



### UICCA 2

## Urban Impact of Climate Change in Africa

### **Planning with Scant Information**

2<sup>\*</sup> International Conference

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## **Non-Climatic Factors of Vulnerability to Climate Change:**

# an Estimation of Population in Dar es Salaam using Remote Sensing

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### Introduction

A Land Cover (LC) classification methodology has been developed for the ACC Dar Project, with the purpose of assessing the urban development patterns of Dar es Salaam.

The methodology was intended to be affordable, rapid, and reliable; therefore, the research has used freely available data (Landsat images, which are provided for free by the United States Geological Survey).

In order to assess Land Cover Change (LCC), in particular for urban areas, several tools and methods were defined, which are available at little cost, and easy to use. LC classifications were produced with a semi-automatic procedure, and have a spatial resolution of 30m, which corresponds to a 900m<sup>2</sup> pixel (Congedo & Munafò, 2012). The following LC classes were defined for urban areas:





- Continuously Built-up: a densely developed class, whose pixels are characterized by homogeneity of urban cover (Figure 2);
- Discontinuously Built-up: a low-density development class, whose mixed pixels are characterized by a variety of land cover types, including urbanized, vegetation, and bare soil (Figure 3).

The results of the LCC analysis for built-up classes are reported in Figure 1 and Table 1.

**Relationship between Land Cover Change and Demographic** Growth

The line graph in Figure 4 represents the evolution of "Continuously Built-up" and "Discontinuously Built-up" areas, as compared with the national census of 2002 and 2012 (United Republic of Tanzania, 2013). This line graph shows that, although the considerable population growth, the increase of "Continuously Built-up" areas and especially the "Discontinuously Built-up" areas is far beyond the demographic growth. This trend confirms the definition of urban sprawl by UN-HABITAT(2010), because population growth and the physical expansion of the city are misaligned.

#### **Population Estimation**

In order to understand if there is a relationship between urban development and demographic growth, a methodology has been developed for the estimation of population, based on LC classifications and household data. Figure 5 illustrates the workflow of the population estimate (Congedo, Munafò, and Macchi, 2013), which is based on the integration of the LC classifications and household survey data. The integration is based on the assumption that the greater the distance (d), the fewer households there are in the neighbourhood where one has been interviewed (Figure 6), considering that household interviewers selected sample households in the field simply by counting 20 households from the last one interviewed (Figure 7). Results

The results of this estimation are reported in Figure 8, where estimates are compared to the census data (United Republic of Tanzania, 2013). Considering a linear trend between 2002 census and 2012 census, estimates are quite reliable, with a margin of error of ±15%. However, it emerges that the estimate for 2002 is below the census value, while the 2011 estimate is above the linear trend; because of the estimation is based on LC classifications, this suggests that the relationship between LC and population growth has changed over the time, in a way that urban expansion is less driven by demographic growth. Conclusions The above considerations highlight that population growth and the physical expansion of Dar es Salaam are correlated, although not directly proportional. A correlation between demographic growth and physical expansion exists, but it is mediated by the settlement pattern that dominates in new urban developed areas, and it is the discontinuously built-up pattern that dominates in Dar es Salaam. Considering the low frequency of census taking (once every ten years), and the growth rate of Dar es Salaam, this estimation method represents a valuable and affordable way for updating demographic information between two census years at the regional and municipal levels. It is worth noticing that Dar es Salaam population's projections provided by the Tanzanian Bureau of Statistics for the census year 2012 had an error margin of -24%, while the error margin for this estimation method is +10%. However, it has proven to be unreliable at ward level, as the accuracy and spatial resolution of LC classifications limit the spatial scale at which it is applicable.

Figure 1. Land Cover Change of Dar es Salaam from 2002 (left) to 2011 (right)

			190		
Class	2002	2004	2007	2009	2011
Continuously	8,415	10,025	10,447	12,370	14,808
Built-up		(+19%)	(+24%)	(+47%)	(+76%)
Discontinuously	8,098	9,134	12,509	17,318	23,678
Built-up		(+13%)	(+54%)	(+114%)	(+192%)



Figure 4. Comparison of built-up evolution and population growth



POPULATION ESTIMATION

	0	0	0	0	0	0	
0	0	0	0	0	0	0	0
0	<u> </u>			0	0	.0.	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0

Interviewed Household

Figure 2. Example of Continuously Built-up class



Figure 3. Example of Discontinuously Built-up class

Table 1. Land Cover Change of Dar es Salaam

#### References

Congedo, L. & Munafò, M., 2012. Development of a Methodology for Land Cover Classification in Dar es Salaam using Landsat Imagery. Tech. rep. Rome: Sapienza University, ACC Dar Project Sapienza University. Congedo, L., Munafò, M. and Macchi, S., 2013. Investigating the Relationship between Land Cover and Vulnerability to Climate Change in Dar es Salaam. Rome: Sapienza University, ACC Dar Project. UN-HABITAT, 2010. State of the World's Cities 2010/2011: Bridging the Urban Divide. London, UK: Earthscan.

United Republic of Tanzania, 2013. 2012 Population and Housing Census: Population Distribution by Administrative Areas, Dar es Salaam: National Bureau of Statistics, Ministry of Finance.

AVERAGE HOUSEHOLD

SIZE

The Conference is organized within the Research Project of National Interest (PRIN)

"Assessing, Planning and Managing the Territory and the Evironment Locally in Sub Saharan Africa"

developed by DIST-Politecnico di Torino (prof. Maurizio Tiepolo) and DICEA-Sapienza University of Rome (prof. Silvia Macchi)

Figure 7. Illustration of the proportionality of the distance between interviewed households (in red) and the number of households in the neighbourhood



Figure 8. Comparison of built-up evolution and population growth

