Challenges for MRV in agroforestry systems using remote sensing techniques

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GÖTTINGEN

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- Agroforestry and REDD+
- Classification of agroforestry systems
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Introduction

Agroforestry has received increased attention in the REDD+ context:

- Potentials for increased carbon sequestration by planting trees on farms
- Intensification to prevent deforestation
- Small and medium size farm systems produce food, fodder, fuel, timber on the same area while conserving and improving soils

Background

Project to promote development of coffee – banana - tree systems in Latin America:

"***Improving small farm production and marketing of bananas under trees***"

- funded by GIZ
- coordinated by Bioversity International
- project sites in Costa Rica, Honduras, Nicaragua and Peru

Research question of WP1: Methods for mapping agroforestry systems

Can remote sensing images be used to identify and characterize small holder shaded coffee with banana for use in extrapolation of field research and for identification of research and development priorities?

Bioversity International

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Definition of Agroforestry System

„Complex land use with features both from forest and agricultural systems“ (Welham et al. 2010)

„Deliberate introduction and management of trees into farming systems“ (Minang et al. 2011)“

„ Systems and practices where woody perennials are deliberately integrated with crops or animals in the same land management unit, either at the same time or in sequence with each other”(ICRAF 1993)

forest trees, fruit trees, rubber trees?

palm and bamboo vegetation?

shrubs?

Definition of Agroforestry System

Generally accepted FAO forest definition:

*Land spanning **more than 0.5 hectares** with **trees higher than 5 meters** and a **canopy cover of more than 10 percent**, or **trees able to reach these thresholds** in situ. It does not include land that is predominantly under **agriculture or urban land** use. (FRA, 2010)*

- **quantitative biophysical land cover criterium**
- **qualitative socio-economic land use criterium**
- **potential criterium**

FAO distinguishes 6 classes:

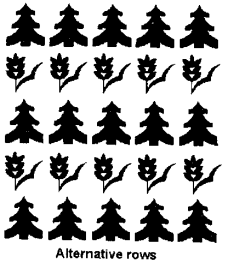
- Forest (FOREST)
- Other Land (OL)
- Other Land with Tree Cover (OLTC)
- Other Wooded Land (OWL)
- Water (WATER)
- Trees outside forests (TOF)

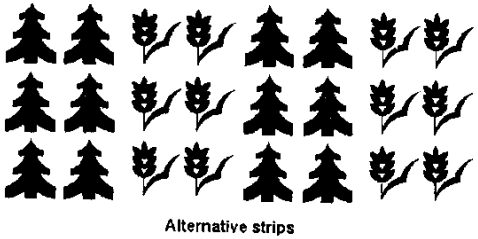
Agroforestry systems are split into 4 classes

Spatial Arrangement of Agroforestry Systems

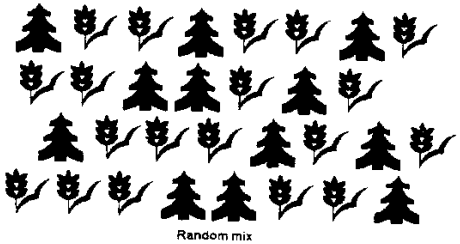
1. Border tree planting

2. Alternate rows and strips



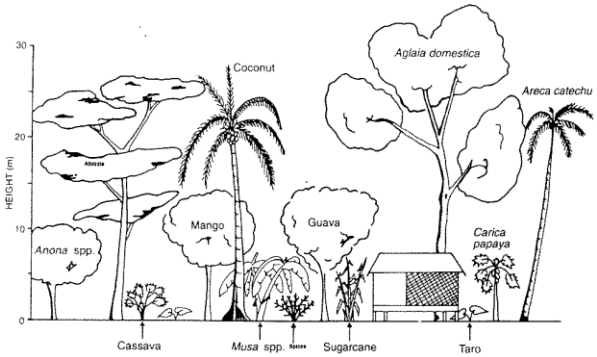


3. Random mix



Umrani and Jain (2010)

4. Vertical stratification

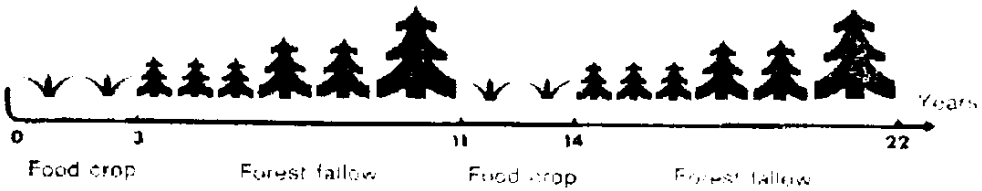


2 or more layers

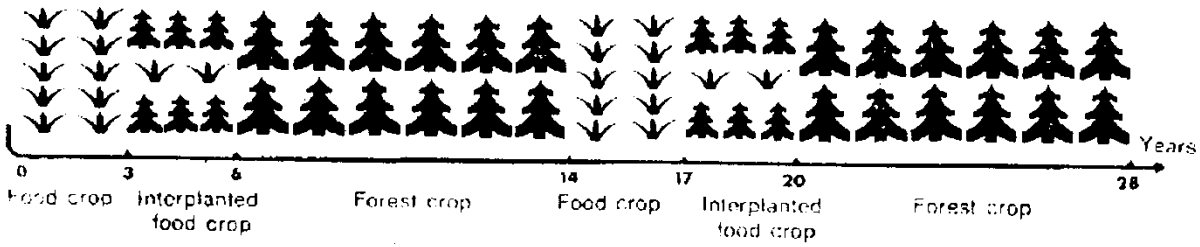
Hasanuzzaman (2012)

Temporal Sequence of Agroforestry Systems

1. Shifting cultivation

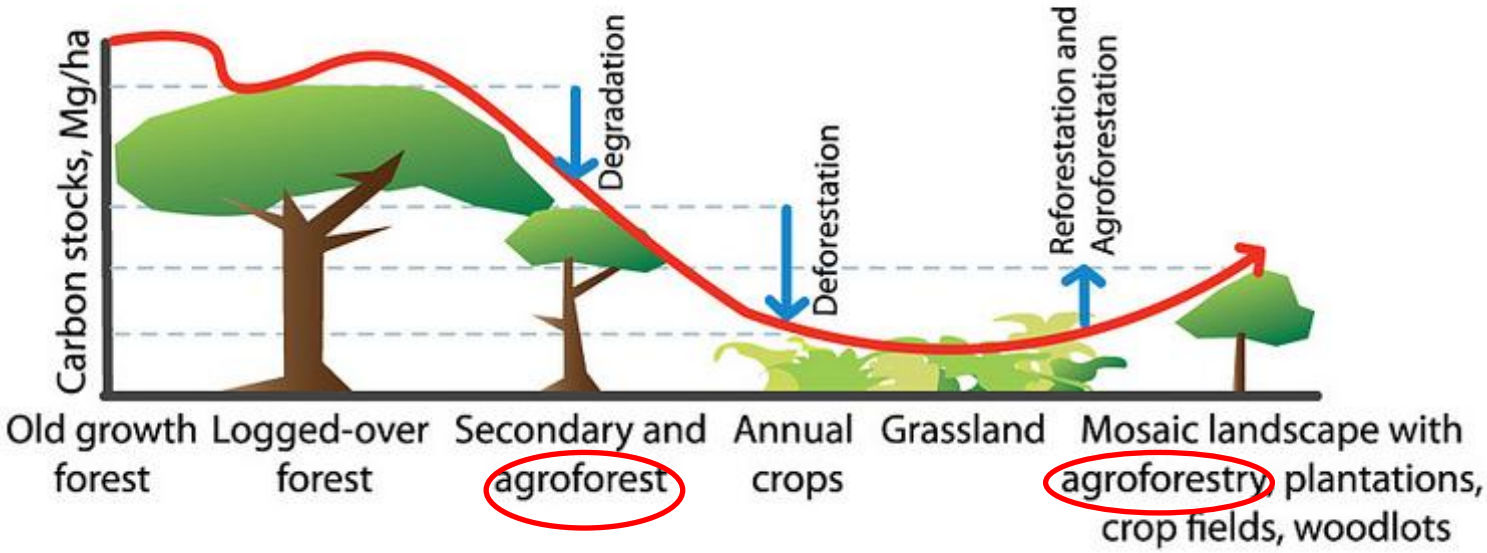


2. Taungya



Umrani and Jain (2010)

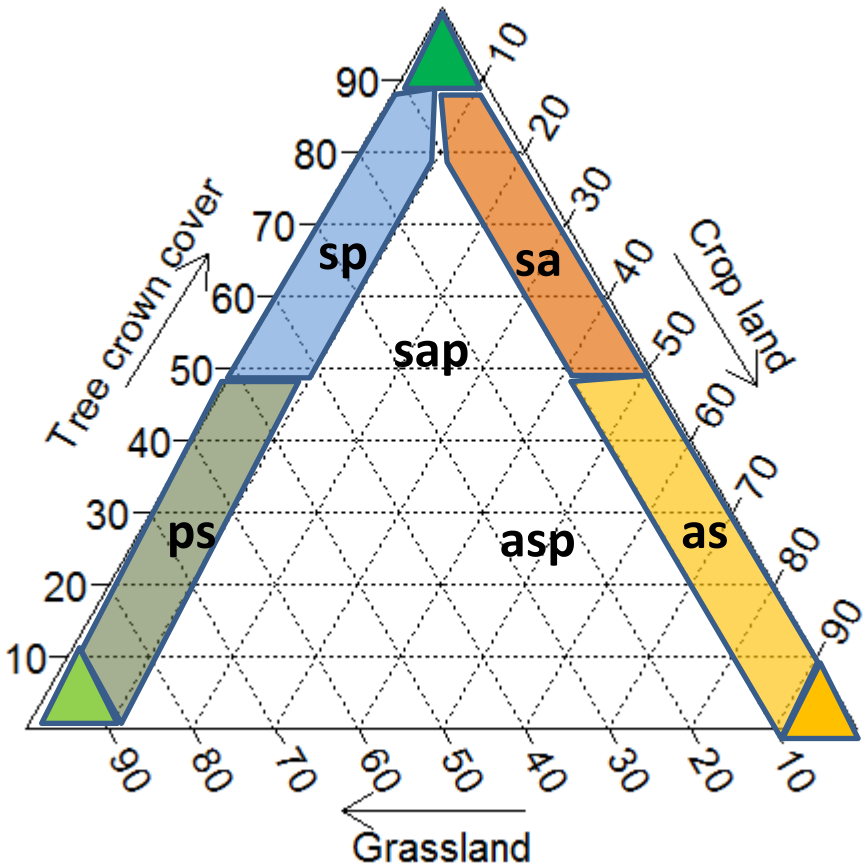
Long-term forest transition curve (CIFOR):



Classification of Agroforestry Systems

Dominance of biophysical land cover (in percent)

Silviculture



sp = silvopasture
sa = silvoagriculture
as = agrosilviculture
ps = pastoral silviculture
asp = agrosilvopasture
sap = silvoagropasture

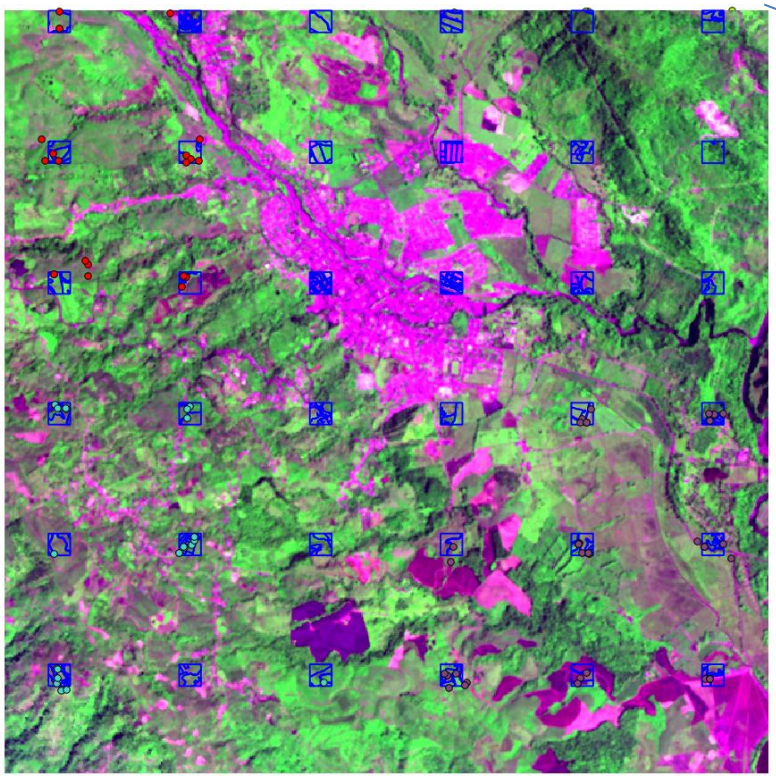
Livestock production

Crop production

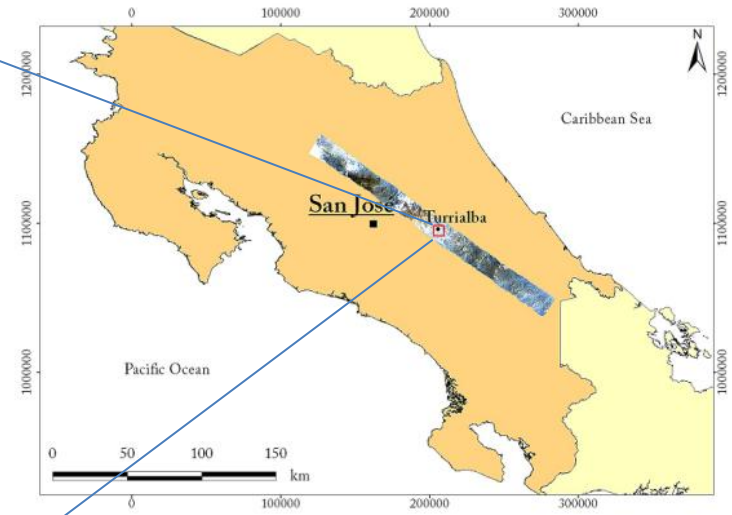
Agroforestry systems in optical remote sensing

Case study: Comparison of two optical sensors:

1. High spectral resolution airborne MASTER, 25 reflective bands, GSD=10m



7x7 km, RGB = 491
MASTER 11.3.2005

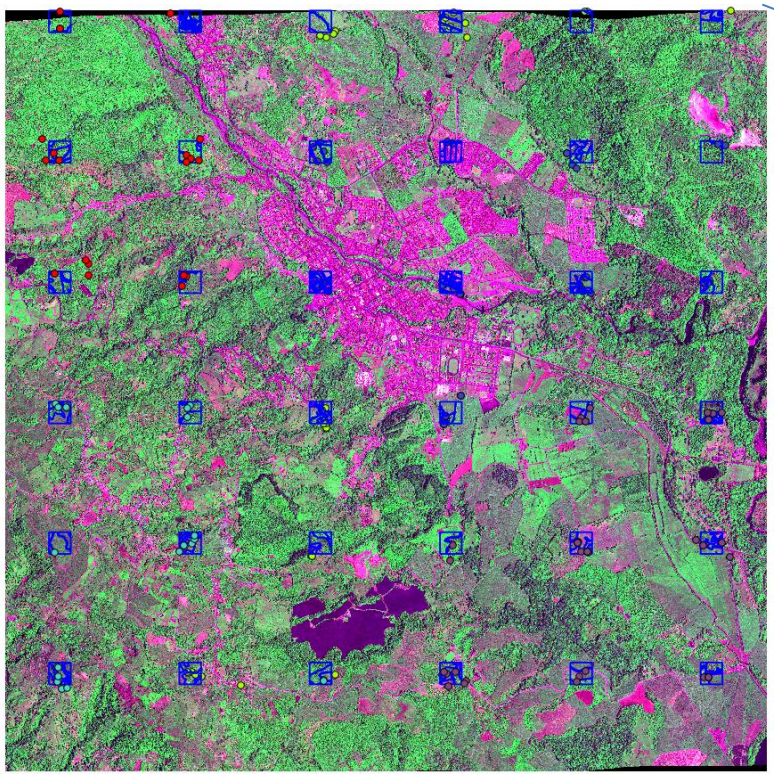


Costa Rica (Martignoni 2011)

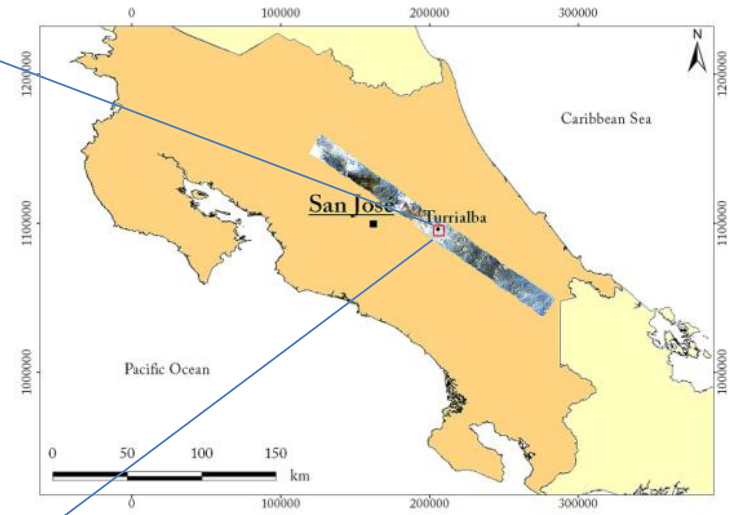
Agroforestry systems in optical remote sensing

Case study: Comparison of two optical sensors:

1. High spectral resolution airborne MASTER , 25 reflective bands, GSD=10m
2. High spatial resolution satellite GeoEye-1 , 5 bands, GSD = 0,5m



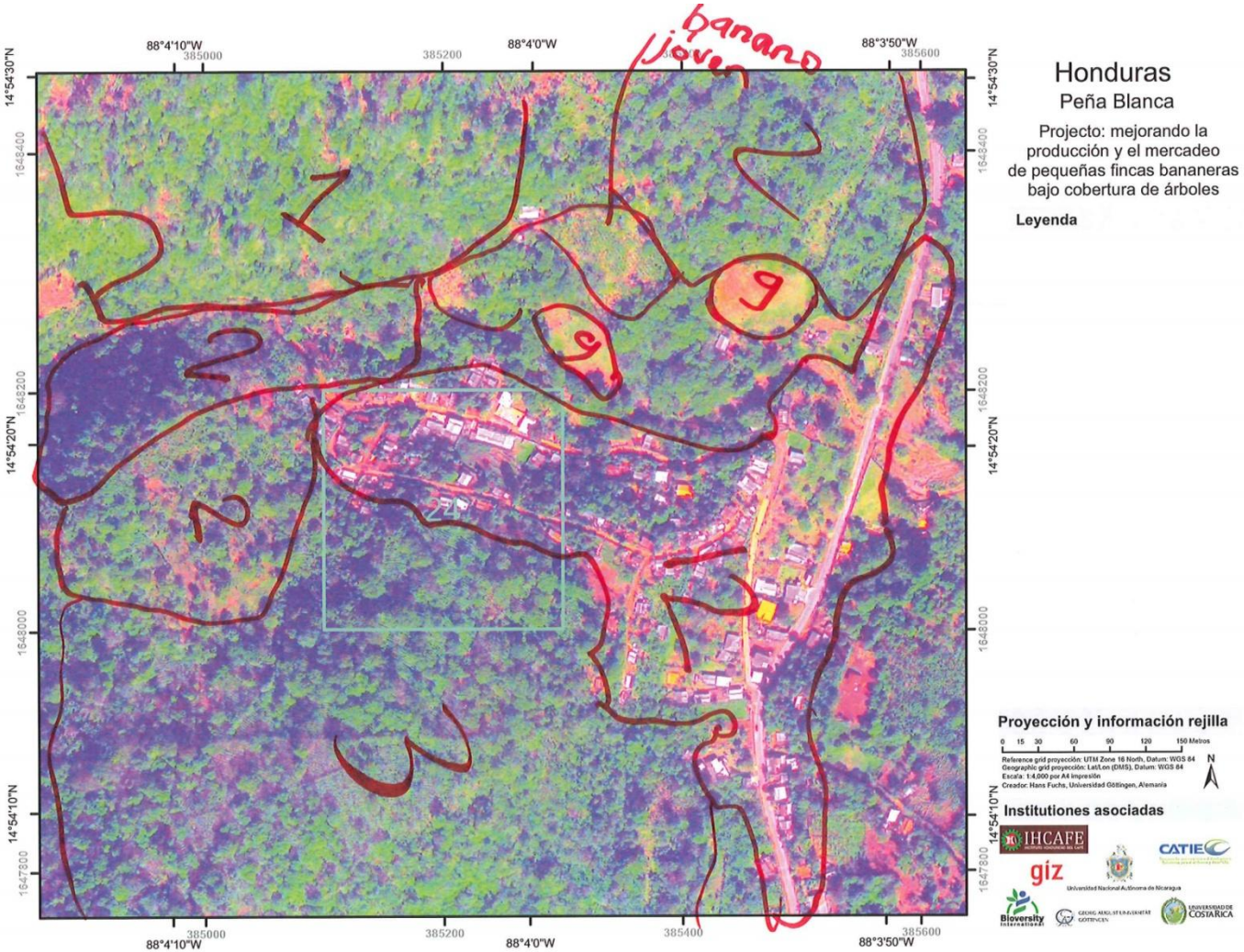
7x7 km, RGB = 491
GeoEye 5.2.2010



Costa Rica (Martignoni 2011)

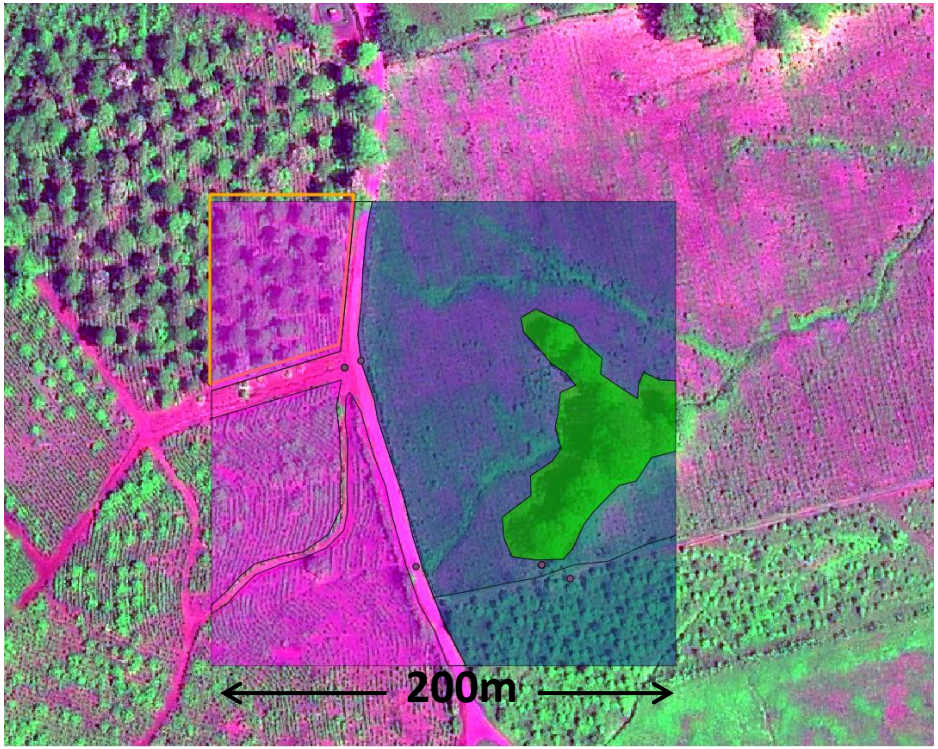
Field data collection

Sketch map (A4) of LUC plot visited by field team:

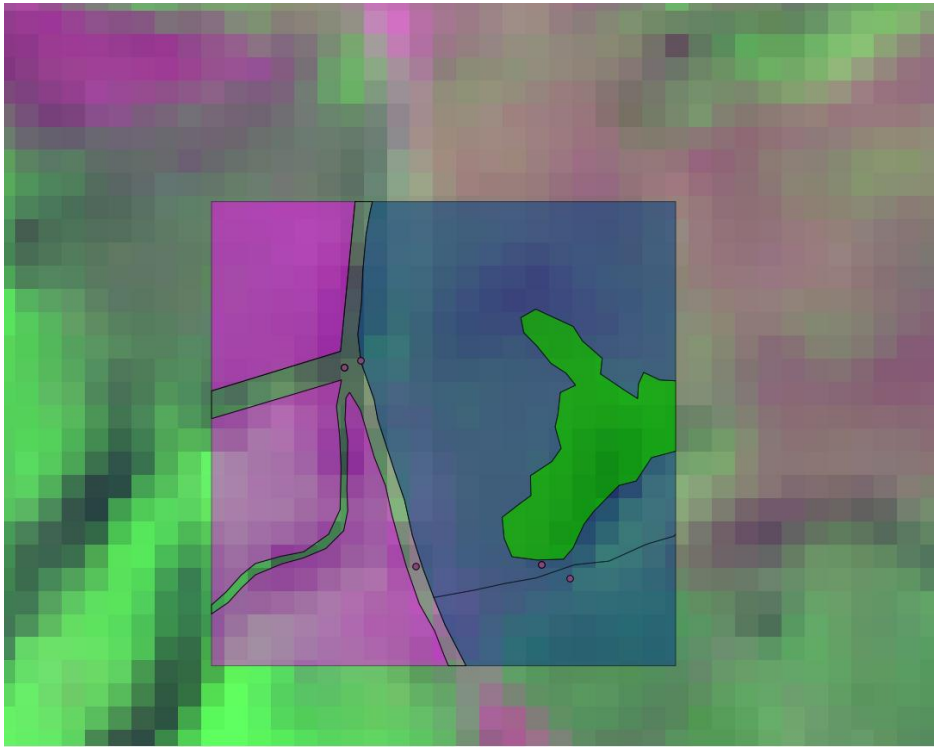


Training Stage

Digitized sketch maps overlaid on color composites:



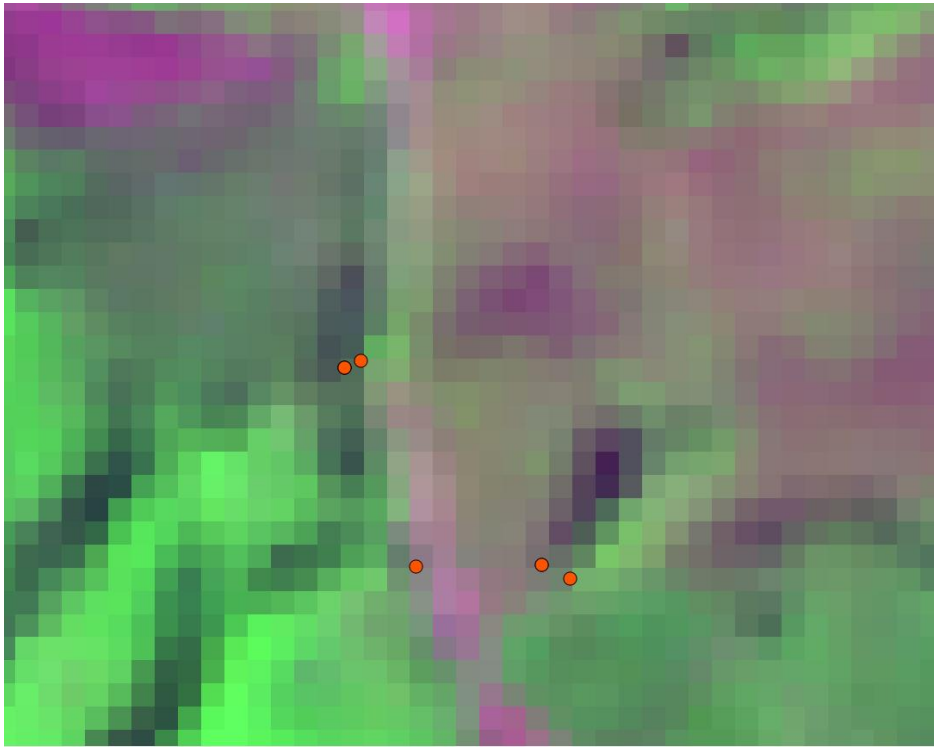
GeoEye-1, RGB=341
5.2.2010



Master, RGB=491
11.3.2005

Training Stage

GeoEye-1, RGB=341
5.2.2010



Master, RGB=491
11.3.2005

Training Stage

Documentation of land cover classes with geotagged digital photos

GeoEye-1, RGB=341
5.2.2010

Tree plantation

Training Stage

Documentation of land cover classes with geotagged digital photos

GeoEye-1, RGB=341
5.2.2010

Tree crown cover

Training Stage

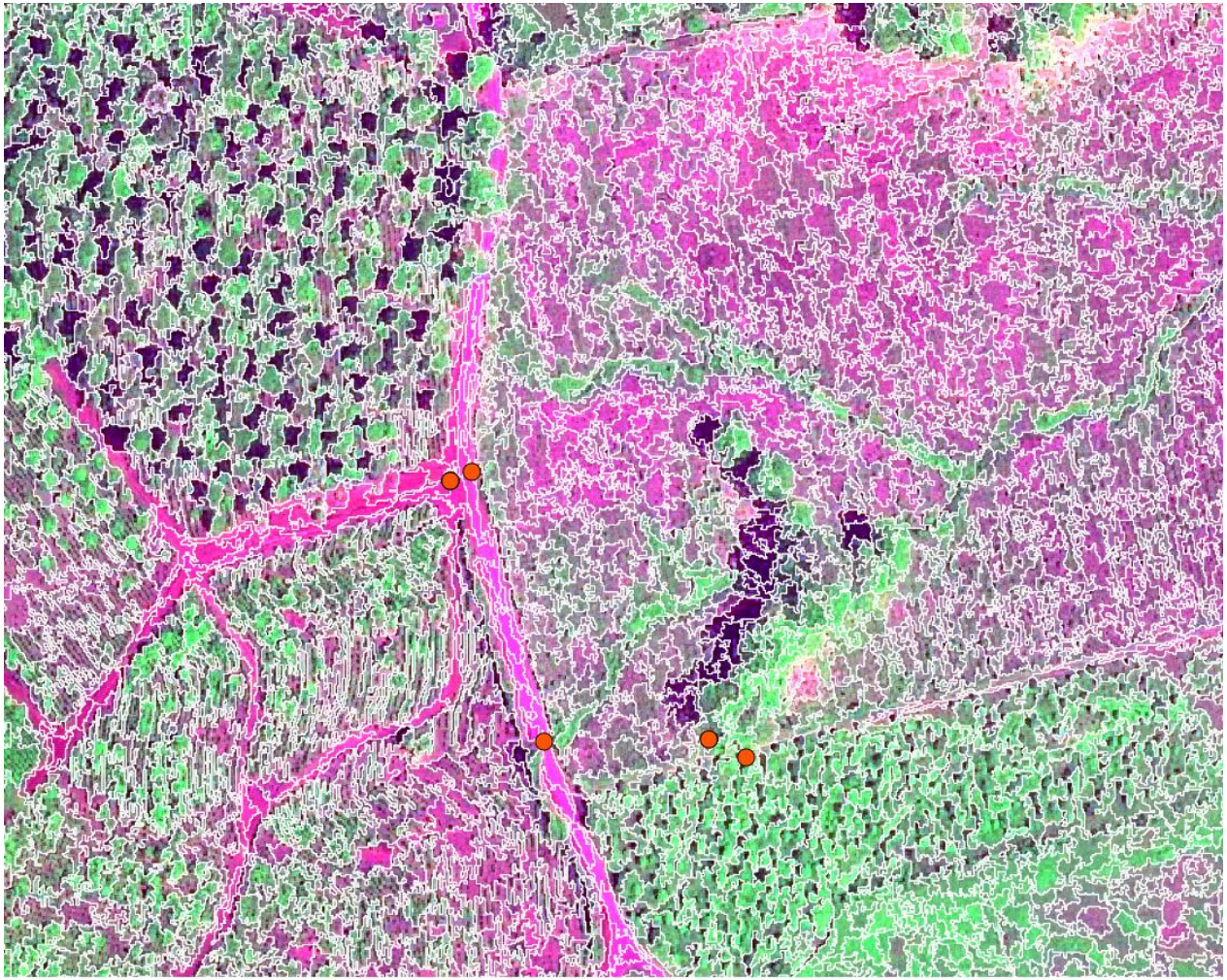
Documentation of land cover classes with geotagged digital photos

GeoEye-1, RGB=341
5.2.2010

Coffee with Poró (Erythrina peoppigiana)

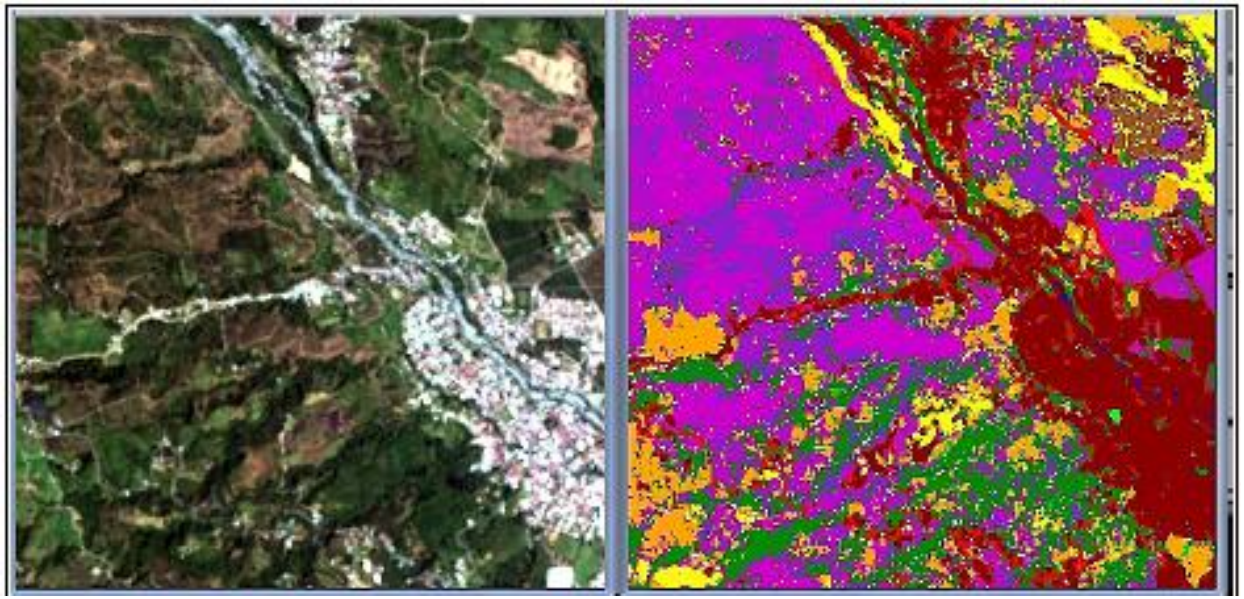
Object-based classification of spaceborne GeoEye-1 image

Automatic segmentation and interactive selection of polygons



GeoEye-1, RGB=341, 5.2.2010

Pixel-based classification of airborne MASTER image



No.	ID Color	Class name
1		Tree crown cover
2		Shade coffee at ≥3 strata
3		Shade coffee at 2 strata
4		Sun coffee
5		Sugar cane
6		Mixed tree-grassland
7		Grassland
8		Bare soil
9		Paved road
10		Building
11		Water bodies

Original airborne MASTER image over Turrialba (left) and standard Maximum Likelihood supervised classifcation results using the radiance-at-sensor MASTER image, 25 spectral bands, (Martignoni 2011).

Maximum Likelihood (ML) algorithm leads to the best LUC classification overall accuracy (77%) as compared to Gaussian Mixture and Support Vector Machine (SVM).
Shade coffee agroforestry systems were classified with similar degree of confidence though it was not possible to detect with certainty the presence of bananas and plantains.

Conclusions

1. Individual tree crowns can be identified using high spatial resolution optical remote sensors.

2. An agroforestry classification scheme based on continuous tree crown cover is proposed.

3. Satellite remote sensing technology is an efficient monitoring tool for agroforestry systems and forests if

   - access to high resolution satellite images is given,
   - hard- and software is available,
   - technical and institutional capacities are enhanced,
   - field measurements and observations are integrated.

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