Mobility data analysis in Greater Maputo Area – Mozambique

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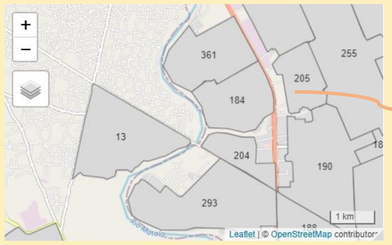
Introduction

Origin-Destination (OD) matrices are a common tool used in mobility settings to track, with GPS data, movements of citizens in a particular environment. Our dataset contains, in the form of OD data, information on flows of 9786 people in the 329 morphological districts, in which the city of Maputo has been divided, collected from July to October 2019. The results we can extract from these data can be useful for policy makers to have a better understanding of urban mobility and address issues with specific policies.

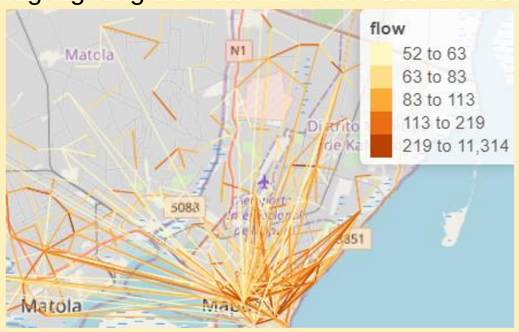


orig	dest	flow
204	204	101
204	205	19
204	208	1
204	21	2

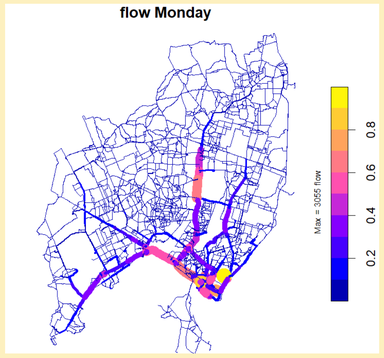
References: *Safari-Njema Polimi, Geocomputation with R (Lovelace, N.,M., 2019), Cran R-project (introduction to OD package), OpenStreetMap*

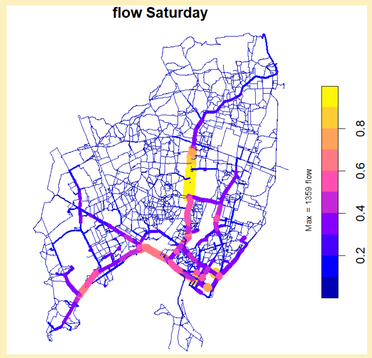
District flows – Methods & results

R-libraries implemented to deal with spatial and mobility data – such as *od, stplanr, sf, osrm* – allow us to translate OD data into first 'desire lines', straight lines connecting centroids of each district; then, by combining these lines with geographical information about the area we can visually represent actual routes connecting different parts of the city of Maputo, highlighting districts with the most flow-density.



Visual results alongside statistical tests to compare mean flow across districts lead us to state that the city center dominates the flows of Maputo, both in terms of internal flow and considering attraction from outer districts and suburban areas, with the province of Matola as the second most flow-dominant area. Another result that can be shown visually below, obtained also by working in the context of repeated measures tests, is how the distribution of flows and roads congestion across the city changes during the week; we can for example assess the impact of weekend on urban mobility versus workdays, as we further study in the next section.

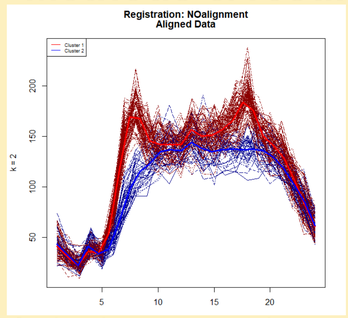




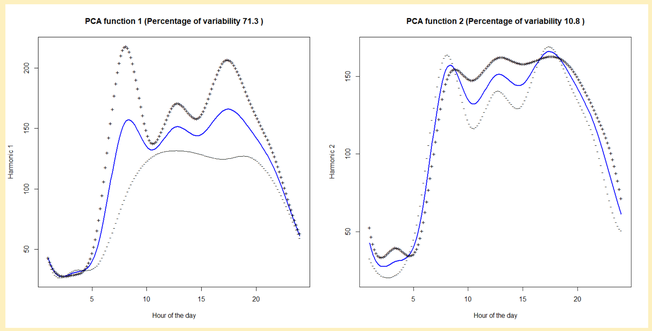
The pictures above show the proportional flows on the road network in Maputo estimated from the desired lines and OpenStreetMap data for Mondays and Saturdays, respectively. Note that the total/maximum flows are different for the two days.

Flows evolution in time - Methods & results

Here is considered a functional data approach, where each line represents the total flow of each day from 1 July to 31 October, hour by hour. The picture on the right shows the original data divided in two clusters thanks to **k-means** without alignment method.

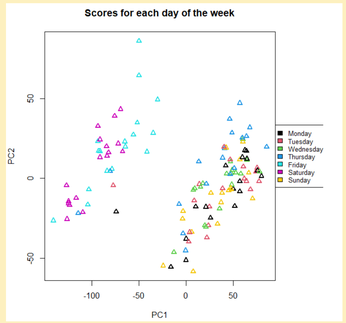


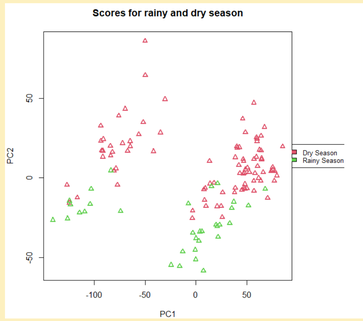
We performed then **functional PCA** to further interpret our data.



The first PC highlights the flow in the peak hours, presumably when people move for work reasons.
The second PC highlights instead the mid-day movements.

Then we plotted the scores along the first two PCs coloring each point, representing each day, with two factors: day of the week and season.



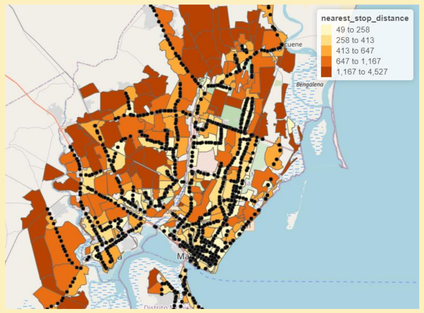


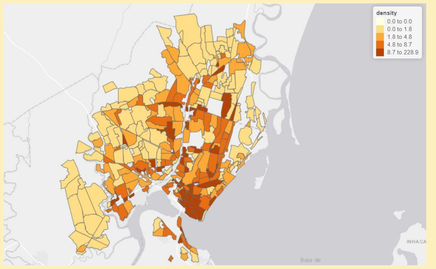
Fridays and Saturdays seem to act like our Weekend: less flow during peak hours and higher flow in the middle of the day. During rainy season instead, there is a general lower flow during all day. We verified those hypothesis thanks to a two-ways MANOVA model over *Weekend* and *Season* as factors.

Public transport analysis

Walking is the most common way of moving in Maputo, so reaching isolated areas and connecting them to central parts of the city where job, education and health services are concentrated is of great importance when dealing with urban mobility in this context.

On the right we reported a map of density (#stops/km^2) of bus stops across district, evidently not uniform between different tipologies of area.





On the left we reported a map estimated evaluating the distance (m) between the center of every district and the closest bus stop, underlining the incapability of bus system to cover vast areas away from the city center.

Conclusion And Further Research

The three-level analysis presented leads us to multiple final considerations: at first, the city center evidently should be the focus of every mobility policy, particularly investing in new infrastructure being able to create a more capillary connection of rural and isolated areas to the central ones. Since it is known that in Maputo, poorer neighborhoods have a huge lack of paved roads, investing in road infrastructures can be the key to create new forms of district mobility, without people relying only on walking long distances and possibly triggering economic development in new areas, that may be able to grow without depending on connections to the city center. Finally, our flow functional analysis can be the starting point of a revision of transport timetables, adapting availability of public and paratransit vehicles to sustain the demand of the most trafficked hours, relieve pressure from the few paved street now available.

Possible extensions for our research could be using the OD flow data in combination with, for example, current infrastructure regarding hospitals which then could be used to give suggestions on where medical infrastructure is missing and where it should be focused. Furthermore, knowledge about the distribution of people in Maputo as well as the distribution of people involved in the study could be valuable as this would help in knowing how representative the data are and give the possible conclusions more details.