ASSESSING VARIABILITY OF PERSONAL EXPOSURE TO AIR POLLUTION IN URBAN MOBILITY USING LOW-COST SENSORS: A STUDY CASE IN BARRANQUILLA METROPOLITAN REGION, COLOMBIA

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WHY IS IMPORTANT?

Many studies on personal exposure to air pollution in urban mobility focus on the differences between travel modes, types of pollutants, and route characteristics.

However, **evidence of variability in personal exposure in these studies usually divests exposed individuals from their social identity**.

By contrast, research about transport and mobility justice, concerned with the links between inequality, social exclusion, and mobility, has brought forward rich evidence about the **variability of experiences and outcomes depending on the socioeconomic and spatial conditions of the person travelling.**

Barranquilla have started to conduct analyses of the distribution and spatial variability of different air pollutants in its metropolitan area.

However, it has not reached the level of detail to assess the personal exposure of its inhabitants. *Gap: assess personal exposure.

WHY THREE WHEELERS?

- Widespread presence- estimated fleet of 24,000 in Colombia

- Rapid unregulated growth

- Benefits: affordable first and last mile connection, avoiding growth of private motor vehicles, low pedestrian fatality, available technological innovations to reduce emissions and predominantly used by women, students and day-to-day workers

OBJECTIVE

- As part of an interdisciplinary collaboration of experts on urban policy, air quality and transport studies the aim of this study is to bring forward evidence that will help **identify the links between the variability in personal exposure to outdoor pollution, mobility practices and socioeconomic and spatial characteristics of urban inhabitants.**

- **To analyse the links between personal exposure to air pollution and mobility practices we designed a pilot study to**
  - (1) measure the variability of $PM_{2.5}$ and equivalent Black Carbon (eBC), and noise exposure and
  - (2) compare concentrations across routes, modes and times.

METHODOLOGY

- $PM_{2.5}$, eBC and noise measurements are in real-time using two HabitatMap AirBeam devices (low-cost sensors), a portable aethalometer (MicroAeth AE51) and a 3M sonometer, respectively.
- Moto, taxi, bus and car (public or private)- pedestrian future
- The variation of exposure constitutes evidence about transport related inequalities. (future) .

- PM2.5 sensor. AirBeam 3 from Habitat Map.

Sampling frequency: 1 min.
Concentrations in µg/m³.

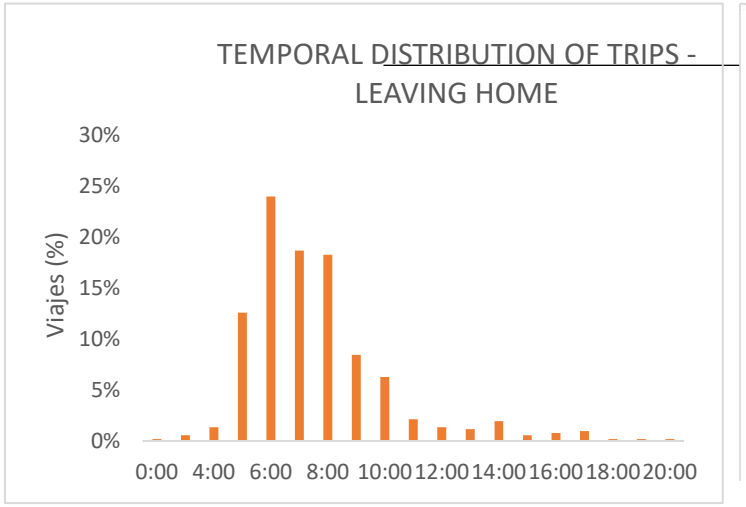
- Black Carbon sensor. MicroAeth AE51 Personal Exposure Monitor.

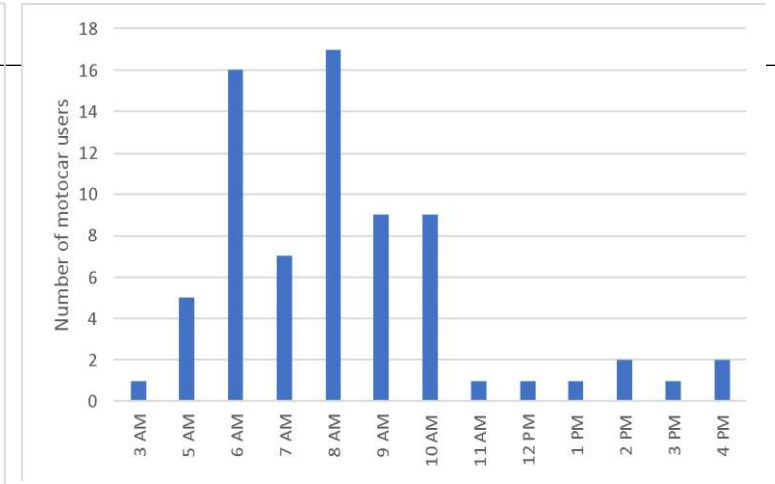
Sampling frequency: 30 s
flow rate of 100 l/min
Concentrations in ng/m³.

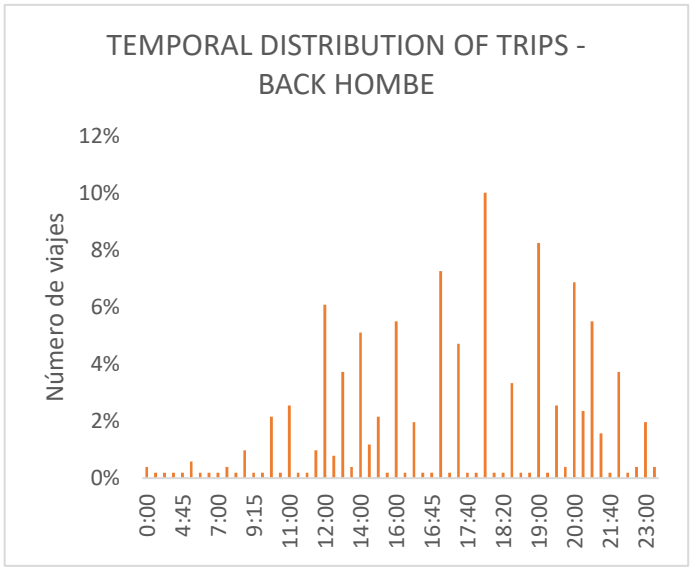
- Series SoundPro SE/DL Sonómetro

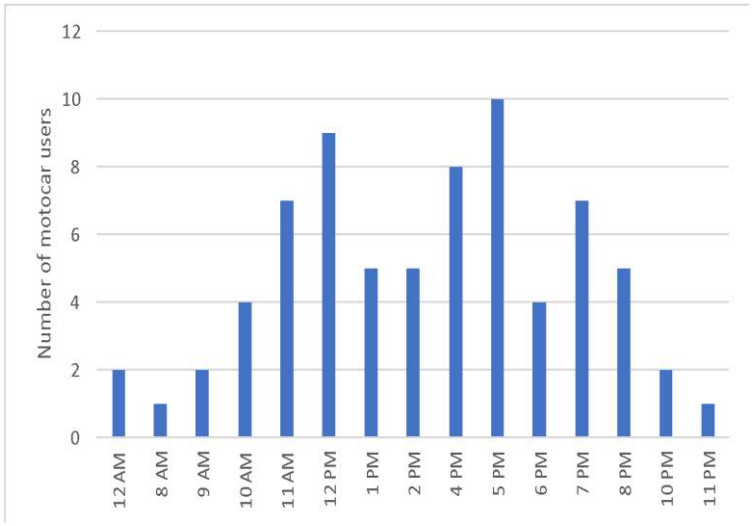
Sampling frequency: 1 min.
Concentrations in dB.

METHODOLOGY









- The measurements will be made on weekdays at peak hours(rush) from 07h-10h; off-peak from 13h-16h.
- Measurements should be random to avoid any systematic differences due to days of the week and monitoring time.
- Night peak times will not be included for equipment safety reasons

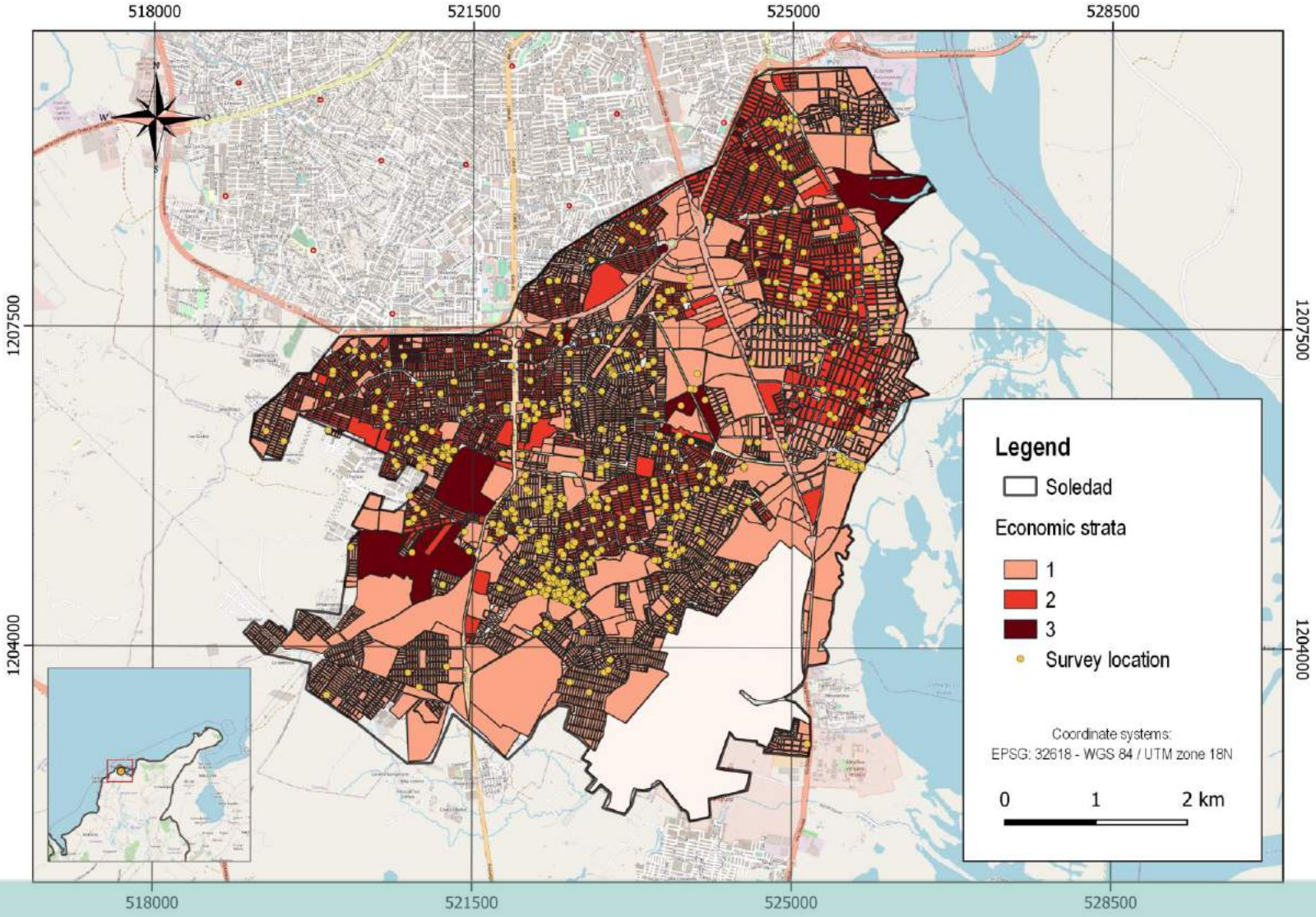
Start & return times do not follow rush hours

Método de muestreo

RESULTS

- **Most users of all taxi-like modes are women, three-wheelers being the one where the difference is the highest (80% are women).**
- **33% of people with a disability uses MTW**
- Around 19% users are >60 or >25, 66% are 25 – 59
- 20% of respondents with primary ed. (25% bus). 73% of uni & postgrad ed. use private modes.
- **37% of people who have going to work as their main travel purpose, use MTW**
- ¼ of the reasons for using MTW are going to work (self-employed, employed with a written contract and without a contract).
- Out of the few respondents that chose recreational activities as their destination 40% were use MTW.
- **MTWs cover the demand for a practical mobility option that is close by for users carrying packages after doing their shopping.**
- Most MTW users have enough income to cover basic needs
- 25% of people without enough income to cover basic needs is a MTW user (28% bus)
- Only 4% users chose cost as the reason to use MTW

MOBILITY SURVEYS

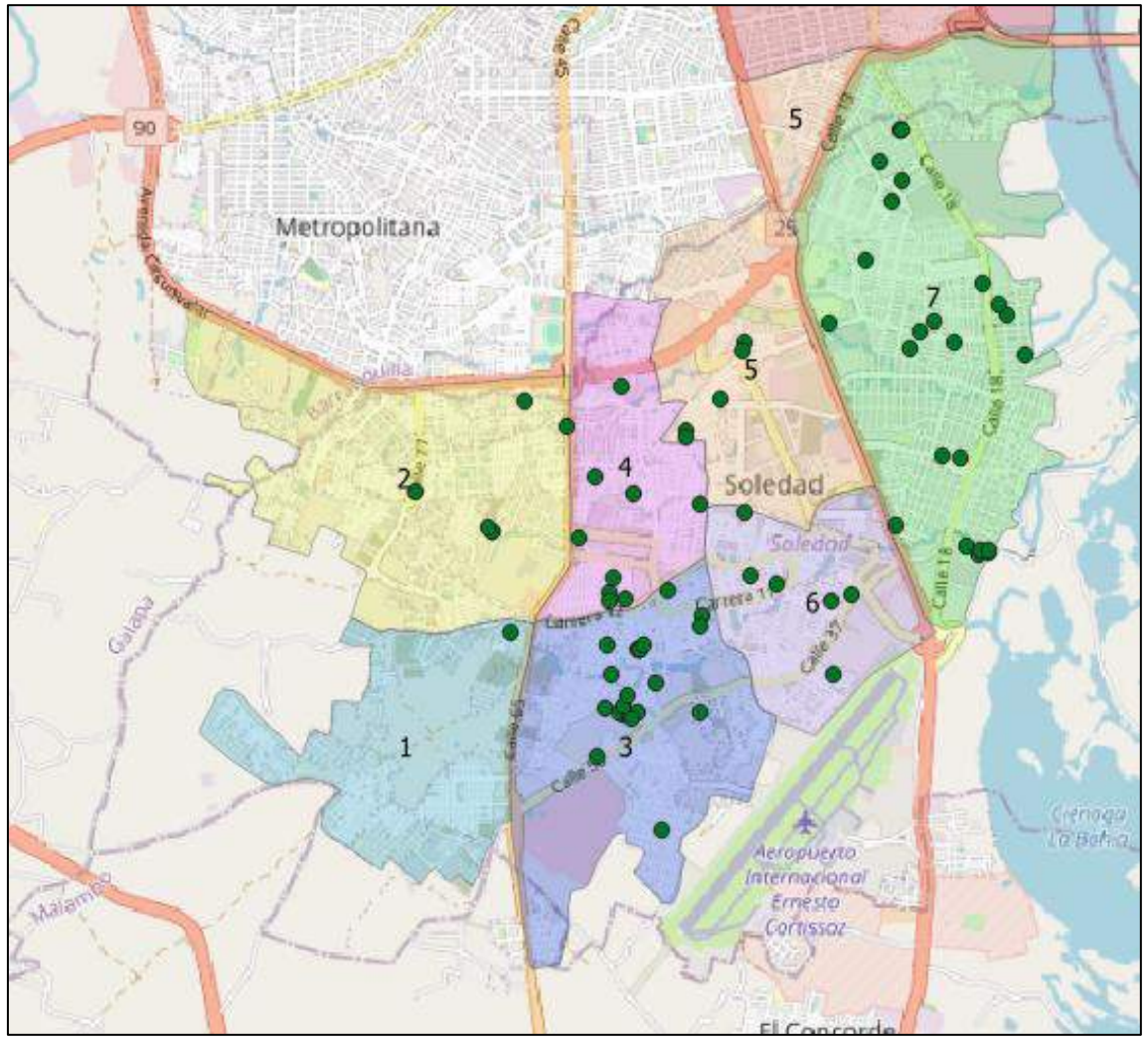


- Georreferenciación de pares Origen-Destino (O-D): GPS, Google Maps.

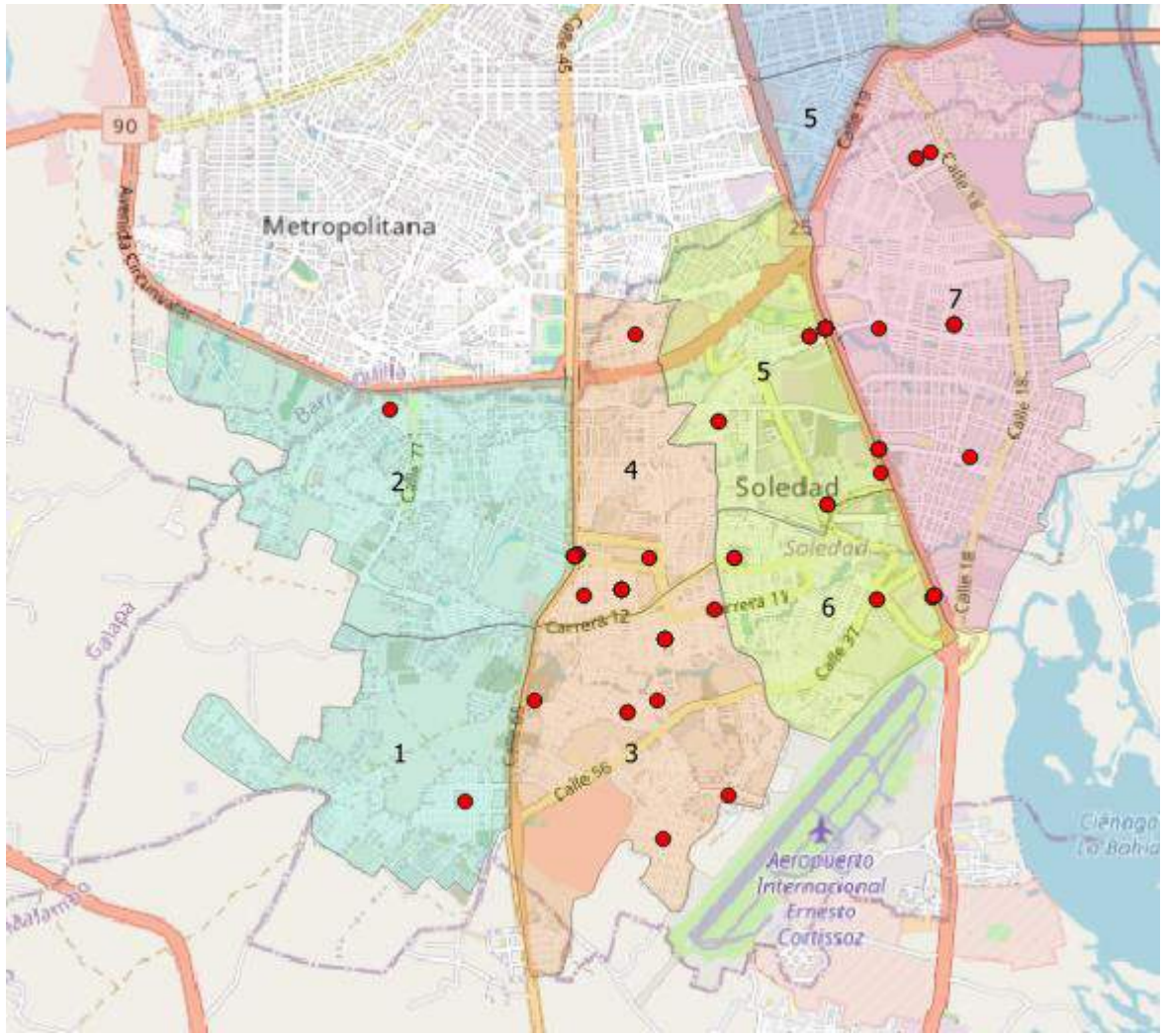
Consolidación y análisis de la base de datos-caracterización socioeconómica

Luego pares O-D

THREE WHEELERS Origin



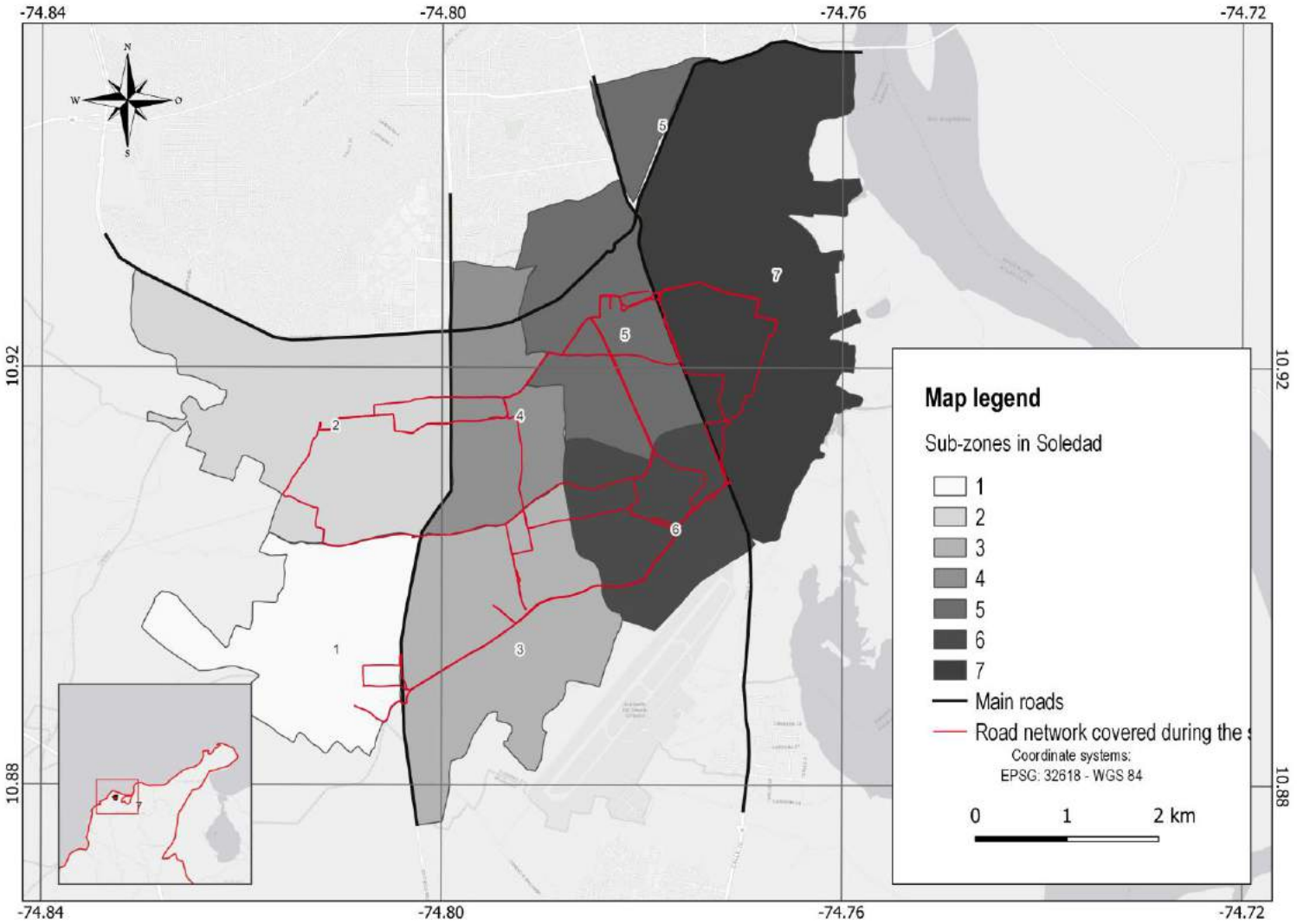
Destination



Zonificación de Soledad -

Con base en los viajes de las encuestas y las vías principales se hizo una zonificación de Soledad y se supone que los viajes representativos son entre los centroides de cada zona.

RESULTS



Road network covered during sampling

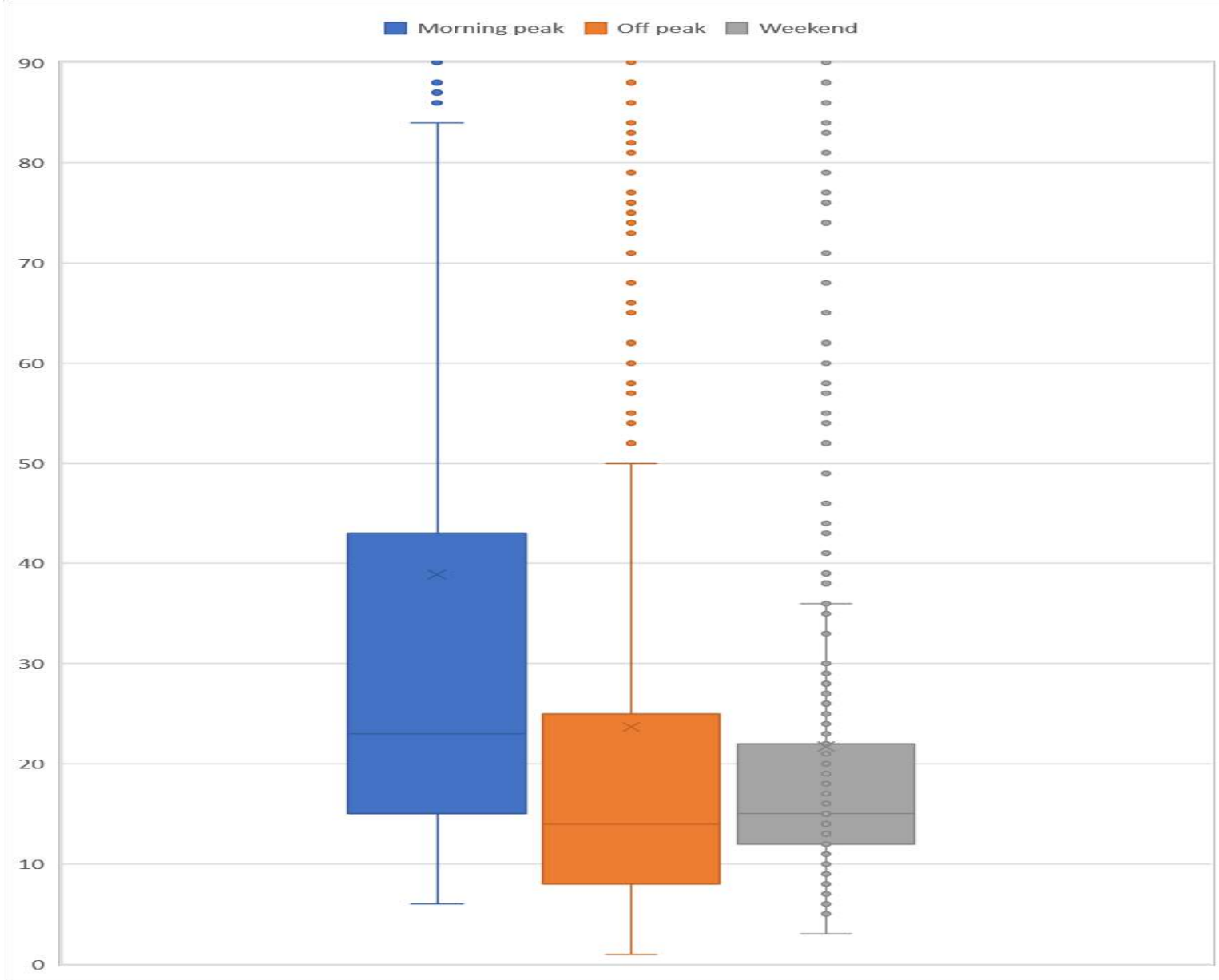
RESULTS

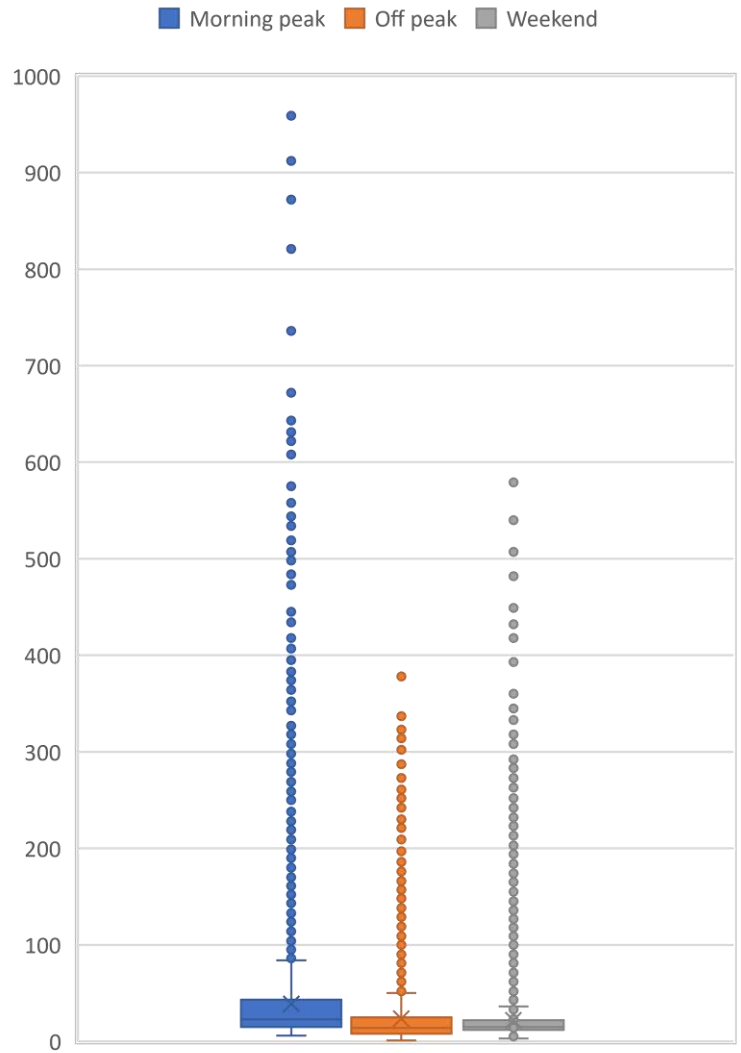
- High $PM_{2.5}$ levels with the highest value of **959 µg·m^{-3}** in the morning peak
- Significant variations depending on location and congestion. Lower during the weekends
- Values are higher than WHO recommended values (15 µg·m^{-3} for PM2.5) and Colombian legislation (37 µg·m^{-3}).

Mean (µg·m^{-3})	Rush-hour peak	Off-peak	Weekend
$PM_{2.5}$	38.9	23.6	21.7
eBC	12.28	7.78	4.29
Noise	78.84	81.39	96.6

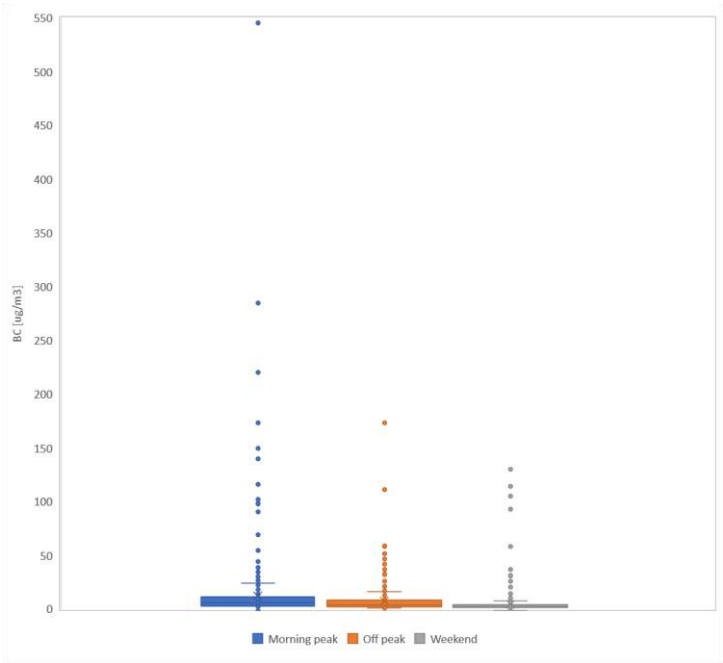
Noise –
High > 65 dB
Low < 50 dB

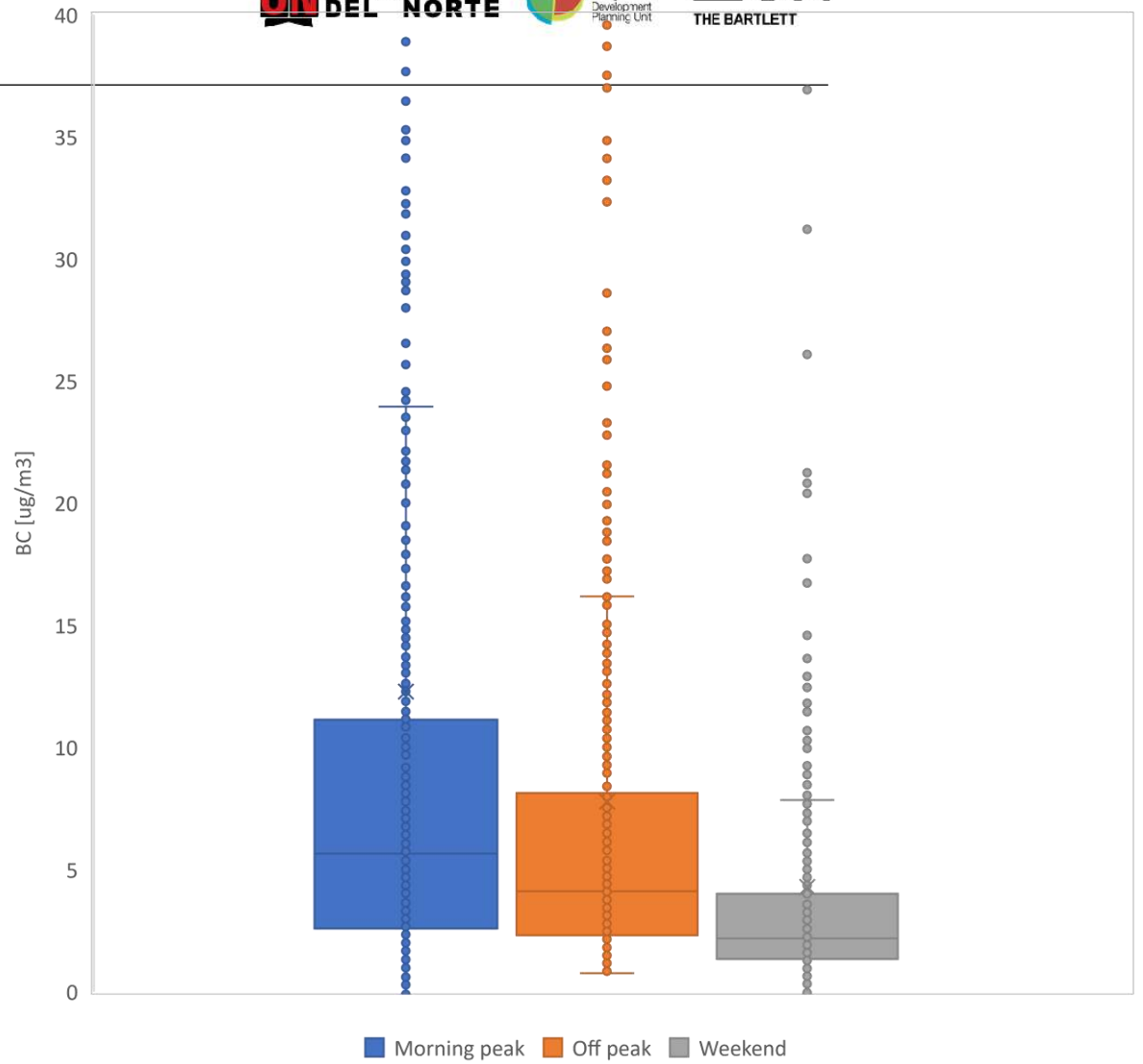
Particulate matter 2.5 μm – PM 2.5



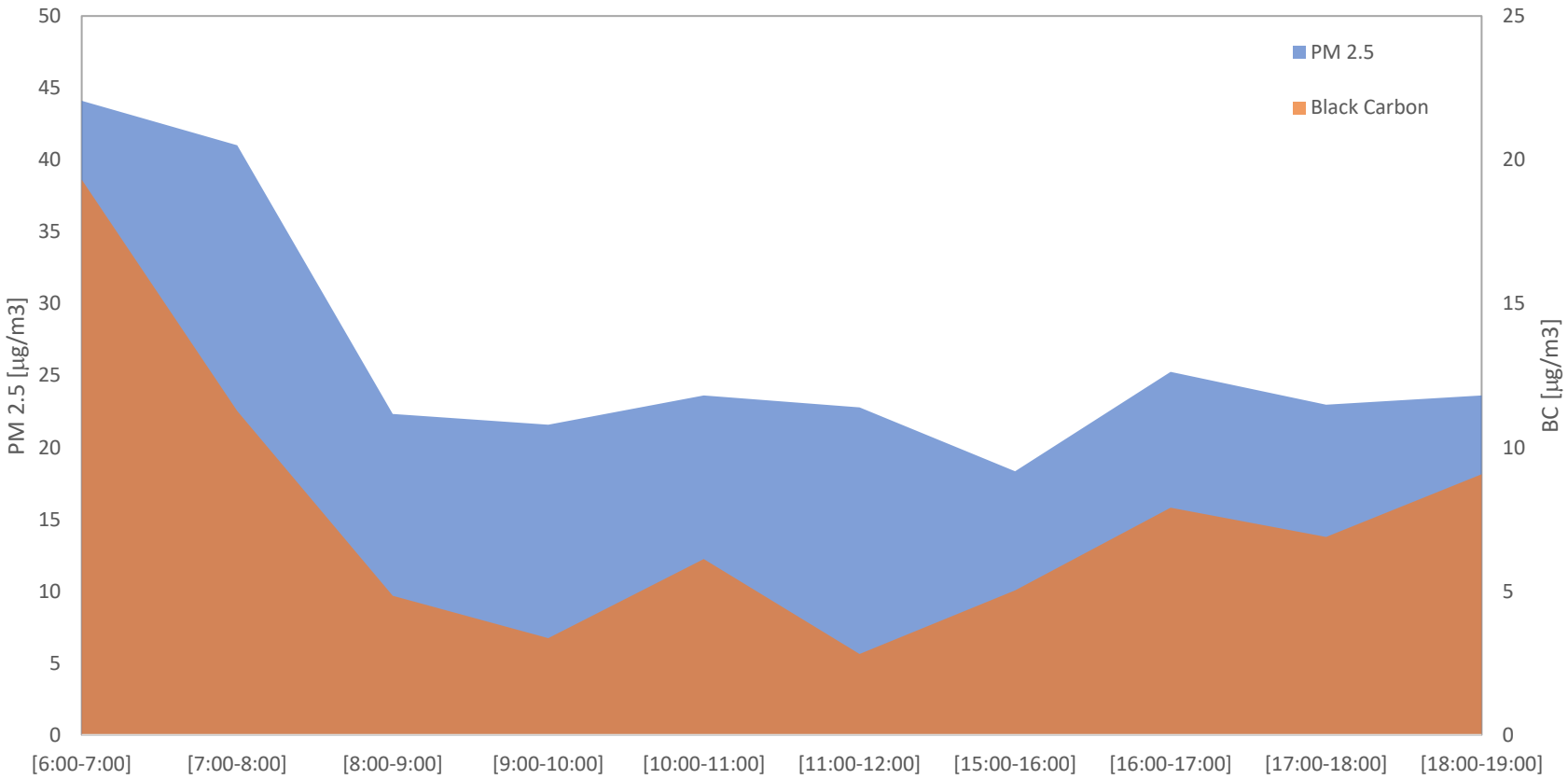


Black Carbon - BC



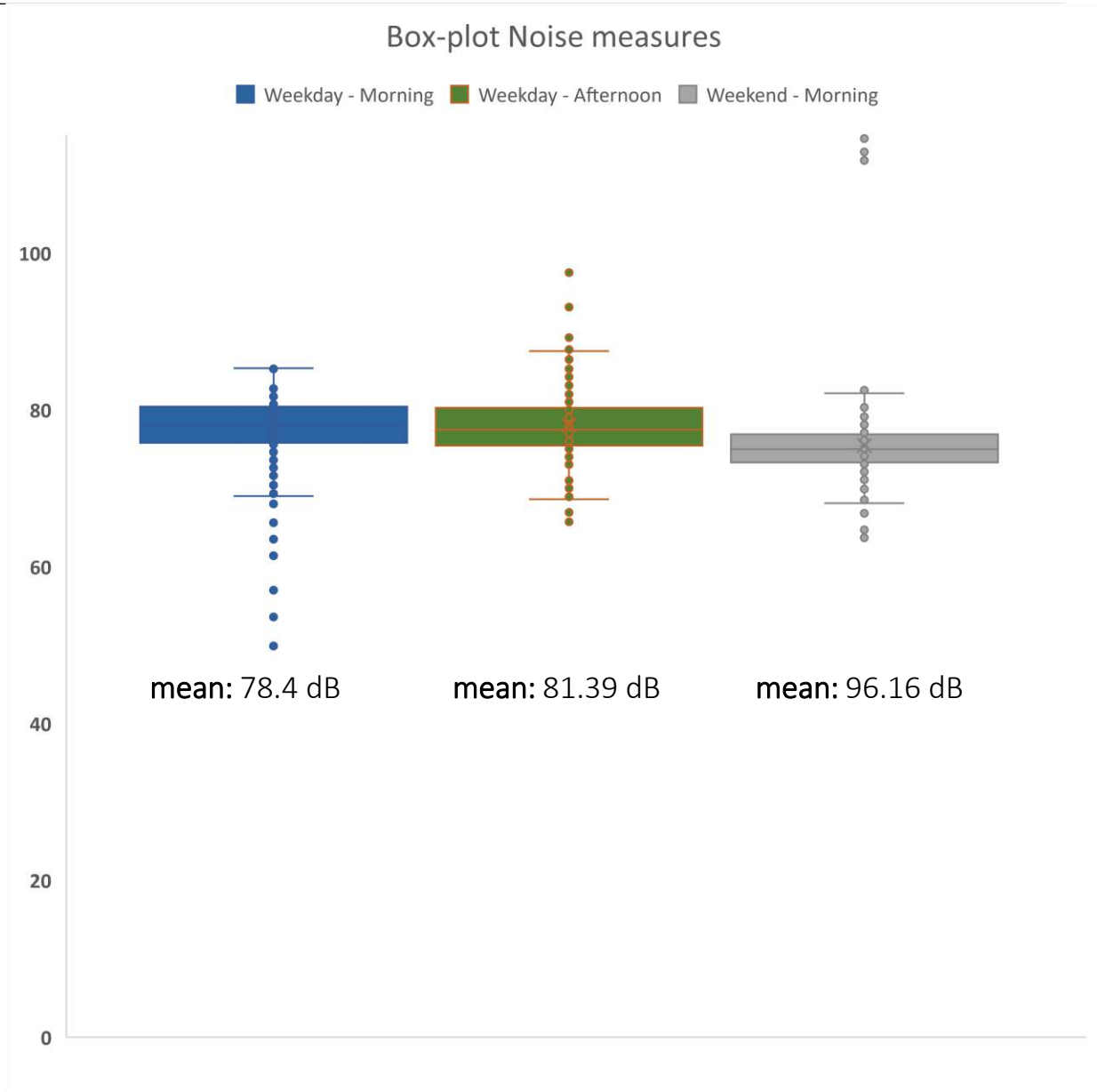


PM 2.5 y BC: Hourly average



Similar pattern
Same range hours

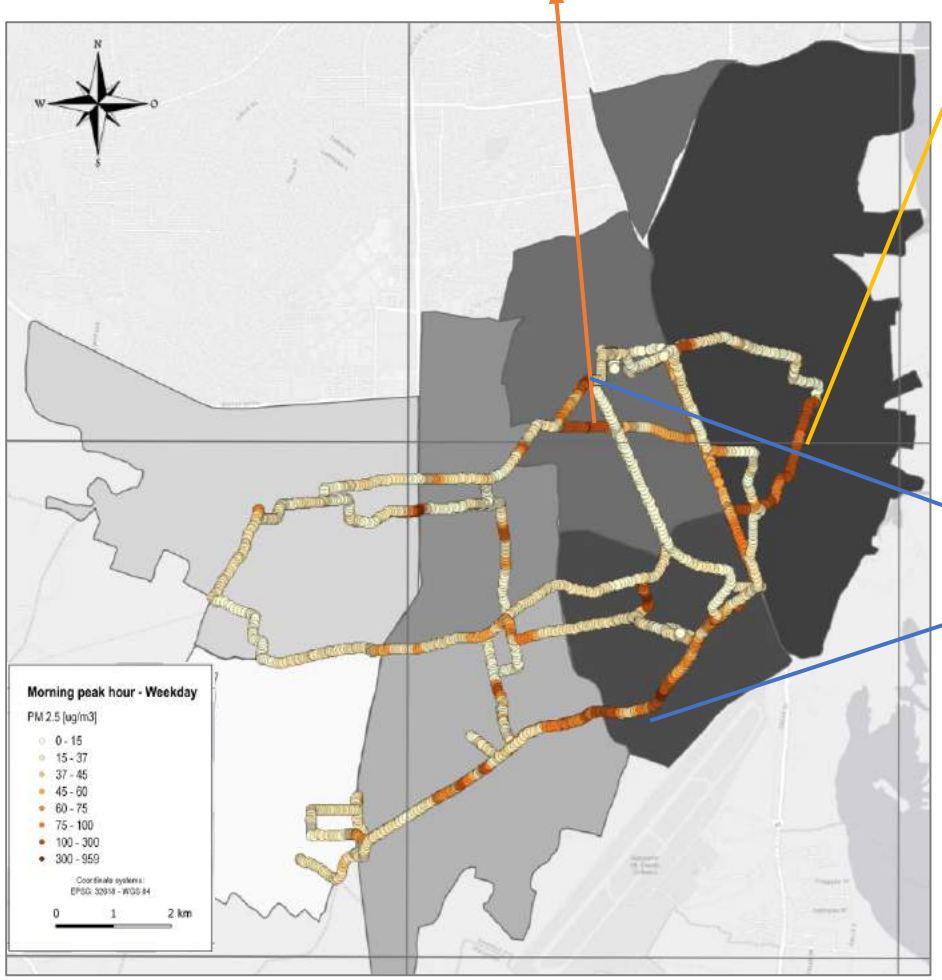
Noise measures

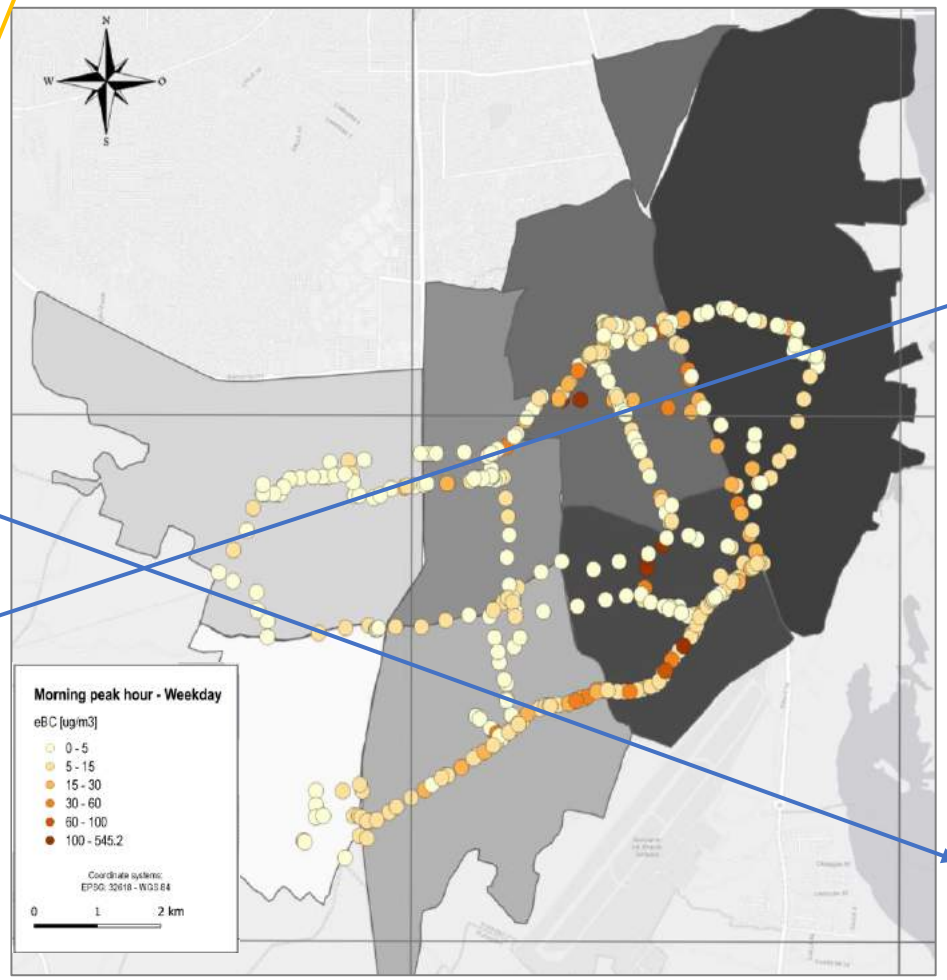


Morning peak - Spatial trend

Vía sin pavimentar

Posibles fuentes industriales de PM2.5 mas no de BC





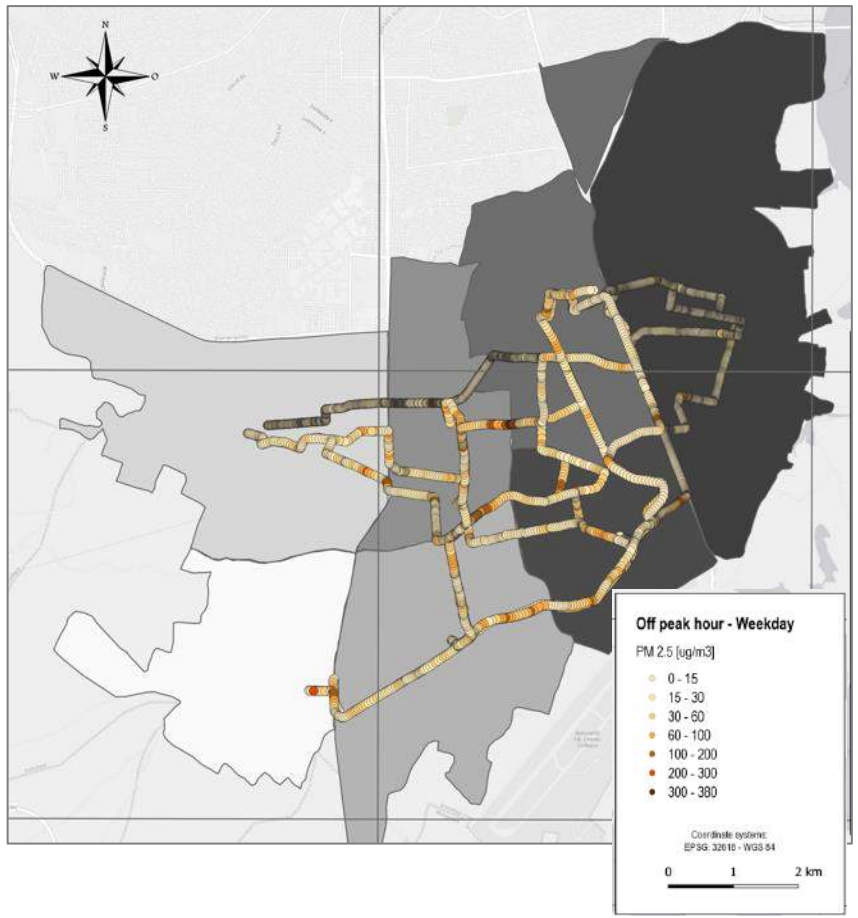
Mayores concentraciones en la vía a Granabastos en zonas de alto movimiento de tráfico vehicular como camiones y buses. Nevadas.

En intersecciones con otras vías

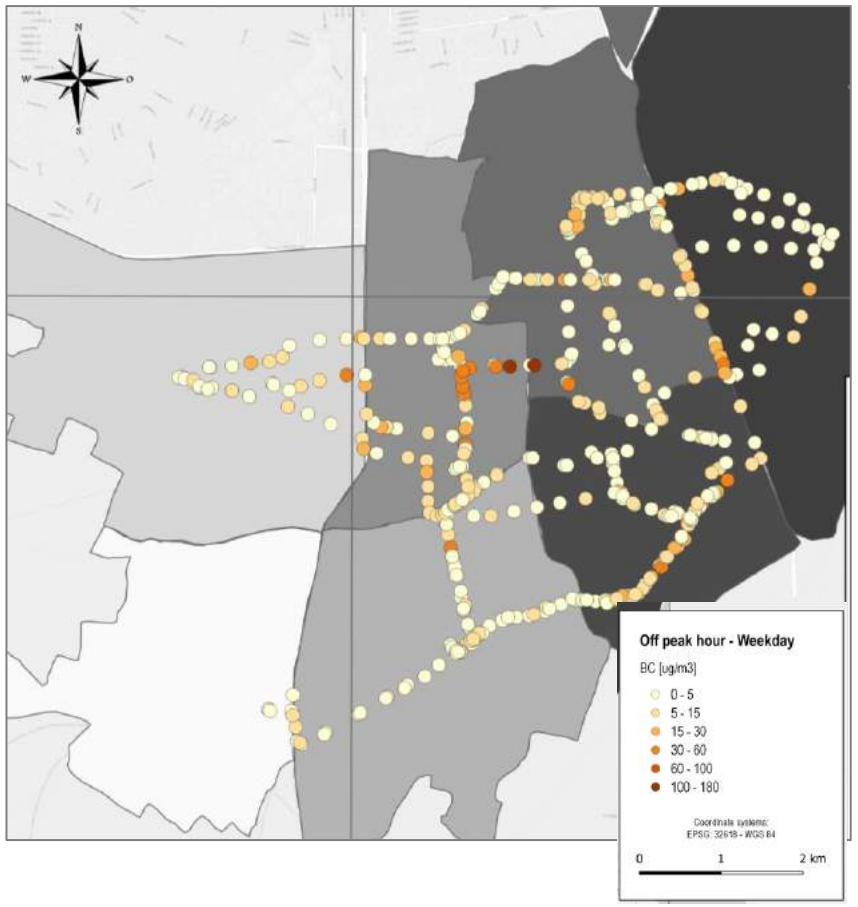
PM 2.5

BC

Off peak - Spatial trend

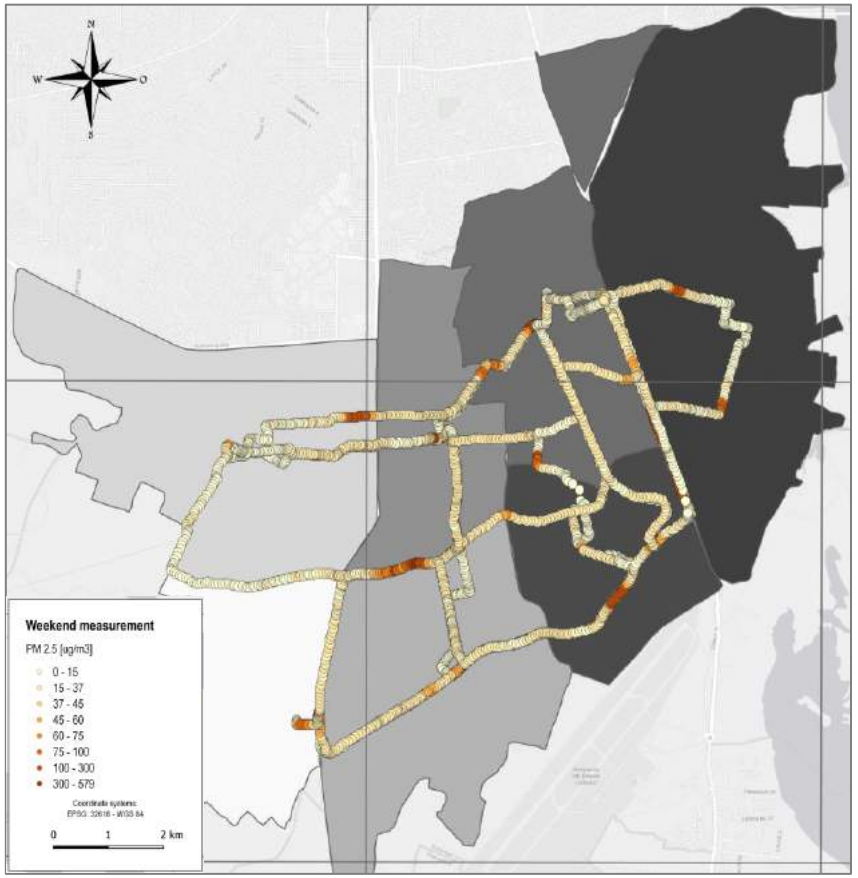


PM 2.5

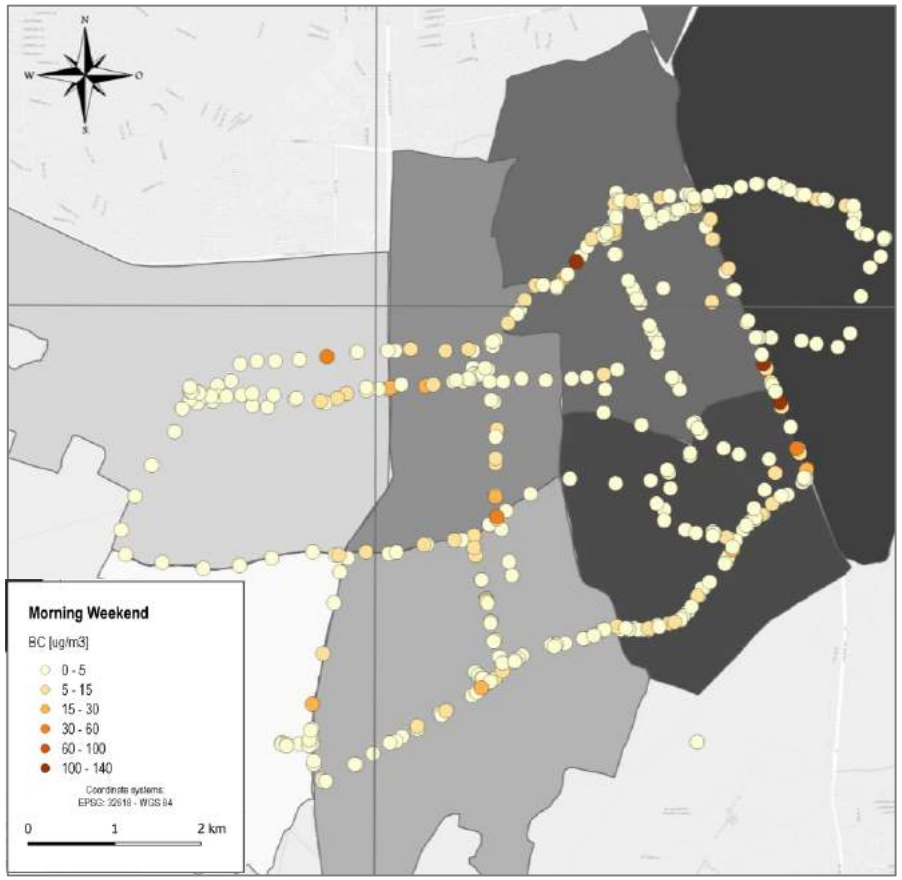


B
C

Weekend- Spatial trend



PM 2.5



B
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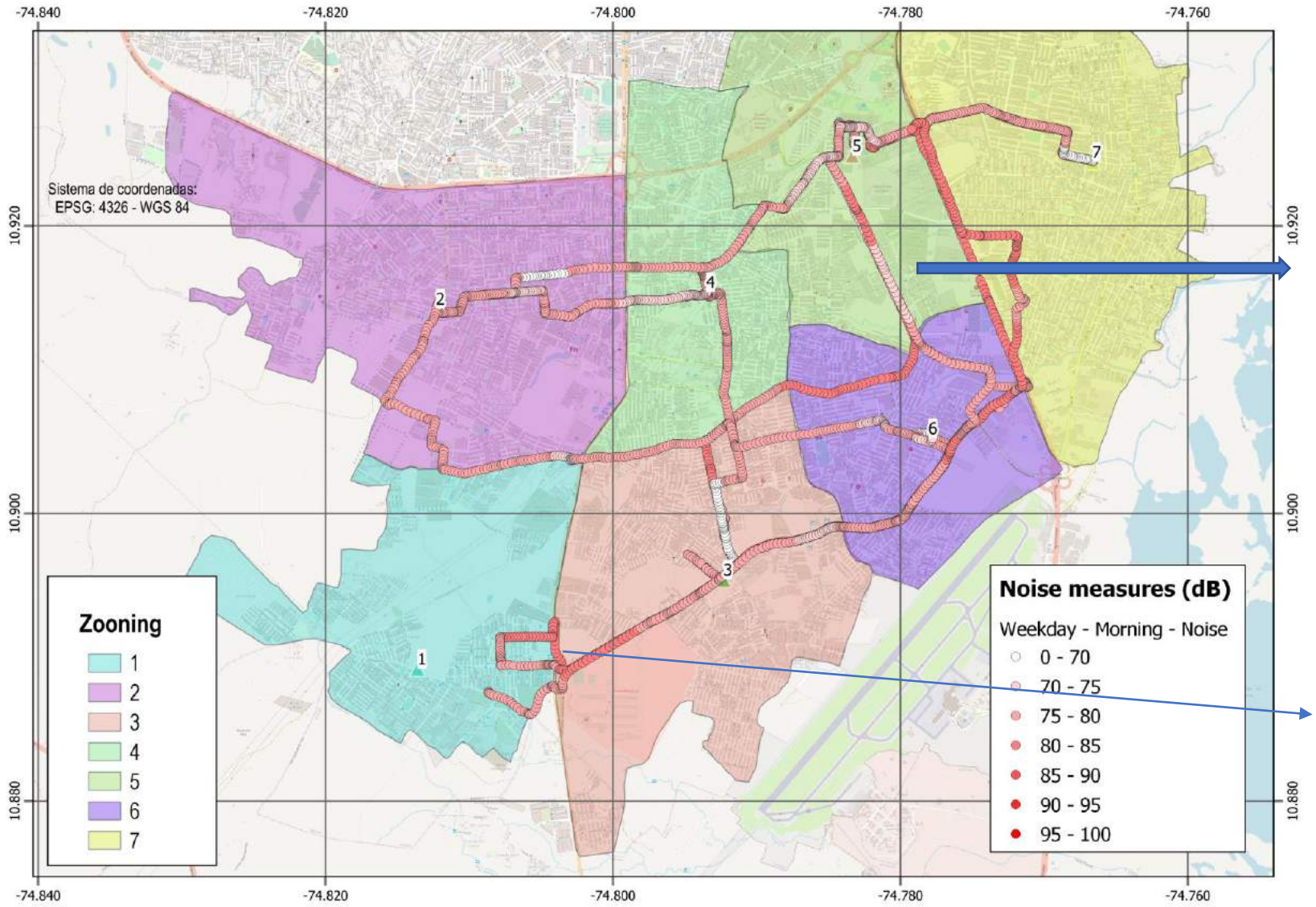
Menores concentraciones que días de semana

Morning rush hour – Weekday: Noise

Ruido elevado en interesecciones y pitos de carros

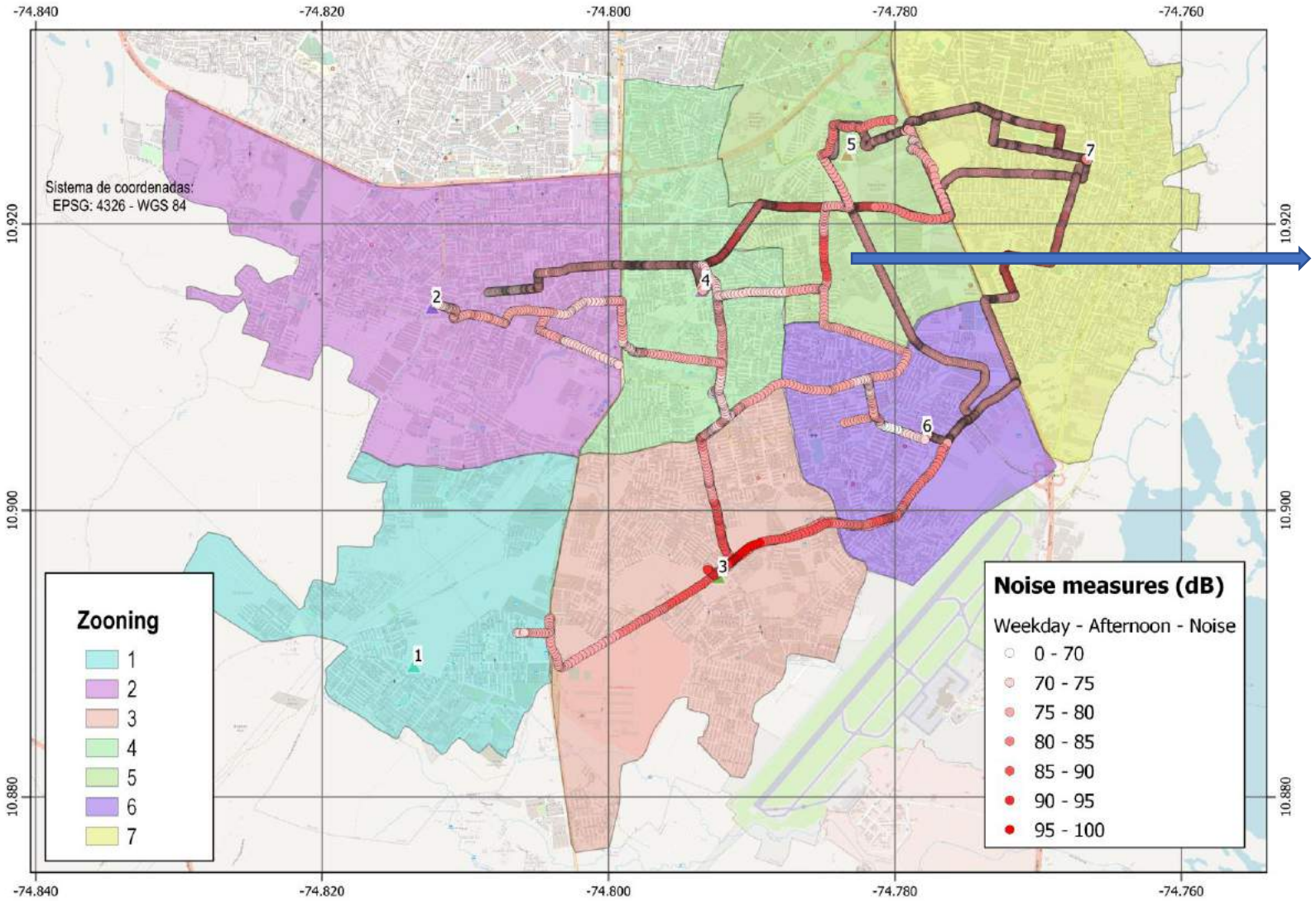
Máximo 114,6 dB Fin de semana



Ruido elevado en la calle 30: Camiones y vehículos pesados-buses intermunicipales

Ruido elevado en la calle murillo- similar a la situación de la calle 30

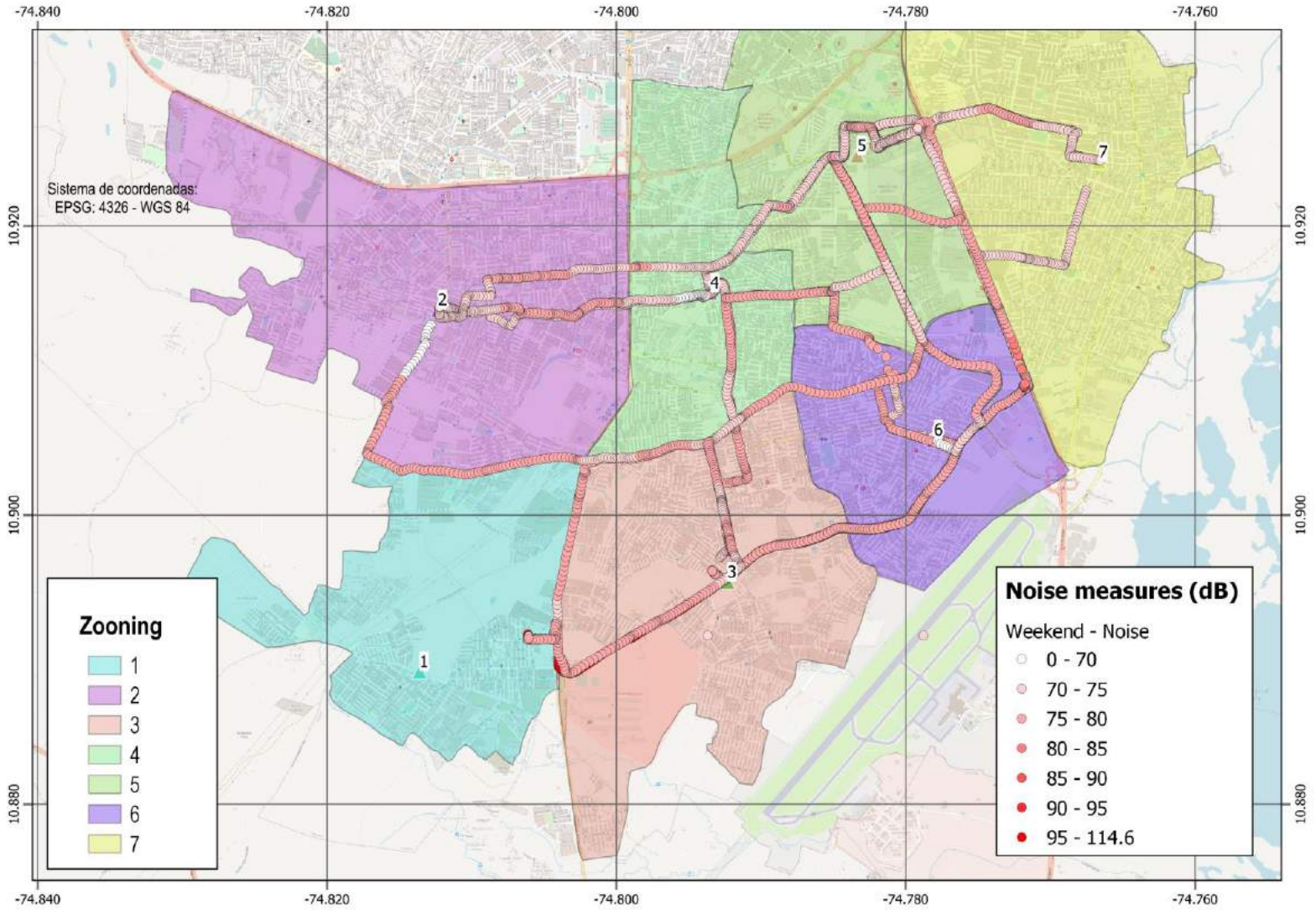
Afternoon off-peak – Weekday: Noise



Vía pavimentada deteriorada

Morning off-peak – Weekend: Noise

Ruido elevado por la presencia de “picós”



CONCLUSIONS

- Exposure to $PM_{2.5}$ and eBC of conmuters and users of the three-wheeler vehicles can affect their quality of life and health in the long term.
- This study can serve as an analysis of environmental justice that can determine the needs of improving the use of these vehicles or fuel changes.
- Insights from our research can serve as the basis for participatory processes seeking to chart a **roadmap for regulation and governance**.
- One of the main contributions was **digitalising local knowledge** and make it more accessible for stakeholders outside of the provision of traditional transport using WMTs.

CONCLUSIONS

- **MTW contribute to accessibility** reducing geographical, temporal and facilities forms of exclusion but is **not disrupting exclusion based on economic affordability.**

- While MTW contribute to road safety of pedestrians, MTW **contribution to reduce exclusion based on safety is not clear**.

- The contribution to environmental sustainability in the two case studies highlights the **potential of these vehicles to less polluting mobilit**y and the burden of their users and drivers of **exposure to the emissions of other vehicles**.

- Findings can also serve as a first step in the **consolidation of an already growing research agenda on popular -rather than informal- transport** in the region.

CASAP IX

CONGRESO COLOMBIANO Y CONFERENCIA INTERNACIONAL

DE CALIDAD DE AIRE, CAMBIO CLIMÁTICO Y SALUD PÚBLICA

Thank you

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