IMPACT ASSESSMENT IN QUITO, ECUADOR

RESULTS FROM THE SOLUTIONSPLUS PROJECT

WE DRIVE CHANGE

WOMEN IN E-MOBILITY DRIVE CHANGE

EXECUTIVE SUMMARY

The Metropolitan District of Quito (DMQ), Ecuador's capital and largest city, has 2.7 million inhabitants (INEC, 2020). SOLUTIONSplus actions in Quito focused on the Historic Center (HCQ), a 376-hectare urban area with about 40,000 residents. The HCQ, a key mobility hub, faces challenges in freight and passenger transport due to narrow streets, high population density, and traffic restrictions, impacting economic activities and increasing costs for shop owners.

Quito's main mobility issues include congestion, dispersed transport services, low public transport quality, and limited capacity, leading to high private vehicle use. To address these, SOLUTIONSplus piloted e-cargo bikes and a mobility-as-a-service (MaaS) application.

E-cargo bikes:

- **Piloted Models:** Seven e-cargo bikes for delivery, restaurant logistics, and recycling.
- **Economic Impact:** Delivery logistics: $8021 net present value, 97.97% internal rate of return, 0.97-year payback.
- **Cost-effectiveness:** Restaurant logistics: $1.47 per m^3; recycling: $7.47 per m^3.
- **CO2 Reduction:** Delivery logistics: 247.4 kg/year; restaurant logistics: 173.3 kg/year; no reduction for recycling.
- **Feedback:** Positive quality and usability perceptions.

MaaS Application:

- **Features:** Trip planning, timetables, routes, schedules, stations, stops, and ticket purchase.
- **Pilot:** One month, 45 students, November-December 2022.
- **Challenges:** Usability issues but potential for improved public transport accessibility and reduced private car use.

Overall, SOLUTIONSplus initiatives show promise in addressing Quito's transport challenges and promoting sustainable mobility.

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QUITO

BACKGROUND

The Metropolitan District of Quito (DMQ), the capital and largest city of Ecuador, has about 2.7 million inhabitants (INEC, 2020) and is situated in the Pichincha province in the northern highlands of Ecuador, within the Guayllabamba river basin. The city, located at an elevation of 2,850 meters, is the second highest official capital in the world and the closest to the equator. The Historic Centre of Quito (HCQ), a 376-hectare urban area with approximately 40,000 residents, is a UNESCO World Cultural Heritage Site and a major commuter hub.

Quito's urban area has expanded in three phases: radial growth until the 1950s, longitudinal north-south growth until the 1990s, and eastward sprawl since then. The DMQ comprises 33 rural and 32 urban parishes.

Quito was the second city in Latin America to implement a Bus Rapid Transit (BRT) system, which now includes 5 lines covering 136 km and handling 1 million trips daily. Recently, 80 bi-articulate diesel buses were introduced. However, the system has reached capacity, and 40% of the fleet is nearing the end of its life. To achieve zero emissions by 2030, Quito plans to replace the BRT fleet with e-buses by 2025. A draft ordinance for the gradual decarbonization of transportation is under discussion, emphasizing fleet renewal starting with 10% of the BRT fleet and prioritizing the HCQ for creating a zero-emissions zone by 2020.

GEOGRAPHY AND SOCIAL CONTEXT

TOPOGRAPHY AND WEATHER

The Metropolitan District of Quito (DMQ) features a diverse altitude range due to its Andean location, with elevations from 500 to 4,870 meters above sea level. The city itself lies on a plateau at 2,850 meters, flanked by the Western and Eastern Ranges of the northern Andes, forming a narrow urban area 42 km long and 15 km wide, with urban expansion in the Tumbaco and Los Chillos valleys.

Climate:

Quito experiences various climatic zones due to its topography:

- **Valleys:** Temperate climate
- **External foothills:** Humid areas
- **High mountain regions:** Climates above 3,000 meters

From 1981-2005, the average annual temperature was 15°C, increasing gradually from the Western Range to the northwestern district. Precipitation varies:

- **Inter-Andean dry zone:** 554 mm/year
- **Inter-Andean zone:** 960 mm/year
- **Inter-Andean rainy zone:** 1,400 mm/year

Annual precipitation is highest in the northwest (2,369 mm) and lowest in the south (1,133 mm).

URBANIZATION AND POPULATION

Quito's urbanization has evolved in three phases, with recent decades showing significant sprawl. Despite this, urban land comprises only a small portion of the Metropolitan District's total area. The land use is primarily natural (87%), with urban residential areas making up 6.8% and residential agricultural areas 2.7%.

Population growth rates have slowed from an average of 3.5% annually (1950s-1970s) to 2.2% (2001-2010). Growth is uneven, with peripheral areas growing over 3.4% and central areas experiencing up to a 2.3% decline.

Quito's demographic profile shows an increasing working-age population, from 73.6% in 2001 to 75.0% in 2010, with a shrinking base of those under 10 years old. By 2010, the population was 48.7% male and 51.3% female.

Annual population growth

1950s-1970s: 3.5%
2001-2010: 2,2%

Population Growth Rates

Peripheral areas: >3.4%
Central areas: -2.3%

SOCIAL AND ECONOMIC DEVELOPMENT

Quito's social and economic conditions are better than the national average. Employment is concentrated in the city center (54% of jobs), while the workforce is dispersed, creating significant daily commutes.

In 2020, Quito's GDP was estimated at USD 24 billion, contributing 24.5% to the national GDP. Key economic activities include professional services and real estate (20%), manufacturing (18%), and public administration (16%). Transport, information, and communications make up 7% of the city's economy.

Working Age Population

2001: 73.6%
2010: 75.0%

Gender Distribution (2010)

48.7% men
51.3% women

EMISSIONS

Quito's 2015 Greenhouse Gas Inventory identifies key CO2 emission contributors: transport (40%), stationary sources (26%), agriculture and land use (24%), and waste (10%). Transport is the largest energy consumer nationally, using 46% of oil annually, with diesel (31%) and gasoline (27%) being the primary fuels. In 2012, transport accounted for 45.2% of GHG emissions within the energy sector, totaling 37.6 million tCO2eq. By 2015, land transport consumed 87% of subsector energy, with heavy freight responsible for 44%.

CO2 Emission Contributors

Transport: 40%
Stationary sources: 26%
Agriculture and land use: 24%
Waste: 10%

URBAN TRANSPORT

Quito's public transport system consists of the Metrobus-Q subsystem and a conventional subsystem. The Metrobus-Q includes two publicly operated corridors and one privately operated corridor, while the conventional subsystem involves private operators authorized to operate on specific routes. Despite these provisions, the public transport system has reached its capacity, resulting in unsafe and uncomfortable travel experiences that have led to an increased reliance on private cars. To address this, Quito has been developing its first subway line, which began operations in 2023. This line runs north to south, mirroring the BRT routes. Additionally, Quito is committed to renewing its bus fleet with electric buses by 2025, aiming for zero emissions by 2030.

MAIN PROBLEMS IN PASSENGER TRANSPORT SERVICES

The public transport system in Quito faces several critical issues:

Redundancy of Routes: Overlapping and unnecessary routes lead to competition among transport providers, decreased road safety, low productivity, and increased pollution.

Congestion and Road Insecurity: High volumes of public transport units, especially buses, saturate the main roads, causing significant congestion and safety issues.

Lack of Complementary Transport Services: Instead of forming an integrated system, public transport services operate as individual routes, lacking coordination and efficiency.

Elementary Business Organization: Public transport services are provided individually by operators, rather than through a cohesive, corporate structure, resulting in inefficiencies.

Non-compliance with Schedules: About 50% of conventional service routes do not adhere to set schedules and frequencies, partly due to the strenuous working conditions of drivers.

Insufficient Comfort: During peak hours, 80% of public transport experiences overcrowding, with occupancy rates exceeding international standards, discouraging public transport use.

Deficit in Passenger Transport Capacity: There is a significant capacity shortage, especially in integrated corridors, causing long waits and overcrowding even during off-peak hours.

Rise of Informal Transport: Due to inadequate public transport services, informal transport options have increased, often operating outside regulations and charging higher fees.

These issues make public transport less attractive compared to private vehicles, leading to increased car usage despite economic challenges. Integrated transportation solutions are crucial for improving urban mobility, economically and environmentally.

TRAFFIC AND POLLUTION ISSUES IN THE HISTORIC CENTRE OF QUITO (HCQ)

The HCQ faces severe traffic congestion with 76,038 private vehicles, 1,233 buses, and multiple bus lines operating daily, reducing traffic speeds to 3 km/h during peak hours. Public transport and walking are the primary modes of travel, but the area's topography and congestion pose significant challenges for pedestrians. Efforts to pedestrianize streets and establish a Low Emission Zone (LEZ) aim to address these issues.

In 2020, air quality in Quito improved due to pandemic-related mobility restrictions, with 26% of days having good air quality, 71% acceptable, and only 3% in a state of caution. Reduced vehicle traffic during this period led to lower concentrations of pollutants like PM2.5 and NO2, highlighting the impact of traffic on air quality.

26% of days in 2020 had good air quality,

3% of days were in a state of caution

71% were acceptable

FREIGHT TRANSPORT SERVICES IN THE HISTORIC CENTRE

Freight Transport Services in the Historic Centre
In the Historic Centre of Quito, the conversion of some streets into pedestrian corridors has complicated goods distribution. Narrow streets and high population density make supply activities challenging, affecting pedestrian enjoyment and business operations. Although ordinance No. 147 regulates logistics, night loading and unloading schedules do not align with business needs, and infrastructure for temporary loading and unloading is inadequate. A survey revealed that 58% of residents see congestion as a major barrier to business provisioning, with 93% receiving supplies weekly and 28% daily. Restrictions on medium and large freight vehicles during daytime further increase costs for shop owners.

58%
of residents identified congestion as a major barrier to business provisioning.

USER NEEDS ASSESSMENT

The user needs assessment in Quito reveals key priorities and challenges for implementing e-mobility solutions. The city aims to reduce emissions and increase e-vehicle use, particularly for transporting goods and people, aligning with inclusive mobility goals. Major obstacles include financial constraints, lack of supportive policies, and regulatory issues related to vehicle homologation. Additionally, there are concerns about vehicle safety, interaction between different transport modes, and the need for infrastructure tailored to the Historic Centre's topography. Stakeholders emphasize the importance of integrating e-mobility into urban planning to improve accessibility and support new business models, though they note challenges such as the lack of a culture around e-vehicles and the need for better infrastructure and planning.

Primary Objectives

- Analyze costs and increase e-vehicle use for transporting goods.
- Reduce emissions and improve air quality.
- Focus on inclusive mobility for all citizens, including those with disabilities and seniors.

Main Challenges

- Financial constraints and lack of enabling policies.
- Regulatory issues, including the absence of specific homologation processes for certain e-vehicles.
- Safety and interaction issues between different transport modes.

Infrastructure and Planning Needs

- Customized design for the Historic Centre's topography.
- Integration with urban planning to enhance accessibility and public space.
- Adequate charging infrastructure and route planning considerations.

Stakeholder Insights

- E-mobility solutions seen as an opportunity for formalizing informal services and improving transport.
- Potential for job creation, new business models, and industry growth.
- Concerns about distribution, culture, and information gaps regarding e-mobility.

Implementation Concerns

- Need for careful planning of e-vehicle deployment and charging infrastructure.
- Addressing safety, accessibility, and urban planning issues.
- Overcoming skepticism and cultural barriers related to e-mobility adoption.

KEY PERFORMANCE INDICATORS

PRIORITIZATION OF KPIS ADDRESSING THE SPECIFIC CITY NEED

In Quito, stakeholders have prioritized Key Performance Indicators (KPIs) based on their relevance to the city's needs. The demonstration's environmental impact is considered the most crucial, with a cumulative weight of 18.65, closely followed by project finances at 18.35, indicating both aspects are of high interest. Other key areas ranked in decreasing priority are society (17.32), climate (16.65), and the institutional framework (15.21), with the wider economy receiving the lowest priority (13.84). For Level 2 KPIs, the effect on greenhouse gas (GHG) emissions is the top priority (16.65). Within project finances, financial viability (9.22) is slightly more important than financial availability (9.12). Environmental concerns prioritize the impact of air pollutants (6.88), while society values road safety (2.38) and accessibility (2.37) most. The wider economy's main KPI is employment (5.15). For Level 3 KPIs, raising external funding (9.12) is most important, followed by recycled resources (5.94) and noise (5.81). User perception KPIs, like perceived comfort and safety, are notably low, with perceived personal security scoring the lowest (0.25). For the wider economy, budget (4.63) is valued higher than wages (2.24).

Priorities

- Environmental Impact: Highest priority with a cumulative weight of 18.65.
- Project Finances: Close second with a cumulative weight of 18.35.

Other Key Areas

- Society: 17.32
- Climate: 16.65
- Institutional Framework: 15.21
- Wider Economy: Lowest priority at 13.84

Level 2 KPIs

- Effect on GHG Emissions: Highest priority at 16.65.

Project Finances

- Financial Viability: 9.22 (higher than financial availability at 9.12)

Environmental Concerns

- Air Pollutants Impact: 6.88

Society

- Road Safety: 2.38
- Accessibility: 2.37
- Affordability and Well-being: 2.35 each

Wider Economy

- Employment: 5.15 (most important KPI)
- External Trade: 4.06 (lowest priority)

Level 3 KPIs

- Ease of Raising External Funding: Highest priority at 9.12.
- Recycled Resources: 5.94
- Noise: 5.81

User Perception

- Perceived Comfort, Safety, and Changeability: Very low scores
- Perceived Personal Security: Lowest at 0.25

Wider Economy

- Budget: 4.63
- Wages: 2.24

BASELINE VALUES

BASELINE PROJECTIONS BASED ON REFERENCE SOURCES

The baseline values for the SOLUTIONSplus project in Quito, targeting 2025–2030, include key socio-economic and environmental indicators. By 2025, Ecuador's population is expected to grow by 7.87%, doubling to 14.07% by 2030. Quito, with 40,000 inhabitants in its Historic Centre, reflects broader national trends. The city's GDP per capita was USD 24 billion in 2018, but national projections suggest a 2.7% decrease. Unemployment is predicted to rise slightly from 3.8% in 2019 to 4.1% by 2025. GHG emissions from transport are projected to increase, reaching 1.9 million tons of CO2 equivalent by 2025 and 2.3 million by 2030, with passenger cars, buses, and taxis as major contributors. Travel patterns indicate a rise in private vehicle use and walking, while public transport by bus may decline. Vehicle ownership is expected to grow from 256 to 368 vehicles per 1,000 inhabitants by 2030. These projections are subject to change due to uncertainties like the COVID-19 pandemic.

Ecuador's population is projected to increase by 7.87% by 2025 and 14.07% by 2030

Private vehicle use is expected to increase from 25.2% of daily trips in 2019 to 35.3% in 2030

COMPONENT 1 – E-CARGO BIKE IMPLEMENTATION

COMPONENT DESCRIPTION

From November 7, 2022, to January 6, 2023, a pilot project introduced ten e-cargo bikes, including Long John bicycles and rear- and front-loading e-tricycles, in Quito's Historic Centre (HCQ) as part of the city's zero-emission zone initiative. Funded by SOLUTIONSplus and local initiatives, these bikes were integrated into existing delivery models by seven logistics operators. The pilot, which included last-mile delivery services for supply, freight, courier, and recycling, delivered a total of 16 tons of cargo (average 313.7 kg/day) and covered 2,547.1 km, with 1,056.7 km within the HCQ. The project utilized GPS tracking and user diaries to monitor performance and operational days for each vehicle.

RESTAURANT LOGISTICS

For restaurant logistics, the rear-loading e-cargo bike costs $3,200 to purchase and has a yearly operational profile with 600 km mileage. Annual operating costs include $200 for personnel, $1 for electricity, and $300 for maintenance, totaling $501. The annualized costs, considering a 10-year lifespan, amount to $1,040 ($539 capital and $501 operational). With a yearly cargo volume of 711 m^3, the cost-effectiveness ratio is $1.47 per m^3.

AVAILABILITY OF FUNDING

The local project team in Quito identified several potential funding sources for the project, including international instruments and commercial banks that offer credit for transportation. Additionally, city funds are allocated as part of Quito's Zero Emissions Historic Centre plan. Consequently, the availability of financial resources is rated with a STAR value of 5 for all three project components.

FINANCIAL VIABILITY

The financial viability of using long john e-cargo bikes for logistics was evaluated using Net Present Value (NPV), Internal Rate of Return (IRR), and payback period metrics. The cost of a long john e-cargo bike is $2,800 with a 5-year lifespan and a $500 battery replacement. The pilot covered 2,547.1 km, with 1,056.7 km in the Historic Centre of Quito. Each bike made an average of 8 round trips per day, covering 1,320 km annually. Operating costs, including salary, electricity, and maintenance, total $2,900 per year. With a revenue of $6,653 per year per bike, the pre-tax NPV is $11,363, IRR is 130.44%, and payback period is 0.75 years. After taxes, the NPV is $8,021, IRR is 97.97%, and payback period is 0.97 years. Previous logistics operations using privately owned motorcycles showed higher delivery volumes and income compared to the e-cargo bikes.

INSTITUIONAL AND POLITICAL INDICATORS

The project aligns well with national and local transport, energy, and environmental policies, including Ecuador's Organic Law of Land Transport and the Sustainable Mobility Plan for Quito, as well as the Climate Action Plan and the Low Emission Zone HCQ. This coherence grants it a STAR value of 5. However, there is some uncertainty regarding compliance with regulations on managing used batteries, resulting in a STAR value of 4. Administrative barriers include the need for approval of several ordinances and municipal space usage, and while political and institutional bodies are in place, their support for project implementation is uncertain, leading to a STAR value of 2.

CLIMATE-RELATED INDICATORS

Impact on GHG Emissions

Logistics Services: With an average daily mileage of 5 km and annual mileage of 1,320 km per vehicle, switching from gasoline motorcycles to e-bikes can save about 274.4 kg of CO2 annually per vehicle, assuming electricity is from renewable sources.

Restaurant Logistics: With an average daily mileage of 2 km and annual mileage of 600 km per vehicle, switching from gasoline cars to e-bikes can save approximately 173.25 kg of CO2 annually per vehicle, given that electricity is emission-free.

Recycling: Switching from manual pushcarts to e-bikes has no impact on CO2 emissions, as the previous method did not generate significant emissions.

ENVIRONMENTAL INDICATORS

Impact on Air Pollutants
Logistics Services: E-bikes can reduce NOx and PM2.5 emissions. For 1,320 km annually, this equates to a reduction of 0.224 kg NOx and 0.0053 kg PM2.5 per vehicle.
Restaurant Logistics: Switching from gasoline cars to e-bikes reduces NOx by 0.464 kg and PM2.5 by 0.023 kg annually, assuming 600 km per year.
Recycling: No impact on air pollutants as the previous method used manual pushcarts.

Impact on Noise
E-bikes have contributed to reduced noise levels in the Historic Center of Quito. Participants rated the noise reduction positively, with an average score of 4.57 out of 5.

Effect on Recycled Resources
Lithium-ion batteries used in e-bikes contain harmful materials such as cobalt and nickel. Without proper recycling practices, these materials can pose environmental and health risks. The current lack of regulations in Quito for battery recycling could lead to environmental issues.

COMPONENT 2 - MAAS APPLICATION FOR PUBLIC TRANSPORT

COMPONENT DESCRIPTION

The MaaS application, developed by PlusService for Quito's public transport companies EPMTPQ and EPMMQ, offers features like multimodal trip planning, schedule information, ticket purchases, and user management. The pilot ran from November 21 to December 16, 2022, with 45 students from the National Polytechnic School testing the app. The evaluation included a user survey and log data collection.

IMPACT ASSESSMENT

Usability Issues: The pilot revealed several usability problems that impacted the application's effectiveness. This affected the observed impacts, which may not fully represent the potential of a MaaS system in Quito.

GHG Emissions, Air Pollution, Noise: The app had minimal impact on GHG emissions, air pollution, or noise since most users replaced walking with public transport rather than reducing private car use.

Accessibility: The app's ability to reach new destinations was seen as limited, with mixed feedback on improving connections. However, with improved usability, it could enhance accessibility.

Travel Time: Users reported minimal changes in travel time. Most responses indicated that the app did not significantly reduce total travel time.

Road Safety: The app did not noticeably decrease private vehicle use among participants, so it likely had no immediate impact on road safety. A broader implementation might better address road safety.

Service Quality: Current feedback suggests the app did not significantly enhance the perceived quality of mobility services. Improvements are needed to make journey planning and execution easier.

Modal Split and Multimodality: The app had a slight effect on increasing public transport use, but its impact was limited.

Traffic Network Efficiency: No significant impact was observed on traffic network efficiency due to unchanged private car usage among participants.

Demand for MaaS Application: Ticket usage peaked shortly after the pilot began but declined thereafter. Despite usability issues, the app showed potential for future use if these issues are resolved. The pilot's impact on reducing private car use was limited, but the MaaS application could still be effective in a broader context where car use is more prevalent.

SCALED-UP CONCEPT AND ASSESSMENT

Overview
The scaled-up project aims to create a zero-emission logistics zone in Quito's Historic Center (HCQ) as part of the city's climate action plan. This project builds on the SOLUTIONSplus pilot from November 2022 to January 2023, focusing on replacing internal combustion engine (ICE) vehicles with electric ones.

Baseline
The HCQ, covering 376 hectares with 40,000 residents and 2,000 businesses, sees significant logistics activity. A 2021 survey indicated an average of 1.7 vehicle deliveries per week per business. Assuming daily deliveries, about 397 ICE vehicles (small trucks, light vehicles, vans, large trucks, and taxis) enter the HCQ daily. Transitioning to electric vehicles could significantly cut these ICE vehicles.

Scaled-Up Impacts

GHG Emissions:
Replacing 397 ICE vehicles with electric ones in the HCQ could reduce CO2 emissions by approximately 296,335 kg annually. This estimate is based on several assumptions regarding vehicle types and fuel consumption.

Safety:
Local experts assessed the safety impacts of the scaled-up project. Their evaluations focused on changes in fatalities, serious injuries, minor injuries, and material damage, but specific results were not detailed.

Security:
Security impacts were evaluated by local experts, with results compiled but not detailed in the summary.

Charging Safety:
Experts noted potential risks related to battery disposal and charging station safety. Concerns included the handling of broken batteries and technical problems with existing charging infrastructure.

Employment:
The impact on job creation was assessed through expert interviews.

Findings included:
- **EV Technicians:** Views varied from no additional need to significant further demand.
- **EV Design Engineers:** Opinions ranged from no additional need to significant demand for specific designs suited to Quito's topography and climate.
- **IT Analysts/Industry 4.0 Experts:** Need for skilled workers ranged from slight to very significant, with a current skills shortage.

In summary, the scaled-up project has the potential to greatly reduce emissions and create new job opportunities, though it faces challenges related to safety, security, and technical skills.

DISCUSSION

In Quito, key transportation issues included an unattractive public transport system and challenges with cargo transport due to narrow streets and restrictions. To address these, the project had two components:

E-CARGO BIKES

From November 2022 to January 2023, eight e-cargo bikes were used in Quito's Historic Center for food delivery, parcel transport, restaurant logistics, and recycling. They moved 16 tons of cargo over 2,547 km, including 1,057 km within the Historic Center. Post-pilot, the bikes continued operations from April 2023 to June 2024, transporting 300 tons, traveling 25,000 km, and avoiding 6 tons of CO2. Financially, the e-cargo bikes had a net present value (NPV) of $8,021 and a payback period of less than a year. They demonstrated cost-effectiveness in logistics but were less efficient than ICE motorcycles. They also reduced emissions and had positive social impacts, improving recycling operations' efficiency.

MAAS APPLICATION

In November-December 2022, 45 students tested a MaaS app for public transport, which integrated scheduling, ticketing, and route planning. Usability issues limited the app's effectiveness. However, with improvements, it has potential to support a shift from private cars to public transport, addressing personal mobility challenges in Quito.

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