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Mortality and environment in Antananarivo, Madagascar: Identification of hotspots at the neighborhood level

Géraldine DUTHÉ[1], Basile ROUSSE[1,2], Hasina Joelinitahina RABARISON[3], Anjarasoa Maharavo RASOANOMENJANAHARY[4], Tamby Alson Ramangalahy ANDRIANJAFIARINOA[4], Valérie GOLAZ[1,5], Sylvain LOBRY[2], Laurent WENDLING[2]

[1] Institut national d'études démographiques (INED), FRANCE
[2] LIPADE, Université Paris Cité, France
[3] Institut Pasteur de Madagascar (IPM), Madagascar
[4] Bureau municipal d'hygiène d'Isotry de la communauté urbaine d'Antananarivo (BMH), Madagascar
[5] LPED, UMR Institut de recherche pour le développement (IRD) Aix Marseille Université (AMU), France

Introduction

In low- and middle-income countries, rapid urbanization in the context of low economic development has led to the surge of slums and, more generally, to large socioeconomic inequalities. A non-negligible share of urban residents does not benefit from the urban health advantage. In this context, the burden of adverse environmental conditions that usually characterize slums and spontaneous installation areas appear to add to other socioeconomic difficulties (poverty, density…) and dramatically impact health and mortality. Vulnerability to high density, pollution, flooding, lack of greenness, and heatwaves lead to higher rates of specific causes (e.g. infectious and respiratory ones). However, little is known about health and environment at a fine scale due to a lack of reliable statistics in many sub-Saharan African cities.

Recent advances in spatial imaging technologies, along with their growing accessibility, allow for the acquisition since 2016 of high-resolution temporal and spatial data worldwide. Utilizing satellite data has the potential to yield further insights into local environments. Moreover, remote sensing images remain unaffected by the political context of the studied location, thus offering objective features.

In this paper, we aim to explore the environmental urban penalty, identifying adverse environmental hotspots and measuring to what extent they are related to relatively high level of total and/or cause-specific mortality. In order to do so, we explore for a recent period (2016-2020) the correlation between environmental characteristics and mortality at the neighborhood level on the basis of the unique dataset that compiles all registered deaths in Antananarivo, the capital city of Madagascar.

As many cities of the Global South, Antananarivo is characterized by large inequalities. As it is located in a region of hill ranges and plains, there are also large differences between the low city and the high city. With population growth, its neighbourhoods have developed over time in different spots of the outskirts, the latest being generally the least well off, i.e. in floodprone areas. In addition, air pollution affects inhabitants differently depending on their localization.

Data and method

Environment data and indicators

For this study, we extracted environmental indicators from both satellite and conventional sources to consider various aspects of the environment. We modeled the environment using three indicators:

- Digital Elevation model (DEM) to take elevation into account.
- Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 satellite images with a resolution of 10m. NDVI indicates the presence of vegetation in a spatial unit.
- Local Climate Zones (LCZs), generated from remote sensing images, that aim to model urban area types according to physical descriptors such as the height of buildings, density, types of surface, and others.

Additionally, we take into account air pollution data available through AirCasting data. Such environmental data can be aggregated at the Fokontany level to describe its environment.

Population data

Population estimates are derived from the last population census conducted in 2018 by the national statistical office INSTAT. We make use of two tables provided by INSTAT: population by sex and age groups for the different districts of the Commune urbaine d'Antananarivo (CUA) (n= 6 districts); and estimation of the total population for the different neighborhoods of the city (n = 192 fokontany).

We estimated age group and sex population for each neighborhood by attributing the sex and age group distribution of each district to all neighborhoods in the district.

Mortality data and indicators

For districts 1 to 5 (161 fokontany), deaths are registered by a team of physicians at the Bureau municipal d'hygiène d'Isotry (BMH), with the support of the Institut Pasteur de Madagascar (IPM), with the following information: sex, date of birth and death, reported address and fokontany, arrondissement, cause of death (classified since 2015 according to the 10th International Classification Diseases, ICD-10).

Because the reported addresses do not necessarily correspond to the official names of the fokontany, we imputed the fokontany using lexical proximity and localization of the given address when possible. Imprecise addresses in the dataset led us to group some of the neighborhoods: for instance the four fokontany called "67 ha South", "67 ha North", "67 ha East", "67 ha West" were grouped in a larger area "67 ha". Finally, we have 106 neighborhoods that correspond to either a fokontany, or a group of fokontany. The remaining deaths for which we could not attribute a neighborhood were age group and sex proportionally redistributed among the neighborhoods (inside one district if it is known).

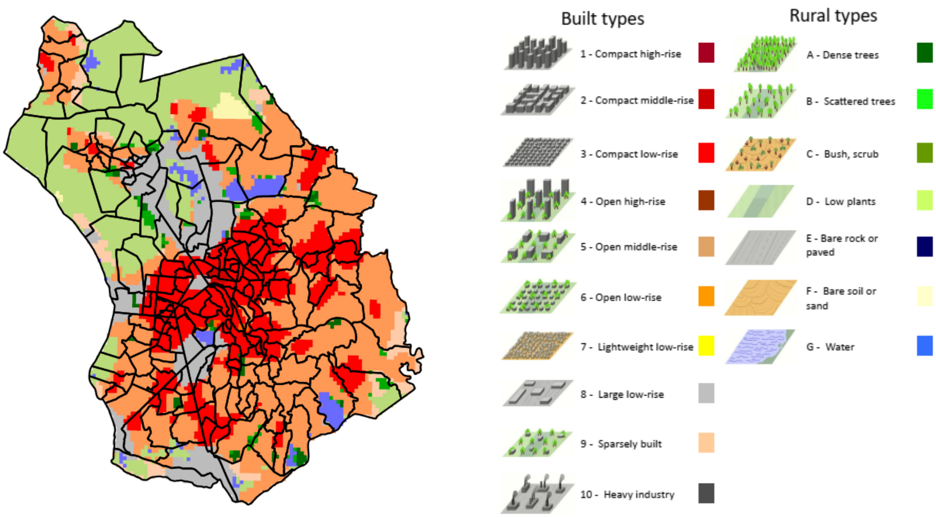
Mortality indicators estimated in the analysis for the period 2016-2020 are: crude death date, infant and child mortality rate (0-5), infectious related mortality rate, respiratory related mortality rate.

Preliminary results

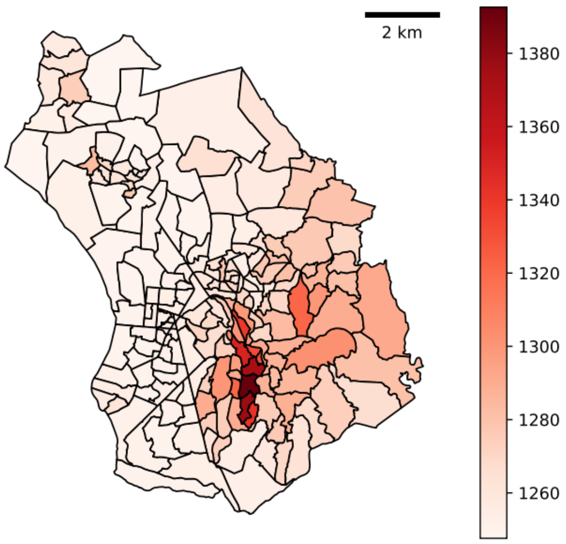
Environmental indicators

Figure 1. Characterization of the environment in Antananarivo

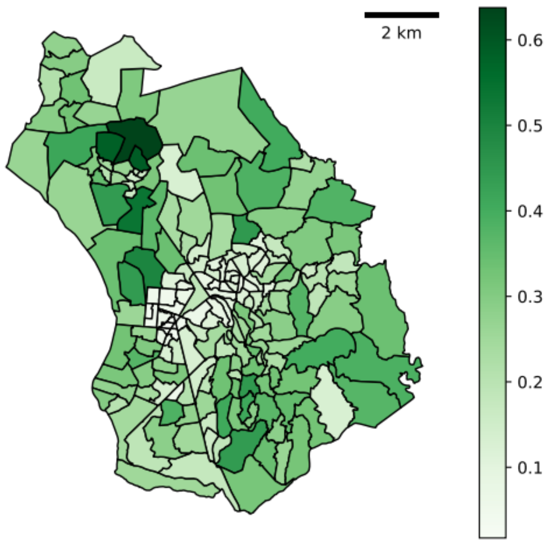
Local Climate Zones (LCZs)



Digital Elevation model (DEM)



NDVI (Normalized Difference Vegetation Index)



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