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Potential of radiometric zoning for spatializing agrarian/farming systems in Benin

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Result2: spatialised indicators of farming systems and landscapes, their dynamics and environmental sustainability



Need: knowledge of agrarian systems through the use of earth observation data

Purpose : reduce the time and costs involved in collecting field data



>Agricultural policies: large homogeneous zones

Two zoning systems in Benin: agro-ecological zones (ZAE) and agricultural development poles (PDA)

Different objectives, different periods

Heterogeneous data sources (Bisquert et al., 2015, Bellón et al., 2017)

> Problems of representativeness and reproducibility

➢ Reproducible generic method without field data





Remote sensing enables exhaustive and regular monitoring of land surfaces

Opportunity of EO data for a more economical and efficient approach:

- Large supply of images
- Regular frequency
- Low acquisition costs

Research question: how can homogeneous landscape units constructed from the radiometric signal contained in the time series of remotely sensed images be used to describe agrarian systems in Benin?



- Use the potential of satellite data to produce 'radiometric' landscape zoning
- Analyse the resulting landscape units in terms of land use, existing zonings and a typology of farming systems produced for Benin



o Benin, west Africa



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Figure1: Study area Source: IGN & MAEP Benin, 2018

Approach



Figure 2: General approach

Data: MODIS

- Time series of the product NDVI MODIS MOD13Q1 V6 (Terra Vegetation Indices 16-Day Global 250m)
- Time period: 2018-2022 (116 images)
- (<u>https://appeears.earthdatacloud.nasa.gov</u>)



Data: Benin's national zoning (1)

Agro-ecological zoning in 8 zones (MDRAC/UNDP, 1995): defined by cross-referencing climatic and pedological data and agronomic potential and constraints with administrative boundaries.

ZAE1 (Zone of the extreme north of Benin)
ZAE2 (Cotton-growing area of northern Benin)
ZAE3 (South-Borgou food-producing zone)
ZAE4 (West-Atacora zone)
ZAE5 (Centre Cotton Zone)
ZAE6 (Bar land zone)
ZAE7 (Depression zone)
ZAE8 (Fishing zone)



Data: Benin's national zoning (2)

Zoning into agricultural development poles (PAG, 2016): Cross-referencing data on crop potential and administrative boundaries

➢ Pole 1 (lowland rice-growing area)

- ➢ Pole 2 (cotton basin zone)
- Pole 3 (cotton-givory zone)
- Pole 4 (cotton-grapefruit-cashew zone)
- ➢ Pole 5 (fruit tree-food crop zone)
- ➢ Pole 6 (Oil palm food crops zone)
- > Pole 7 (Fisheries market gardening zone)



Data: Land use map



Figure 5: Land use 2015 OSFACO Source : Production DGEFC, 2019

Project OSFACO: more recent and more accurate nationwide

images SPOT6/7 à 1.5 m resolution

fifteen (15) class :

- Cultivation and fallow ;
- Cultivation and fallow under palm trees ;
- Open forest and wooded savannah,
- Dense forest ;
- Gallery forest and riparian formation,
- Forest and swamp savannah;
- Habitat ;
- Mangroves ;
- Water body ;
- Forest plantation ;
- Fruit plantation;
- Tree and shrub savannahs;
- Eroded and bare soil ;
- Rocky surface ;
- Sandy surface .

Data: Villages Database bases and survey

Geographic database produced by the National Geographic Institute (IGN) of Benin in 2018

Agricultural survey database (Adegbola *et al.*, 2017)

Extracting villages of interest

Twelve (12) departments and eight (08) ZAEs in the country, with a total sample of 437 villages

Methods: Radiometric zoning production

Production of the radiometric unit map

Classification into radiometric zones



Figure 6: Diagram of the method for producing radiometric unit maps from MODIS NDVI image time series (*Lemettais et al.*, 2023).

Figure 7 : Diagram of the production of radiometric zones by cross-referencing radiometric unit maps and information on land use T_3

Methods: Typology of farming systems



Figure 8 : Typology of farming systems

Radiometric Zoning production: Results



Figure 9 : Temporal representation of the first 4 components of the NDVI MODIS PCA, and monthly rainfall series

PC1 is correlated with mean NDVIvegetation productivity

PC2 correlated with rainfall-natural phenology of vegetation

PC3 also shows a seasonal profile, but shifted in relation to rainfall

PC4 shows 2 annual cycles, with a peak during the rainy season and another peak during the dry season

Radiometric Zoning production: Results



Figure 10: Map of Benin's 36 radiometric units represented on different colour compositions

Radiometric Zoning production: Results

Figure 11 : Map of the 9 radiometric zones expressed in terms of land use (OSFACO land use map on Benin)



Nine (09) classes of radiometric zones according to land use in Benin

Zoning analysis: Zoning and land use

Radiometric Zones



Agroecological Zones

Agricultural Developpement Poles



- Culture et jachère
- Forêt dense
- 🕽 🗖 Habitat
- Plantation forestière
- Sol érodé et dénudé

- Zone_II Zone_I 0 10 20 30 40 50 60 70 80 90 100 Culture et jachère sous palmier Forêt galerie et formation ripicole
 - Mangroves

Zone_VIII

Zone_VII

Zone VI

Zone V

Zone IV

Zone III

- Plantation fruitière
- Surface rocheuse

- Forêt claire et savane boisée
- Forêt et savane marécageuse
 - ∎ Plan d'eau
 - Savanes arborée et arbustive
 - Surface sableuse

Typology of agricultural farming systems: results

Table 2 : variables that distinguish types of agricultural system

	Variables discriminantes	1	2	3	Total	Test F
Irrigated systems mechanized systems intensive systems	% of households without sufficient land	76	42	61	57	91,395***
27% 29% 44%	% of households with commercial plantations	50	54	45	50	7,107***
	% of households using tractors	36	62	23	38	51,563***
	% of households using chemical fertiliser	60	44	90	62	103,166***
	% of arable land in the village	58	72	71	68	27,483***
	% of households with current access to credit	61	43	46	49	20,502***
	% of households using organic fertiliser	59	23	21	35	87,694***
Figure 13 : Proportion of type of farming systems	% of households using pesticides	42	33	65	45	91,479***
	% of irrigated fields in the village	54	19	12	31	23,673***

Typology of agricultural farming systems: results

Characterization of typical systems

- Type1: irrigated systems
 - Low availability of agricultural land
 - High use of organic fertilizer
 - High proportion of irrigated land
- Type2: mechanized systems
 - > High availability of commercial plantations
 - ➢ High use of tractors
 - Large proportion of arable land
- Type3: intensive systems (chemical inputs)
 - High use of chemical fertilizers
 - High use of pesticides



Figure 14 : Geographical distribution of types of farming systems

Analysis of zoning with regard to types of farming systems



Radiometric Zones & types of farming systems

Agroecological Zones & types of farming systems

Agricultural development poles & types of farming systems

Discussion/Conclusions



Objective zoning method Reproducible if land use maps available Significant difference between land use proportions by radiometric zone (not the case for agro-ecological zones and development poles)



Good identification of the landscapes found in Benin in terms of land use

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Existing zoning schemes are not very discriminating in terms of land use, as they are divided up on an administrative scale. Problem of operationalisation in the application of agricultural policies (not in line with administrative boundaries, unlike agroecological zones and agricultural development poles)

Perspectives

Test of radiometric zoning using classification of variables derived from image time series (rather than land cover)

Statistical tests to assess the relevance of the zones in terms of the different types of farming systems Assessment of zones based on land-use maps with a greater agricultural focus for North and Central Benin (land-use maps)

THANKS!

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