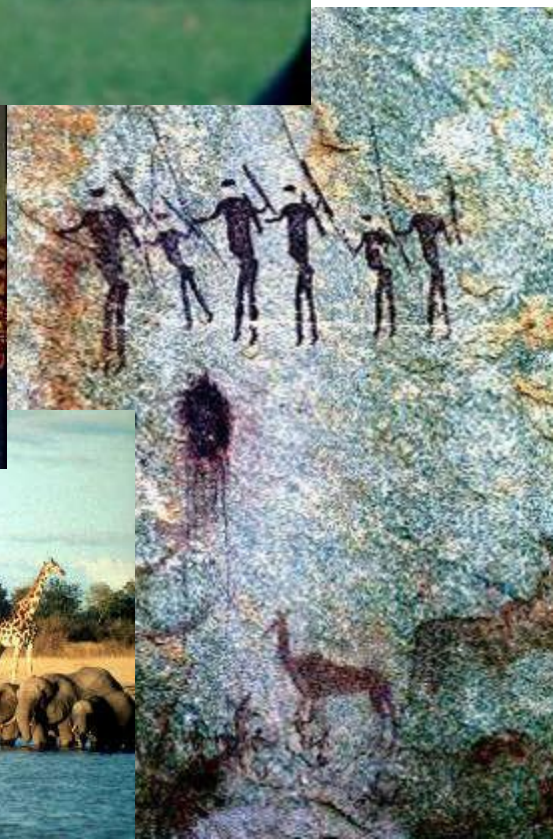
COOPERAZIONE ITALIANA

AGRICONSULTING

Integrated Assessment of Mozambican Forests



Nature of the Project and specific objectives

The Direcção Nacional de Terras e Florestas through the PIDA Program, financed by the Italian Cooperation, carried out the Interagted Assessment of Mozambican Forests (AIFM). The AIFM was funded with 2.5 million euros, and was executed by the consortium formed by Agriconsulting S.p.A (Italian) e Rural Consult Lda (Mozambican), between 2005 and 2007.

The main objective of AIFM was to evaluate the extent and composition of the forest resources of the entire country, in order to provide to the Mozambican Government updated information on the present state of such resources for a better protection, conservation and utilization.

The main results of the AIFM were the following

National and provincial assessment of forest resources

- Updated land cover map (2004-2005)
- National Forest Inventory
- Two provincial forest inventories (Manica and Maputo)

Other studies at national level

- Preliminary evaluation of wildlife distribution
- Preliminary evaluation of Non Timber Forest Products

Special studies in selected locations

- Asessment of wildlife in Machaze area
- Community forestry study in Inchope/Muda area.

Implementation of an Information System

All spatial and statistical informations collected by AIFM were integrated in a comprehensive Information System (IS), in form a geo-database. The IS constitute perhaps the most valuable result produced by AIFM, since it is a flexible repository of multiple information layers that can be integrated to support strategic planning and decision making.

The National Forest Inventory

The National Forest Inventory was designed to provide comprehensive information on forest resources, including:

Quantitive information (forest areas, total volume and commercial volume, etc.)

Qualitative information (species composition, structure of the forest, ecological zoning, wood quality, etc.)

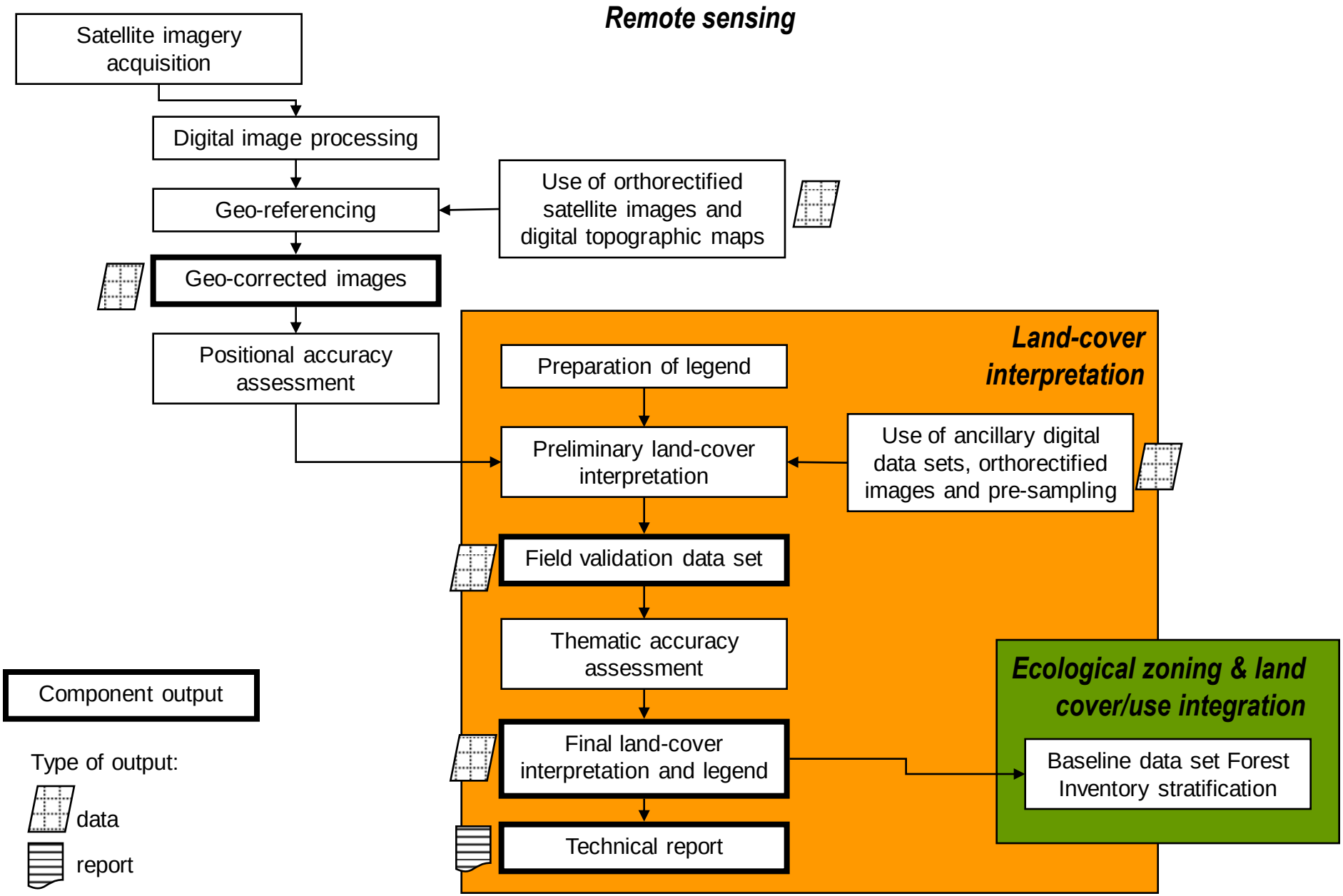
Florestas húmidas de montanha (Área 1.3 milhões de hectares)

The results allow a statistical analysis at national level and the precision estimated was of 10-15% for total volume

For productive forests the following parameters were calculated

- ❑Commercial volume
- ❑Commercial quality classes
- ❑Annual allowable cut

Workflow of the remote sensing and land-cover component



Classification of the vegetation types

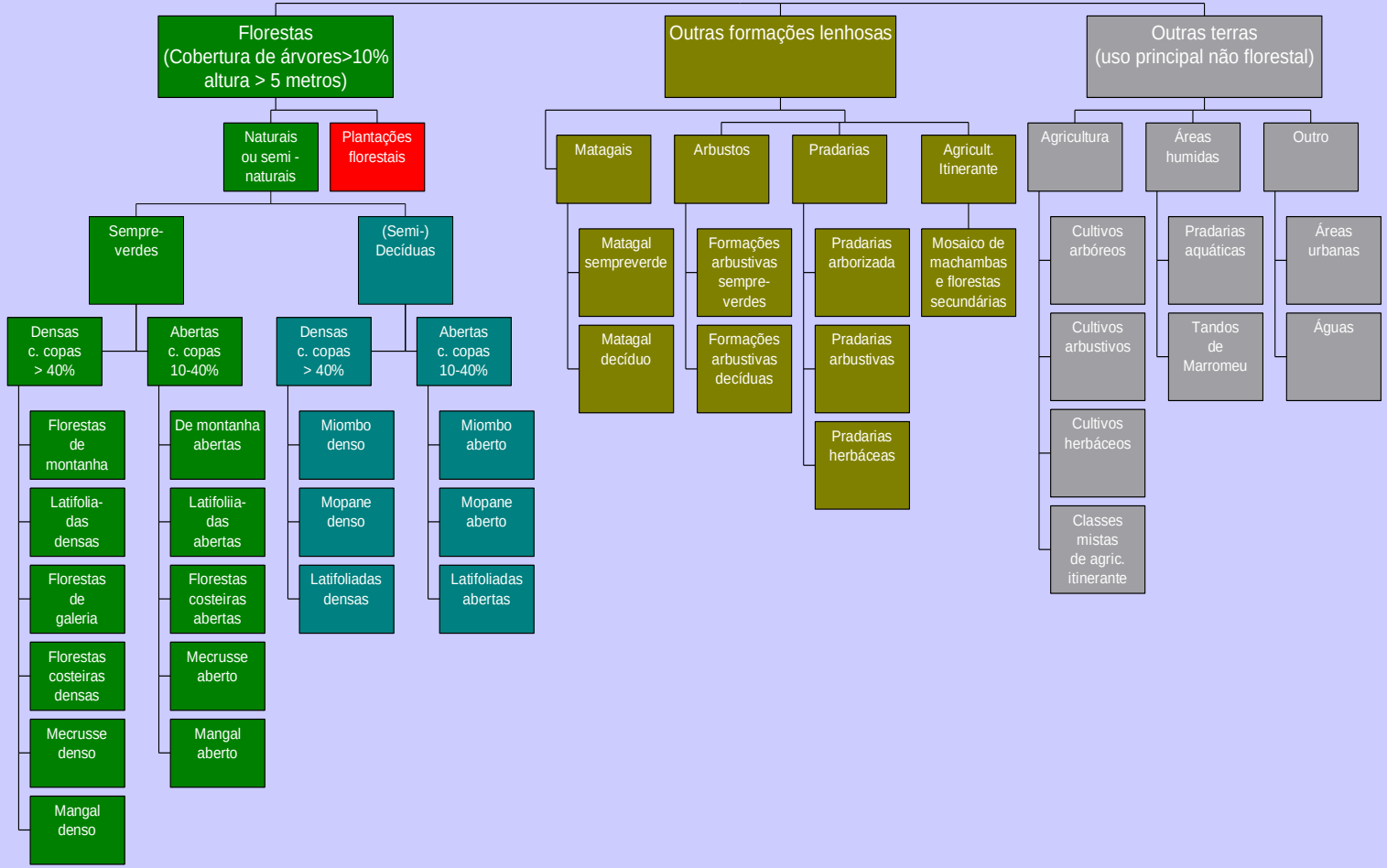
AIFM - Classificação da vegetação

I - Uso e cobertura

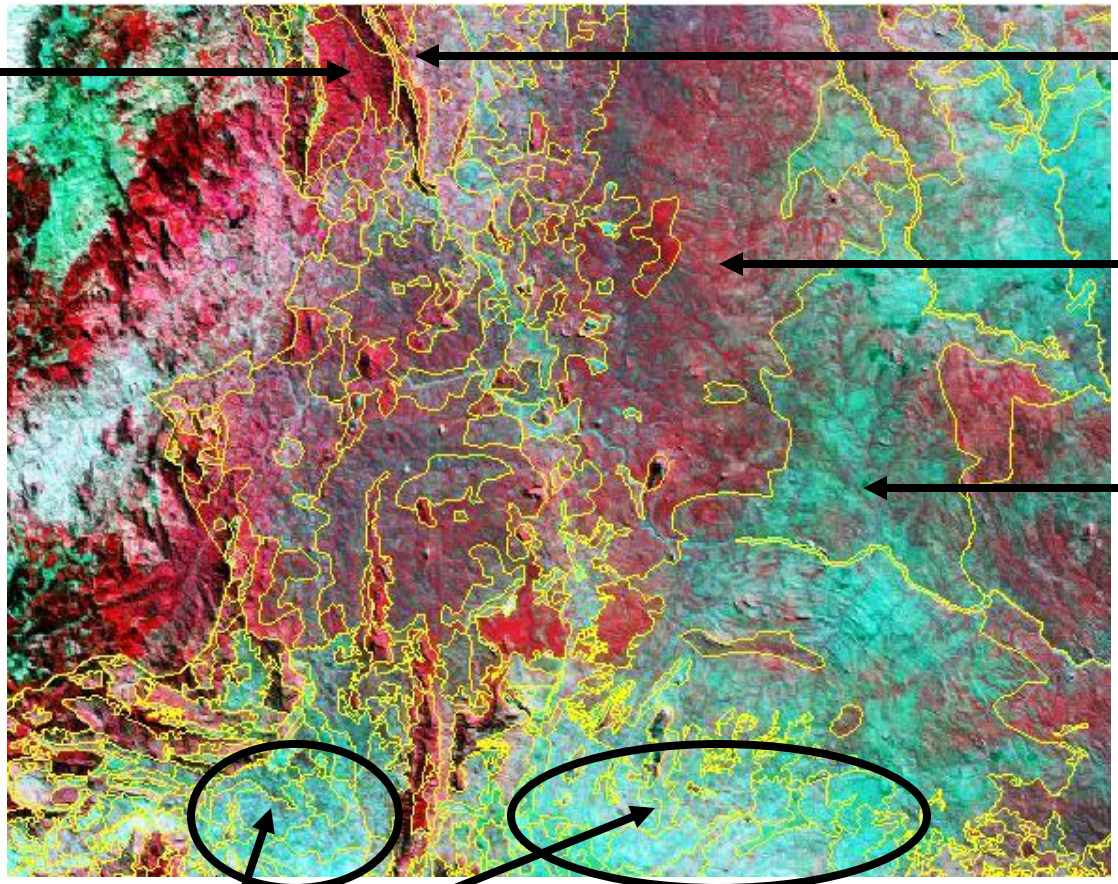
II - Fenologia

III - Densidade

IV - Aspectos florísticos



Interpretation of land cover types using Landsat



Broadleaved evergreen closed forest

Forest with shifting cultivation

Miombo dense

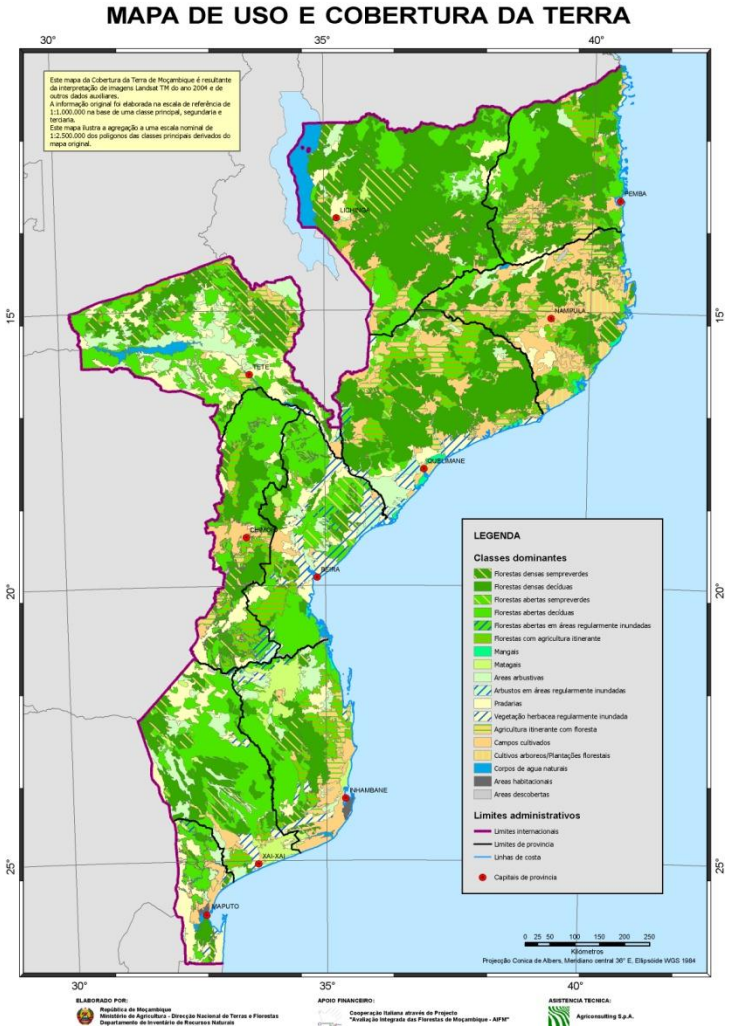
Miombo open

Zone dominated by agriculture with shrubs and grasslands

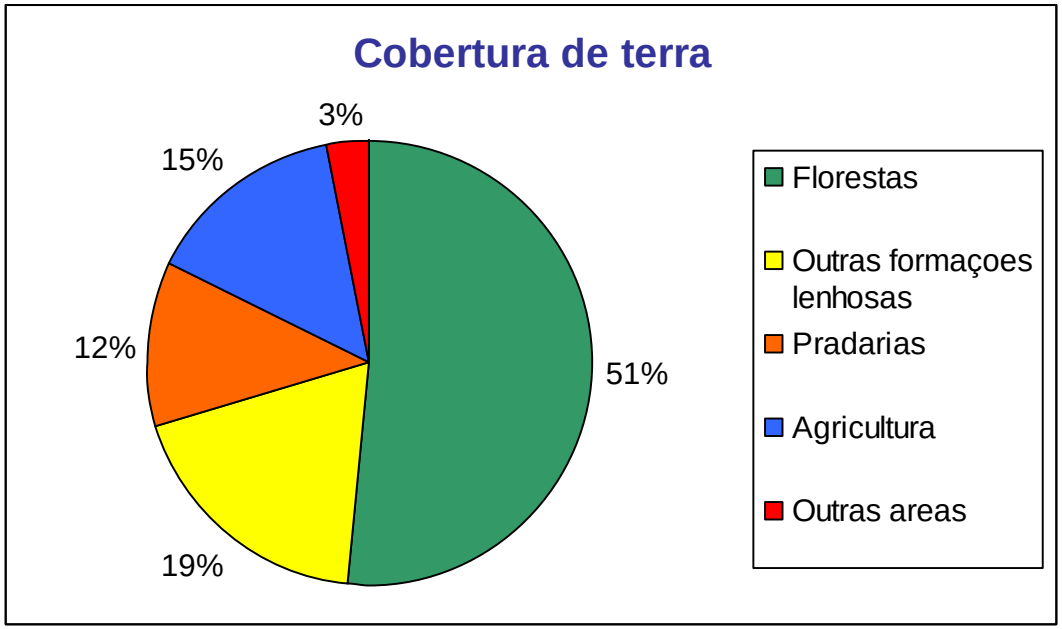
Definition of the classes with the FAO/UNEP standard

Land cover map

The AIFM Project produced a land cover map based on interpretation of satellite imagery (LANDSAT 5 TM of year 2004-2005). The classification system was based on internation standard (FAO, Land Cover Classification System –LCCS), modified according to the national requirements.



The map validation was carried out, whenever possible, with ground truthing, or high resolution images (ASTER).
Using statistical methods, the accuracy of the map was calculated, and ranged from 86% and 88% for the main classes and 90% for the forest classes.
The AIFM land cover map will constitute an updated reference for land cover and forest cover of Mozambique.

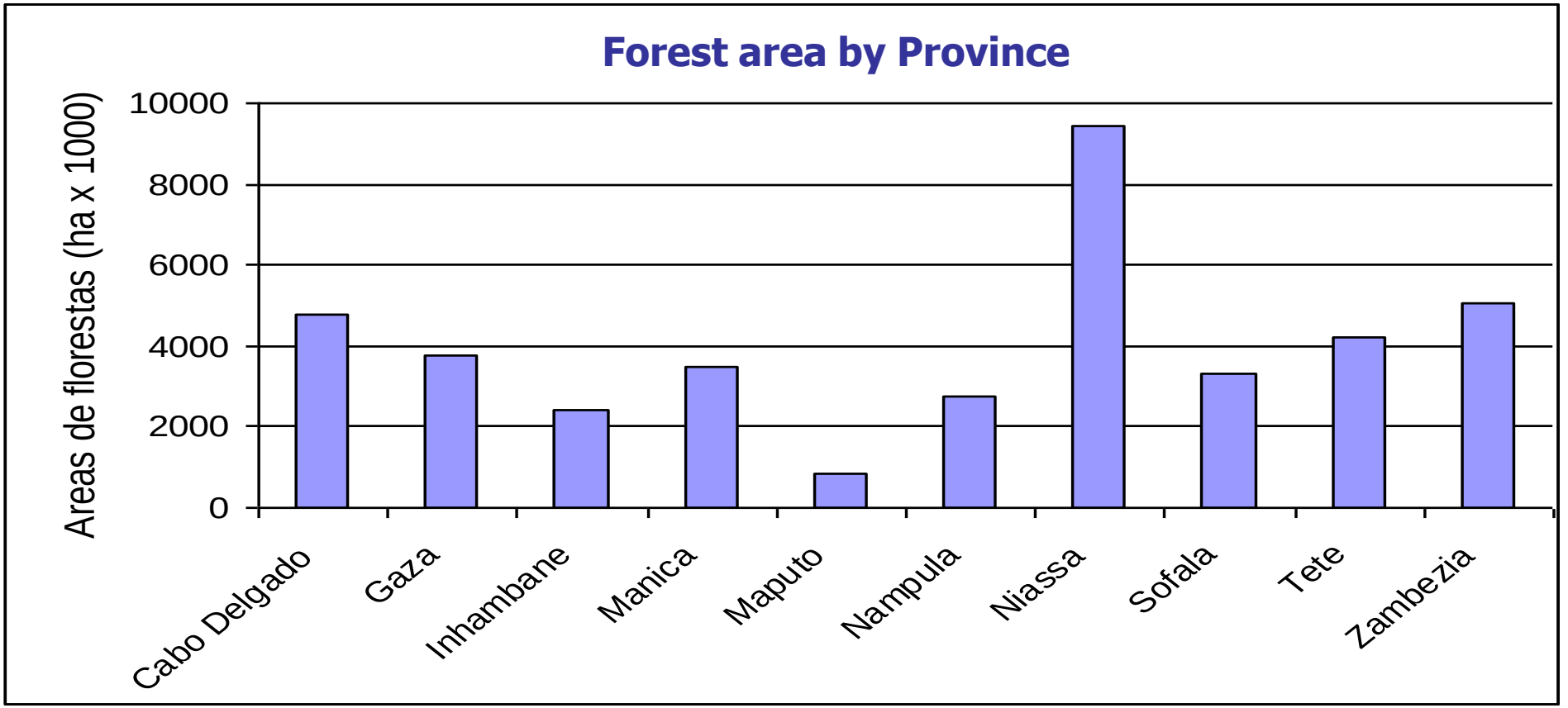


Estimation of forest cover

Using the land cover map decribed above the following areas for forests and other wooded formation were calculated

Around 70% of the country (65.3 million hectares) is covered with forests or other wooded formations

The forests cover an area of 40.6 million hectares (51% of the country), while other wooded formations (thickets, shrubs and forests with shifting cultivation) cover around 14.7 million hectares (19% of the country)



Field inventory

Stratification

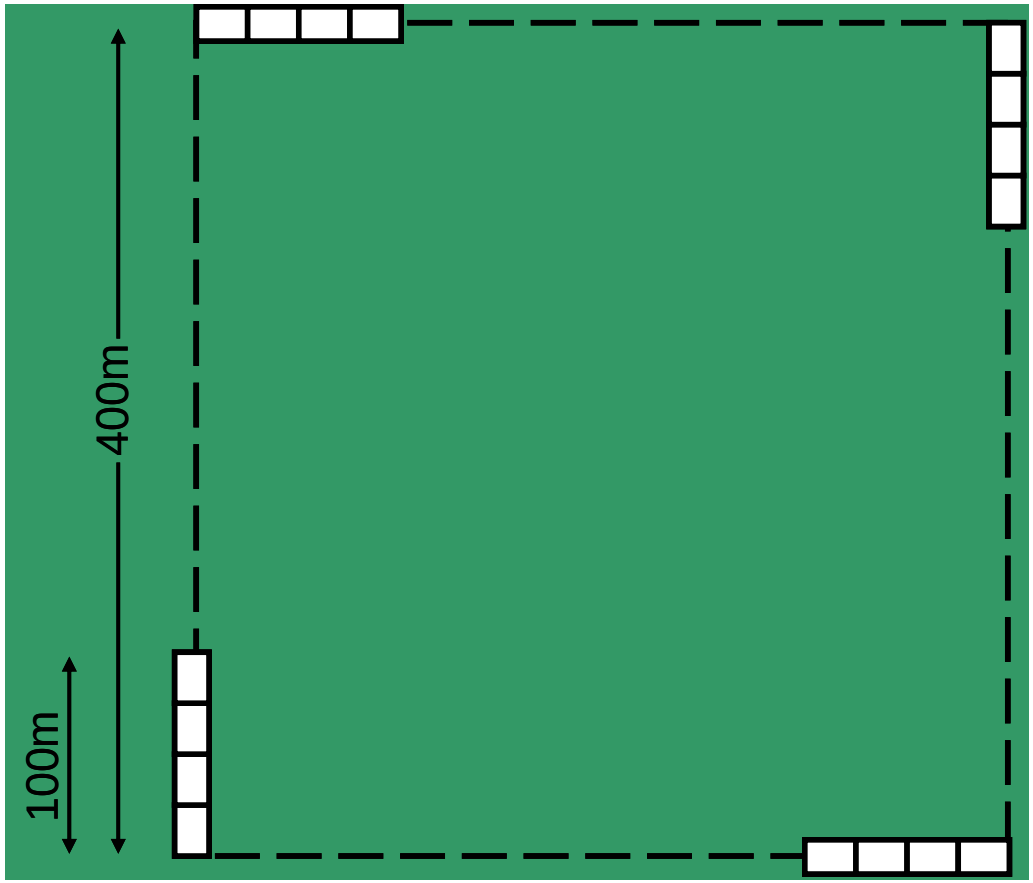
Main vegetation type	Stratum	Number of samples
Forest	Dense forest	341
Forest	Open forest	176
Other wooded land	Thickets / Shrubs	36
Other wooded land	Forest with shifting cultivation (long fallow)	97
Forests and OWL	Total	650

Field work

Each sampling unit was composed by a cluster of 4 plots (recording units). Each plot consisted of a line of 100 * 10 meters, where all trees with dbh > 10 were measured. The presence of regeneration (trees < 10 cm) was also measured in smaller sub-plots (5 * 5 meters)

For each tree the following variables were recorded in the field:

- **Species identification (local name and botanical name)**
- **Diameter**
- **Total height**
- **Commercial height**
- **Tree quality**
- **Health status**



Data processing

The following variables have been calculated for each sampling units and then expanded to values per hectare and per stratum

- Number of trees
- Basal area
- Total stem volume
- Commercial volume (bole height)
- Merchantable volume (based on presently commercial species and minimum cutting diameters)
- Volumes by species, quality and diameter class

Inventory results - Volume

Stratum	Total stem volume (m^3/ha)	Commercial volume (m^3/ha)	Merchantable volume (m^3/ha)
Dense forest	40.1	12.8	4.8
Open forest	32.2	9.1	4.1
Thickets / shrubs	18.8	5.6	1.9
Long fallow	20.6	5.7	1.9

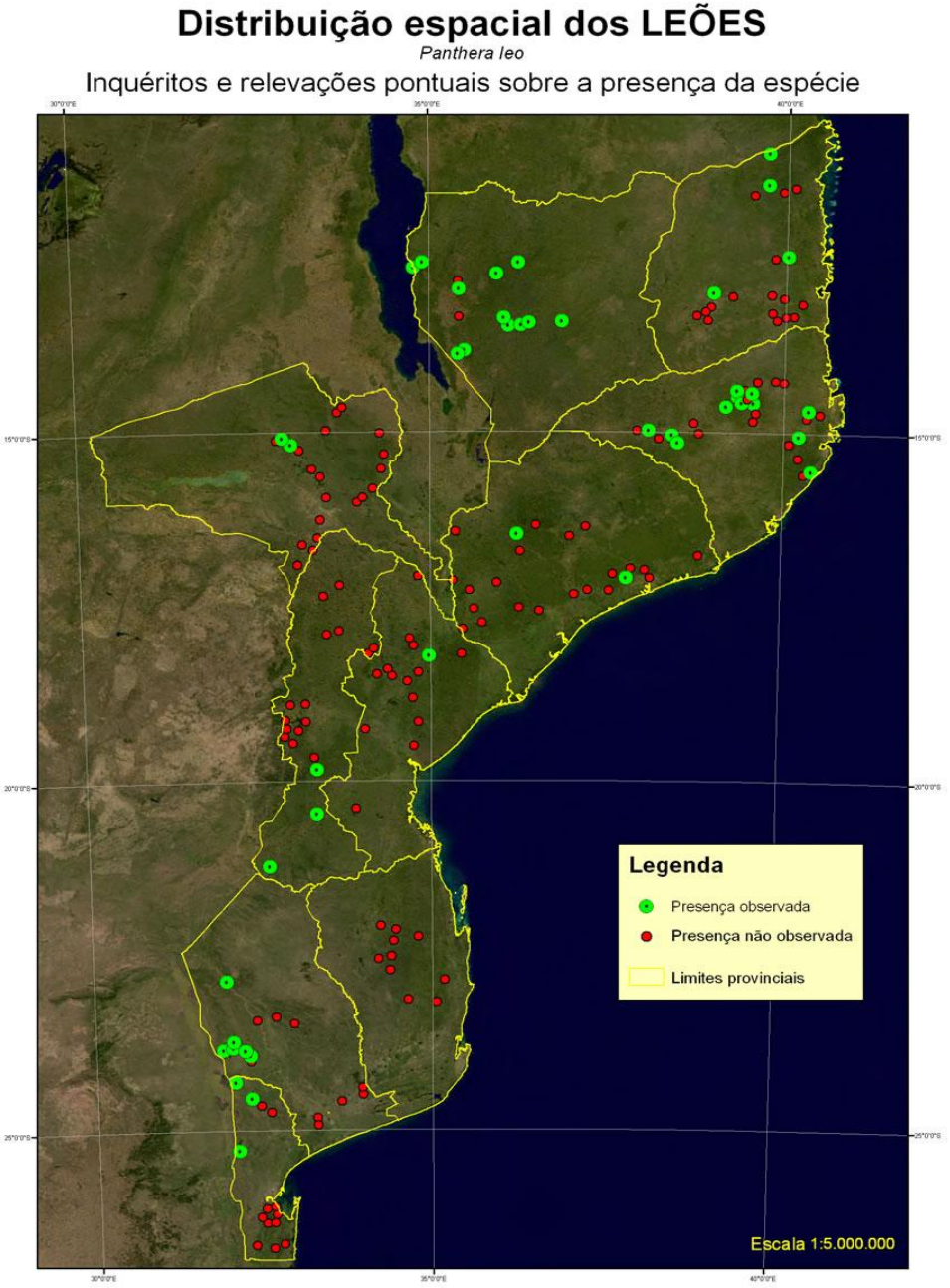
National Forest Inventory – Statistical analysis

Stratum	Vegetation type	Std error (%) num. of trees	Std error (%) basal area	Std error (%) total volume	Confidence interval (%) num. of trees	Confidence interval (%) basal area	Confidence interval (%) total volume
2	Dense forest	2.1	3.0	3.6	3.5	5.1	6.1
4	Open forest	3.6	5.8	6.5	6.0	9.9	11.1
6	Thickets / shrubs	10.1	13.7	13.8	17.1	23.3	23.5
8	Long fallow	10.3	9.4	11.1	17.6	16.0	18.9
Total	**Forests and other wooded land**	**2.1**	**2.8**	**3.2**	**3.6**	**4.8**	**5.4**

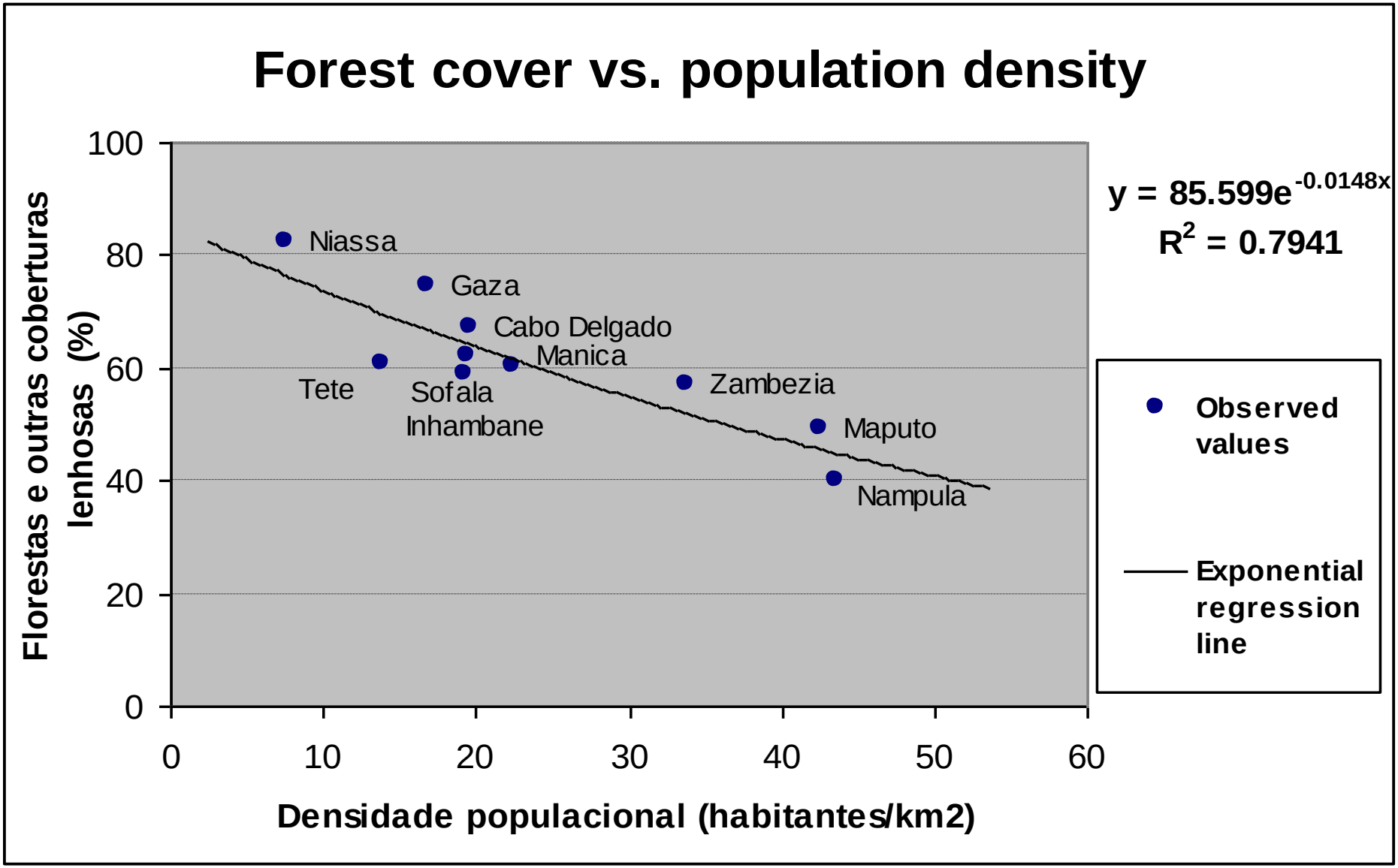
Information System and modelling

Basic information	Auxiliary information	Combined information / Product
Land cover map	•Conservation areas •Land units (geomorphology, lithology, slope, soils, etc.)	Timber production suitability
•Land cover map •Forest Inventory Results	•Potential Vegetation Map (Flora Zambeziaca) •Land Units •Bio-climatic data (temperature, precipitation, length of the dry season, etc.)	Ecological zoning
Observations of wildlife at national level	Ecological zoning	Predictive models of large mammal distribution
•Volumes •Above-ground biomass •Ecological zoning •Population pressure	Statistical analysis MODIS	Woody biomass stock and supply/demand estimations

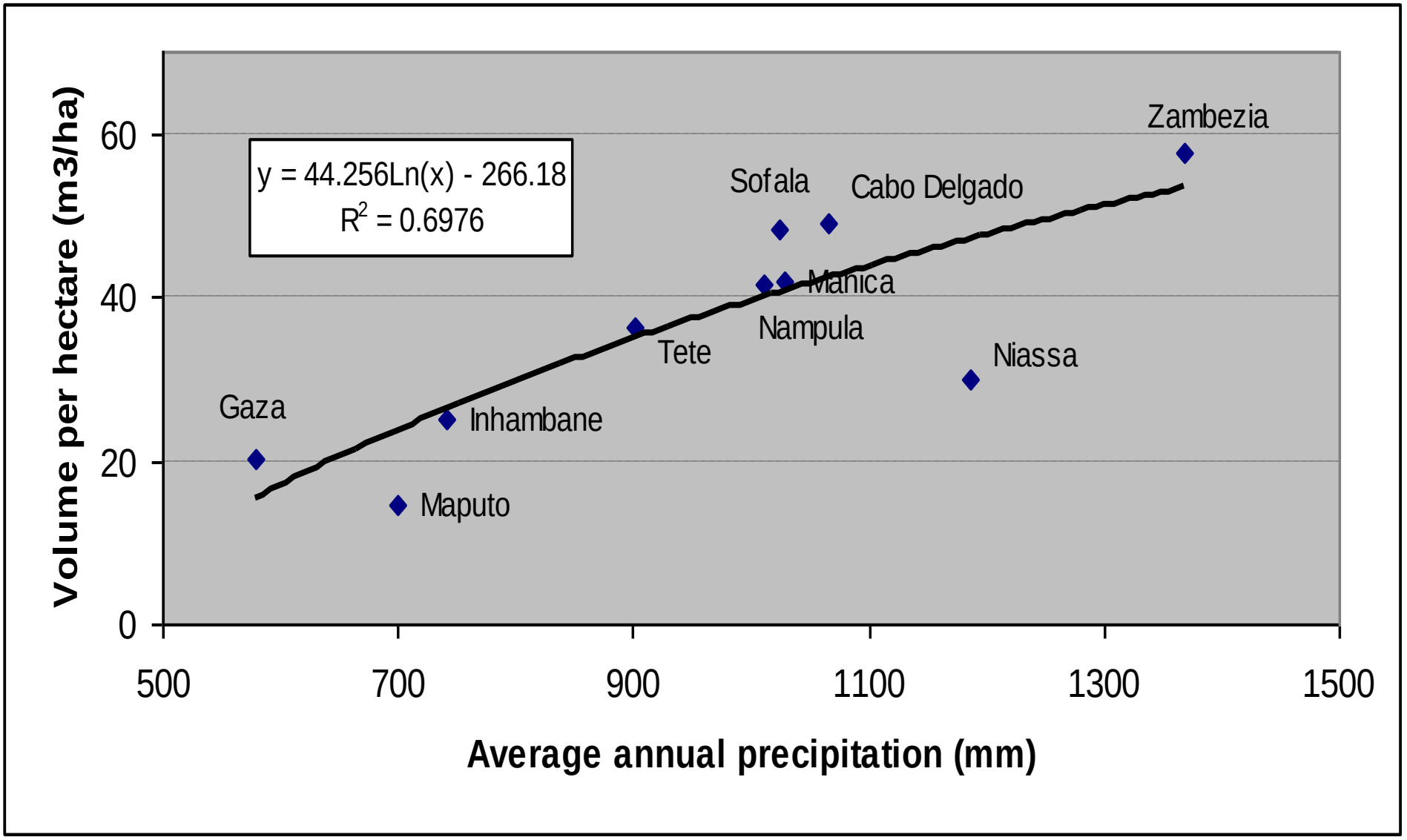
Model Large mammals distribution



Model Forest cover and population density – Deforestation analysis



Model Productivity vs. Bio-climatic data



Estimation of biomass from NFI data

The NFI data were used to estimate Total Above-ground Biomass for each field sampling unit.
After an extensive review of the existing studies at national and regional level, the following estimation procedures were selected:

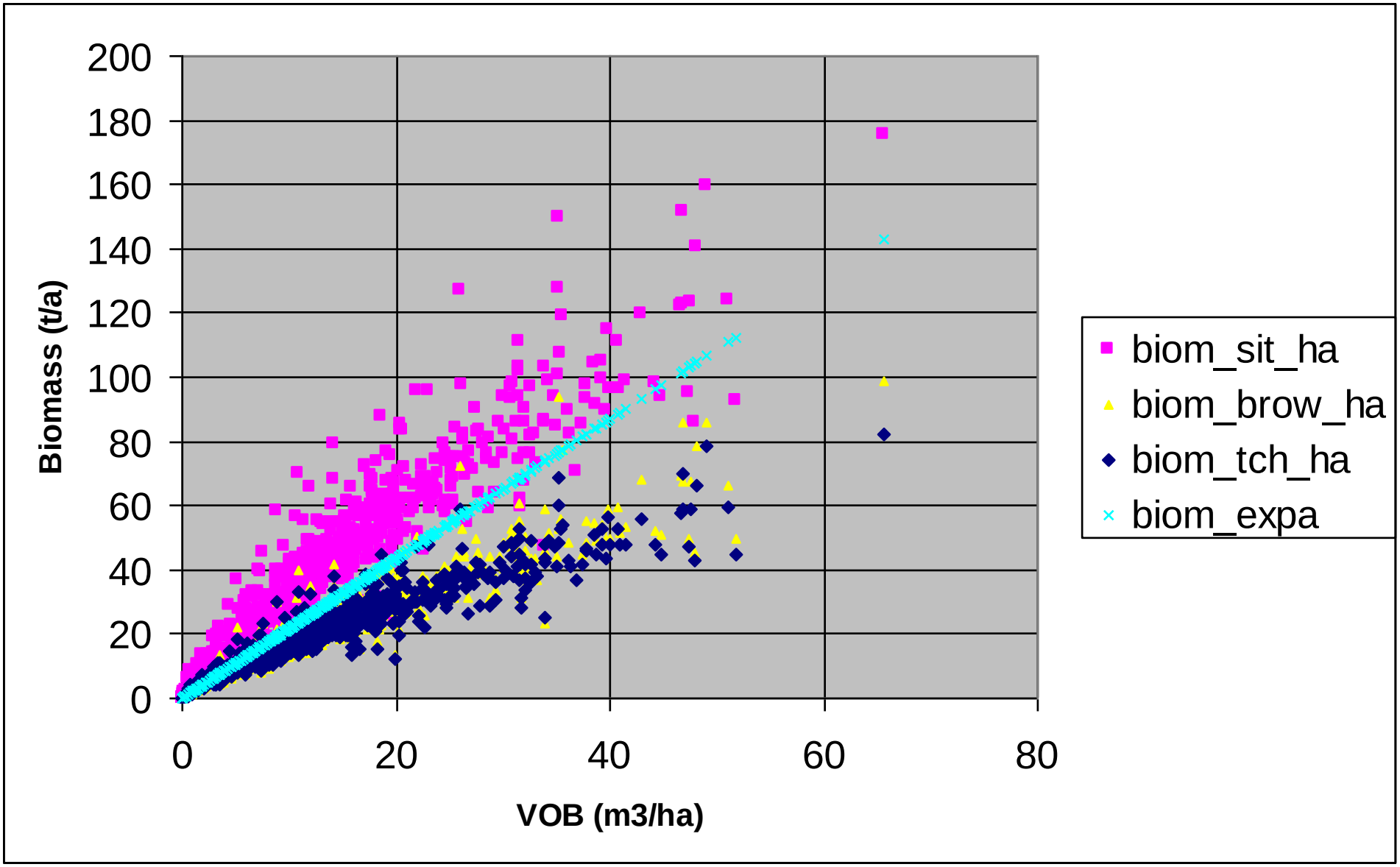
Models based on individual tree biomass, where Tree biomass = f (dbh)

1. Tchaúque (2004)
2. Brown (1997)
3. Sitoe et al (2001)

Models based on Volume expansion factors

Where Biomass = VOB * WD * BEF
4. Brown (1997)

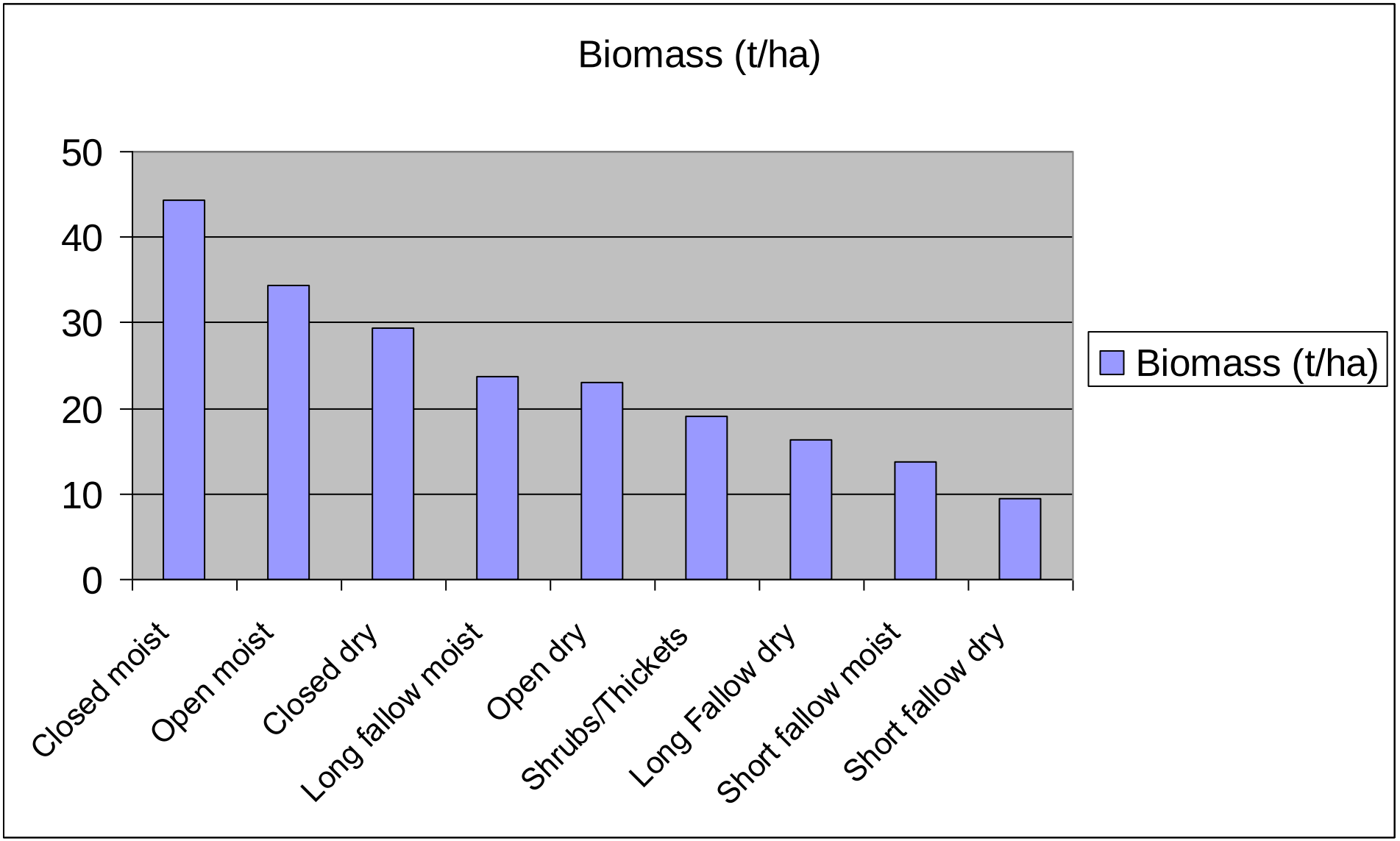
Comparison of biomass expansion factors



Ecological zoning

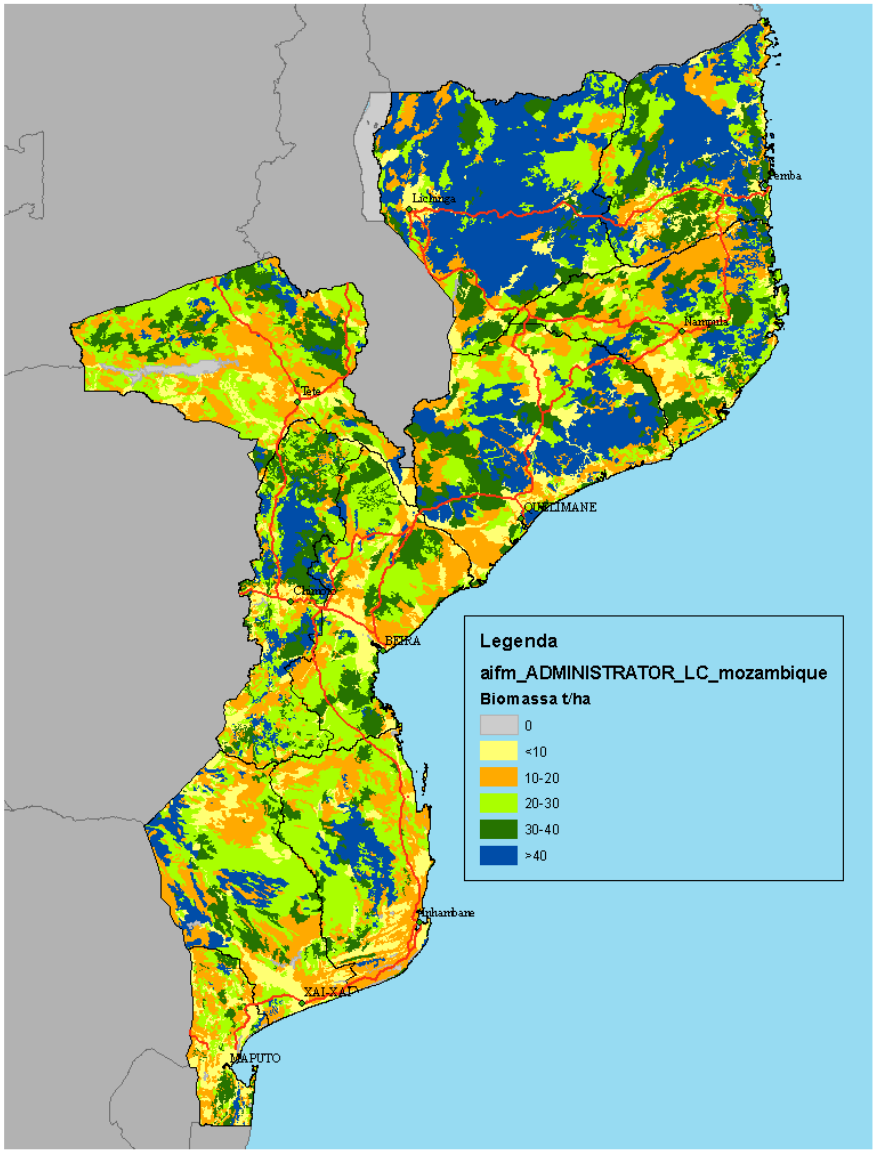
1	Florestas (semi)-sempreverdes úmidas de montanha, pradarias de montanha e miombo úmido
2	Florestas úmidas sub-litoral
3	Miombo medio
4	Miombo seco
5	Florestas secas deciduas indiferenciadas
6	Florestas de mopane
7	Zonas sub-aridas e pradarias secas
8	Mosaicos de vegetação costiera e matagais e mangais
9	Areas inundadas

Calibration of biomass estimates - Results



Biomass map

Mapa preliminar da biomassa lenhosa



Spatial distribution of biomass 1

Main source data used in the estimation process were:

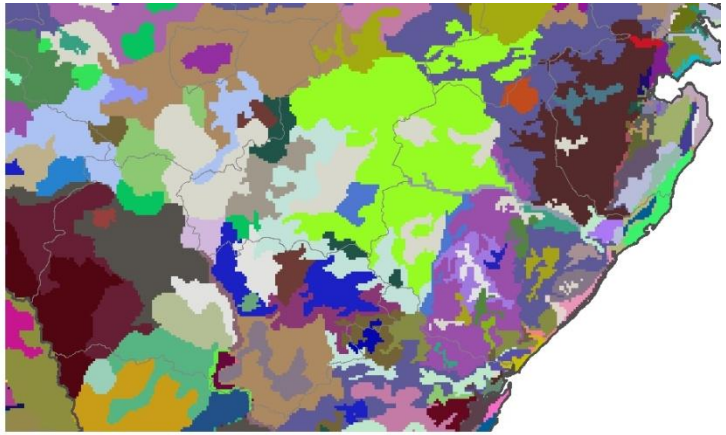
- National forest inventory data.
- Land cover/ecological class groupings.
- Biomass expansion factors, wood density factors and chosen increment estimation equations.
- Stock and sustainable productivity of surveyed land cover classes. The estimation of (minimum, medium and maximum) biomass stock per hectare and productivity was done considering the individual land cover classes, the ecological regions where they occur (considering only meaningful land cover-region combinations) and the class combinations (primary, secondary and tertiary, with relevant internal proportions) that are actually represented in the final land cover map. This resulted in 2277 individual "biounits" (intended as multi-polygon entities) each of which carrying a certain biomass stock (t/ha) value.

The spatial distribution of woody biomass stock and sustainable biomass productivity was done using the MODIS Tree Cover Percent values as proxy of spatialization to represent the stock and productivity variance within the entire "biounit" category, according to the following formulation:

$$\textit{value in cell}_i \textit{ of biounit}_b = \textit{tree cover}_i / \textit{average tree cover of biounit}_b * \textit{average value of } b_b$$

Spatial distribution of biomass 2

BIOUNITS :
2277 unique
combinations
of land cover
and land regions

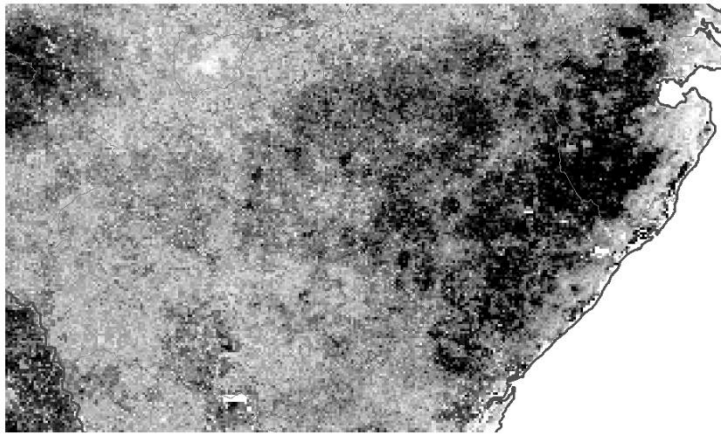


Tree cover

Percent

High : 100

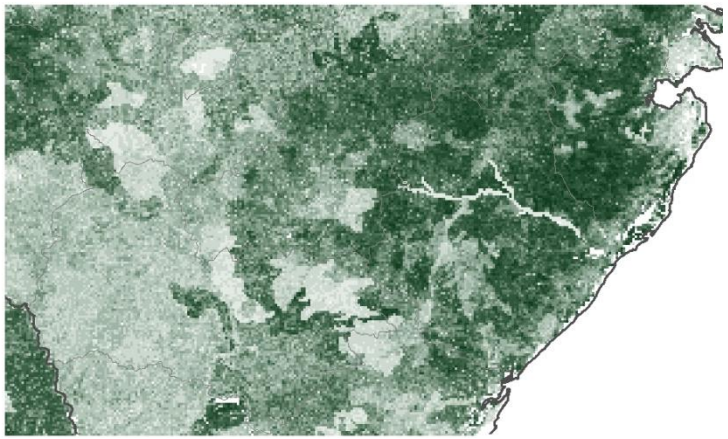
Low : 0



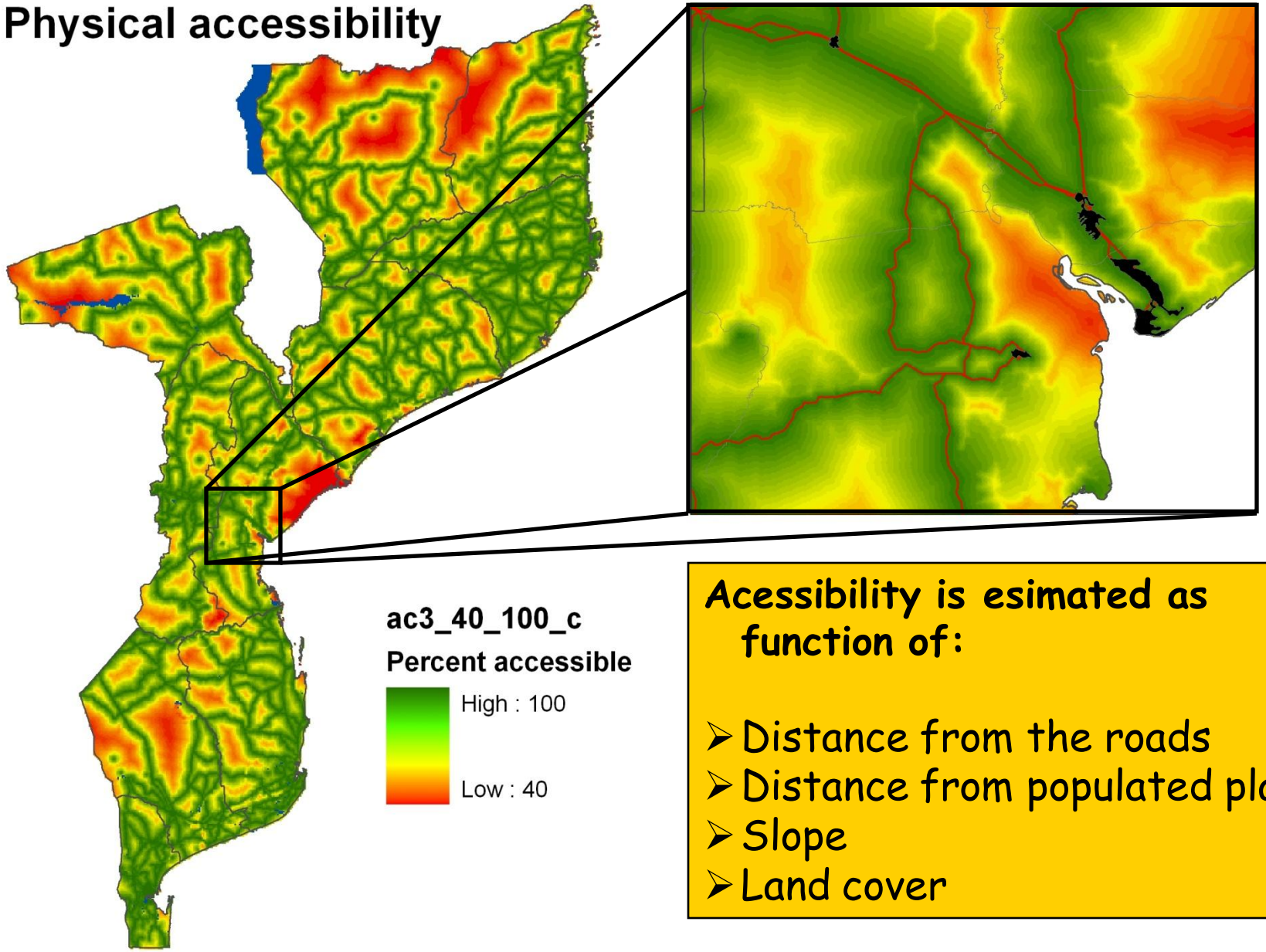
woody biomass

t/pixel(6.25ha)

- 0
- 1 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- 101 - 125
- 126 - 150
- 151 - 175
- 176 - 200
- 201 - 250
- 251 - 300
- 301 - 400
- 401 - 3,000



Estimation of accessibility



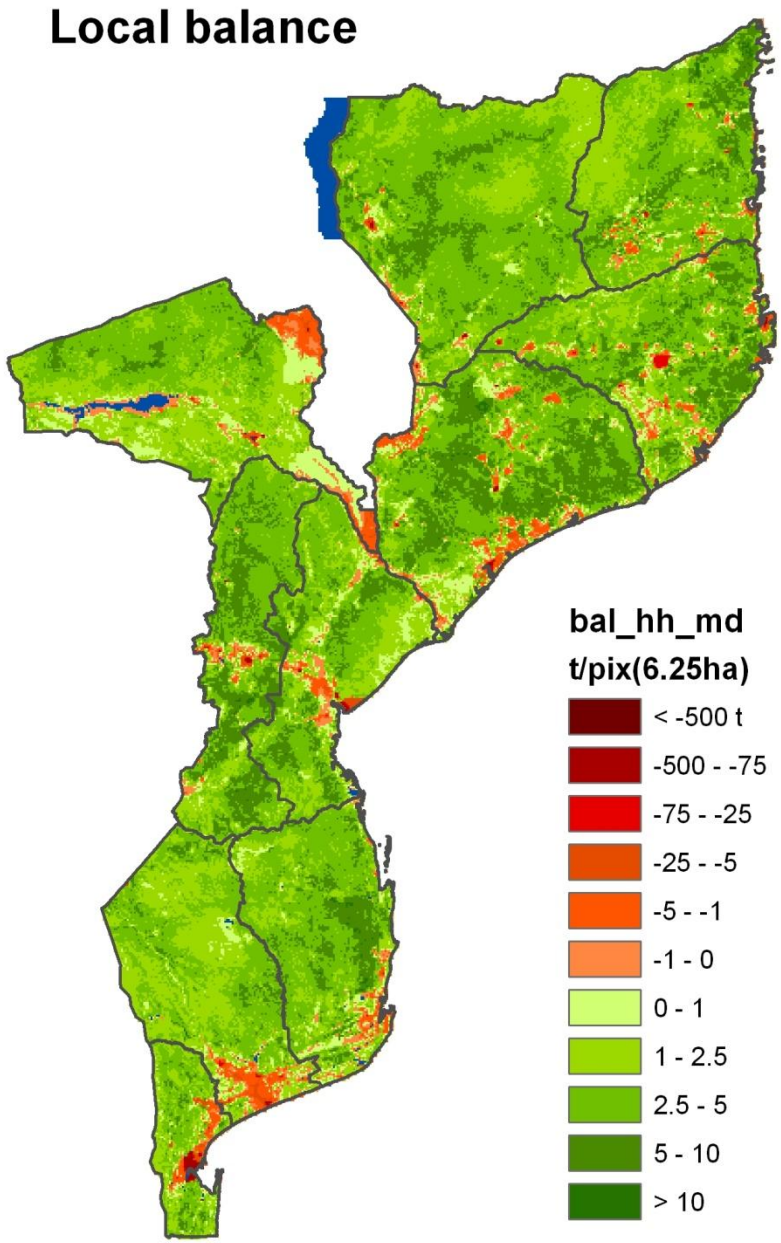
Acessibility is esimated as function of:

- Distance from the roads
- Distance from populated places
- Slope
- Land cover

Integration module (local balance)

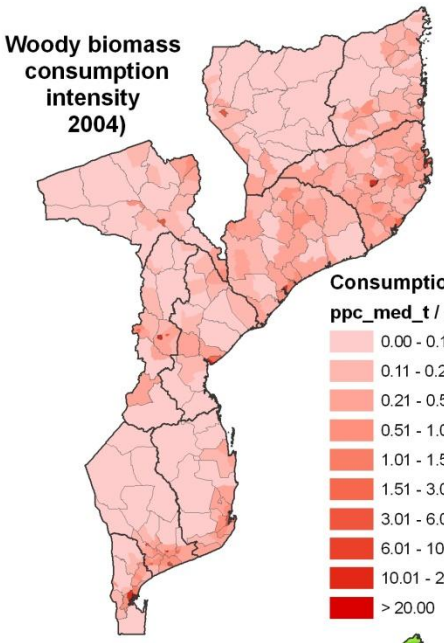
Balance at pixel level=

Potential production
- local consumption

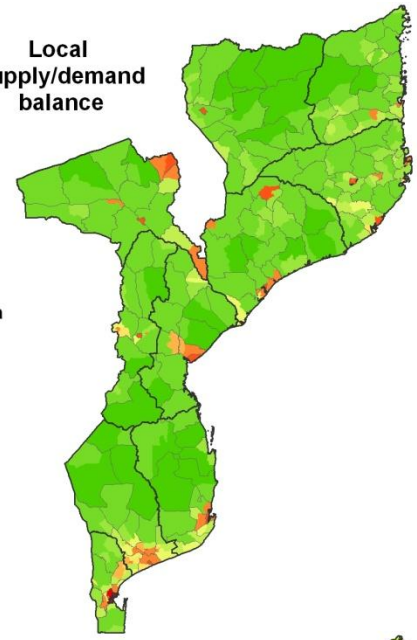


Summary of results by administrative unit (Posto Administrativo)

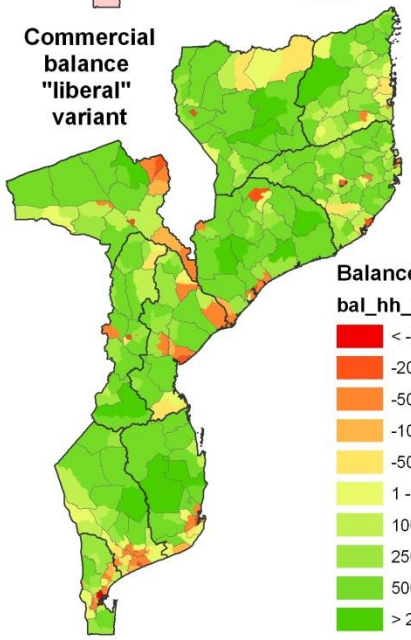
Woody biomass consumption intensity



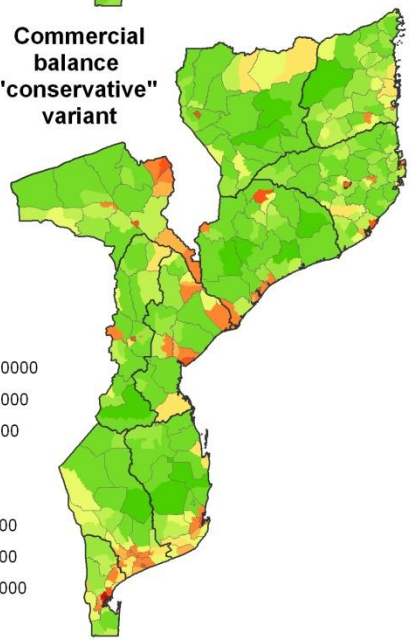
Local balance



Commercial balance "liberal" variant

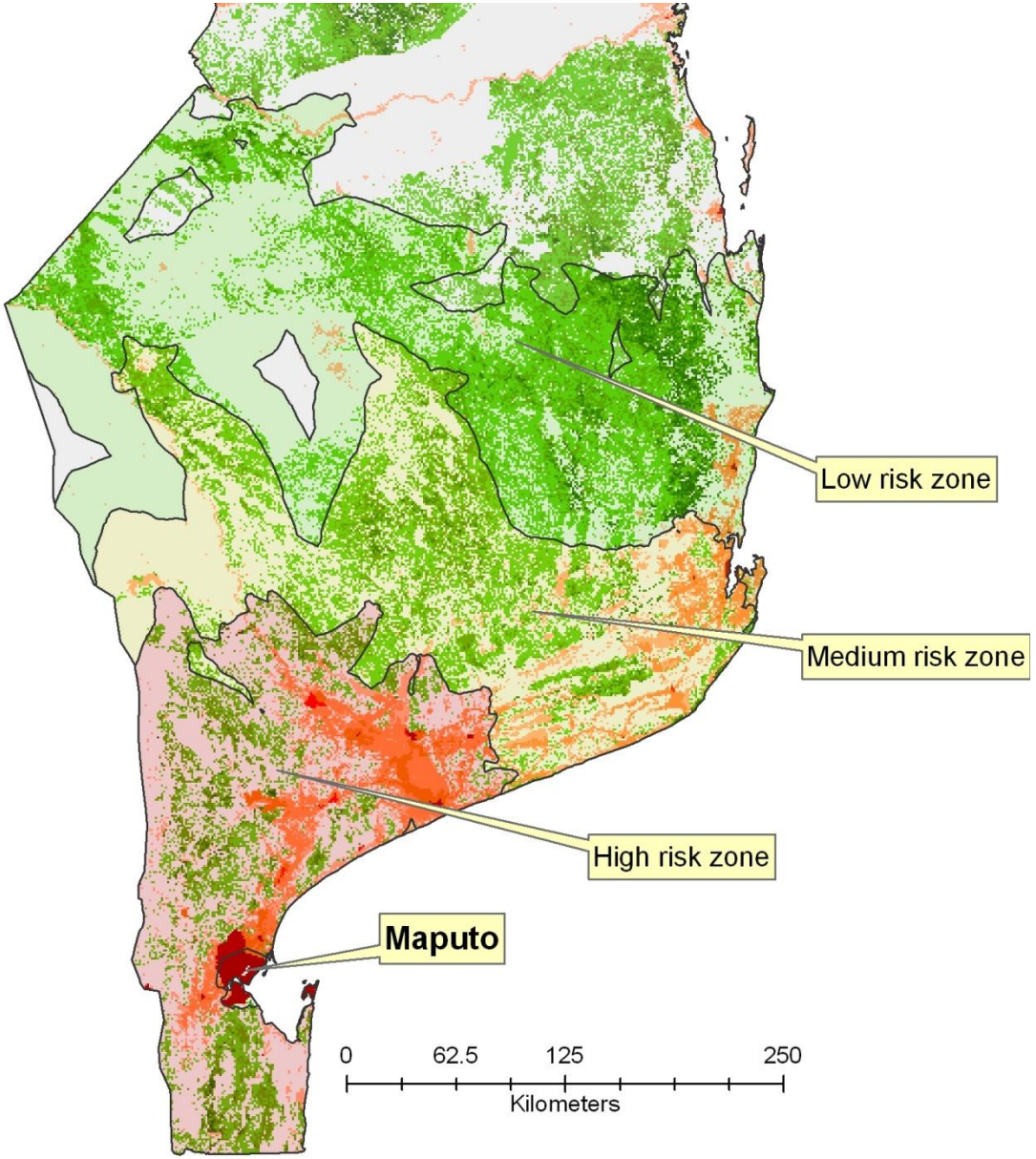


Commercial balance "conservative" variant



Woodshed analysis

Degradation / Deforestation risk zoning



Conclusions and recommendations

The AIFM Project provided a major contribution to the knowledge of the forest resources of Mozambique. Based on the AIFM experience, the following recommendation can be made.

- ❑Continue the monitoring of the forest change processes taking place in the country. This activity is essential for controlling the magnitude and location of deforestation and forest degradation processes. The methodology applied by AIFM in Manica Province, based on interdependent interpretation of Landsat imageries, which produces not only total changes but transition matricies as well, should be extented to the whole country.

- ❑Establish a network of permanent plots to estimate forest growth and yield, for a more precise estimate of Annual Allowable Cut..

- ❑Strengthen the monitoring of forest concessions activities and facilitate the information flow between forest concessionaires and the UIF. In particular forest inventory and other data collected by conessionaires should be integrated systematically in the AIFM Information System.

- ❑Develop sustainable strategies for forest/energy (establishment of concessions for fuelwood and charcoal production, forest management for fuelwood production, urban-rural partnerships, rural markets for woodfuel, etc.)

- ❑The capacity building initiated by AIFM should be continued, taking advantage of the momentum created by the Project

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Avaliação Integrada Das Florestas De Moçambique - AIFM