Standardizing Urban Spatial Analysis

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Introduction

This poster describes an approach for geospatial analysis using scripting techniques. Scripting offers advantages over graphical user interfaces, for repeatable geospatial analysis, when considering both regional and city scales [1].

Objective

The results of urban geospatial analysis are difficult to compare. Studies are often made on a case by case basis.

To standardize urban geospatial analysis the following general scientific principles should be followed:

1. Easy to replicate
2. Clear assumptions
3. Possible to compare analysis

We argue that publicly available analysis scripts facilitate this approach. This poster illustrates these principles with two examples.

Method

This analysis was conducted using the following three tools:

1. *ArcGIS*: spatial analysis
2. *Python*: scripting of spatial analysis
3. *R*: statistical analysis

The scripts used in the analysis will be available at: `http://www.urbmet.org/analysis`.

References

[1] Rindfuss et al.(2004) Developing a science of land change: Challenges and methodological issues. *Proceedings of the National Academy of Sciences of the United States of America*, 101(39):13976–13981, 2004.

Land Cover Change in San José, Costa Rica

Two land use maps for the metropolitan area of San José, the capital of Costa Rica, have been constructed for the years 1989 and for 2001. The land use maps will be used to measure land cover change induced greenhouse gas emissions in the region. For a sample of roughly 4% of the study area, nine different types of land use have been determined by visual inspection.

Input Data

- **Climate**

  Percipitation & Temperature

- **Digital Elevation Model**

  Elevation, Aspect & Slope

- **Land Sat Images**

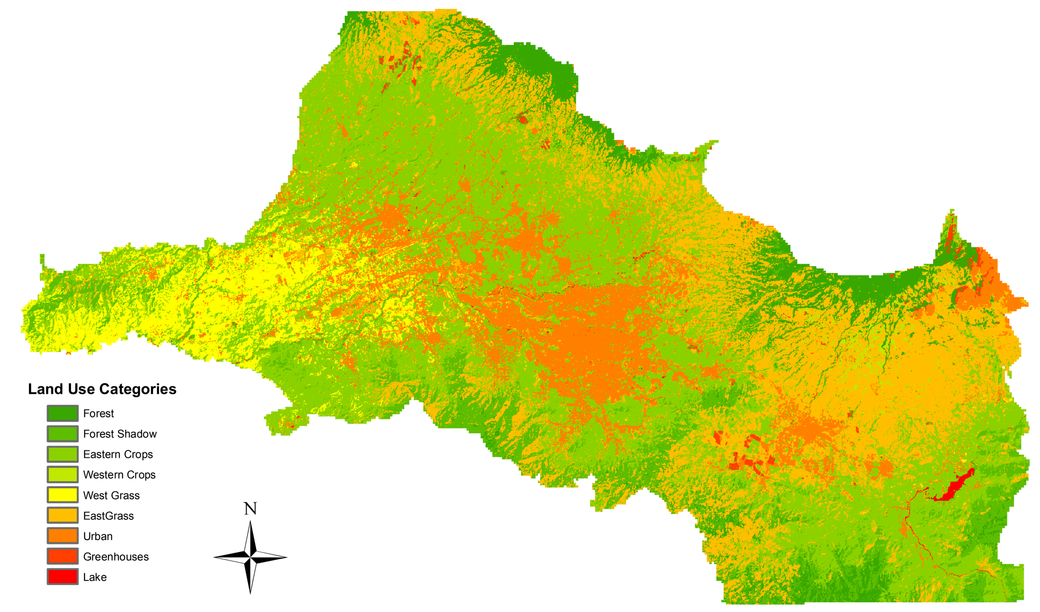
  Bands 10, 20, 30, 40, 50, 70.

Multinomial Logistic Regression

A multinomial logistic regression has been used to relate this sample land use with satellite imagery, digital elevation data and climate data. The logistic regression successfully reproduced 95% of the sample land use and has been used to determined the land use patterns in the rest of the study area. The assumed logistic distribution from the regression is described by Equations 1 and 2.

$$P(y_i = j|\vec{X}) = \frac{\exp(\vec{X}\cdot\vec{\beta}_j)}{\sum_{j=0}^{N}\exp(\vec{X}\cdot\vec{\beta}_j)} \quad (1)$$

$$\begin{aligned}\vec{X}\cdot\vec{\beta}_j \quad = \quad & \beta_0 + \beta_1\text{Temp} + \beta_2\text{Aspect} + \beta_3\text{DEM} + \\ & \beta_4\text{Slope} + \beta_5\text{Precip} + \beta_6\text{b10} + \beta_7\text{b20} + \\ & \beta_8\text{b30} + \beta_9\text{b40} + \beta_{10}\text{b50} + \beta_{11}\text{b70}.\end{aligned} \quad (2)$$



Land Use	Count	Share %	Misspec.%
Forest	3882	4.1	3.0
Forest shadow	2707	2.8	3.4
Western Crops	33455	35.5	1.6
Eastern crops	880	0.9	27.4
Western Grass	6023	6.4	< 0.1
Eastern Grass	23474	24.9	3.4
Urban	22386	23.7	3.4
Greenhouses	540	0.1	2.8
Lake	1016	1.1	< 0.1
Total	94363	100	4.3

Examining Road Distribution Patterns in 40 US Cities

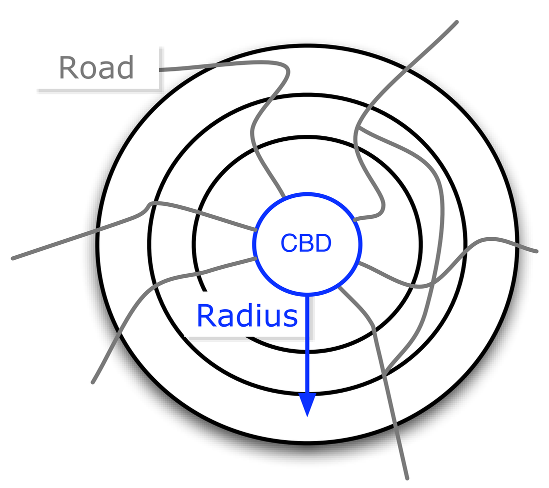


Figure 1: Analysis of City

The total road density decreases as the radius increases. This relationship was observed to follow a power law with the following structure:

$$y = Ar^b \quad (3)$$

where y is the road density, r is the radius from the urban center, and A and b are parameters for each city. The values for A ranged from 15–198, while b ranged from $-0.55 - -1.6$.

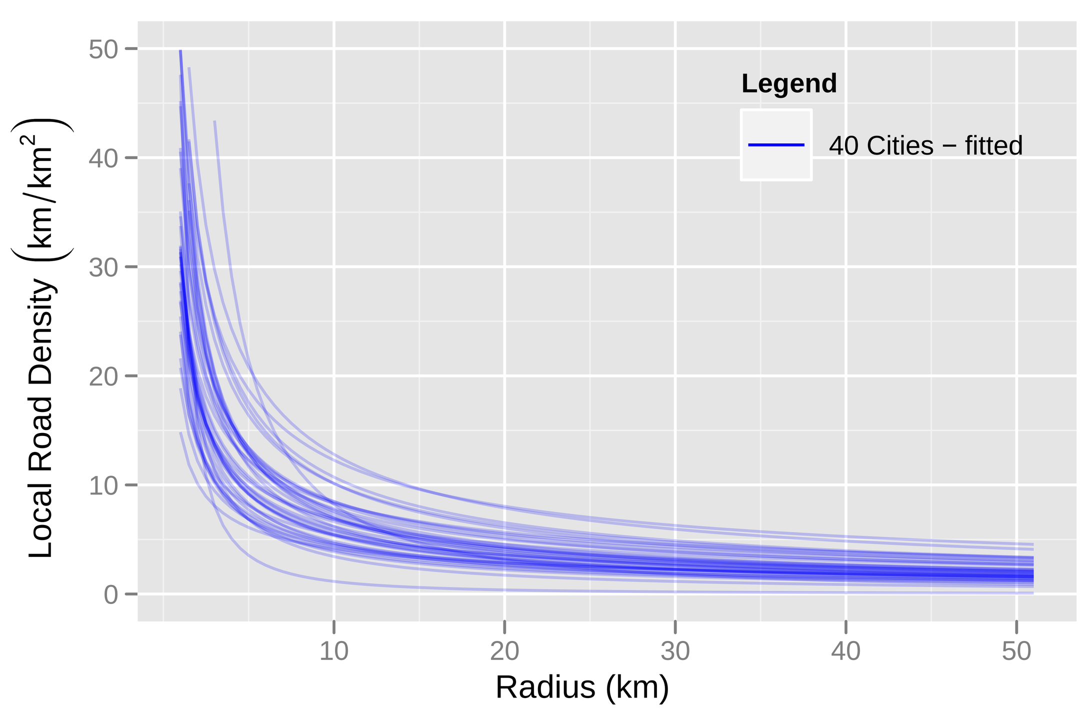


Figure 2: Pattern of Road Density

The amount of material required for local road construction is as follows:

$$Material = Ar^b \times Area \times Cross\text{-}Section \quad (4)$$

Distance [km]	Road Length [m]	Asphalt [m^3]	Gravel [m^3]
10	6862	3137.56	6536.59
30	3585	1639.13	3414.86

Table 1: Material for local roads in Atlanta

Assumptions

1. Cross-sectional area of asphalt for a local road is 0.4572 m^2; for gravel it is 0.9525 m^2
2. Road construction material used for secondary and local roads depends on state construction standards and local ground conditions.

This approach assumes that patterns in cities enable general observations to be made about material resources.

Conclusions

The examples above illustrate the potential for rigorous application of computational methods to analyze urban areas from a sustainability perspective. We propose this approach as the most efficient way to achieve verifiable and comparable results from spatial analysis at the urban scale. Wherever possible analysis should be made using scripts, public data and open-source software.