PhD thesis:

The urbanization process through urban ecology: which definitions & which resilience among ecosystems?
Introduction: a growing urban population

ONU, 2004
Introduction: a growing urban population
Introduction: a growing urban population

ONU, 2004

Adapted from UN, 2012
Objectives
Objectives

1. Delimit the zones included in the urban-rural gradient
Objectives

1. Delimit the zones included in the urban-rural gradient
2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-saharan Africa
Objectives

Forstall et al, 2008

<table>
<thead>
<tr>
<th>Official UA or MA definition [WUP]: Definition used by UN</th>
<th>Type of definition (see Table 2)</th>
<th>Population 2000</th>
<th>Area (km²) 2000</th>
<th>Population per km² 2000</th>
<th>Annual average Population change</th>
<th>Annual average Percent change</th>
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<tr>
<td>Tokyo (2000 and 1995 censuses)</td>
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Objectives

1. Delimit the zones included in the urban-rural gradient
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Cities: which exact extent?
Objectives

1. Delimit the zones included in the urban-rural gradient

Cities: which exact extent?

Grow: which surface?
Objectives

1. Delimit the zones included in the urban-rural gradient
   - Review
   - Segmentation using landscape indexes
   - Methodology of classification for satellite images
   - Application to the study zone (1 dozen of cities in sub-Saharan Africa)
   - Typology based on the (sub)urbanization dynamic
Objectives

2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-saharan Africa
Objectives

2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-Saharan Africa

Sensitive ecosystems to preserve?
Objectives

2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-Saharan Africa

Sensitive ecosystems to integrate as green spaces?
Objectives

2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-Saharan Africa

ECOSYSTEMS

Unadapted for urban development?
Plan of the objectives

O1. Delimit the zones included in the urban-rural gradient
   - Review
   - Methodology of classification for satellite images
   - Segmentation using landscape indexes
   - Application to the study zone (1 dozen of cities in sub-Saharan Africa)
   - Typology based on the (sub)urbanization dynamic

O2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-Saharan Africa
Plan of the objectives

O1. Delimit the zones included in the urban-rural gradient

- Review
- Methodology of classification for satellite images
- Segmentation using landscape indexes
- Application to the study zone (1 dozen of cities in sub-saharan Africa)
- Typology based on the...

- What are the different configurations of cities?
- Which appellations are synonyms?
- Which characteristics differentiate the different zones?
- Which characteristics are the most relevant for the second part of the study?

O2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-saharan Africa
O1. Review

What are the different configurations of cities?

- Concentric model (Continuous & decreasing density)
- Sectoral model
- Multicore model
O1. Review

- What are the different configurations of cities?

  - Ribbon model
  - Leapfrog model
  - Satellite towns model
O1. Review

Which appellations are synonyms?

- Urban zone = core = central city = city centre
- « Zone de banlieue » = dwelling quarters = urban crown
- Suburban zone = urban fringe
- Rural zone
O1. Review

- Which characteristics are the most relevant for the second part of the study?
### O1. Review

Which characteristics differentiate the different zones?

<table>
<thead>
<tr>
<th>Caractéristique</th>
<th>Type de caractéristique</th>
<th>Urbain</th>
<th>Banlieue</th>
<th>Péri-sub-urbain</th>
<th>Exurbain</th>
<th>Étalement urbain</th>
<th>Rural</th>
<th>Ifg</th>
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</thead>
<tbody>
<tr>
<td>Position dans un gradient s'éloignant du centre-ville</td>
<td>Morphologique</td>
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## O1. Review

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O1. Review

- New definitions
O1. Review

Dominance of constructed surfaces
AND
Continuous built, constructions mainly two or three facades
yes no/don’t know

Land use mainly residential
AND
French speaking study zone
yes no/don’t know

Explicit zonation of land use
yes no/don’t know

Land use and land cover almost only agricultural and/or natural
yes no/don’t know

Workers commuting from the area toward the urban area
yes no/don’t know

Study area: French speaking
yes no/don’t know

Exurban, rurban rural periurban suburban
Plan of the objectives

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O2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-saharan Africa
O1. Methodology of classification

A lack of data and of maps

Lubumbashi

- Avant 1958
- Entre 1958 et 1973
- Entre 1973 et 1984
- Depuis 1984

BEAU, 2009
O1. Methodology of classification

- localisation of the two study cases

Munyemba 2010, Google Earth 2013
O1. Methodology of classification
01. Methodology of classification

Material:

- SPOT 5 images
- Two years:
  - 2002 and 2008 (2009) for Lubumbashi
  - 2002 and 2010 for Kisangani
O1. Methodology of classification

Method: oriented-object classification

Study zone of Lubumbashi, SPOT Image, July 17, 2002
O1. Methodology of classification

- **Herbaceous layer**
  - **High herbs**
    - **Tree crown cover (8 or 10m)**
      - 0%
      - 1 - 25% (disseminated)
      - 25 - 60%
    - **Shrub cover (2 -> 8m)**
      - 0%
      - 0 - 50%
    - **Savannah**
    - **Wooded savannah**
  - **No herbs or low (Cetaria)**
    - **Tree crown cover (8 or 10m)**
      - < 40%
      - > 15m: 40 - 60%
      - > 8m: 40 - 100%
      - > 15m: > 60%
    - **Shrub cover (2 -> 8m)**
      - < 40%
      - 40 - 80%
      - > 80%
    - **Old fallow/Regenerating forest**
    - **Woodland**

- Presence of ridges?
  - yes
    - Crops
  - no
    - Young fallow
O1. Methodology of classification
O1. Methodology of classification

2. Oriented-object classification

Study zone of Lubumbashi, SPOT Image, July 17, 2002

Classification, 2002
O1. Methodology of classification

2. Oriented-object classification
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O1. Segmentation using landscape indexes

Dominance of constructed surfaces AND
Continuous built, constructions mainly two or three facades

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</tr>
</thead>
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</table>

Land use mainly residential AND
French speaking study zone

<table>
<thead>
<tr>
<th>Yes</th>
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Land use and land cover almost only agricultural and/or natural

Workers commuting from the area toward the urban area

<table>
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<tr>
<th>Yes</th>
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Study area: French speaking

<table>
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</table>

Exurban, rurban
Rural
Periurban
Suburban
O1. Segmentation using landscape indexes

Dominance of constructed surfaces

AND

Continuous built, constructions mainly two or three facades

- yes
- no/don’t know

Land use mainly residential

AND

French speaking study zone

- yes
- no/don’t know

- banlieue
- urban

Explicit zonation of land use

- yes
- no/don’t know

Land use and land cover almost only agricultural and/or natural

- yes
- no/don’t know

Workers commuting from the area toward the urban area

- yes
- no/don’t know

- exurban, rurban
- rural

Study area: french speaking

- yes
- no/don’t know

- periurban
- suburban
O1. Segmentation using landscape indexes

- Dominant class index
- Dominance index
- Built proportion index
- Patch density ($\rho$)
- Nearest neighbour distance ($z$)
- Aggregation index ($R$)
- Proximity index ($PX$)

**Dominance of constructed surfaces AND**
- Continuous built, constructions mainly two or three facades
  - yes
  - no/don’t know

**Land use mainly residential AND French speaking study zone**
- yes
- no/don’t know
  - banlieue
  - urban

**Explicit zonation of land use**
- yes
- no/don’t know
  - sprawl

**Land use and land cover almost only agricultural and/or natural**
- yes
- no/don’t know

**Workers commuting from the area toward the urban area**
- yes
- no/don’t know
  - exurban, rural

**Study area: french speaking**
- yes
- no/don’t know
  - periurban
  - suburban
O1. Segmentation using landscape indexes

1. Dominant class index
2. Dominance index
3. Built proportion index

- Dominance of constructed surfaces
  - AND
  - Continuous built, constructions mainly two or three facades
    - yes
    - no/don’t know

- Land use mainly residential
  - AND
  - French speaking study zone
    - yes
    - no/don’t know

- Explicit zonation of land use
  - yes
  - no/don’t know

- Land use and land cover almost only agricultural and/or natural
  - yes

- Workers commuting from the area toward the urban area
  - yes
  - no/don’t know

- Study area: French speaking
  - yes
  - no/don’t know

- Patch density (\(\rho\))
- Nearest neighbour distance (\(z\))
- Agregation index (\(R\))
- Proximity index (\(PX\))
O1. Segmentation using landscape indexes

3. Landscape metric calculation:

**Built area proportion (%)**
O1. Segmentation using landscape indexes

4. Field work reference points for each areas

Study zone of Lubumbashi, SPOT Image, July 17, 2002
O1. Segmentation using landscape indexes

4. Field work reference points for each areas

Study zone of Lubumbashi, SPOT Image, July 17, 2002
O1. Segmentation using landscape indexes

5. Recursive segmentation

K = 0.81
Plan of the objectives

O1. Delimit the zones included in the urban-rural gradient
   - Review
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   - Application to the study zone (1 dozen of cities in sub-saharan Africa)
   - Typology based on the (sub)urbanization dynamic

O2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-saharan Africa
O1. Typology

5 zones

No dynamic suburban zone

No non-dynamic suburban zone

No dynamic urban zone

No suburban zone
O1. Typology

Lubumbashi
O1. Typology

Lubumbashi
O1. Typology

Lubumbashi

5 zones

Lubumbashi, 2008 & 2009, Built density index and zones

- 0.00 - 20.07 Rural
- 20.07 - 40.02 Suburban
- 40.03 - 70.00 Urban
- 2002-2008(09) New Urban
- 2002-2008(09) New suburban

2002 - 2008(09) New Urban
2002 - 2008(09) New suburban
O1. Typology

Kisangani
O1. Typology

Kisangani
O1. Typology

Kisangani
Plan of the objectives

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O2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-saharan Africa
O2. Landscape ecological consequences

Built densities and areas

- 2.2 %
+ 1.5 %
+ 0.7 %

Area 2002 (Ha)
Area 2008&09 (Ha)
O2. Landscape ecological consequences

Lubumbashi

Percentage of the occupied area (%)
# O2. Landscape ecological consequences

<table>
<thead>
<tr>
<th>Hemeroby level</th>
<th>Type of anthropogenic influence</th>
<th>Description</th>
<th>Examples of land use types found in Austria</th>
<th>Ecosystems (land use / land cover) in the area of Lubumbashi</th>
<th>Matching image classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Natural</td>
<td>No or only minimal anthropogenic influence (e.g. global pollution)</td>
<td>Bare rock, sparsely vegetated areas, glaciers and perpetual snow, inland marshes, peatbogs, natural forests</td>
<td>Mihulu, Wetlands, Dembo, Copper hills</td>
<td>Wetlands, Dembo</td>
<td></td>
</tr>
<tr>
<td>2. Near-natural</td>
<td>Anthropogenic influences</td>
<td>Structure and type of ecosystem is basically the same as naturally expected at the side but some characteristics (e.g. plant species composition) are altered</td>
<td>Natural grasslands (above timberline), moors and heathland, water bodies, sustainably managed forests</td>
<td>Miombo, Water</td>
<td>Miombo, Streams</td>
</tr>
<tr>
<td>3. Semi-natural</td>
<td>Anthropogenic activities</td>
<td>The naturally occurring ecosystem is no longer present but has been transformed into a new ecosystem type because of anthropic activity</td>
<td>Alpine meadows substituting forest pastures, fallow land</td>
<td>Regenerating forest, Wooded savannah, Old fallow</td>
<td>Wooded savannah and old fallow</td>
</tr>
<tr>
<td>4. Altered</td>
<td>Regularly disturbing anthropogenic activities (e.g. drainage, regular passing over, intense fertilisation)</td>
<td>Changed ecosystem type, edaphon regularly disturbed</td>
<td>Vineyard, intensively used grasslands, plantation of energy forests</td>
<td>Young fallow, Savannah, Bushland, Grassland, Pastures</td>
<td>Savannah and bushland</td>
</tr>
<tr>
<td>5. Cultural</td>
<td>Intense and regular impacts</td>
<td>Destruction of the natural occurring edaphon. Natural occurring floristic elements are reduced to a minimum (&lt; 25% coverage)</td>
<td>Arable land, green urban areas, sport and leisure facilities</td>
<td>Anthropised wetlands, Crops, Reservoirs, Anthropised Dembos</td>
<td>Anthropised wetlands; Crops, pastures, grassland and young fallow; Recurrent burned areas; Reservoirs</td>
</tr>
<tr>
<td>6. Artificial with natural elements</td>
<td>Intensive and irreversible changes of terrain and landscape structure; soil sealing up to 30%</td>
<td>Natural elements only in the form of secondary biotopes</td>
<td>Rural settlements, mineral extraction sites, dump sites, airports</td>
<td>Discontinuous built, Bare soil</td>
<td>Discontinuous built, Bare soil</td>
</tr>
<tr>
<td>7. Artificial</td>
<td>soil sealing over 30%</td>
<td>Artificial systems or structures</td>
<td>Continuous urban fabric, industrial or commercial units, road and rail networks</td>
<td>Continuous built, Slag heap</td>
<td>Continuous built, Slag heap</td>
</tr>
</tbody>
</table>
O2. Landscape ecological consequences

Lubumbashi

Legend:
-3
-2
-1
0
1
2
3

Area Increase between 2002 and 2013 (% total area)

- Anthropisation level
1: natural or near-natural landscape
2: cultivated landscape with substantial amount of natural elements
3: extensively cultivated landscape, few natural elements
4: urbanised or intensively cultivated landscape

Degree of anthropisation increase

Net increase

0.5
1
8
18
4
5
18

Area (% total)

0
10
20
30
40
50
60

0
1
2
3
4

-15
-10
-5
0
5
10

0 15 30 60 90 Kilometers

N
O2. Landscape ecological consequences

**Kisangani**

Built densities and areas

- 0.2 %
- 0.1 %
+ 0.3 %

<table>
<thead>
<tr>
<th>Rural</th>
<th>Suburban</th>
<th>Urban</th>
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<tbody>
<tr>
<td>Area 2002 (Ha)</td>
<td>Area 2010 (Ha)</td>
<td></td>
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Map showing changes in built densities and areas from 2002 to 2010.
O2. Landscape ecological consequences

Percentage of the occupied area (%)

- suburban Fields, young fallow and bamboos
- urban Fields, young fallow and bamboos
- suburban Continuous built
- urban Continuous built
- suburban Discontinuous built
- urban Discontinuous built
- suburban Water
- urban Water
- suburban Burned areas and bare soil
- urban Burned areas and bare soil
- suburban Old fallow and secondary forest
- urban Old fallow and secondary forest
- suburban Ponds and wetlands
- urban Ponds and wetlands
- suburban Floating vegetation
- urban Floating vegetation
- suburban Unclassified
- urban Unclassified
- suburban Primary forest
- urban Primary forest
Discussion and perspectives
Discussion

- Secondary effect? -> Rural anthropized areas
Discussion

- Secondary effect? -> Rural anthropized areas
- Time interval different for the two cities
- Depends on the spatial resolution of the images and on the accuracy of the classification
Perspectives

- Satellite image (LANDSAT) disponibility (clouds!)
- «Circular» shape
- Inhab. > 100 000
- Technical feasibilty
- Biome
Conclusions
Plan of the objectives

O1. Delimit the zones included in the urban-rural gradient
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O2. Study of the landscape ecological consequences of the urbanization and periurbanization processes in sub-saharan Africa
THANKS FOR YOUR ATTENTION!

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