Capabilities and Limitations of Land Cover and Satellite Data for Biomass Estimation in African Ecosystems

Valerio Avitabile

Kaniyo Pabidi - Budongo Forest Reserve

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Outline of the presentation

- Biomass from Land Cover:
  - Africover Database
  - FAO Wisdom (Wood Energy Maps)
- Limitations of Land Cover
- Biomass from Satellite data
  - Issues related to Spatial Resolution
- Landsat Data available for Uganda
IAO - Presentation

- IAO: Overseas Agronomic Institute of Italy
- A branch of the Italian Ministry of Foreign Affairs (founded in 1904)
- A scientific and technical institution devoted to agriculture, environment and development
- Geographic focus: developing countries, mainly Africa
Africover, GLCN and IAO

1995 – 2002: Africover

Africover

- 8.5 M km² (1/3 Africa)
- Landsat data (30 m) 1995 - 2002
- Scale: 1:200,000/1:100,000
- Based on LCCS

Not just a Land Cover map... A Land Cover Database!

2003 – present: GLCN

GLCN

Global Land Cover Network:
- FAO – UNEP – Italian Cooperation
- Based on LCCS

IAO

UNEP
Pilot studies and applications

**Biomass from Land Cover data**

Development of a **methodology** to estimate the aboveground Biomass/C stock on the basis of **Land Cover** data compatible with the Land Cover Classification System (LCCS)

LCCS Land Cover Database
What is LCCS?
(Land Cover Classification System)

- LCCS is a comprehensive methodology for classification and comparison of land cover types.

LCCS has the ability to map any land cover/environment in the world at any scale and independently by the source (satellite images, aerial photos, etc.) maintaining data comparability.

Land Cover Classes are defined by a combination of a set of independent diagnostic criteria (classifiers).
LCCS Classifiers

For natural vegetation formations, LCCS always indicates, in a standardized and unambiguous way:

- **Life form** (tree, shrub, herbaceous)
- **Canopy cover** (%) (closed, closed to open, open,...)

**Life form + Canopy cover**

**Physiognomy and structure of vegetation**
Assumptions:

- C content = 50% dry biomass
- Dry biomass is related to physiognomy and structure of vegetation
- Dry biomass is influenced by ecological factors (for natural formations)
Land Cover based approach

**Methodology**

Land Cover + Ecological zone → Physiognomy & Structure of Vegetation

Environmental Info (Climate, Land form, Soil, etc.)

“Vegetation Unit” + Field data → Mean Biomass stock/unit
Land Cover based approach

**Methodology**

Biomass/canopy cover correlation curves

Correlation between biomass and canopy cover for:

- each life form;
- each ecological zone;

Linear trend based on reliable field data.

*Trees: Correlation between woody biomass and canopy cover for each ecozone*
Land Cover database: Africover

- 8.5 M km² (1/3 Africa)
- Landsat data (30 m) 1995 - 2002
- Scale: 1:200,000/1:100,000
- Based on LCCS
The Global Ecological Zone Map, reported in the FAO Forest Resource Assessment Report (FRA 2000), is based on Koppen – Trewartha climatic type.
Wood energy maps for East African Countries (2005)

Woody Biomass map for the Africover countries
Land Cover based approach

Result

- Woody Biomass Database for Africover countries:
  - Complete
  - Georeferenced
  - Detailed (Africover scale)

All vegetation forms covered:
- Tree – shrub – herbaceous
- Terrestrial and aquatic
- Natural and cultivated

The C stock is estimated for each vegetation strata, the sum of all strata giving the formation total C stock
**Land Cover based approach**

**Methodology:** Limiting factors

- **Field data scarcity:**
  - Few reliable, consistent and recent data on C/biomass of vegetation
  - Very little data for not “productive” ($) formation (e.g. shrubland, trees outside forest, agroforestry, savannas, etc.)

- **“Qualitative” Classes:** Field samples for each class

- **Ecozones:** Global ecological classification, low-detailed at sub-continental scale (6 ecozones for Africover countries)

- Propagation of Land Cover Classification errors
Land Cover based approach

Methodology: **Limiting factors**

- **Spatial issues:**
  - MMU (62 ha for Africover)
    - mixed land cover types (40% polygons)

- **Thematic issues:**
  - Few LC classes (~5 – 10 classes)
    - Complex vegetation structure
Use satellite data for Biomass estimation over large/remote areas?

“Integrated Approach”: Satellite data + Land Cover + Ancillary info

Quantitative input (DNs)
Regression model
- Continuous Biomass estimates

Fully exploit the spectral information!
“Integrated approach”

Satellite data:

- **Radar**
- **Lidar**
- **Optical**
  - Moderate resolution (MODIS, 500 m – 1 Km)
    - Daily Global coverage
    - Harmonized dataset
    - Free!
    - Low spatial resolution
  
- High resolution (Landsat, 30 m)
  - Spatial resolution compatible with stand and plot sizes
  - Free (just now!)
  - Only in SLC-on mode (1999-2003 for Africa)
**Field Plot Upscaling:**

MODIS = 1 Km (500 m)

Field plots = 10 - 50 m

*(In heterogeneous areas)*
LANDSAT spectral information

Land Cover (Africover) Vs. Image Segmentation

Segmentation inputs:
- ETM 3 – 4 – 5 – 7
- Texture (ETM 3, 3x3 to 9x9)
- Tasseled Cap (BGW)
From 1 scene to national scale

Issues with 2+ images (mosaic):

• Atmosphere and Sensor calibration
• Changes in vegetation phenology (intra-annual)
• Land Cover changes and fires (inter-annual)
• Clouds
Uganda Landsat Mosaic

Year: 2003 (and 2001)
Month: January
Cloud Cover < 10%
Uganda Landsat Mosaic

Months: January, February
Cloud Cover < 10%

Options:
• Compile 1 temporally consistent cloud-free National dataset
• Develop a model for each temporal set
• Use Moderate Resolution data (MODIS)
Conclusion

- **Land Cover based approach**
  - “Qualitative” classes (vegetation units)
  - Spatial and Thematic issues

- **Integrated approach**
  - **High resolution** (Landsat-type, 30m):
    - Spatially detailed biomass estimates
    - Mosaicking issues
    - Adapt for local – subnational studies
  - **Moderate resolution** (MODIS-type, 500m – 1 Km)
    - Harmonized data over large areas
    - Lower spatial resolution
    - Adapt for regional – continental – global studies
Thank you...
Webale!

Email: avitabile@iao.florence.it

Web sites: www.carboafrica.net
           www.iao.florence.it
           www.eo.uni-jena.de