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Land Cover Change and Demographic Growth: an Estimation of Dar es Salaam's Population Using Remote Sensing

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The ACC Dar Project

 Project aim: investigate urban vulnerability to Climate Change (CC) in coastal Dar es Salaam (Tanzania)

 Activity 2.1: develop methodologies for monitoring changes in peri-urban settlements using remote sensing





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Land Cover Change and Vulnerability to CC





Land Cover Change and Demographic Growth: an Estimation of Population in Dar es Salaam Using Remote Sensing



Land Cover Change and Vulnerability to CC





Land Cover Change and Demographic Growth: an Estimation of Population in Dar es Salaam Using Remote Sensing



This Study

- A method of demographic estimation through remote sensing
- Hypothesis: Land Cover Change in Dar es Salaam is related to demographic growth
- Thesis: demographic growth can be estimated by monitoring Land Cover (LC) through remote sensing



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Land Cover Classification

- Data: Landsat images (provided for free by the USGS)
- Spatial resolution: 30m
- Classification methodology: supervised semi-automatic
- Identified LC classes:
 - "Continuously Built-up", a densely developed class
 - "Discontinuously Built-up", an urbanized class with low-density development
 - "Soil", bare soil or sparse vegetation
 - "Full Vegetation", very green and abundant vegetation (mainly trees)
 - "Mostly Vegetation", a less green class of vegetation (typically grass and brush)
 - "Water"



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Land Cover Change from 2002 to 2011





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Population Estimation Workflow





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Household data

- 2011 Household Survey, under Activity 1.1 of the project
- 5860 households interviewed and georeferenced with GPS
- 20 households counted between each interviewed household
- The distance between two interviewed households varies with household density





Interviewed Household

Counted Household



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Household Estimation

- Assumption: the household density around a given interviewed household is inversely proportional to the distance between that interviewed household and the next one in the sample
- It is then possible to calculate the average household density per LC class ($\bar{\rho}_i$) in relation to the distance (GIS spatial analysis)
- Estimation of households in Dar es Salaam =

Average Household Density x LC Class Area

| Land Cover Class | Household Estimate | |
|--------------------------|--------------------------------------------------------------------------------|--|
| Continuously Built-up | $ar{ ho}_{ m Continuously Built-up}*Area_{ m Continuously Built-up}$ | |
| Discontinuously Built-up | $ar{ ho}_{ m Discontinuously Built-up} * Area_{ m Discontinuously Built-up}$ | |
| Soil | | |
| Full Vegetation | ā i Amar | |
| Mostly Vegetation | $\rho_{\rm Soil}*Area_{\rm Discontinuously Built-up}$ | |
| Water | | |



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Household Estimation: Results

- Assumption: average household densities did not change over the years considered
- Household estimation in Dar es Salaam for 2002 and following years

| Land Cover Class | Area [ha] | Average Household Density [household/ha] | Estimated Households |
|--------------------------|---------------------|---------------------------------------------|----------------------|
| Continuously Built-up | 8,365.5 | 31.11 | 260,251 |
| Discontinuously Built-up | 8,032.0 | 17.56 | 141,043 |
| Soil | 8,032.0 | 13.78 | 110,682 |
| | | | Total 511,975 |

Comparison between estimates and census data: ±15%





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Population Estimation

- Estimation of population in Dar es Salaam =
 Estimated Households x Average Household Size
- Average Household Size (National Bureau of Statistics, 2013)
 - Dar es Salaam 2002 = 4.2
 - Dar es Salaam 2012 = 4.0
- Average Household Size

| Year | Average Household Size |
|------|------------------------|
| 2002 | 4.20 |
| 2004 | 4.16 |
| 2007 | 4.10 |
| 2009 | 4.06 |
| 2011 | 4.02 |



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Population Estimation: Results

- Population estimates in Dar es Salaam from 2002 to 2011
- Comparison between estimates and census: margin of error $\pm 15\%$
- Comparison between estimates and projections





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Population Estimation: Results at Municipal Level

Comparison between estimate and census: margin of error ±25%





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Limits of This Method

- Margin of error ±15% at city level and ±25% at municipal level
- Spatial resolution and accuracy of LC classifications
 - LC classifications do not distinguish land uses, which can have different population densities
- The relationship between LC and population depends on the specific development of the city
- Influenced by variations over time of:
 - Average Household Density
 - Average Household Size



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Advantages of This Method

- Rapid and affordable demographic estimation
- Valuable alternative to traditional census, which has low frequency given the growth rate of Dar es Salaam
- Valuable alternative to projections, especially when growth is rapid or unexpected, or when census data is outdated





Conclusions



 Urban Sprawl "happens when population growth and the physical expansion of a city are misaligned" (UN-Habitat, 2010, p.10)



Other drivers also cause urban sprawl in Dar es Salaam, and this affects the reliability of this estimation method.



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Thank you

References:

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