Landscape metrics for estimating population characteristics in rural areas

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Introduction and aims

- Rural landscapes change unevenly over time (fast or slow transformations depending on the local context).
- Agricultural transformations, new land management practices and deforestation or reforestation processes modify landscape structure (Lambin et al., 2003).
- Landscapes are dynamic, influenced by human and environmental factors.

Main objective of the thesis: To analyze the dynamics of land use and the evolution of structures in order to construct an indicator for assessing population density in rural areas

Aims of the poster:
➢ To produce land use maps using high-resolution Pleiades images.
➢ To calculate landscape metrics that quantify changes in rural landscape structures.
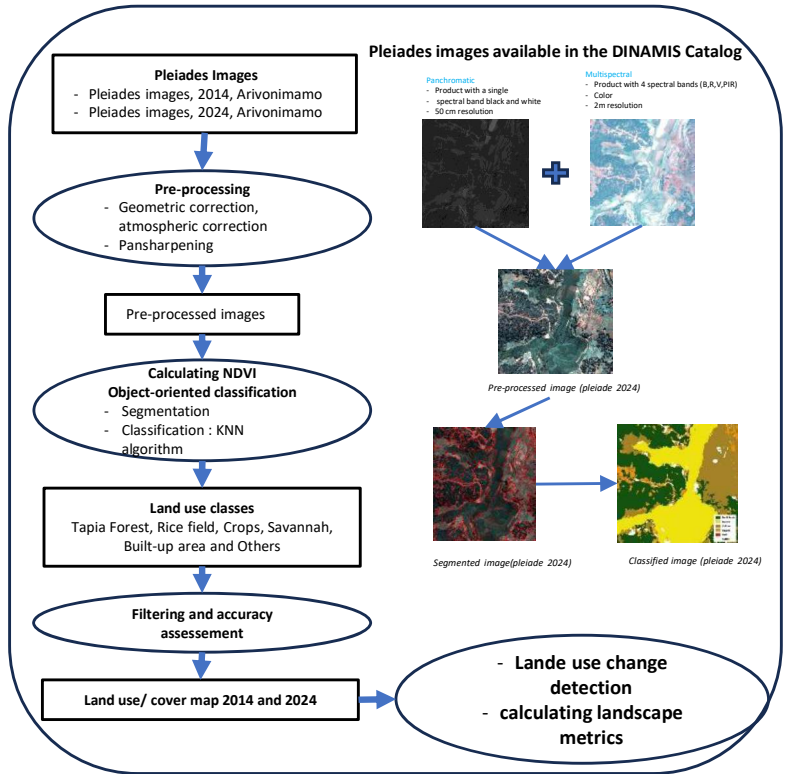
Study area

In this poster, we present the results for the Tapia Forest Landscape. Tapia forest, an endemic forest in Madagascar. It is used and managed by the local population as an economic and food resource (Kull et al., 2005).
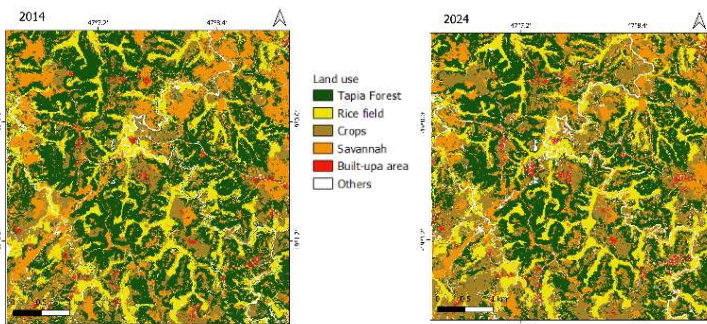
Delimitation of landscape types on the Arivonimamo site carried out by colleagues from the LMI-Paysage Madagascar using Sentinel-2 images, with the selection of 3 study areas for each landscape type, including the sites where demographic surveys were conducted.

Methods

Pleiades Images
- Pleiades images, 2014, Arivonimamo
- Pleiades images, 2024, Arivonimamo

Pre-processing
- Geometric correction, atmospheric correction
- Pansharpening

Pre-processed images

Calculating NDVI
Object-oriented classification
- Segmentation
- Classification : KNN algorithm

Land use classes
Tapia Forest, Rice field, Crops, Savannah, Built-up area and Others

Filtering and accuracy assessement

Land use/ cover map 2014 and 2024

- Lande use change detection
- calculating landscape metrics

Pleiades images available in the DINAMIS Catalog

Panchromatic
- Product with a single spectral band black and white
- 50 cm resolution

Multispectral
- Product with 4 spectral bands (B,R,V,PIR)
- Color
- 2m resolution

Pre-processed image (pleiade 2024)

Segmented image(pleiade 2024)

Classified image (pleiade 2024)

Results

Land use/cover map for 2014 and 2024 from Pleiades images

Land use map developed from Pléiades images from 2014. © CNES (2014), distribution Airbus DS.

Land use map developed from Pléiades images from 2024. © CNES (2024), distribution Airbus DS.

Land use:
- Tapia Forest
- Rice field
- Crops
- Savannah
- Built-upa area
- Others

Detection of land use change based on land use/cover maps derived from Pléiades images for the years 2014 and 2024

Land cover	2014 (%)	2024(%)	Change (%)
Tapia Forest	41,024	35,68	-13,03
Rice field	16,992	17,11	0,69
Crops	16,729	23,59	41,01
Savannah	20,443	17,98	-12,05
Built-up area	1,085	1,39	28,11
Othres	3,728	4,25	14,00

- **increase in cultivated areas (+41%)**: agricultural expansion to meet food needs; Increased demographic pressure

- **Reduction in forests (-13%) and savannah (-12%)**: Conversion of natural land for agriculture, Deforestation due to demographic pressure

Evolution of landscape structures

Some landscape metrics

Métriques	Description
Numbers of patchs (NP)	- Indicate the degree of fragmentation of natural areas. - Creation of new fragments: Closely related to the activities of local populations and their land use practices.
Mean Patch Area (MPA) (ha)	
Area	- Enables us to quantify the extent of landscape units. - For larger agricultural areas, it is often correlated with higher population densities due to the increased need for food production.

Evolution of landscape metrics for the land use Tapia forest class and crops class

	Forêt Tapia			Culture Pluviale		
	2014	2024	Change (%)	2014	2024	Change (%)
NP	23264	33205	29,93	14130	23264	39,26
MPA (ha)	0,054	0,0324	-66,66	0,035	0,030	-16,66
Area (ha)	1237,20	1075,97	--14,98	504,51	711,36	29,07

Increase in the number and average size of cultivated plots: Increased demand for agricultural land due to population growth, indicating intensive farming practices

Creation of new forest fragments and reduction in average size of forest fragments: Demographic growth could explain the increased fragmentation of forest patches, with an increase in the number of fragments and a decrease in their average size.

Perspectives

- Spatial correlation or Spatial modeling: Use spatial modeling tools to simulate land-use scenarios based on variations in population density.

References
- Kull C.A., Ratsirarson J. & Randriamboavonjy G., 2005. Les forêts de tapia des hautes terres malgaches. *Terre Malgache*, **24**(2), 22-58.
- Lambin, E., Geist, H., Lepers, E., 2003. Dynamics of Land-use and land-cover change in tropical regions. Annu. Rev. Environ. Resour 20, 49205–41.