Concept Note: Assessing Potential Health Equity Implications of Industrial Emission Reductions at Ternium Brazil in Santa Cruz

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GLOSSARY

Term	Definition
PA	Planning Area
BAU	Business as Usual
BRT	Bus Rapid Transit
CO	Carbon Monoxide
CONAMA	National Environmental Council
GHG	Greenhouse Gases
HIA	Health Impact Assessment
ICD-10	International Classification of Diseases, 10th Revision

IGVOL	Overall Traffic Volume Index
INEA	Rio de Janeiro State Environmental Institute
IQAR	Air Quality Index
NO_2	Nitrogen Dioxide
O_3	Ozone
PM2.5	Fine Particulate Matter with aerodynamic diameter of 2.5 micrometers or less
PM10	Particulate Matter with aerodynamic diameter of 10 micrometers or less
SMAC	Municipal Department of Environment and Climate
SMS-Rio	Rio de Janeiro Municipal Health Department
WHO	World Health Organization

1. Purpose and scope of the concept note

The objective of this concept note is to bring some evidence to argue that the presence of a major industrial facility in a socially vulnerable territory requires a dedicated, transparent and scenario-based assessment of air pollutant emissions and potential health benefits from emission reductions.

In this context, this document brings a scenario-based approach in Santa Cruz and surrounding areas to examine how verified or modelled reductions in industrial air pollutant emissions related to Ternium Brazil could affect ambient air quality, population exposure and potential health risks.

This does not imply attributing observed health outcomes to the company or to a single emission source. Rather, it recognizes that the presence of a major industrial facility in a socially vulnerable territory requires a dedicated, transparent and scenario-based assessment of air pollutant emissions, ambient concentrations, population exposure and potential health benefits from emission reductions.

In this sense, this concept discusses whether Ternium Brazil should be incorporated into the Breathe Rio analytical framework as a specific industrial-emissions module for Santa Cruz. The Ternium Brazil case can be a methodological opportunity for Breath Rio to define how an industrial source can be incorporated into an equity-oriented air quality and health framework.

Santa Cruz, located in Planning Area 5 (PA5), is used as the territorial and population context for this analysis. The area is relevant because it combines industrial and logistics activities, socioeconomic vulnerability, a large Black and Brown population, a comparatively young demographic profile, dependence on public transport, long-distance commuting patterns and relevant health indicators (RIO DE JANEIRO CITY HALL, 2025). These characteristics make Santa Cruz an important case for assessing how industrial air pollution, mobility and health inequities may overlap.

FIGURE 1 - TERNIUM LOCATION IN RIO DE JANEIRO MUNICIPALITY

The central methodological question is:

If verified reductions in air pollutant emissions are achieved through the implementation, upgrading, maintenance or effective operation of filtration and emission-control systems at Ternium Brazil, what potential reductions in pollutant concentrations and population exposure could be expected, and how might these reductions translate into potential health benefits under established concentration-response functions?

The maps and indicators presented in this note should be interpreted as territorial screening tools. They help identify where vulnerability, potential exposure and observed health burdens overlap, but they do not establish direct causality between a specific industrial source and health outcomes. Establishing source-specific causality would require detailed emissions data, atmospheric dispersion modelling, exposure assessment, epidemiological modelling and control for confounding factors.

2. Why Ternium Brazil requires a specific industrial-emissions module

Ternium Brazil should be treated as a specific analytical module because industrial emissions differ from transport emissions in terms of source characteristics, pollutant profile, dispersion patterns, monitoring requirements and mitigation technologies (CREA, 2024; PACS, 2022).

The broader Breathe Rio analysis focuses primarily on transport-related interventions, including bus fleet electrification, zero-fare public transport and modal shift. These scenarios are highly relevant for Rio de Janeiro because road transport is a major contributor to urban emissions and because transport exposure is unevenly distributed across the city. However, the Santa Cruz case requires an additional industrial lens.

Industrial sources such as steel production may involve emissions of particulate matter, nitrogen oxides, sulfur dioxide and other pollutants associated with combustion, raw material handling, industrial processes, road dust, stockpiles, internal logistics and fugitive emissions. These emissions may affect air quality at different spatial and temporal scales depending on stack characteristics, operating conditions, meteorology, emission-control systems and local dispersion patterns.

For this reason, the Ternium Brazil module should be structured around a source-to-risk pathway:

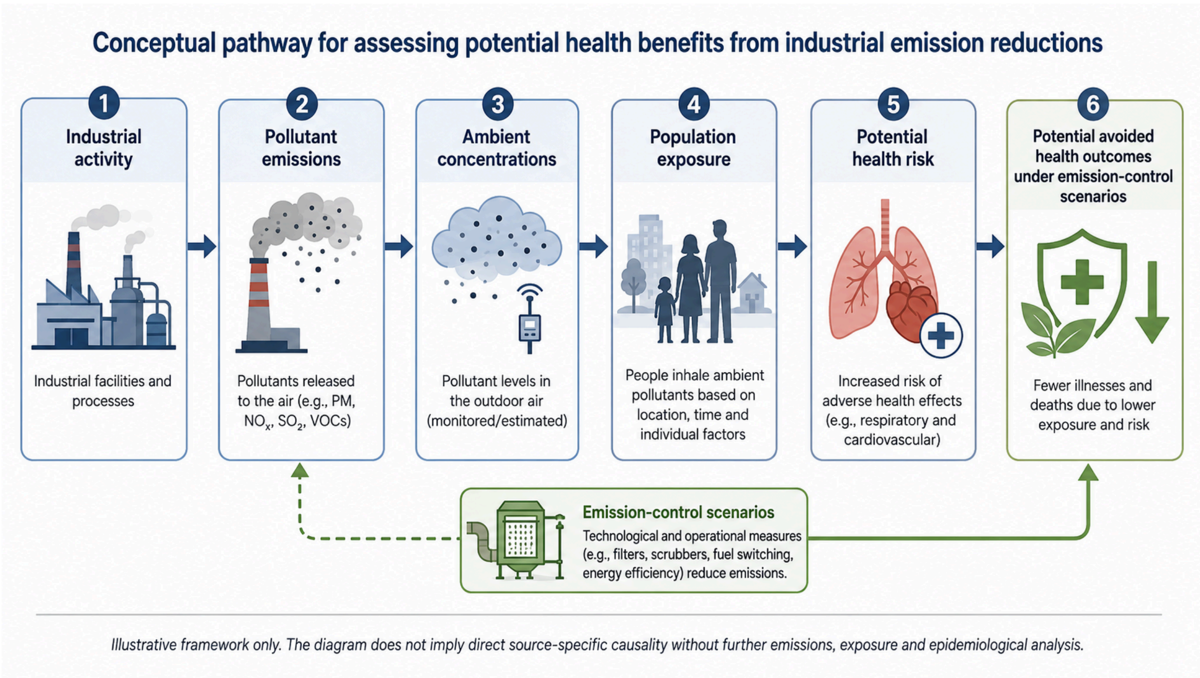

FIGURE 2: CONCEPTUAL PATHWAY FOR ASSESSING POTENTIAL HEALTH BENEFITS FROM INDUSTRIAL EMISSIONS REDUCTIONS

This pathway allows the analysis to assess the potential health relevance of emission reductions without making unsupported claims about source-specific causality. The focus is not on attributing existing health outcomes to Ternium Brazil, but on identifying what additional data, modelling and monitoring would be needed to estimate the potential public health benefits of reducing industrial emissions in Santa Cruz.

The module should distinguish between different types of emissions and controls, including:

- stack emissions;
- fugitive emissions;
- emissions from handling and storage of raw materials;
- internal traffic and logistics emissions;

- resuspended dust;
- particulate filtration systems;
- gas-cleaning and desulfurization systems, where applicable;
- continuous emissions monitoring;
- ambient air quality monitoring;
- maintenance and operational procedures;
- regulatory compliance and public reporting.

This distinction is important because the effectiveness of filters and other control technologies depends not only on their installation, but also on their design, operational performance, maintenance, monitoring, enforcement and transparency.

3. Existing evidence, public debate and methodological caution

Ternium Brazil has been the subject of public and technical debate regarding air emissions, environmental monitoring and potential health implications in Santa Cruz (PACS, 2024; G1, 2024), further intensified by the tax exemptions provided by the local government (RIO DE JANEIRO STATE, 2005, 2022; ALERJ, 2022, RIO DE JANEIRO CITY HALL, 2009, 2011). This context reinforces the need for a transparent, cautious and scenario-based methodological framework.

External assessments have attempted to estimate the potential health impacts associated with emissions from the Santa Cruz steel plant using health impact assessment methods (FIOCRUZ, 2018). At the same time, the company has contested some of these assessments and has stated that it operates under environmental licensing and monitoring requirements. This note does not seek to adjudicate this debate or validate one position over another. Instead, the note proposes that Breathe Rio should treat the Ternium Brazil case as a methodological opportunity to define how an industrial source can be incorporated into an equity-oriented air quality and health framework. The appropriate question is not whether the existing maps prove that Ternium has caused specific health outcomes. <u>The appropriate question is what evidence, data and modelling steps would be necessary to estimate the potential exposure and health benefits associated with verified reductions in industrial emissions.</u>

This framing is important for three reasons:

First, Santa Cruz is affected by multiple potential pollution sources, including industrial activity, logistics, road traffic, freight movement, resuspended dust and regional atmospheric processes. A robust analysis must therefore avoid assuming that all observed health or air quality patterns are linked to one source.

Second, health outcomes such as respiratory diseases, cardiovascular diseases and cancer are influenced by multiple factors, including age, income, housing conditions, occupation, smoking, access to health care, previous illness, environmental exposure and broader socioeconomic determinants.

Third, the available territorial maps are useful for screening, prioritization and communication, but they are not designed to establish source-specific causality. They should therefore be used to justify further analysis, not as evidence of direct attribution.

4. Santa Cruz/PA 5 as the receptor territory: demographic and socioeconomic context

Santa Cruz and PA5 provide the territorial and population context for assessing the potential relevance of industrial emission reductions at Ternium Brazil. The baseline maps indicate that PA5 should be interpreted as a territory where several dimensions of vulnerability overlap.

Figure 3, which presents total population by neighborhood, shows the relevance of the West Zone in demographic terms. Although PA5 has a large territorial extension and lower average density than some central areas, it contains a substantial resident population distributed across neighborhoods such as Santa Cruz, Campo Grande, Bangu, Realengo and Guaratiba.

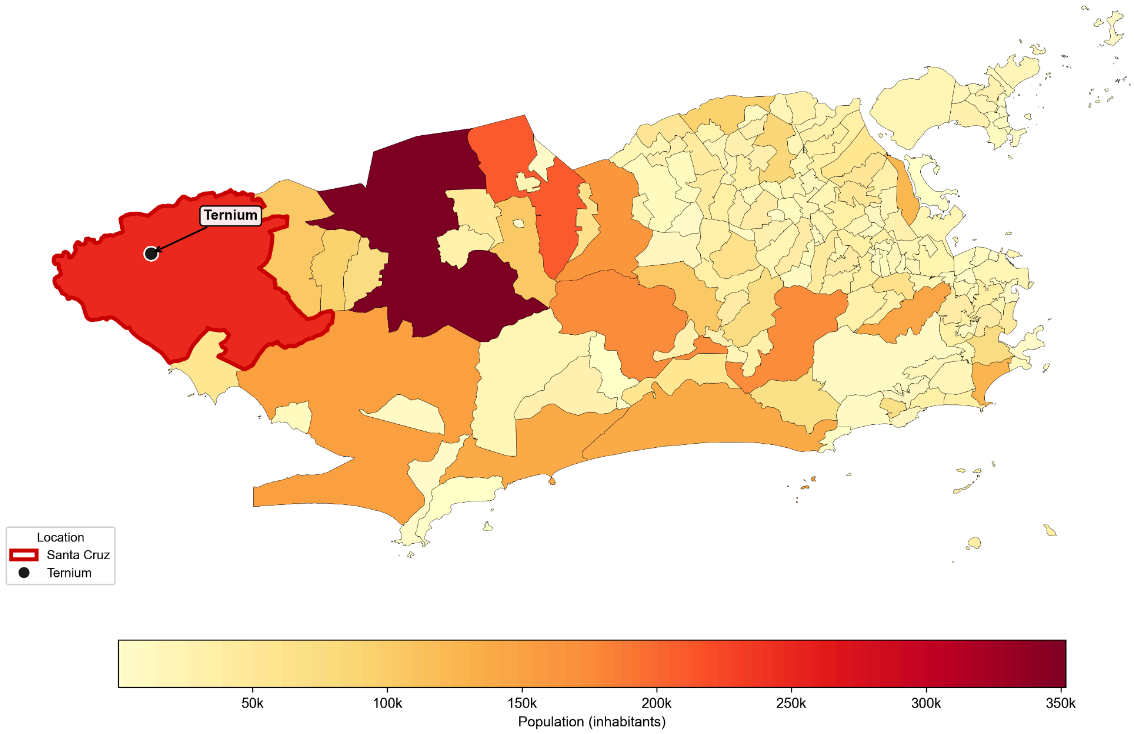

FIGURE 3 - POPULATION MAP: TOTAL POPULATION BY NEIGHBORHOOD (2022)

This is important because the public health relevance of air pollution reduction depends not only on pollutant concentration levels, but also on the number and characteristics of people potentially exposed. In territories with large populations, even moderate reductions in exposure may generate relevant aggregate health benefits.

The age structure reinforces this point. Figure 4 shows the spatial distribution of children aged 0–14 years. PA 5 stands out as one of the youngest parts of the city. This is relevant because children are more vulnerable to respiratory conditions and may be more affected by short-term changes in air quality. A young population profile also means that preventive environmental and health policies may produce long-term benefits by reducing exposure over the life course.

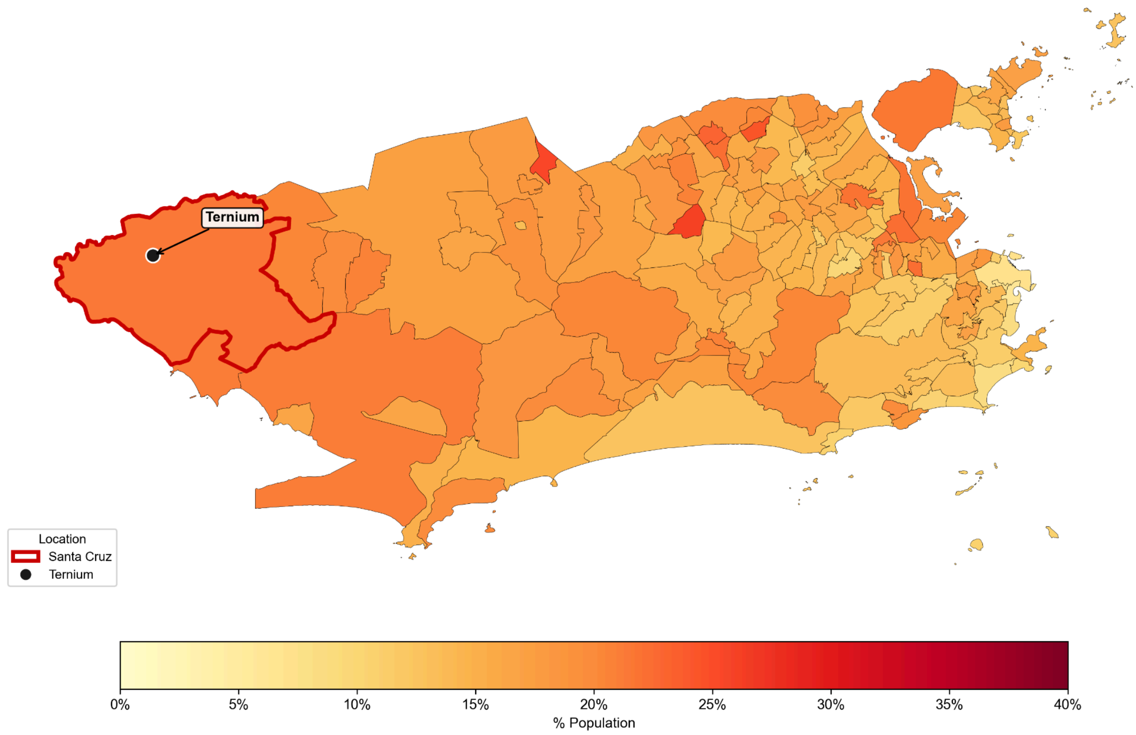

FIGURE 4 - AGE GROUP MAP: CHILDREN (0-14 YEARS) BY NEIGHBORHOOD (2022)

The equity dimension is central to the interpretation of Santa Cruz/P5. Figure 4 shows the distribution of the Black and Brown population by neighborhood. The map indicates a stronger concentration of Black and Brown residents in the North and West Zones, including PA5.

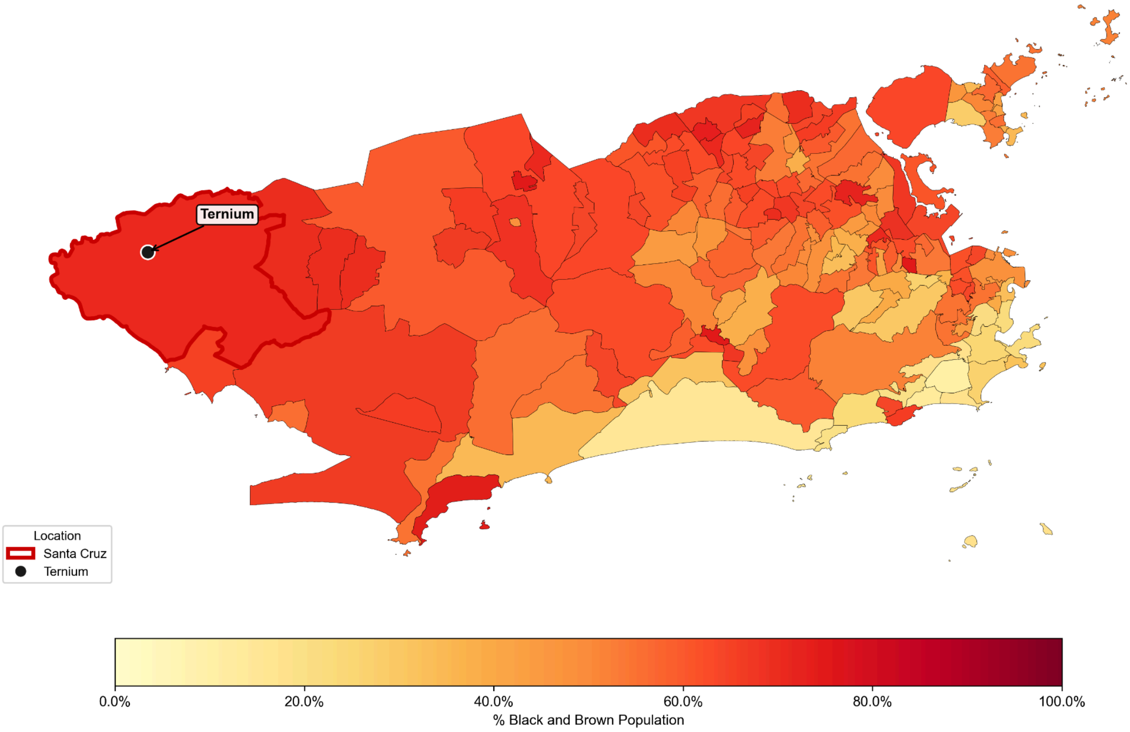

FIGURE 5 - RACE DISTRIBUTION MAP: PERCENTAGE OF BLACK AND BROWN POPULATION BY NEIGHBORHOOD

Figure 6, which presents median income by Planning Area, shows PA5 as the lowest-income Planning Area in Rio de Janeiro.

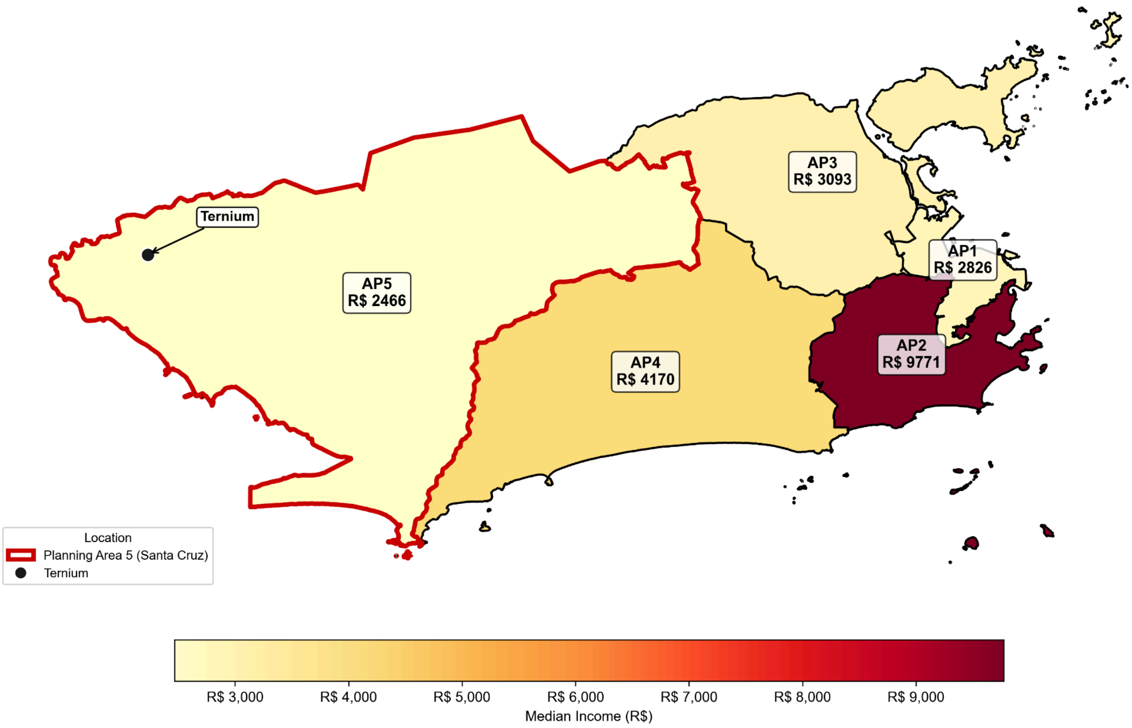

FIGURE 6 - INCOME MAP: MEDIAN INCOME BY PLANNING AREA (2022)

These maps should be interpreted together. They indicate that Santa Cruz/PA5 is not only a territory of environmental concern, but also a territory shaped by structural inequalities. Lower income can affect the capacity of households to reduce exposure, access timely health care, choose housing locations, absorb transport costs or respond to illness. Race/color should not be interpreted as a biological risk factor. Rather, it should be understood as a marker of historically unequal access to urban infrastructure, income, housing, mobility and public services.

5. Observed health burden and methodological caution

The health maps provide important context for understanding why Santa Cruz/PA5 should be considered a priority territory for the implementation of air quality projects. However, they must be interpreted with caution, for they describe the territorial distribution of morbidity and mortality indicators, but do not establish causal links between air pollution and observed health outcomes.

Figure 7, which presents morbidity rates for child respiratory diseases by Planning Area, should be used together with Figure 3. The combination of a young population profile and respiratory morbidity indicators suggests that child respiratory health is an important dimension for the Santa Cruz/PA5 analysis.

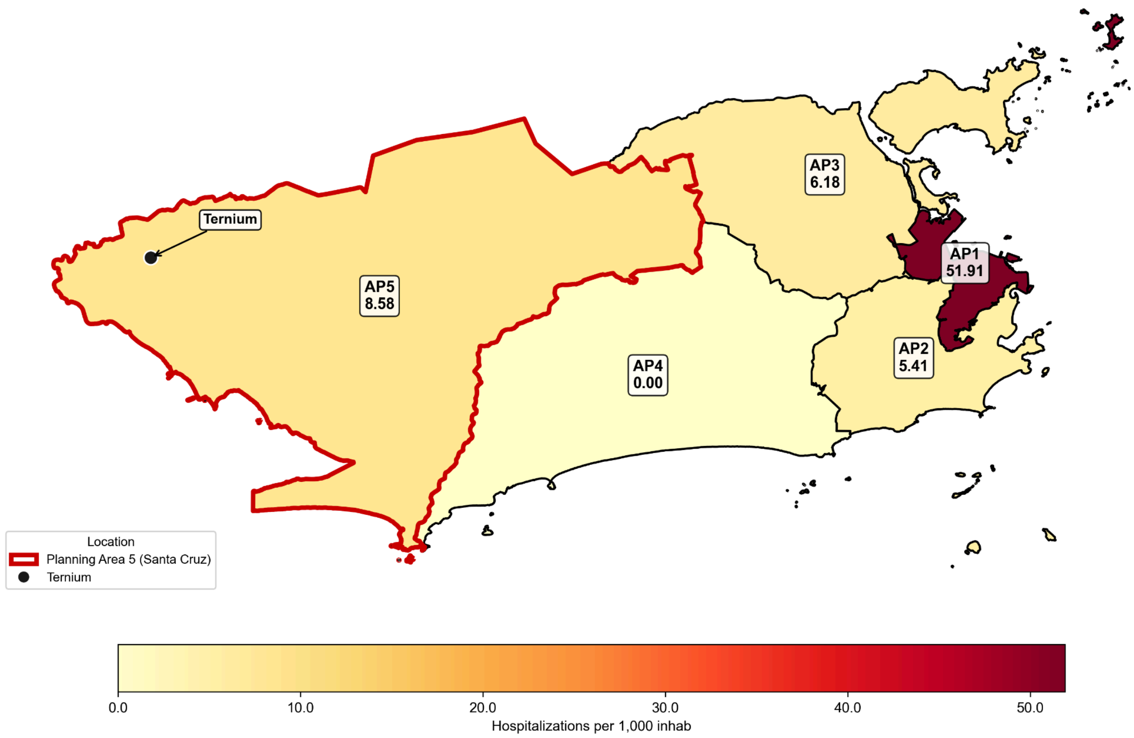

FIGURE 7 -HEALTH MAP: MORBIDITY RATE - CHILD RESPIRATORY (0-4 YEARS) BY PLANNING AREA (2022)

However, the interpretation should remain descriptive. The map identifies a health burden that may justify further investigation, not a causal effect of local pollution or of a specific industrial source.

Figure 8, which presents mortality rates for child respiratory diseases by Planning Area, provides an additional reason to consider PA5 as a priority territory. If PA5 appears among the areas with higher child respiratory mortality, this should be treated as a strong equity signal. The note should frame this as a territorial health concern that deserves attention in future health impact assessment, particularly when combined with socioeconomic vulnerability and potential exposure to air pollutants.

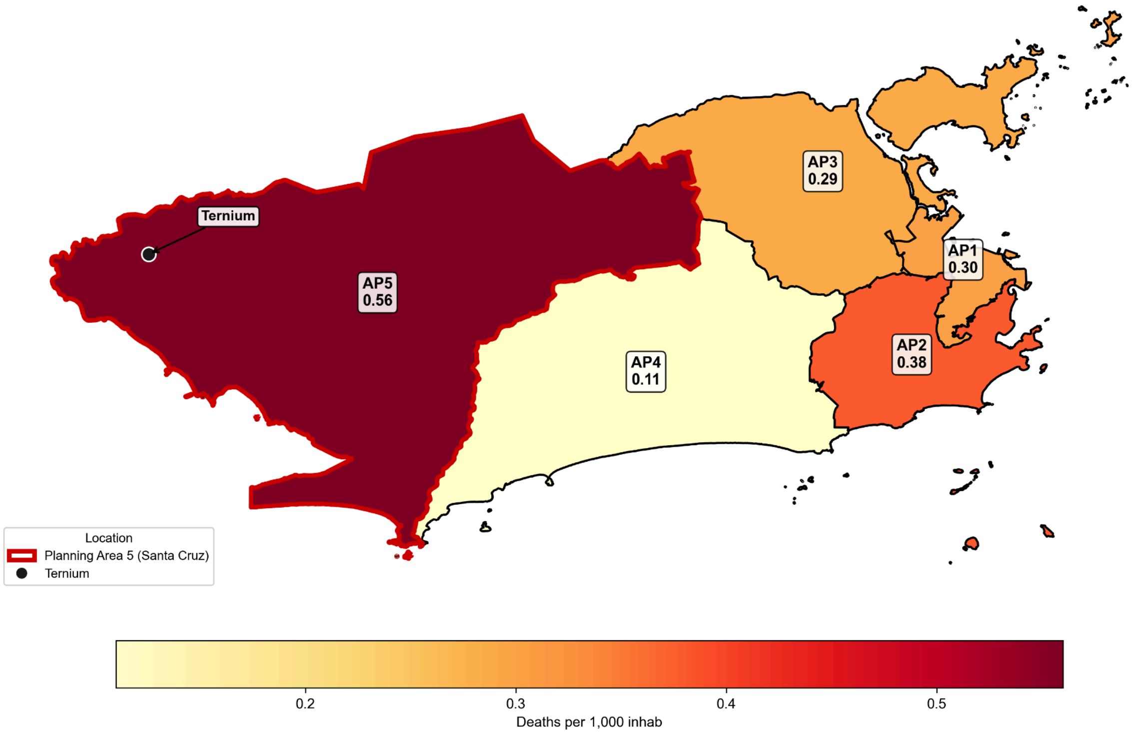

FIGURE 8 - HEALTH MAP: MORTALITY RATE - CHILD RESPIRATORY (0-4 YEARS) BY PLANNING AREA (2022)

Figure 9, on cardiovascular mortality, and Figure 10, on elderly respiratory mortality, expand the analysis beyond children. These maps are relevant because air pollution is associated in the epidemiological literature with both cardiovascular and respiratory outcomes. In this note, however, the maps should not be used to claim that air pollution has caused observed mortality patterns. Instead, they should be used to identify where vulnerable groups and relevant health outcomes overlap spatially.

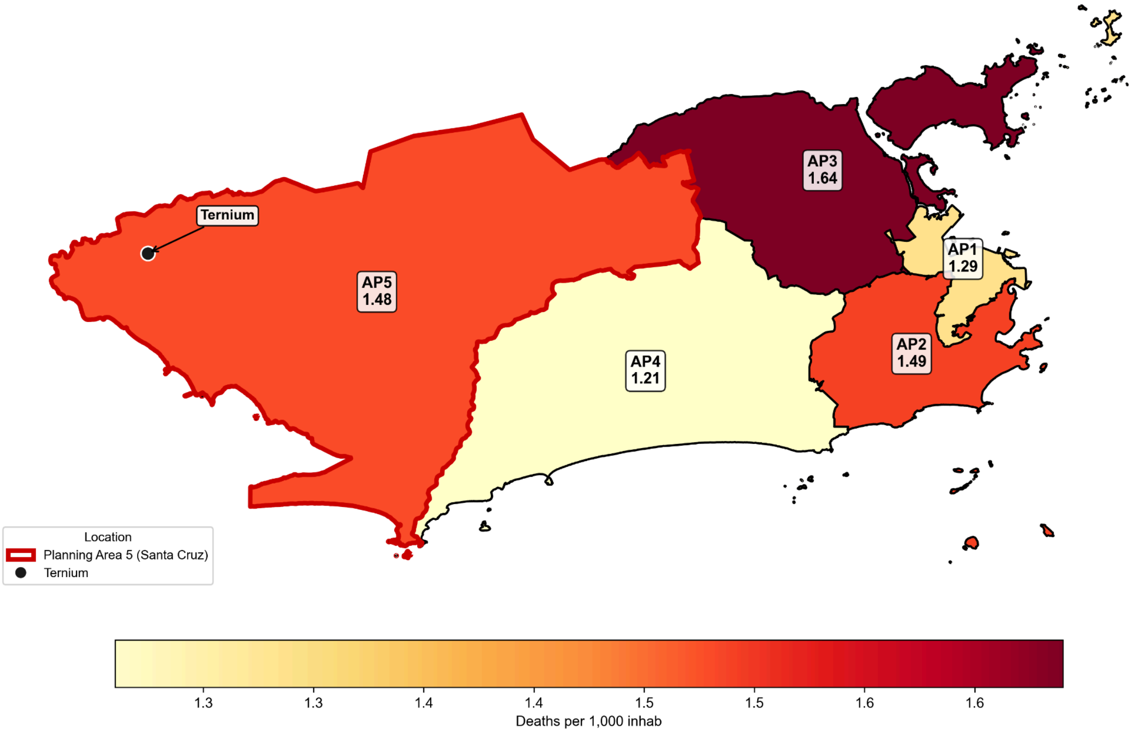

FIGURE 9 - HEALTH MAP: MORTALITY RATE - CARDIOVASCULAR BY PLANNING AREA (2022)

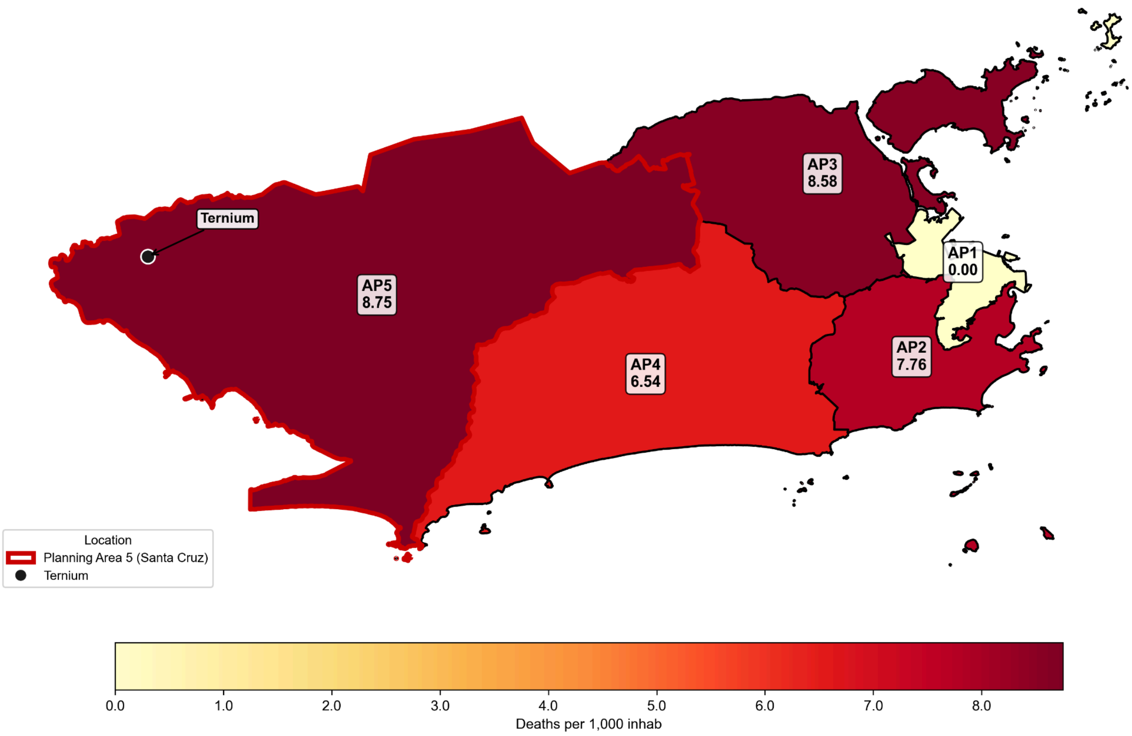

FIGURE 10 - HEALTH MAP: MORTALITY RATE - ELDERLY RESPIRATORY (60+ YEARS) BY PLANNING AREA (2022)

Figures 11 and 12, which show total mortality cases for cancer and cardiovascular diseases by neighborhood, should be interpreted as indicators of absolute health burden.

These maps are useful for policy planning because they show where the total number of cases is concentrated. However, total cases are strongly influenced by population size and should not be interpreted as risk rates. For this reason, they should be used alongside population maps, age structure, income and race/color indicators.

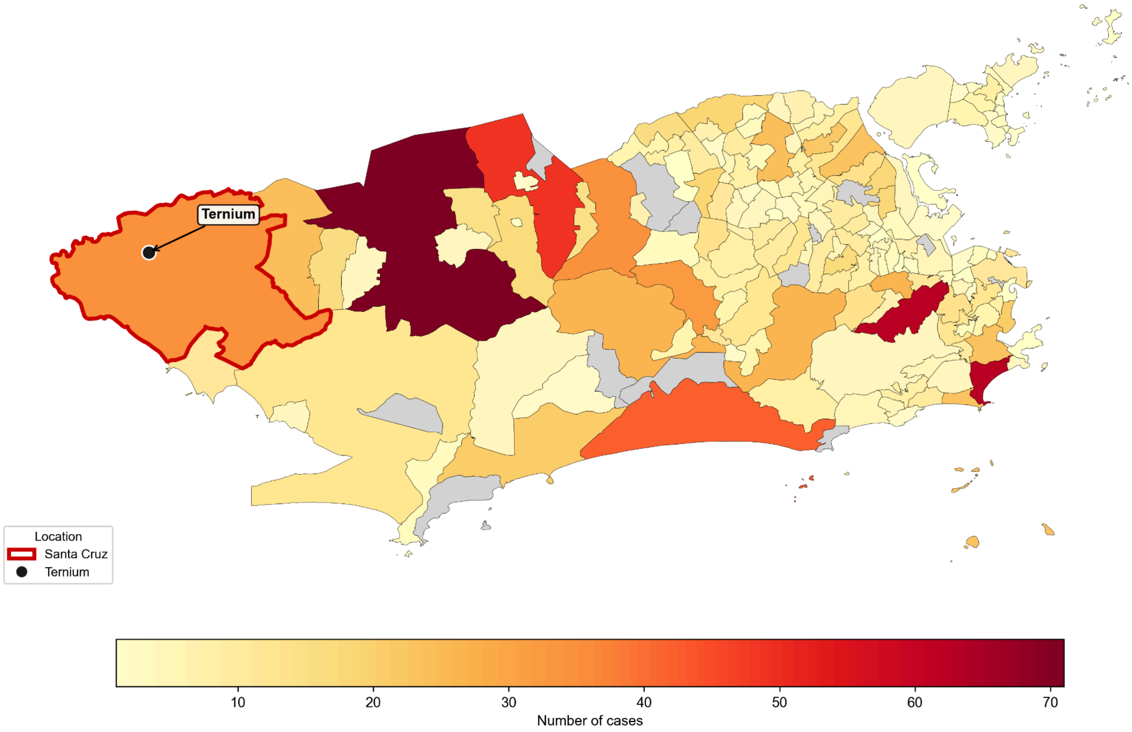

FIGURE 11 - HEALTH MAP: TOTAL MORTALITY CASES - CANCER BY NEIGHBORHOOD (2022)

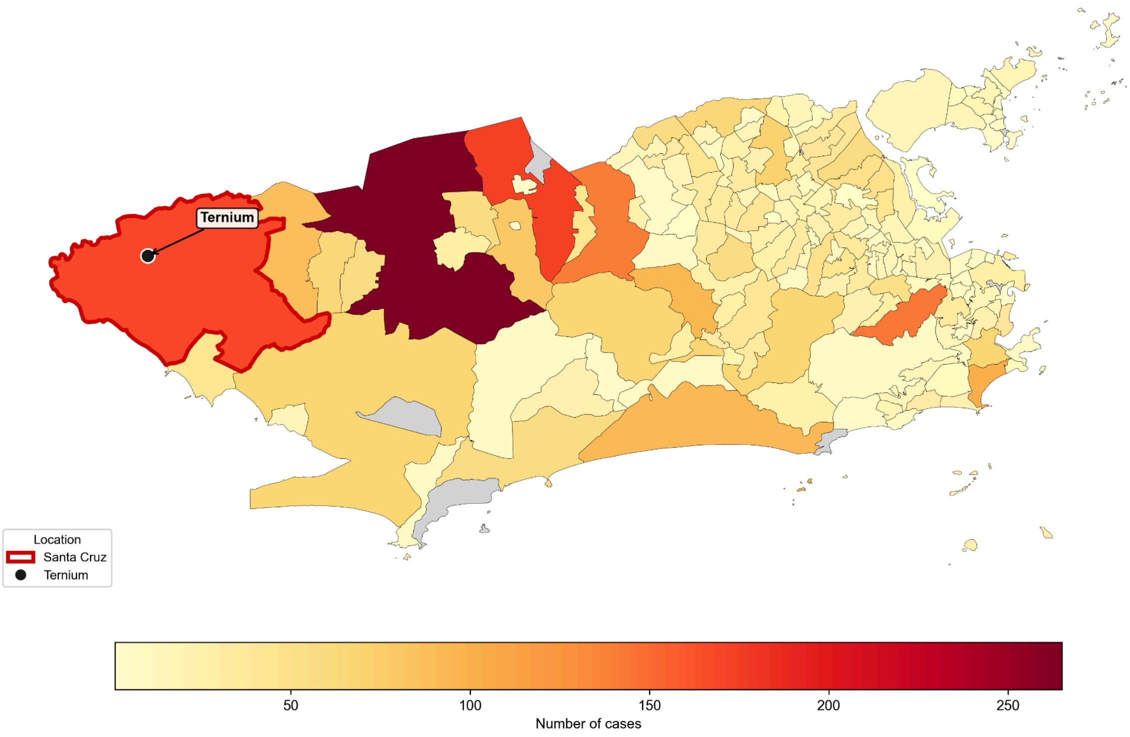

FIGURE 12 - HEALTH MAP: TOTAL MORTALITY CASES - CARDIOVASCULAR BY NEIGHBORHOOD (2022)

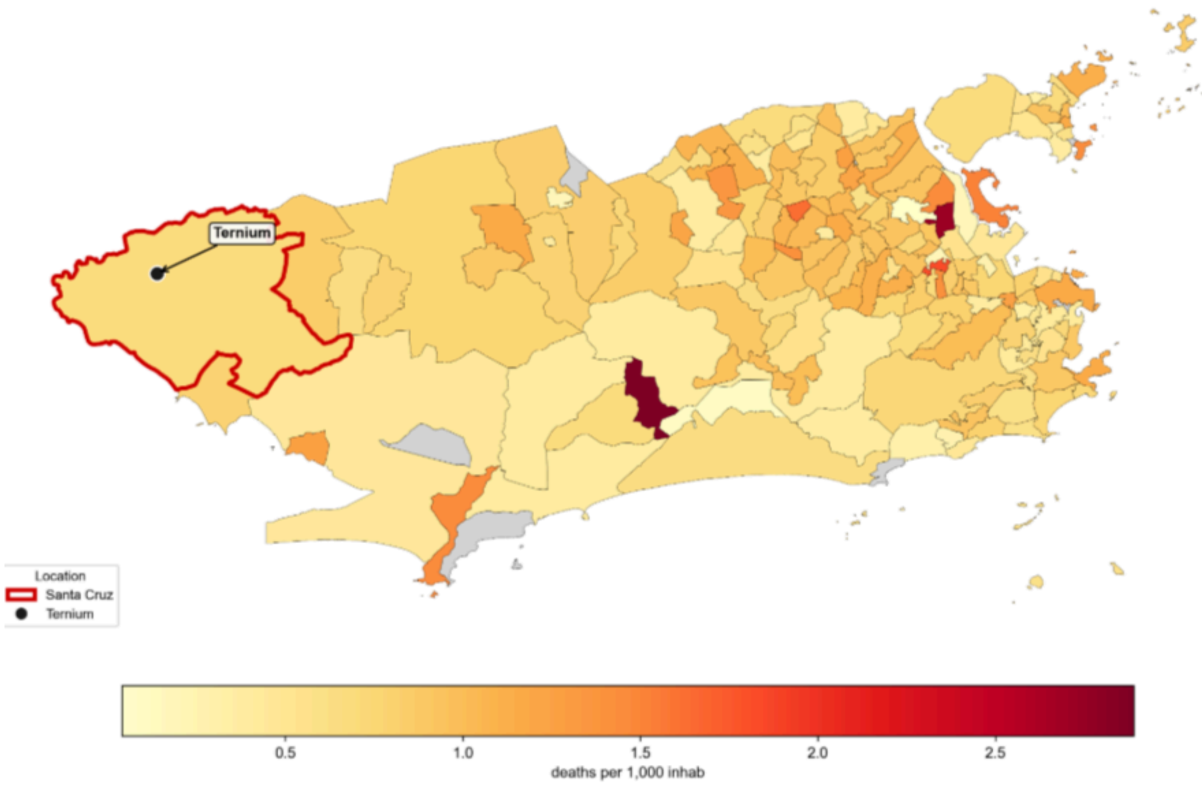

FIGURE 13 - HEALTH MAP: MORTALITY RATE - CARDIOVASCULAR BY NEIGHBORHOOD (2022), RATE PER 1,000 INHABITANTS OF THE TARGET POPULATION (ELDERLY AND YOUNG)

The comparison between Figures 11, 12 and 13 highlights an important distinction between mortality rates and the absolute number of mortality cases. In the cardiovascular mortality rate map (Figure 13), Santa Cruz and the broader AP5 territory do not appear as the most critical areas of the municipality. The highest rates are concentrated in other neighborhoods, suggesting that Santa Cruz should not be interpreted as an outlier in terms of proportional cardiovascular mortality risk.

However, the maps showing total mortality cases for cancer and cardiovascular diseases by neighborhood (Figures 11 and 12) tell a complementary story. Santa Cruz appears as a territory with a relevant absolute number of mortality cases, particularly when compared with several other neighborhoods. This result is partly explained by the demographic structure of AP5. Although AP5 has a lower average population density than more central areas of Rio de Janeiro, it has a large territorial extension and contains a substantial resident population. Therefore, even when mortality rates are not among the highest in the city, the absolute number of health events may still be significant from a public health planning perspective.

This distinction is methodologically important for this concept note. Mortality rates are useful for identifying areas where the relative risk or burden is more intense, while total cases are useful for identifying territories where the aggregate number of affected people is large. In the context of a health impact assessment, both dimensions matter. A territory with moderate rates but a large exposed population may still generate a relevant number of potential avoided cases under an emission-reduction scenario.

For this reason, the Santa Cruz analysis should not rely only on rate-based indicators, nor only on absolute counts. Rate-based indicators help avoid misinterpreting population size as risk. Absolute-count indicators, in turn, help identify the potential scale of public health benefits if exposure is reduced. The combination of these two perspectives supports the interpretation of Santa Cruz as a priority receptor territory for further analysis, without implying that the observed cancer or cardiovascular mortality patterns are caused by Ternium Brasil or by any single emission source.

In practical terms, this means that the Ternium Brazil module should assess potential health benefits using a population-exposure framework. If emission-control measures lead to verified or modelled reductions in pollutant concentrations, the potential health benefits will depend not only on the size of the concentration reduction, but also on the number of people exposed, their baseline health rates, age structure and socioeconomic vulnerability. The maps therefore reinforce the need for a cautious scenario-based assessment: Santa Cruz may not always appear as the highest-risk area in rate maps, but it represents a large and socially vulnerable receptor population where reductions in exposure could still be relevant for public health.

The main conclusion from the health maps in this section is cautious but policy-relevant: Santa Cruz/PA5 presents a combination of demographic vulnerability, socioeconomic vulnerability and observed health burdens that justifies a more detailed analysis of potential exposure reduction and potential health benefits from industrial emission-control scenarios.

6. Exposure pathways: industrial emissions, mobility and cumulative exposure

A key contribution of the Breathe Rio baseline is that exposure to air pollution should not be understood only through place of residence. In Rio de Janeiro, daily mobility patterns are central to understanding cumulative exposure.

For the Ternium Brazil module, the concept of cumulative exposure is particularly important. Residents of Santa Cruz may be exposed through different pathways:

- near their place of residence;
- in areas influenced by industrial or logistics activity;
- along local roads and freight corridors;
- inside or near buses and BRT corridors;
- during long-distance trips to other Planning Areas;
- in central areas where employment, services and specialized health facilities are concentrated.

Figures 14, 15 and 16 are therefore important for interpreting Santa Cruz/PA5 as a territory of mobility-related exposure. Figure 14 presents total public transport transactions by neighborhood, Figure 15 presents bus transactions by neighborhood, and Figure 16 presents BRT transactions by neighborhood. Together, these maps show how public transport demand is distributed across the city and how peripheral populations depend on collective transport systems to access employment, services and health care.

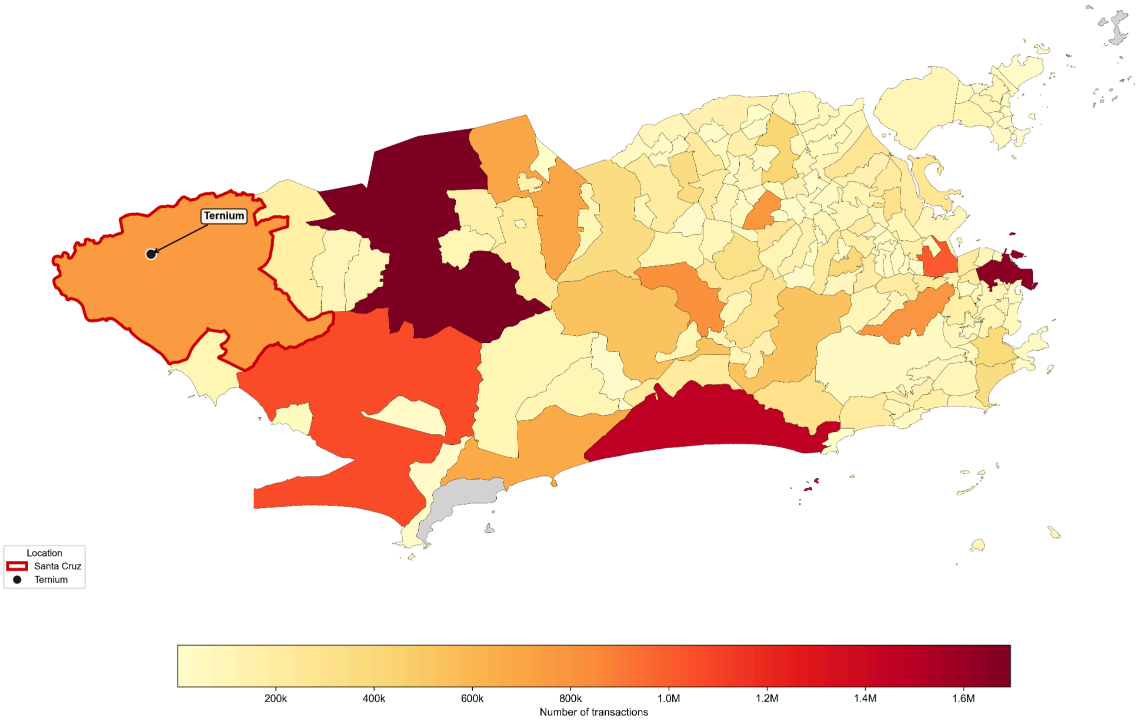

FIGURE 14 - TRANSPORT MAP: TOTAL PUBLIC TRANSPORT TRANSACTIONS BY NEIGHBORHOOD (2025)

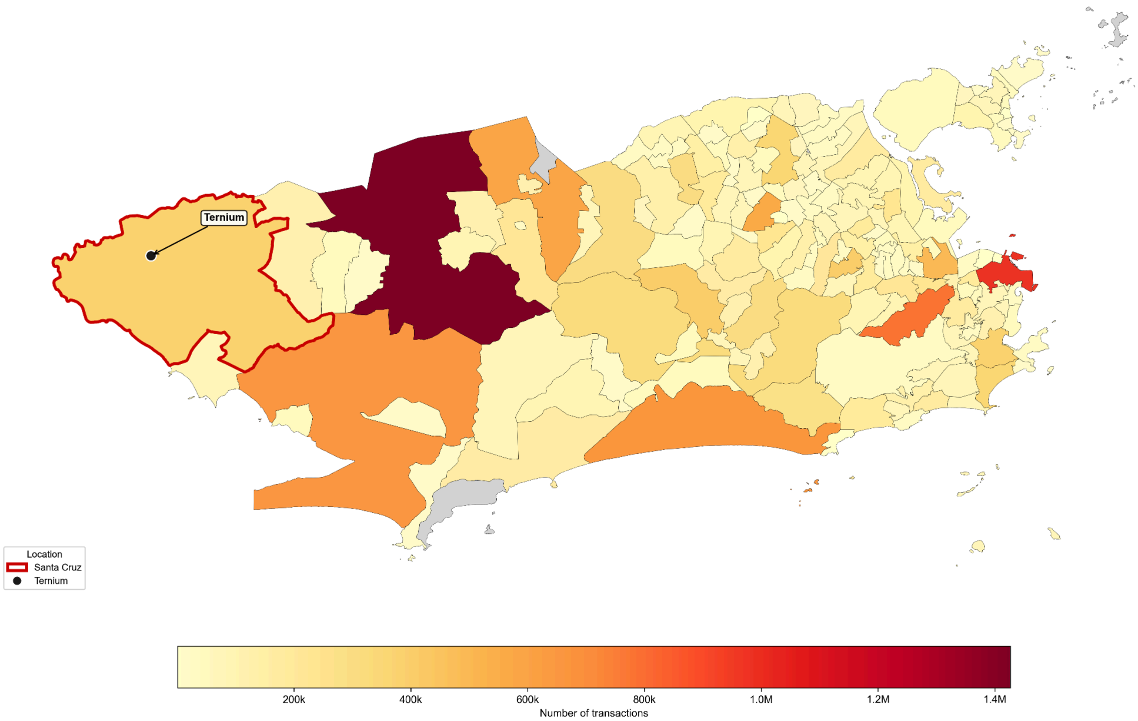

FIGURE 15 - TRANSPORT MAP: BUS BY NEIGHBORHOOD (2025)

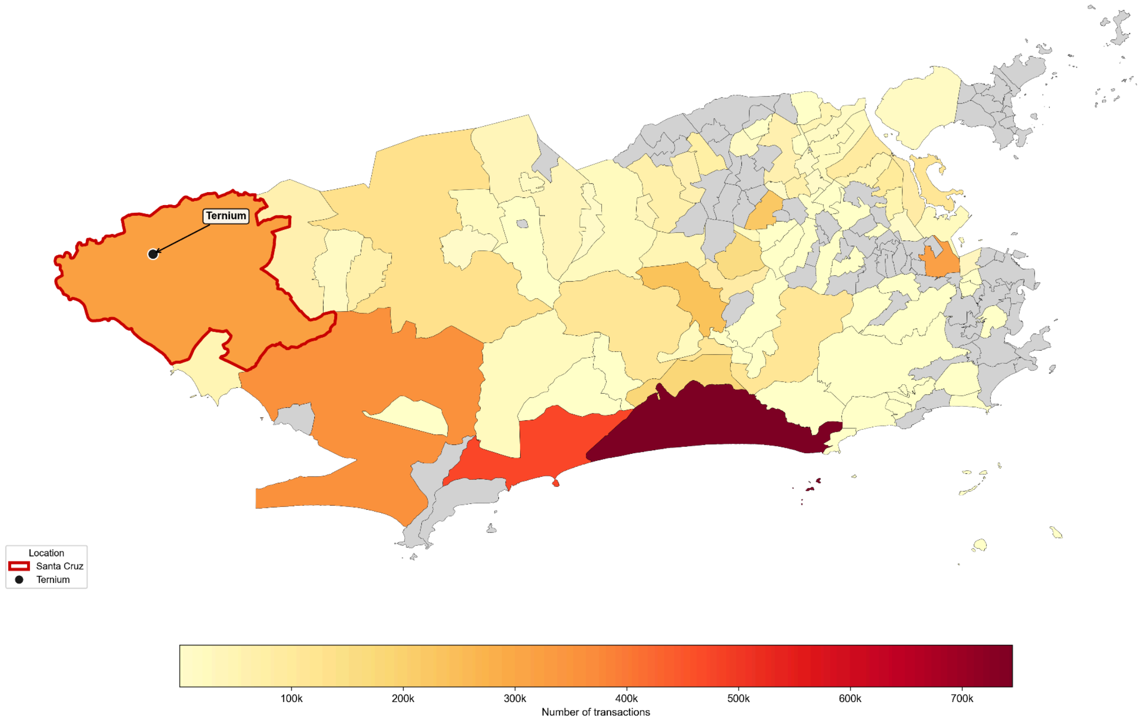

FIGURE 16 - TRANSPORT MAP: BRT BY NEIGHBORHOOD (2025)

For Santa Cruz, this matters because many residents of PA5 travel long distances to other Planning Areas, especially PA4, PA3 and PA1. These trips may involve long travel times, transfers, waiting periods and circulation through congested corridors. As a result, exposure may occur across multiple microenvironments: near the place of residence, around local industrial and logistics areas, along bus and BRT corridors, and in central areas where jobs and specialized services are located.

This is particularly relevant for people who travel to PA1 for specialized health care, including cancer diagnosis and treatment. In these cases, health vulnerability and mobility burden may reinforce each other. A resident may face environmental pressure in the territory of residence, long travel times to access care, and additional exposure during the journey.

This interpretation connects the Ternium Brazil module to the broader Breathe Rio scenarios. Bus fleet electrification, public transport improvements and zero-fare policies may reduce transport-related emissions and change mobility patterns. For AP5 residents, these interventions may generate benefits not only by reducing transport emissions across the city, but also by improving the conditions under which long-distance trips are made.

However, the industrial module adds a complementary dimension: even if transport emissions are reduced, Santa Cruz may still require specific analysis of local industrial emission sources. For this reason, the Ternium Brazil module should be developed as a complementary pathway within the broader air quality and health equity framework.

7. Air quality evidence and monitoring limitations

The air quality maps provide an environmental layer for the Santa Cruz/PA5 analysis. Figure 17 presents PM2.5 24-hour maximum values in relation to World Health Organization and CONAMA guidelines. Figure 18 presents the number of days in which PM2.5 exceeded WHO guidelines. Figure 19 presents O_3 24-hour maximum values in relation to WHO and CONAMA guidelines.

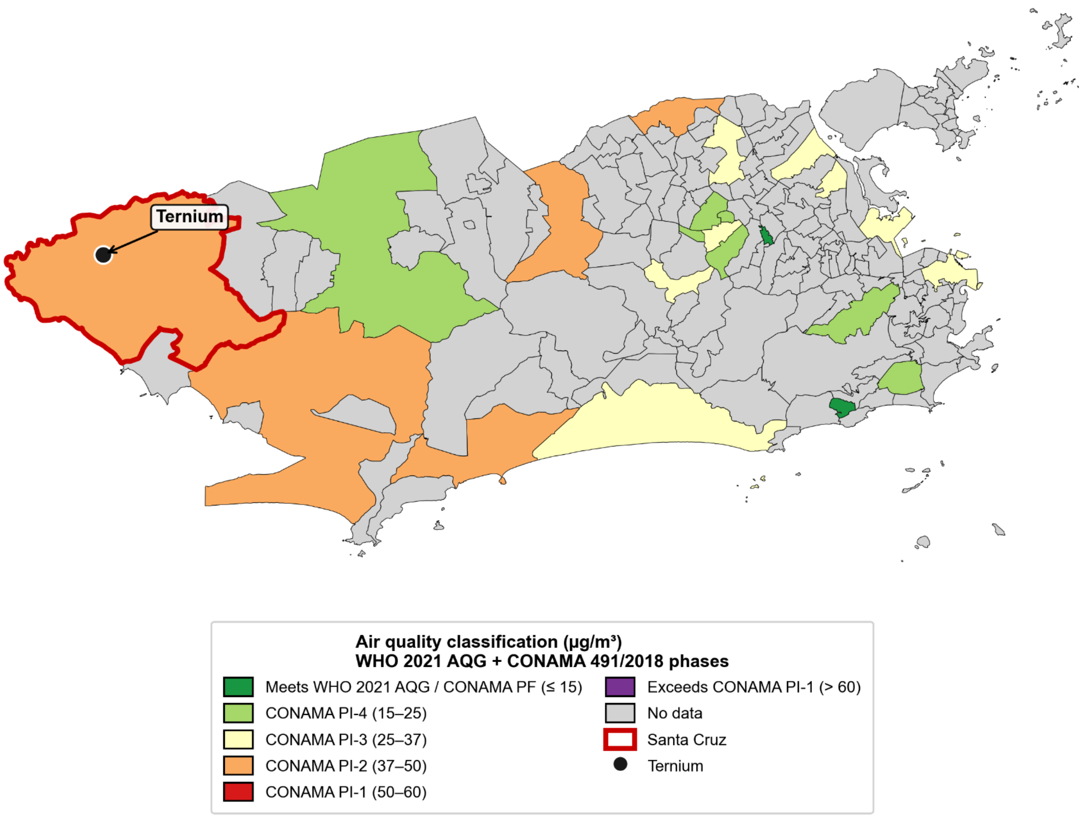

FIGURE 17 - AIR QUALITY MAP: PM2.5 24-HOUR MAXIMUM VALUES IN WORLD HEALTH ORGANIZATION GUIDELINES AND CONAMA GUIDELINES (2025)

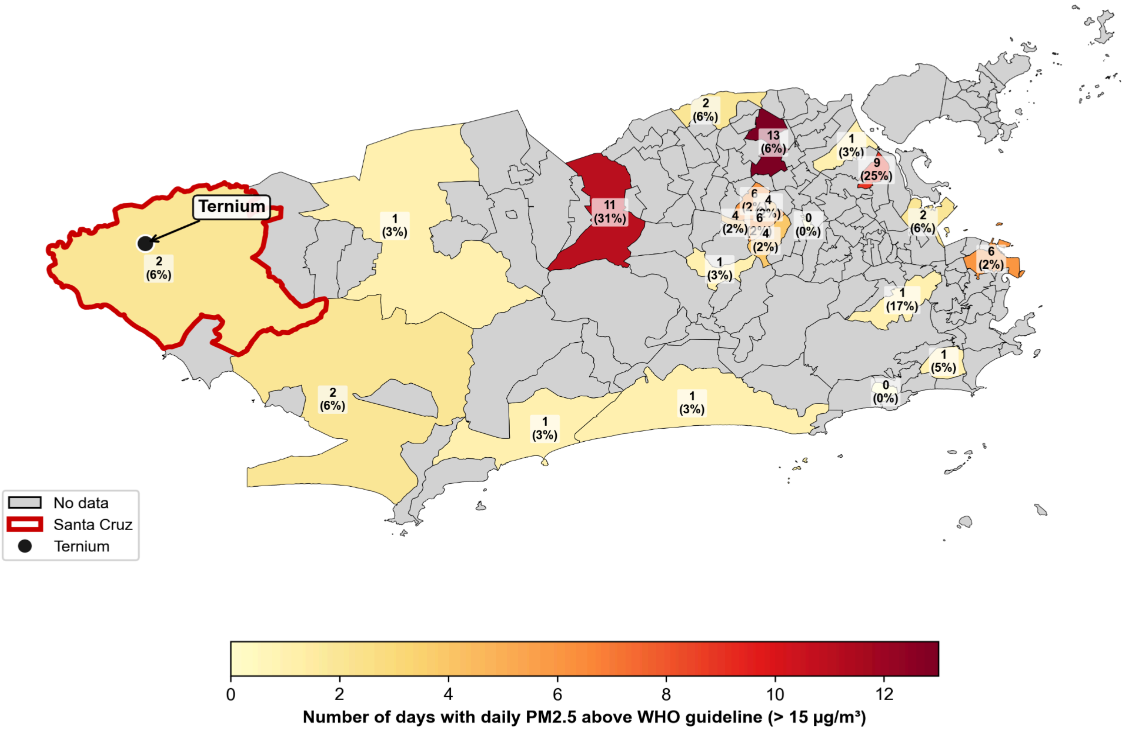

FIGURE 18 - AIR QUALITY MAP: NUMBER OF DAYS THAT PM2.5 EXCEEDED WORLD HEALTH ORGANIZATION GUIDELINES (2025)

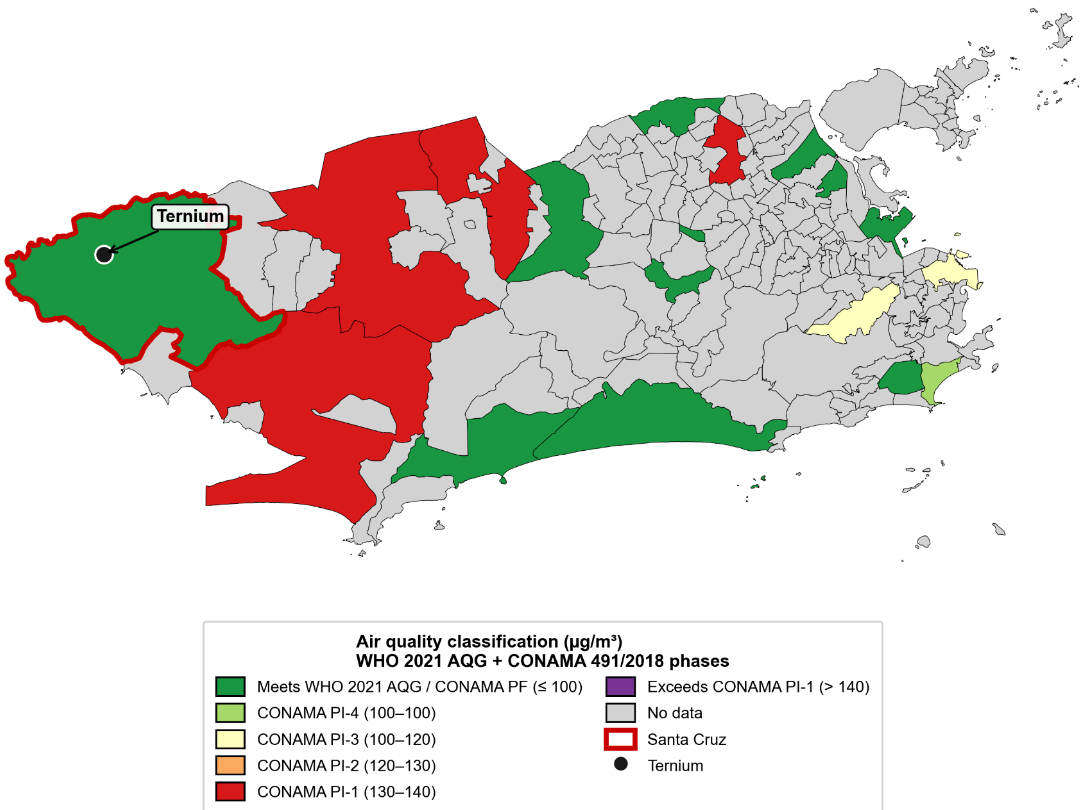

FIGURE 19 - AIR QUALITY MAP: O3 24-HOUR MAXIMUM VALUES IN WORLD HEALTH ORGANIZATION GUIDELINES AND CONAMA GUIDELINES (2025)

These maps are important because they move the analysis from emission pressure to observed air quality conditions. However, they must be interpreted with attention to monitoring coverage. Areas with no data should not be treated as areas with no air quality concern. Similarly, differences across neighborhoods may reflect not only real differences in pollution, but also differences in monitoring availability, sensor location, data coverage and meteorological conditions.

For PM2.5, Figures 17 and 18 should be used to identify where short-term exposure may exceed health-based reference values. If Santa Cruz or nearby western neighborhoods show exceedances or elevated values, this strengthens the case for more detailed local analysis. If they do not show high values, the conclusion should not be that Santa Cruz has no relevant exposure, but that available monitoring data are insufficient to rule out risk, especially given the presence of industrial and logistics activities.

For O_3, Figure 19 deserves particular caution. Ozone is a secondary pollutant formed in the atmosphere from precursor pollutants such as NOx and volatile organic compounds, under specific meteorological conditions. For this reason, O_3 should not be attributed to a single local source. However, if the map shows relevant exceedance patterns in western neighborhoods, it indicates that PA5 may be affected by broader regional atmospheric processes and not only by local emissions.

The methodological implication is that air quality monitoring in Santa Cruz should be strengthened. A robust analysis would require combining fixed monitoring stations, low-cost sensors, meteorological data, source-specific emissions data and, where possible, atmospheric dispersion or chemical transport modelling.

For the Ternium Brazil module, monitoring should ideally distinguish between:

- background air quality;
- contributions from transport and road traffic;
- contributions from industrial stack emissions;
- contributions from fugitive emissions;
- resuspended dust;
- meteorological effects;
- temporal variation associated with operating conditions.

Without this distinction, it is not possible to reliably attribute observed concentrations to a specific source. However, monitoring improvements can still support scenario-based analysis by estimating how changes in emissions may affect local air quality.

8. Scenario-based assessment of emission-control systems at Ternium Brazil

The central analytical component of this concept note is the scenario-based assessment of emission-control systems at Ternium Brazil. The purpose is to estimate how verified or modelled reductions in emissions could affect pollutant concentrations, population exposure and potential health risks in Santa Cruz and surrounding areas.

This assessment should not be framed as a legal attribution exercise. It should be framed as a public health and policy analysis. The guiding question is:

<u>If emissions are reduced through filtration, operational improvements or other emission-control measures, what potential exposure and health benefits could be expected for the surrounding population?</u>

The proposed analytical sequence is:

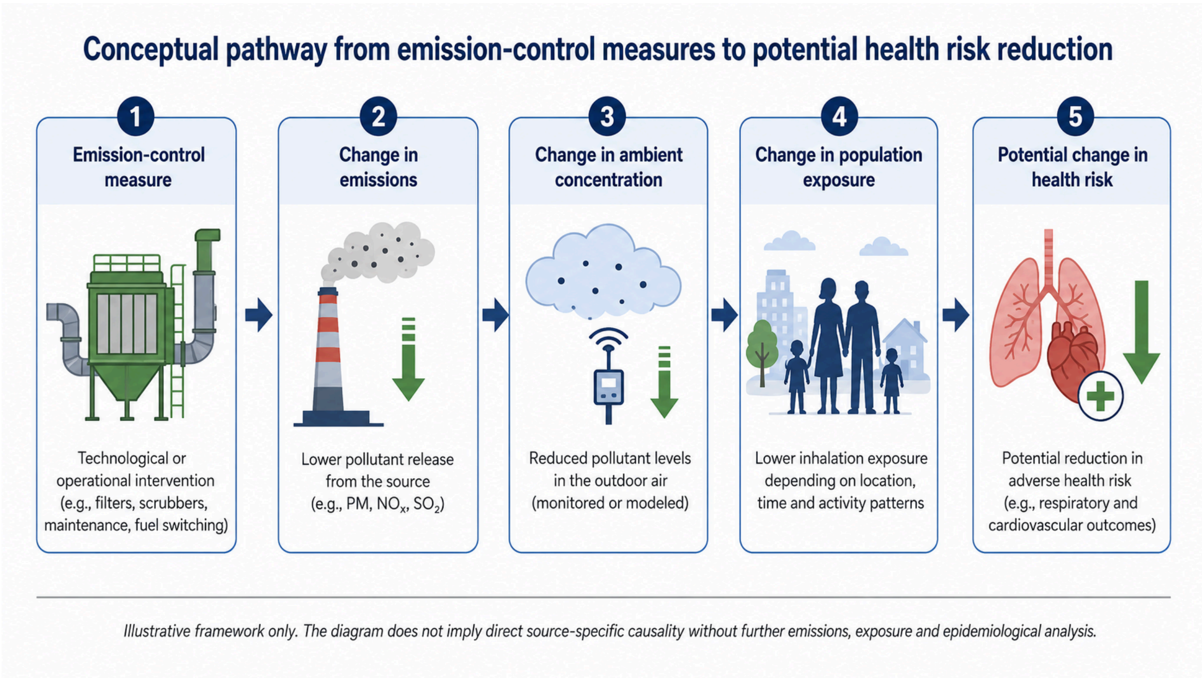

FIGURE 20: CONCEPTUAL PATHWAY FROM EMISSION-CONTROL MEASURE TO POTENTIAL HEALTH RISK REDUCTION

The emission-control scenario may include:

- installation or upgrading of particulate filters;
- improved maintenance and operation of existing filters;
- improved control of fugitive particulate emissions;
- improved management of raw material storage and handling;
- reduction of dust resuspension;
- better control of internal logistics emissions;
- continuous emissions monitoring;
- improved public reporting of emissions and air quality data;
- enhanced enforcement and independent verification.

The pollutants to be considered should include PM2.5, PM10, NOx/NO_2 and SO_2. Where data allow, the analysis may also consider the chemical composition of particulate matter and other pollutants relevant to steel production. This is important because not all particulate matter has the same toxicity profile, and industrial particles may differ from traffic-related particles in composition and potential health relevance.

The preferred approach is to use source-specific data, including:

- stack emissions data;
- continuous emissions monitoring data;
- operating hours;
- production volume;
- emission factors;
- technical specifications of filters and control systems;
- maintenance records;
- environmental licensing documents;
- compliance reports submitted to environmental authorities;
- ambient monitoring data from stations near the facility;
- meteorological data;
- population distribution around the facility.

If source-specific data are not available, the analysis may use sensitivity ranges based on literature values, regulatory benchmarks or engineering assumptions. In this case, the results should be clearly presented as illustrative and conditional on assumptions, not as definitive estimates.

The scenario analysis should include at least three cases:

Scenario 1 — Current or baseline conditions

This scenario represents current or most recently available conditions, using observed emissions and air quality data where available. It should describe the industrial source, the surrounding population, monitoring coverage and existing uncertainties.

Scenario 2 — Improved emission-control scenario

This scenario estimates potential reductions in emissions and exposure associated with improved filtration, maintenance, operational control or other emission-reduction measures. The scenario should be based on verified data where possible. If verification is not possible, assumptions should be transparent and presented as ranges.

Scenario 3 — Combined industrial and transport scenario

This scenario combines industrial emission reductions with the broader Breathe Rio transport scenarios, including bus electrification, public transport improvements and zero-fare policies. This combined scenario is important because PA5 residents may benefit from both local industrial emission reductions and lower exposure during long-distance travel.

The output of the scenario analysis should not be a statement that current health outcomes are caused by Ternium Brazil. Instead, it should be a set of estimates showing how much exposure and health risk could potentially decline under specific, transparent and verifiable emission-reduction assumptions.

9. Potential health outcomes and health impact assessment approach

The health impact component should be developed only after the exposure pathway has been defined. The analysis should avoid jumping directly from the presence of Ternium Brazil to observed health outcomes. Instead, the assessment should follow a concentration-response approach.

The basic analytical sequence is:

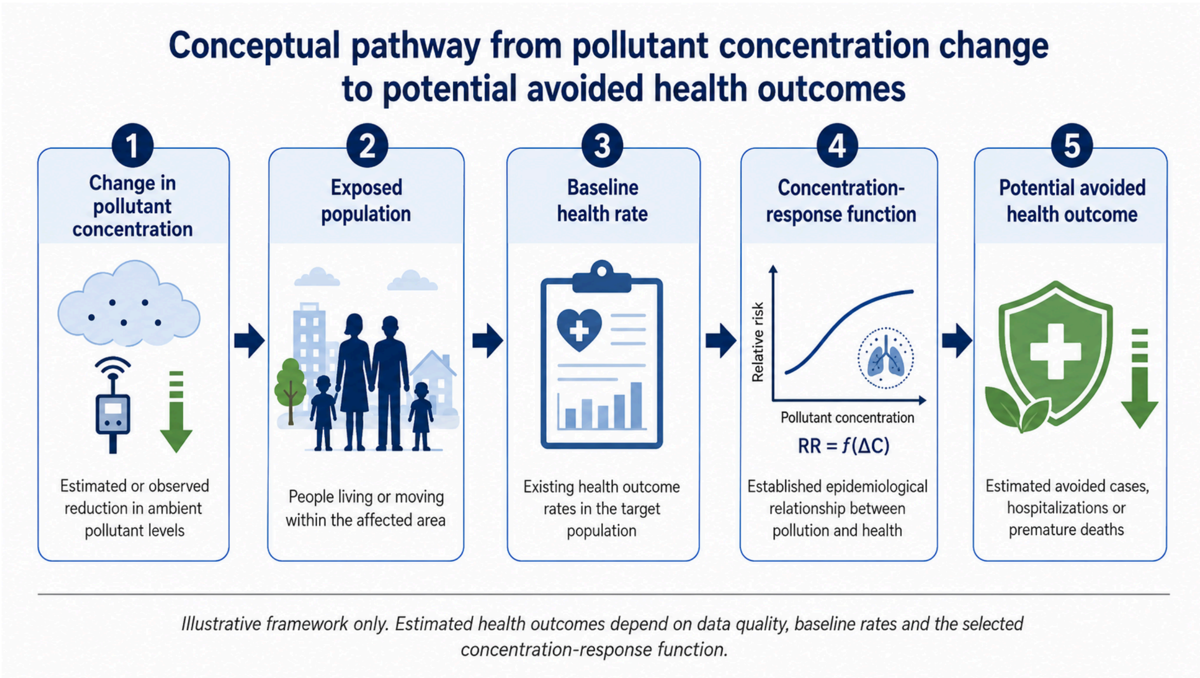

FIGURE 21: CONCEPTUAL PATHWAY FROM POLLUTANT CONCENTRATION CHANGE TO POTENTIAL AVOIDED HEALTH OUTCOMES

Potential outcomes may include:

- avoided hospital admissions for respiratory diseases;
- avoided hospital admissions for cardiovascular diseases;
- avoided emergency visits for asthma;
- avoided cases of acute lower respiratory infections in children;
- avoided premature mortality associated with long-term exposure to PM2.5;
- avoided mortality associated with cardiovascular outcomes;
- avoided mortality associated with lung cancer, where supported by the literature and data availability.

The health outcomes should be aligned with the Breathe Rio framework, which already considers respiratory diseases, cardiovascular diseases and lung cancer as relevant outcomes for air pollution-related analysis.

However, the note should clearly state that these are potential avoided outcomes under a scenario of reduced exposure. They are not evidence that existing cases were caused by Ternium Brazil. Results should be reported with uncertainty intervals whenever possible.

To strengthen the equity dimension, the HIA should also disaggregate potential benefits by population groups and territories when data allow. This may include:

- children;
- older adults;
- low-income residents;
- Black and Brown populations;
- residents living near industrial and logistics areas;
- public transport users;
- residents with long-distance travel needs for health care and employment.

This distributional lens is essential. The goal is not only to estimate aggregate health benefits, but also to assess whether emission reductions may reduce unequal exposure and unequal health risks in Santa Cruz/PA5.

10. Data needs and analytical next steps

The Ternium Brazil module would require a structured data plan. The following data categories should be prioritized.

Industrial source data

- emissions by pollutant and source type;
- stack characteristics;
- production volume and operating hours;
- emission-control technologies;
- filter specifications and performance;
- maintenance records;
- continuous emissions monitoring data;
- licensing and compliance documents;
- information on fugitive emissions and dust-control measures.

Air quality and meteorological data

- ambient PM2.5, PM10, NO_2, SO_2 and O_3 concentrations;
- data from fixed monitoring stations;
- low-cost sensor data, where validated;
- meteorological data, including wind direction, wind speed, temperature, precipitation and humidity;
- data completeness and quality-control procedures.

Population and vulnerability data

- population by neighborhood and census tract;
- age structure;
- income;

- race/color;
- health vulnerability indicators;
- location of schools, health units and other sensitive receptors;
- housing and settlement patterns.

Health data

- hospitalizations for respiratory diseases;
- hospitalizations for cardiovascular diseases;
- mortality from respiratory diseases;
- mortality from cardiovascular diseases;
- lung cancer morbidity and mortality;
- age-specific rates;
- spatial aggregation levels that protect privacy.

Mobility and access data

- public transport transactions;
- bus and BRT use;
- commuting patterns;
- travel time to central areas;
- travel time to specialized health services;
- location of reference hospitals and cancer treatment facilities.

The next analytical steps should include:

1. defining the geographic boundary of the Ternium Brazil influence area for scenario analysis;
2. identifying available emissions and monitoring data;
3. assessing data quality and gaps;
4. selecting pollutants and health outcomes;
5. defining baseline and emission-control scenarios;
6. estimating changes in pollutant concentrations;
7. estimating exposed population;
8. applying concentration-response functions;
9. reporting uncertainty ranges;
10. communicating results with clear methodological safeguards.

11. Main Conclusion

This concept note argues that Ternium Brazil should be incorporated into the Breathe Rio analytical framework as a specific industrial-emissions module for Santa Cruz. This does not imply attributing observed health outcomes to the company or to a single emission source. Rather, it recognizes that the presence of a major industrial facility in a socially vulnerable territory requires a dedicated, transparent and scenario-based assessment of air pollutant emissions, ambient concentrations, population exposure and potential health benefits from emission reductions.

Santa Cruz and PA5 provide the territorial context that makes this analysis particularly relevant. The maps from Outcome 1 show that PA5 combines low income, a large Black and Brown population, a young demographic profile, dependence on public transport, long-distance mobility and observed health burdens. These factors may increase the importance of understanding how local and cumulative exposure pathways operate in the territory.

The proposed approach is therefore cautious but policy-relevant. It would assess potential health benefits only under verified or clearly stated assumptions about reductions in emissions and pollutant concentrations. In this sense, filters and other emission-control systems should be analysed not as isolated technological measures, but as part of a broader industrial air quality management scenario.

The value of this concept note is to clarify how industrial policy, air quality monitoring, public health assessment, transport-related exposure and environmental justice can be connected in the case of Santa Cruz. By placing Ternium Brazil at the centre of a dedicated industrial-emissions module, the Breathe Rio project can expand its health equity framework beyond transport while maintaining methodological caution and transparency.

REFERENCES

CENTRE FOR RESEARCH ON ENERGY AND CLEAN AIR (CREA). Air quality impacts of the Ternium Brazil Santa Cruz steel plant. Helsinki: CREA, 2024. Available at: https://energyandcleanair.org/wp/wp-content/uploads/2025/02/CREA_HIA_Ternium_Brazil_Steel_PT_08.2024.pdf. Accessed on: 17 Jun. 2026.

POLÍTICAS ALTERNATIVAS PARA O CONE SUL INSTITUTE (PACS). Climate change and the steel industry: local and global impacts of Ternium Brazil. Rio de Janeiro: PACS, 2022. Available at: https://biblioteca.pacs.org.br/publicacao/mudancas-climaticas-e-siderurgia-impactos-locais-e-globais-da-ternium-Brazil/. Accessed on: 14 Jun. 2026.

OSWALDO CRUZ FOUNDATION (FIOCRUZ). Observatory on Health and Sanitation Rights. Stroke mortality is ten times higher in Santa Cruz than in Gávea. Rio de Janeiro, 2018. Available at: https://dssbr.ensp.fiocruz.br/mortalidade-por-avc-e-dez-vezes-maior-em-santa-cruz-do-que-na-gavea/. Accessed on: 18 Jun. 2026.

RIO DE JANEIRO CITY HALL. Municipal Law No. 5,248 of 27 January 2011. Rio de Janeiro, 2011. Available at: https://www.data.rio/documents/e6219ac014a2475d97e16dd45f995640/explore. Accessed on: 16 Jun. 2026.

RIO DE JANEIRO CITY HALL. Municipal Secretariat of Transport. Product 2: Data Collection and Analysis. Rio de Janeiro: Prefeitura da Cidade do Rio de Janeiro, 2025. Available at: https://transportes.prefeitura.rio/wp-content/uploads/sites/31/2025/02/PRODUTO-2-LEVANTAMENTO-E-ANALISE-DE-DADOS-.pdf. Accessed on: 10 June 2026.

POLÍTICAS ALTERNATIVAS PARA O CONE SUL INSTITUTE (PACS). Rio: capital of climate cynicism. Rio de Janeiro, 2024. Available at: https://www.global.org.br/blog/apoio/rio-capital-do-cao-climatico/. Accessed on: 15 Jun. 2026.

RIO DE JANEIRO CITY HALL. Municipal Law No. 5,133 of 22 December 2009: Grants tax incentives to services linked to steel complexes located in the West Zone of the Municipality of Rio de Janeiro and amends Law No. 4,372 of 13 June 2006. Rio de Janeiro, 2009. Available at: https://www.jusBrazil.com.br/legislacao/873983/lei-5133-09. Accessed on: 19 Jun. 2026.

LEGISLATIVE ASSEMBLY OF THE STATE OF RIO DE JANEIRO (ALERJ). Tax benefits for steel companies in Rio de Janeiro extended until 2032. Rio de Janeiro, 2022. Available at: https://www.alerj.rj.gov.br/Visualizar/Noticia/53446. Accessed on: 13 Jun. 2026.

RIO DE JANEIRO STATE. Law No. 4,529 of 31 March 2005: Approves the inclusion of CSA Companhia Siderúrgica do Atlântico, ThyssenKrupp Stahl A.G. and Companhia Vale do Rio Doce in the RioInvest Strategic Investment Attraction Program. Rio de Janeiro, 2005. Available at:
https://leis.org/estaduais/rj/rio-de-janeiro/lei/lei-ordinaria/2005/4529/lei-ordinaria-n-4529-

2005-aprova-o-enquadramento-das-sociedades-csa-companhia-siderurgica-do-atlantico-thyssenkrupp-stahl-a-g-companhia-vale-do-rio-doce-no-programa-de-atracao-de-investimentos-estruturantes-rioinvest-instituido-pelo-decreto-n%C2%BA-23012-97-para-a-construcao-e-exploracao-de-complexo-siderurgico-no-estado-do-rio-de-janeiro-e-da-outras-providencias?origin=instituicao. Accessed on: 18 Jun. 2026.

RIO DE JANEIRO STATE. Law No. 9,693 of 19 May 2022: Amends Paragraph 7 of Article 3 of State Law No. 4,529 of 31 March 2005. Rio de Janeiro, 2022. Available at: https://leisestaduais.com.br/rj/lei-ordinaria-n-9693-2022-rio-de-janeiro-altera-o-7-do-art-3-da-lei-estadual-n-4529-de-31-de-marco-de-2005?origin=instituicao. Accessed on: 17 Jun. 2026.

G1 RIO. Steel company cited for “devastating” pollution in Santa Cruz stopped disclosing emission levels of a pollutant harmful to health. Rio de Janeiro, 23 Sept. 2024. Available at: https://g1.globo.com/rj/rio-de-janeiro/noticia/2024/09/23/siderurgica-citada-por-poluicao-devastadora-em-santa-cruz-tem-falha-na-divulgacao-niveis-de-emissao-de-poluente-nocivo-a-saude.ghtml. Accessed on: 19 Jun. 2026.