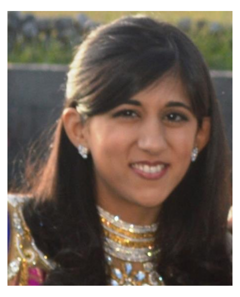

# Water demand profiling as a decision support system for network operation and planning


Aisha Mamade*, Dália Loureiro*, Dídia Covas**, Sérgio T. Coelho*

*National Laboratory for Civil Engineering, aisha@lnec.pt

**Instituto Superior Técnico, Universidade de Lisboa, didia.covas@tecnico.ulisboa.pt


the international water association

## INTRODUCTION

The present paper aims at providing reference values of consumption variables and daily consumption patterns for a variety of scenarios based on rigorous analysis work over 37 different urban and peri-urban DMA (District Metering Areas) in the northern and southern regions of Portugal. A comprehensive methodology that involves collecting, processing, characterizing and profiling demand, infrastructure, billing and socio-demographic data was adopted. This paper focuses on the results obtained on consumption data characterization step. Main results have shown that the analysed regions have distinct socio-demographic, infrastructure and billing make-ups that reveal differences in terms of water consumption trends. In the north region, families are bigger, consume less water per capita comparatively to the south and have a more regular consumption throughout the day. In the south region, population is more active and consume water essentially in the morning and night periods.

## METHODS

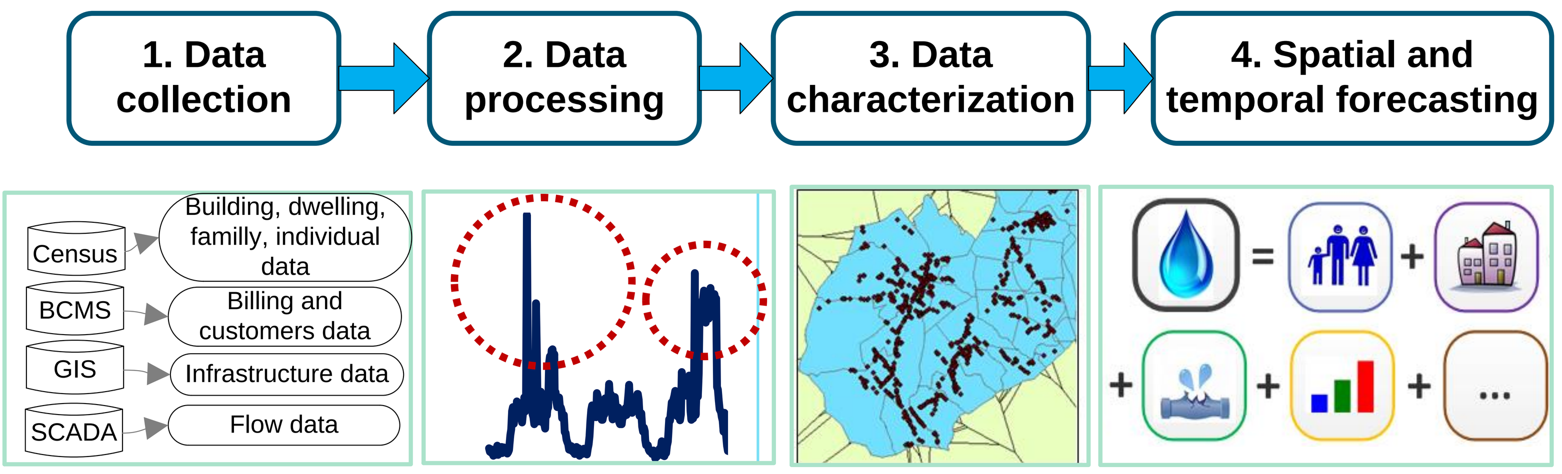


**Figure 1 – General methodology for water demand profiling.**

- ***Data collection***: includes collecting data from different DMA, in terms of infrastructure, billed consumption and customers and flow data. Continuous flow data readings from the utilities' SCADA systems were also collected. Socio-demographic data were downloaded from the last census held in Portugal at the subsection level (2011).
- ***Data processing:*** for flow data, this stage involved data validation, normalization and outlier detection and cleaning. For socio-demographic data, a geoprocessing tool was improved and explored.
- ***Data characterization:*** involves calculating socio-demographic, infrastructure, billing and consumption variables for all the DMA taking into consideration the different seasonal and weekday consumption scenarios. Some variables are listed in Table 1.
- ***Demand profiling:*** involves correlating socio-demographic, billing and infrastructure variables with consumption variables in order to find empiric relations between variables.

**Table 1 – Socio-demographic, billing, infrastructure and consumption variables.**

| Variable | Category | Designation |
|---|---|---|
| Socio-demographic | Building | Building age; Number of floors |
| | Family | Families with adolescents/ elderly; Family size |
| | Individuals | Elderly; University graduates; Economic mobility |
| Infrastructure | Service connection | Service connection density (sc/km); Average service connection pipe length (m) |
| | Pipe | Average diameter (mm); Pipe material |
| Billing | Domestic | Average domestic consumption (l/inh·day) |
| | Non-domestic | Commerce-industry (%); Collective (%); Public (%) |
| Flow | Peaking | Instantaneous peaking factor (-); Daily peaking factor(-) |
| | Average | Average daily consumption (l/inh·day) |
| | Night | Minimum night consumption period (l/inh·hour) |
| | Minimum | Minimum consumption value (l/service connection·day) |

## RESULTS

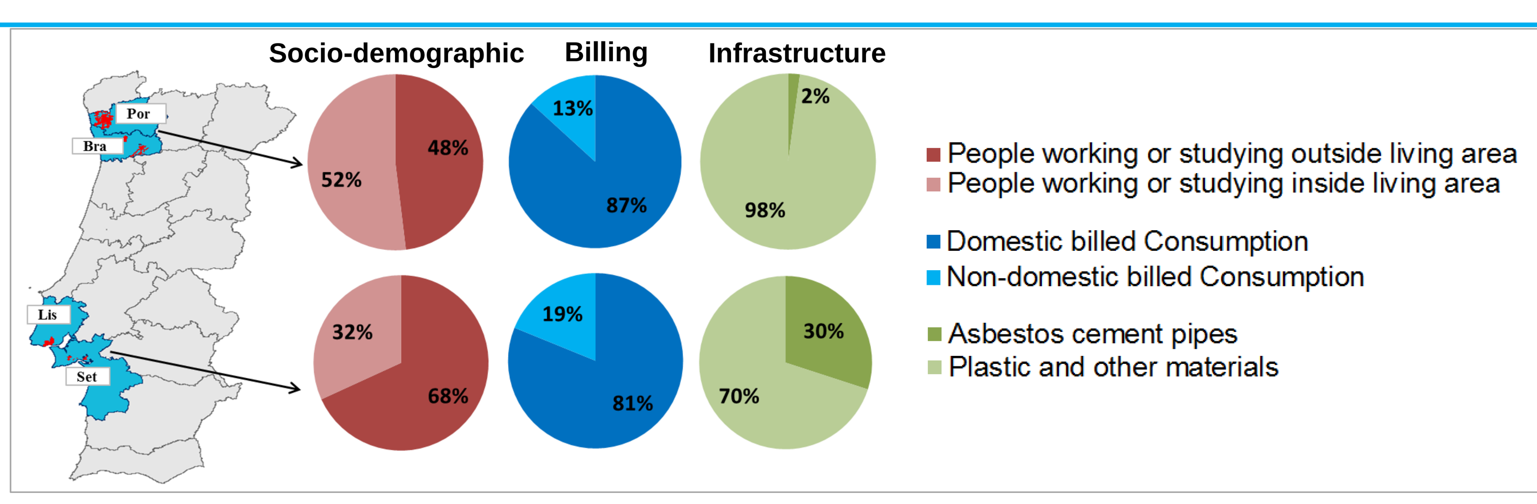


**Figure 2 General socio-demographic, billing and infrastructure characterization.**

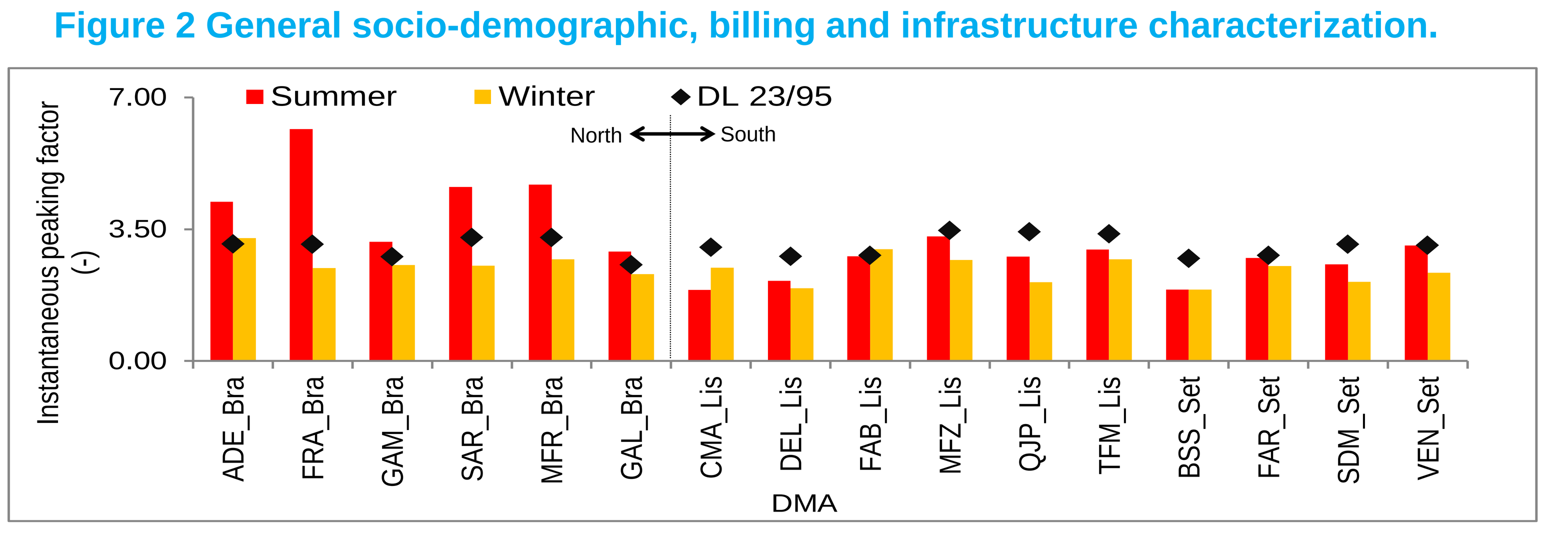


**Figure 3 – Instantaneous peaking factors and comparison with DL23/95.**

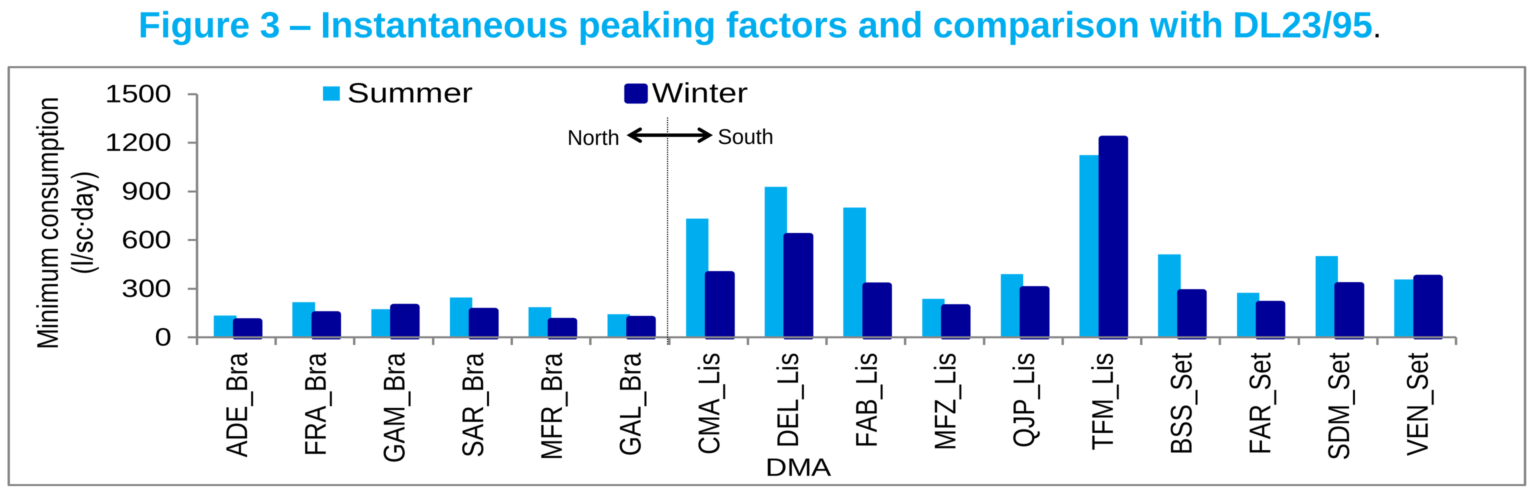


**Figure 4 – Minimum night consumption (0:00-6:00)**

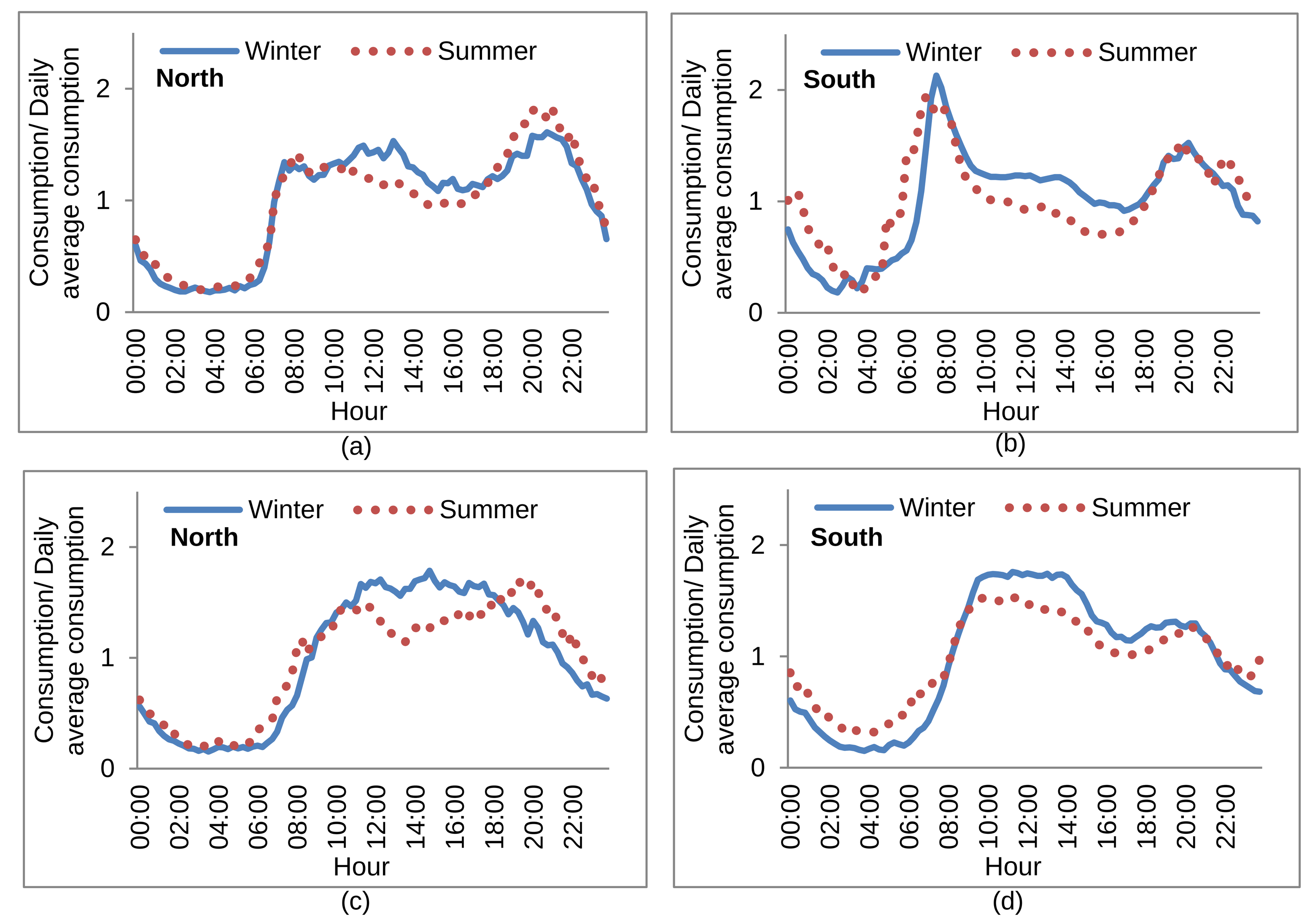


**Figure 5 – Daily consumption patterns for working days: North region (a); South region (b); and for saturdays: North region (c) and South region (d)**

## DISCUSSION

**Peaking factors**

- Instantaneous peaking factors were calculated and compared with the expression formulated in the Portuguese Decree-Law nº 23/95, Article n. º 19 (abbreviated herein as DL 23/95). Peaking factors in the winter are very similar for both regions (with an average 2.5) and in general lower than the reference value.
- In the summer, this variable can be two times higher for the north region, whereas the south has only a little increase. This difference can be associated to the lower number of inhabitants in the north region. In higher density regions such as the south, the maximum consumptions have a lower impact in terms of peaking values. Hence, south peaking factors calculated for both seasons are typically lower than the ones provided by the DL 23/95, thereby suggesting over-designed mains.

**Average daily consumption**

- In terms of average daily consumption per inhabitant, the north region shows an average consumption per inhabitant of 70 l/inh.day, whereas in the south this variable is considerably higher with an average of 200 l/inh·day.

**Minimum consumption**

- Another variable subject to analysis was minimum night consumption in the winter between midnight and early morning (6:00), the period where real losses are typically higher. Figure 4 shows that in the north, this variable is quite regular for all DMA and for both seasons, with an average of 134 l/sc.day.
- In opposition, the south region is characterised by a higher variability in terms of DMA and seasons. Previous studies, particularly Lambert et al. (2000), refer that a system with a good performance and average operating pressures and density has averagely 100 l/sc.day of real losses. In the south, many DMA exceed this reference value, suggesting that there might be consumers with high night consumption that should be metered individually. The fact that DMA in the south have a higher proportion of AC pipes can be also important to explain a higher losses.

**Daily consumption patterns**

- For working days, consumption patterns in Figure 5 show that in the north region, there is a steady consumption of 1.4 during the day, with a night peak of 1.7. In the south region where 68% of the population works or studies outside their municipalities, there is a morning peak of 2.1, a considerable consumption decrease during the day and a night peak of 1.5.
- In what concerns differences between the winter and summer, these patterns show that behaviours are quite similar for both seasons.
- For Saturdays, the north region shows different behaviours for winter and summer: in the winter consumption is higher during the day while in the summer it has two peaks, similarly to working days.
- In the south, summer and winter patterns are similar. In the winter, there is a steady consumption in the morning of 1.7 and another at night, of 1.2. In the summer, night consumption increases while daily consumption decreases.

## CONCLUSIONS

This study has shown regional socio-demographic, billing and infrastructure differences that have direct impact on water consumption profiles.

In the north region, families are larger, consume less water per capita and have a more regular consumption throughout the day.

In the south region, population is more active and consume water essentially in the morning and night periods. These data provide a wider understanding of clients and their behaviours, serving as direct decision support tool for utilities to operate, manage and plan their networks more efficiently.


**References**:

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