Optimization of Waste Management Scenarios by Principal Component Analysis: A Case Study in Reunion Island

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Context

Waste management is often defined at a territorial level. The overall waste production is determined and a waste management scenario is built accordingly, covering the entire territory. Although this approach is interesting to size and deploy massive treatment plants, it lacks adaptation to sub-territorial specific waste flux characterization and treatment.

In fact, when waste management is studied at small-scale like municipalities, waste production can be analyzed in depth in order to capture specificities and optimize its management. Starting from this observation, our goal is to obtain a territorial waste management scenario out of small-scale waste management scenarios without multiplying the number of scenarios to build.

So, we propose a methodology to optimize waste management at small-scale by identifying correlation between small-scale areas' waste production, thus enabling mutualisation and co-creation of local scenarios.

01 Methodology

Our approach is directly based on the quantitative and qualitative evaluation of wastes at the desired level of observation.

So, the <u>first step</u> is to choose waste categories (municipal solid wastes, organic wastes, recyclable wastes, e-wastes, etc.) and to determine the associated waste production for each studied area. At this step, we build a database with the classified wastes streams and their quantities. The database must be consolidated and reliable since all the analysis is based on it.

At the <u>second step</u>, we use Principal Component Analysis as our main analysis tool. With this method, we want to determine: i) if there is any correlation or similar behaviors in terms of composition and tonnages between two or more areas; ii) if there are indeed some similarities, which waste management scenarios can be established and their tonnages.

So, this methodology can be used as follow:

- To compare behaviors into different administrative area (regions, municipalities, towns, etc.);
- To extract some similarities between studied areas;
- And to classify areas with the same profile.

Two-steps methodology

<u>STEP 1: Biowaste production database</u>

Identification of waste streams studied
Quantification of each waste streams

<u>STEP 2: Principal component analysis</u>

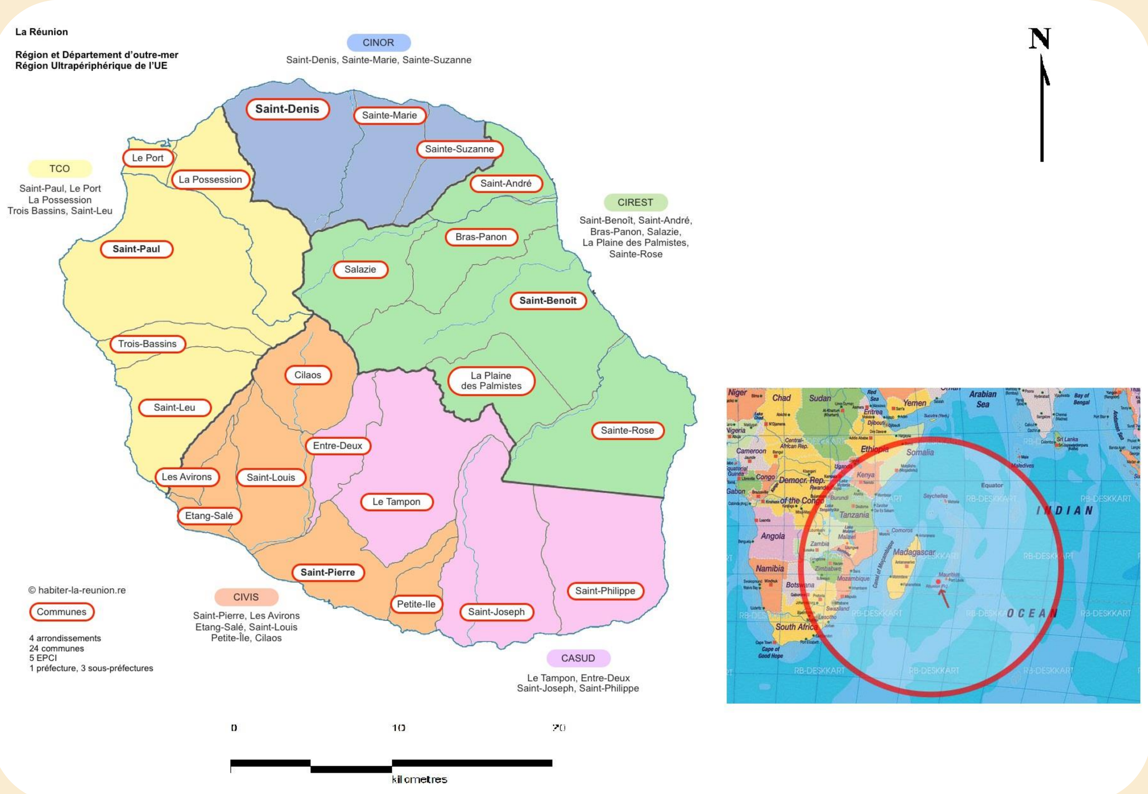
Statistical analysis of biowastes generation
Dataset discrimination

<u>Results</u>:

Highlighting of town typology
Correlation/anti-correlation between waste streams

02 Focus on La Réunion

Our methodology has been applied to Reunion Island (RI) and is focused on Biowastes streams. Reunion Island is a French oversea territory of approximately 2500 km², located in the Indian Ocean, between Mauritius and Madagascar. Its population reached 833 000 inhabitants in 2010. RI is structured with 24 municipalities which are regrouped into 5 public communities in charge of waste management.



04 Conclusion

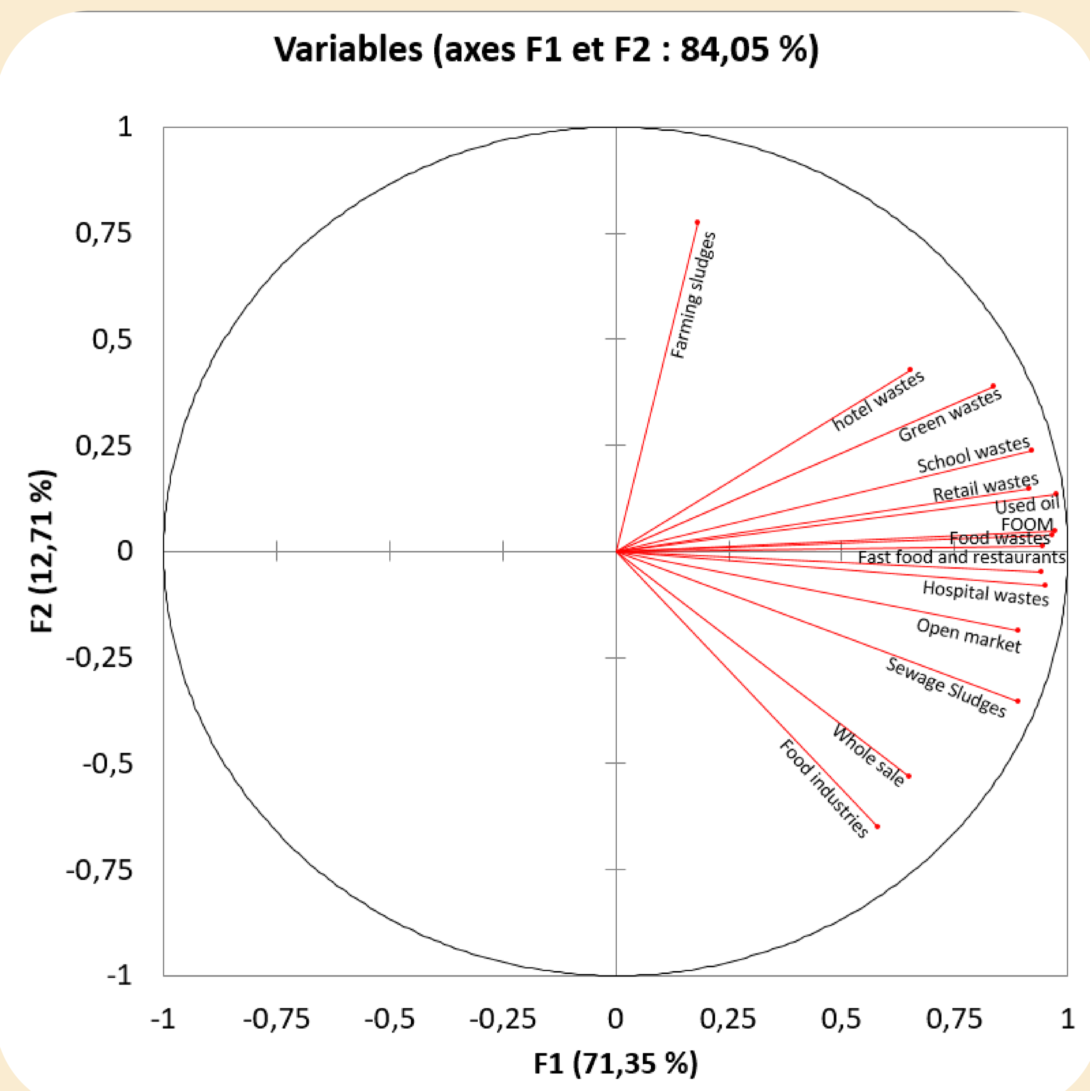
With our PCA application, we demonstrate that it is possible to analyze a dataset of wastes production for many towns with greater ease than the usual analytical techniques like classic plots. Based on waste flux analysis, this approach is useful to better anticipate waste and urban development, thus improving forecasting decision-making. It enables to highlight similarities between local administrative areas. It also highlights the shared or discriminant waste characteristics, thus inducing collaboration strategy.

This study will be particularly useful toward making towns of a same group working together to mutualize solutions. We think it is important to propose more specific waste management scenario adapted to the territory.

03 PCA Results: Case Study Of La Réunion

With landfills having reached their maximal capacity and an ever-growing population, the waste management scenario on RI must be revised. An optimal global scenario is particularly difficult to build due to the specificities of waste composition and production of each municipality. These differences motivate the definition of waste management scenarios at the municipality scale, thus facing the creation of 24 local scenarios. PCA is used as the main analysis tool. It enables to highlight similarities between local administrative areas.

3.1) Wastes stream graphical repartition



<u>Axes interpretation of PCA results:</u>

- F1 is positively correlated with municipal wastes (green wastes, school wastes, used oil, FOOM, food wastes, fast food and restauration, etc.).
- F2 is positively correlated with farming sludges and industrial wastes (food industries).

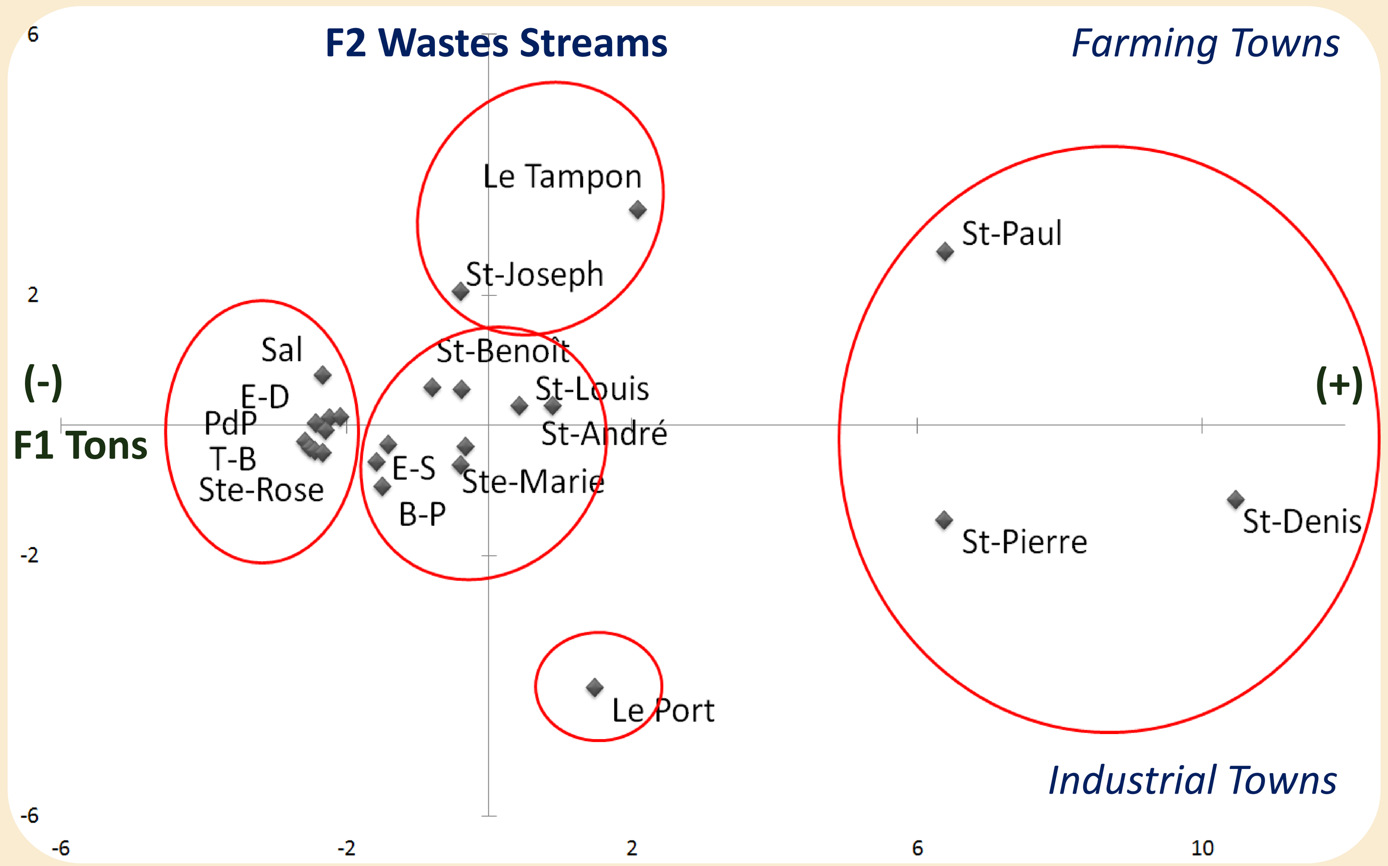
To interpret the waste streams graphic repartitions, we can see that food wastes and FOOM are positively correlated. This means that the more food wastes are produced by a town, the more FOOM wastes will be produced, and inversely. And the more GMS and FOOM wastes are produced, the less institutional catering wastes, fast food waste and open market wastes will produced. Lastly, farming sludge are principally represented in the axis F1 and are positively correlated to F1 (quasi aligned with axis F1).

So, we can conclude that the axis F2 is representing anthropic activities and the axis F1 farming activities.

3.2) Towns graphical repartition

<u>Interpretation of PCA results:</u>

- 5 groups of municipalities
- 5 different waste management scenarios
- Correlation between towns and characteristics of towns (urban, farming or industrial waste production)



Axis F2 organizes towns according to the composition of their waste (farming character to industrial character). Thus, Le Tampon does not produce the same waste as Le Port. But we can say that Le Tampon and Le Port have the same quantity of wastes (the same position on axis F1). Moreover, the least productive town is La Plaine des Palmistes (PdP) and the most productive is Saint-Denis (location at the opposite on axis F1).

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