Towards Land Use Dynamics Investigation
A case study of the Democratic Republic of the Congo

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Outline

Introduction

Modeling Process

From Administrative-level Data to Human Population Distribution

Multimodal Accessibility Simulation

Land Use Dynamics Investigation

Summary
Introduction

Demographic growth and accessibility to main cities/markets are considered as important factors of land use dynamics.

These factors are however inaccurately estimated for many countries (in the Congo Basin region) due to many factors: data availability, scarcity and coarse spatial of network datasets at the national scale, etc.

The current research illustrates how the population distribution and accessibility could be estimated using spatial modeling techniques.
Modeling Process

- Pop. Counts by Admin. level
- DRC land cover
- Road and River Network
- Friction Surface

- Areal Interpolation
- Network Analysis

- Human Population Distribution
- Other Land Information
- Accessibility to the Nearest City

- Modeling

- Land Use Dynamics
DRC Population Figures
Regression Weighted Areal Interpolation

Population \((y_i)\) as a function of land cover composition \((x_{ik})\) and considering population densities \((\beta_i)\) as spatially invariant:

\[
y_i = \beta_1 x_{i1} + \cdots + \beta_k x_{ik} + \varepsilon_i \quad \forall i = 1, \ldots, n
\]

Where \(\varepsilon_i\) refers to the corresponding error in terms of population

Or using standard matrix notations:

\[
y = X\beta + \varepsilon \quad \implies \quad \hat{\beta} = (X'X)^{-1}X'y \quad \text{where} \quad X = \begin{pmatrix} x_{11} & \cdots & x_{1k} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nk} \end{pmatrix}
\]
Constrained Regression

Using alternative information to reduce discrepancies between observed and predicted population (e.g. DRC urban population is about 30% of the total population)

\[
\begin{pmatrix}
{X}'X & s_a & s_b \\
s'_a & 0 & 0 \\
s'_b & 0 & 0
\end{pmatrix}
\begin{pmatrix}
\beta \\
\lambda_a \\
\lambda_b
\end{pmatrix}
=
\begin{pmatrix}
{X}'y \\
(0.3)y_T \\
(0.7)y_T
\end{pmatrix}
\]

with \(y_T = \) the total population, \(s'_a = (s_1, 0, \ldots, 0)\) and \(s'_b = (0, s_2, \ldots, s_k)\), where \(s_1\) denotes the total urban area, respectively, whereas \(s_2, \ldots, s_k\) refer to total areas for the various other classes.
Estimated Sp. Distribution of Human Population
Assessing Sources of Errors

Confusion matrix and simulation of spatially varying densities
Framework

- LU Dynamics models tend to use euclidean distances as an accessibility indicator.
- However, a reliable accessibility model must integrate multimodal aspects as well as transport capacities.
- Need to overcome limitations of a scarce and coarse network dataset.
Illustration of DRC road and river dataset
Accessibility Simulation Process

Road & River Network

Multimodal Simulation

Allocated Zones (AZ)

Traveler Optimal Choice (TOC) & Binary Surface (BS)

(AZ x BS) + TOC

Accessibility Surface

Friction Surface (FS)
(e.g., land cover, slope,...)

Optimal Decision
Accessibility to Main Cities
MLW Case Study - Previous Presentations

- Janet Nackoney (UMd)
- Jef Dupain (AWF)
- MLW Consortium activities
Summary

- Results of human population distribution and accessibility modeling are promising
- Need for an external validation of derived population densities estimates
- Better characterization of markets’ roles
- Better calibration of the model
THANKS FOR YOUR ATTENTION...