTAL | Producer's accuracy (%) | User's accuracy (%) |
|----------------|-----------------|-----------------|-----------|-------|--------------------------|---------------------|
| | | Annual cropland | Other LCC | | | |
| Classification | Annual cropland | 181 | 26 | 207 | 93.78 | 87.44 |
| | Other LCC | 12 | 681 | 693 | 96.32 | 98.27 |
| | TOTAL | 193 | 707 | 900 | Global accuracy = 95.78% | |
| | | | | | Kappa index = 0.88 | |

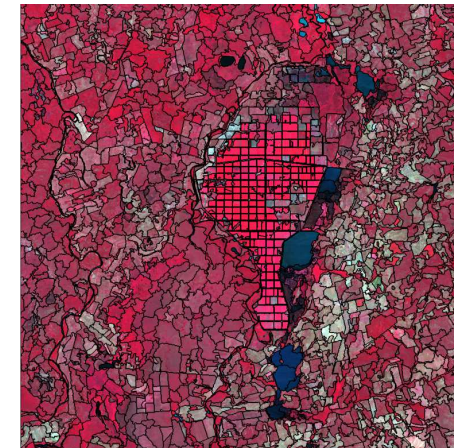
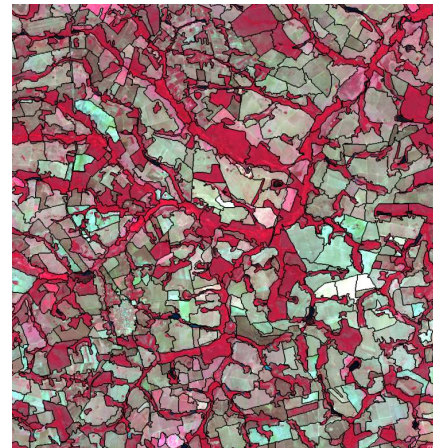
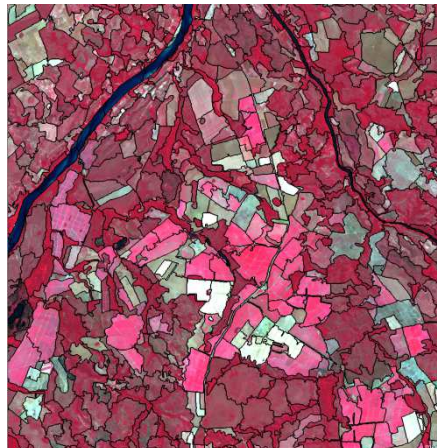
CONFUSION MATRIX

Cropping systems classification

| | | Reference | | | | TOTAL | Producer's accuracy (%) | User's accuracy (%) |
|----------------|------------------|----------------|------------------|----------------|-----------|-------|--------------------------|---------------------|
| | | Soybean single | Soybean - Cereal | Rice - Soybean | Other LUS | | | |
| Classification | Soybean single | 35 | 8 | 0 | 14 | 57 | 92.11 | 61.40 |
| | Soybean - Cereal | 0 | 116 | 0 | 12 | 128 | 87.22 | 90.63 |
| | Rice - Soybean | 0 | 0 | 22 | 0 | 22 | 100 | 100 |
| | Other LUS | 3 | 9 | 0 | 681 | 693 | 96.32 | 98.27 |
| | TOTAL | 38 | 133 | 22 | 707 | 900 | Global accuracy = 94.89% | |
| | | | | | | | Kappa index = 0.86 | |

SEGMENTATION PARAMETERS

| | Data | Spatial resolution | Bands (all same weight) | Scale parameter | Color | Shape |
|------------|--|--------------------|--|-----------------|-------|---|
| Land units | Principal components from NDVI TS | 250m | PC2 - PC20 | 1000 | 1 | 0 |
| Fields | Landsat 8 mosaic July 2015 (19 Landsat scenes) | 30m | B (b2) G (b3) R (b4) NIR (b5) SWIR1 (b6) | 110 | 0,2 | 0,8 Compactness= 1 Smoothness = 0 |



CONFUSION MATRIX

Annual cropland classification

```
Confusion Matrix and Statistics

      Reference
Prediction  1   2
      1 181  26
      2   12 681

      Accuracy : 0.9578
      95% CI   : (0.9425, 0.97)
No Information Rate : 0.7856
P-Value [Acc > NIR] : < 2e-16

      Kappa : 0.8779
McNemar's Test P-Value : 0.03496

      Sensitivity : 0.9378
      Specificity : 0.9632
      Pos Pred Value : 0.8744
      Neg Pred Value : 0.9827
      Prevalence : 0.2144
      Detection Rate : 0.2011
      Detection Prevalence : 0.2300
      Balanced Accuracy : 0.9505
```

Cropping systems classification

```
Confusion Matrix and Statistics

      Reference
Prediction  1   2   3   4
      1   35   8   0  14
      2    0 116   0  12
      3    0   0  22   0
      4    3   9   0 681

overall statistics

      Accuracy : 0.9489
      95% CI   : (0.9324, 0.9623)
No Information Rate : 0.7856
P-Value [Acc > NIR] : < 2.2e-16

      Kappa : 0.8622
McNemar's Test P-Value : NA

Statistics by Class:

      Class: 1 Class: 2 Class: 3 Class: 4
Sensitivity   0.92105  0.8722  1.00000  0.9632
Specificity   0.97448  0.9844  1.00000  0.9378
Pos Pred Value 0.61404  0.9063  1.00000  0.9827
Neg Pred Value 0.99644  0.9780  1.00000  0.8744
Prevalence    0.04222  0.1478  0.02444  0.7856
Detection Rate 0.03889  0.1289  0.02444  0.7567
Detection Prevalence 0.06333  0.1422  0.02444  0.7700
Balanced Accuracy 0.94777  0.9283  1.00000  0.9505
```