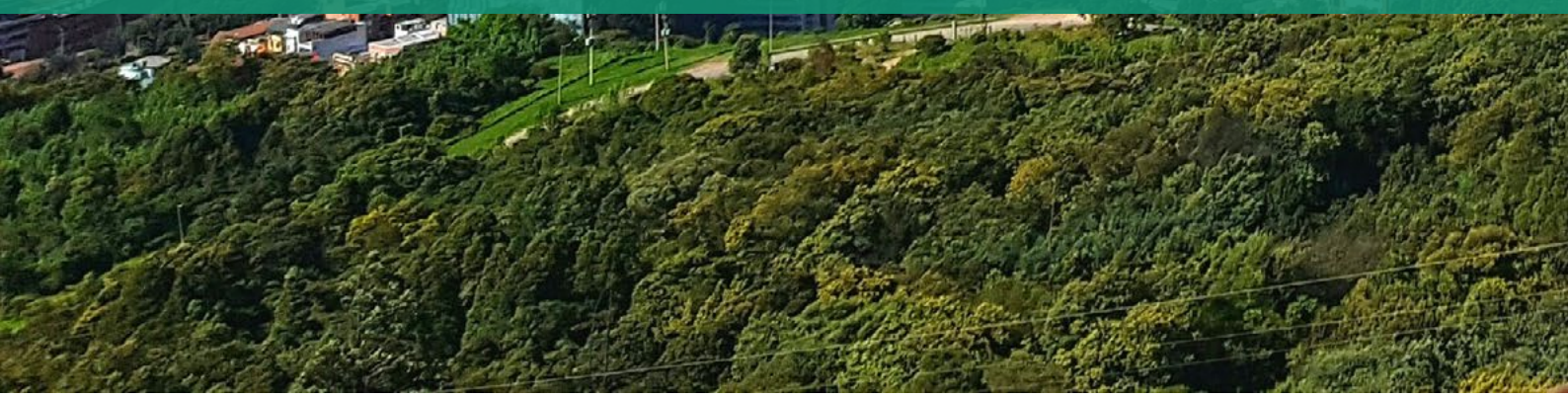
Bogotá / Colombia

SOLUTIONSPLUS I SCALE-UP CONCEPT NOTE



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PROJECT PARTNERS

ABOUT

This is a summary of the paper, submitted to the journal 'Sustainable Earth Review' developed under SOLUTIONSplus project. Currently the paper is under peer review.

TITLE

Capacity and market potential for local production and distribution of electric two-wheelers in Southeast Asia, focused on Thailand, Indonesia, and Vietnam

PREPARED BY

Hyung Ju Kim, Wuppertal Institute (Visiting scholar)/ National Institute of Green Technology Korea
Shritu Shrestha, Wuppertal Institute
Kanya Pranawengkapti, Wuppertal Institute

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DISCLAIMER

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LAYOUT

Yasin Imran Rony, WI

PICTURES

All the pictures are provided by the ITDP

June, 2024

SOL+ Replication Pilot - Latam

Scale-Up Concept

Project Title: **Persons with Disabilities or reduced mobility access by incorporating electric engines to convert handcycles into electric-assisted bicycles**

City/Country: Bogotá, Colombia
Implementing partner: Despacio
Other supporting partners: Tembici Colombia
Document developed by: Camilo Urbano, Miguel Ángel Cuellar, Christian Rincón, Despacio

1. Background

Despacio is the project implementer of this project, and it is a research center legally constituted as a non-profit organization in Colombia in 2011. It aims to promote quality of life in cities and during all life cycle stages through applied research and emphasizing challenging the intuitive. Its four areas of work are sustainable and safe mobility, urban development, healthy cities, and gender and city, in which it works through projects, publications, events, and a laboratory.

Despacio works with an interdisciplinary team of more than 30 professionals in more than 190 projects, 40 publications, and 30 events at global, regional, and local levels related to urban development policies, sustainable mobility, promotion of non-motorized transport, urban logistics, micromobility of passengers and cargo in the first and last mile, bicycle infrastructure planning and design, road safety, demand management, data analysis, gender mainstreaming and differential approach, healthy cities, urban lighting, citizen culture, and climate change.

In these initiatives, he has worked together with international organizations like UN-Habitat, the German Cooperation Agency (GIZ), the United States Agency for International Development (USAID), the French Development Agency (AFD), the Inter-American Development Bank (IDB), the World Bank (WB), the Development Bank of Latin America (CAF), the WRI Ross Center for Sustainable Cities, Danish Cycling Embassy, the Institute for Transportation and Development Policy (ITDP), ICLEI, the Global Road Safety Partnership (GRSP), the Global Health Advocacy Incubator (GHAI), Fondation Botnar, among others.

On the other hand**,** ***Tembici*** *is* one of Latin America's most relevant and leading micromobility companies, responsible for operating docked bike-sharing systems in more than 14 cities within Brazil, Chile, Argentina, and Colombia. Since its inception, Tembici has achieved more than 70 million bike rides and has avoided more than 26 thousand tons of CO_2 emissions.

Tembici is implementing the first Shared Bicycle System (SBS) in Bogotá. The Shared Bike System is located in Bogotá's city-expanded center, allowing easy connection to the city's Public Transport System. In this sense, the SBS complements the public transportation network, offering users greater proximity to TransMilenio stations and SITP stops. The system's operating areas are Usaquén, Chapinero, Barrios Unidos, Santa Fe, La Candelaria, and Teusaquillo. It has 3,300 bicycles, of which 1,500 are pedal-assisted and 1,500 are mechanical. In addition, it has 150 box bicycles or cargo bikes that are used to transport goods by users and 150 handcycles for people with physical disabilities, such as users of wheelchairs.

As it's going to be explained in the following sections of this report, the main aim of the project is to develop, test, and monitor the incorporation of electric engines into mechanical handcycles that are part of Bogotá's SBS so that they improve access for People With Disabilities (PWD) or reduced mobility to the shared bicycle system of Bogota. In this context, Despacio and Tembici have joined efforts to develop a scale-up concept note for a new alternative and more sustainable transportation options to PWD and restricted mobility of sustainable mobility with the implementation of the e-handbike. In this sense, Tembici's role will be to provide the physical infrastructure of the SBS, the bicycles for developing this pilot, and the necessary tools for data collection and processing.

Despacio, with its experience and trajectory in the analysis of sustainable mobility and the development of data capture methodologies in universal accessibility and zero-emission transport projects, will provide the project design, data analysis, and evaluation of the implemented technologies to formulate recommendations for replicability and scalability.

2. About the Pilot Project

Objectives

The main objective of the pilot project is to prototype, test, and monitor the incorporation of electric motors into mechanical handcycles that are part of the shared bicycle system of Bogota so that they improve access for people with disabilities or reduced mobility to the shared bicycle system of Bogota, foster the use of sustainable modes of mobility, and can be scaled and replicated this technology in more bicycles of the system and other cities in the region with similar features. To achieve this central objective, Despacio will carry out the following complementary objectives:

1. Developing and incorporating electric motors into five mechanical handcycles to improve the usability and accessibility of these vehicles by users with physical disabilities and reduced mobility in Bogota's SBS.
2. Define objective indicators and collect data to monitor the performance of the electro-assisted hand trucks in terms of operational efficiency, road safety, and universal accessibility.
3. Set subjective indicators of user satisfaction and collect these data to measure their perception of the accessibility, operational efficiency, and safety of the e-bikes.

4. Collect the necessary information from objective and subjective indicators to carry out the prototyping of the handcycles to incorporate the electric motors in the handlebars to turn them into electro-assisted bicycles.
5. Test and monitor the performance of the electro-assisted handbikes in terms of operational efficiency, road safety, and universal accessibility by users with physical disabilities or reduced mobility.
6. Make recommendations for replicability and scalability of the technology incorporated in the handcycles based on the data from the indicators collected in the pilot so that these suggestions lead to an increase in this technological solution in more bikes, as well as increasing accessibility to PWD into sustainable transportation modes in other cities with similar SBS.

Project structure

The project is divided into two phases:

I. *Phase 1, e-handcycle development and definition of monitoring and assessment indicators*: the objective of the project's first phase is to install an electric motor on one handcycle (Model 1) and test its operational performance and accessibility. To this end, Model 1 will be developed based on the results of a focus group, composed of at least five people with physical disabilities or reduced mobility, that will enable improved operational performance, safe operation, optimal accessibility, and user perception of the handcycle.

II. *Phase 2: e-handcycles implementation, measurement, monitoring, and formulation of scalability and replicability recommendations*: In the second phase of the pilot, six additional electro-assisted handcycles will be adapted with the electric engine and tested with an extended group of PWD. These handcycles will incorporate the recommendations based on the results from the previous project stage to improve their reliability, safety, and universal design. As a result of the tryouts, recommendations for scalability and replicability of this technology will be formulated based on the data collected from the indicators battery in areas of Bogota as well as for other similar cities where the SBS operates.

3. Phase II: Scale-up Concept and Strategy

3.1. Objective and approach

The main objective of the scale-up is to increase and improve access to sustainable modes of mobility for people with physical disabilities with more accessible and optimized vehicles that help the user with physical disabilities develop first- and last-mile trips.

3.2. Scale-up and timeframe

The project's expansion involves seven stages, which are explained below and can be viewed in the timeline. It is noteworthy that the scaling process described here is designed for one year, the first year of e-handbike operation, in which Tembici will not only incorporate the technical adaptations proposed by this project, but also gather the necessary information to develop a long, sustainable, inclusive and optimal operation of e-handbikes in the Bogotá SBS.:

1. **Electrification of handcycles/ design of the handcycles:** During the initial stage, the adaptations necessary for the transformation of mechanical handcycles into electric vehicles will be carried out. In meetings between Tembici and Despacio, it was decided that the project would prioritize scalability. As a result, Model 1 of the handbikes will be developed, with 5% of the total fleet of 150 e-handcycles being adapted, or a total of 8 vehicles. The decision was based on the consideration of CAPEX and OPEX costs required for the incorporation of these handbikes in the Bogotá SBS.

   Although the project was able to make progress in the development of Model 2, incorporating improvements in the wheelchair anchorage and enhancing the pedal height to make the vehicle easier to steer, this model still requires further testing and data collection. Furthermore, it was considered that the interventions required to progress to Model 2 are more costly than those required for Model 1, over three times more expensive (See Table 3 and Table 4 with the scalability budget). Additionally, the current handcycle's chassis and overall structure are not strong and rigid enough to make these modifications. Therefore, Tembici, Despacio, and the manufacturer that supported these developments, Pargal, recommend not advancing with Model 2 for scalability. In this scenario, it is better to develop a new vehicle, taking into account the information and lessons learned from this project.

2. **Identifying and defining the locations or stations where the e-handcycles will be available for PWD for the use:** Considering the data collected during the project, we suggest locations for the e-handcycle implementation base on series of conditions and criteria: the final destinations in a regular day of PWD, their trip motivations and the different bus services that PWD can use to commute (SITP buses or TransMilenio). These conditions are the following:

   a. **Destinations:** Considering the data of the project baseline there are 6 specific places located within the Tembici area and frequently visited by 29 of the 76 registered wheelchair users who answered the form. They are the only ones who frequently go to the Tembici operating area (see the map in the figure below).

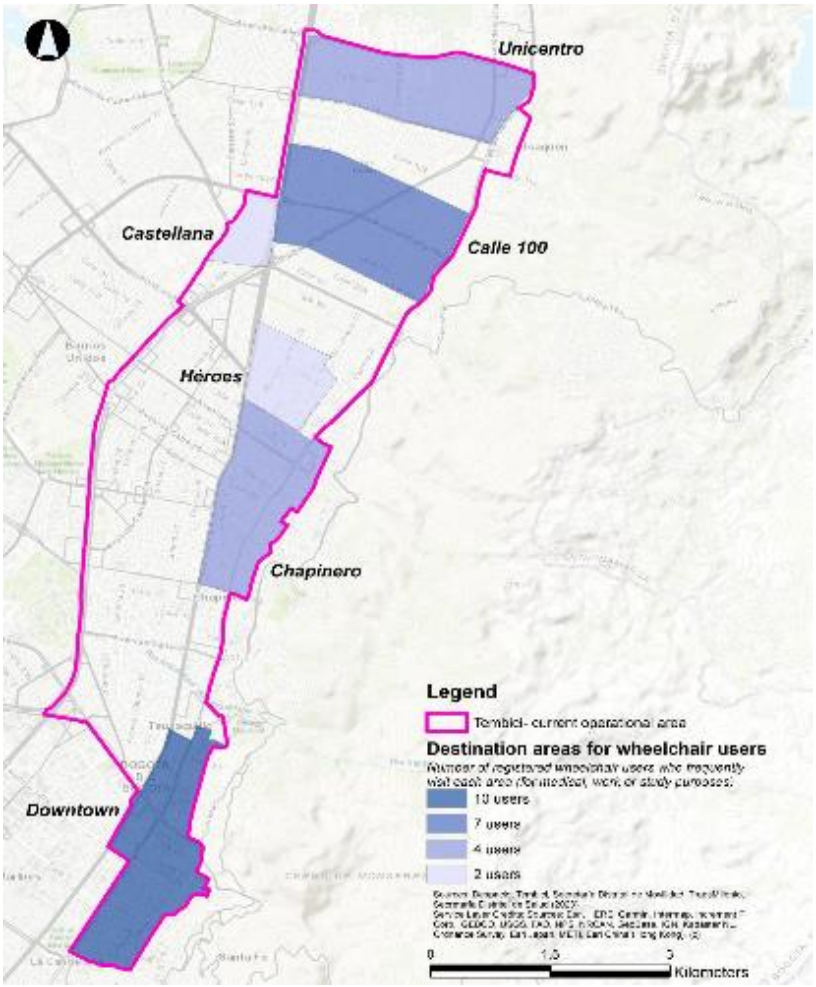

Figure 1. User's destinations from the project's baseline database

b. **Healthcare facilities in the Tembici area.** 58 healthcare facilities (clinics and hospitals) are located within the Tembici operational area (Secretaría Distrital de Salud, 2020). At this point, it should be noted that, according to the results of the project registration form, 42 of 76 wheelchair users move around the city mainly to attend medical appointments.

c. **The Public Transportation Systems in the Tembici area:** these criteria are based on the location of the TransMilenio stations in the SBS area of operation and the information established in the Bogotá Decree 324 of 2014, which lists the SITP routes that must serve the PCD and have accessibility conditions in buses and bus stops where e-handbikes can be placed. The suggested locations are also mentioned below.

- TransMilenio stations: Currently, there are 38 TransMilenio stations located into or near the Tembici operating area (TransMilenio, 2023a). These stations are part of different lines, such as:
  - Av. Caracas
  - Autopista Norte
  - Av. Jiménez

- NQS
- Av. El Dorado
- Calle 80.

- SITP bus services accessible routes: the bus services provide wheelchair access to Bogotá's public bus system. The following 9 accessible routes cover Tembici's operational area, meaning these services comprehend 89 bus stops (TransMilenio, 2023b).
  - 112: Cortijo- El Porvenir
  - ZP 126: Casa Linda - Villa Glady*s*
  - *166*: Metrovivienda - Porciúncula
  - 341: Metrovivienda - La Estrellita
  - 579: El Recreo - Centro Internacional
  - 621: Bachue - Santo Domingo
  - 736: Paraíso - Calle 222
  - C52: Villa del Río - El Retiro
  - C15: Bosa San Pedro - Chapinerod.

d. **Selection criteria for the e-handcycles scalation.** Given the last conditions, we define a set of criteria to suggest the location of the e-handcycles can beplaced in Tembici docks:

1. The dock has to be within 150m of a TransMilenio station and/or a SITP stop (accessible routes only).
2. It has to be within a radius of less than 2 km of the six identified destination areas of the project (Unicentro, Calle 100, Centro de Bogotá, Chapinero, Castellana, Héroes)
3. The Tembici dock has to be around 2 km area of a healthcare facility
4. The dock must have a high flow of daily trips. We set these trips in more than 250 trips per day, according to Tembici operational data (Tembici, 2023)
5. The dock has to be 400 meters of a public bicycle parking lot to maximize the operational cost and security of these e-handbikes.

e. **Stations selected.** Considering the criteria of the last point, there are 15 proposed Tembici stations (see Table 1). However, given the scale-up costs (CAPEX and OPEX) of scenario 1, we suggest the first five Tembici stations to locate the e-handcycles (See Figure 2):

1. Centro Comercial Andino: Calle 82 entre Carrera 11 y Carrera 12
2. Universidad EAN: Carrera 11 entre Calle 78 y Calle 77
3. KR 7 con CL 70ª: Carrera 7 entre Calle 70A y Calle 70
4. KR 18A con CL 102: Carrera 18A entre Calle 102 y Calle 103
5. CL 123 con KR 9: Calle 123 entre Carrera 7C y Carrera 9

Table 1. Suggested Tembici stations for e-handcycle location

Priority level	Station Name	Daily trips	Current handcycle availability?	Distance to nearest Hospital	Distance to nearest TM station	Distance to nearest public bicycle parking	Distance to nearest SITP stop (accessible routes)	Nearest PWD destination area	Distance to nearest PWD destination area
1	**Centro Comercial Andino** (Calle 82 entre Carrera 11 y Carrera 12)	2971	No	501m	841m	85m	64m	Héroes	0m (inside destination polygon)
2	**Universidad EAN** (Carrera 11 entre Calle 78 y Calle 77)	917	Yes	369m	694m	162m	31m	Héroes	0m (inside destination polygon)
3	**KR 7 con CL 70ª** (Carrera 7 entre Calle 70A y Calle 70)	838	No	213m	807m	192m	91m	Chapinero	0m (inside destination polygon)
4	**KR 18A con CL 102** (Carrera 18A entre Calle 102 y Calle 103)	727	No	123m	832 m	132m	127m	Calle 100	0m (inside destination polygon)
5	**CL 123 con KR 9** (Calle 123 entre Carrera 7C y Carrera 9)	305	No	547m	2.4km	261m	37m	Unicentro	0m (inside destination polygon)
6	**CL 95 con KR 49ª** (Calle 95 entre Carrera 49A y Carrera 49)	271	No	292m	148m	354m	359m	Castellana	0m (inside destination polygon)
7	**Museo Nacional** (Carrera 7 entre calle 28 y Av Calle 32)	2129	No	526m	86m	359m	57m	Centro	0m (inside destination polygon)
8	**KR 23 con CL 114ª** (Carrera 23 entre calle 114a y calle 116)	392	No	460m	149m	299m	2.3km	Unicentro	99m
9	**Estación Marly** (Calle 50 entre Carreras 14 y 15)	502	No	213m	66m	274m	334m	Chapinero	416m
10	**U. Tadeo 1** (Calle 22 entre Carrera 3 y Carrera 4)	1252	No	1.6km	168m	88m	610m	Centro	0m (inside destination polygon)
11	**Parque 7 de agosto** (Calle 64 entre Carrera 16 y Carrera 17)	350	No	351m	489m	357m	78m	Chapinero	330m
12	**Estación TM Las Aguas** (Carrera 3 entre Calle 19 y Calle 18)	871	No	1,9km	13m	198m	938m	Centro	0m (inside destination polygon)
13	**CL 93 con DG 92** (Calle 93 entre Carrera 19b y Diagonal 92)	521	No	193m	510m	350m	81m	Calle 100	650m
14	**U. Piloto** (Calle 45 entre Carrera 7 y Carrera 8)	1802	No	297m	322m	367m	85m	Chapinero	964m
15	**Estación U. Nacional** (Avenida Carrera 30 entre Calle 47a y Calle 46)	999	No	455m	50m	180m	278m	Chapinero	1.5km

Source: Despacio

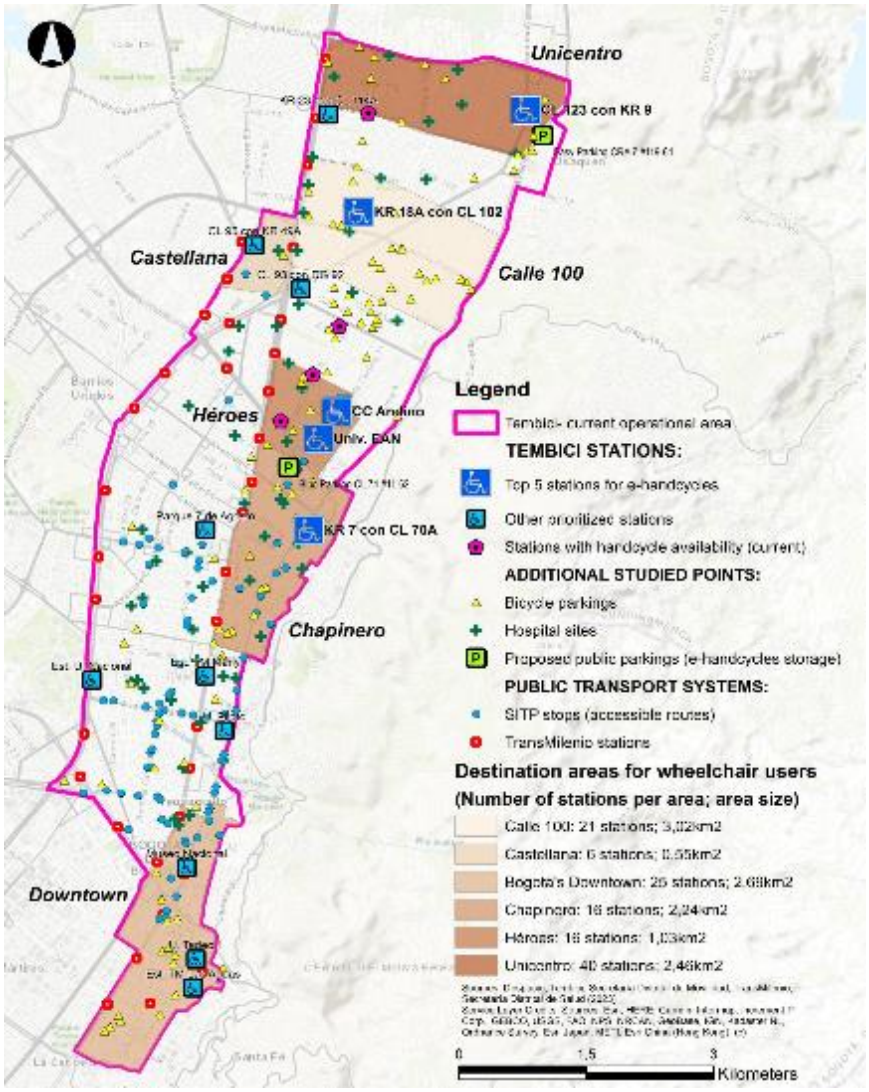

Figure 2. Location of the suggested Tembici stations for e-handcycle operation. Source: Despacio

3. **Integration of the indicators proposed in this project for tracking and monitoring the performance and usability of e-handcycles in the Tembici platform**: The indicators and data capture strategies developed by this project should be integrated into Tembici's monitoring platform. This will enable Tembici to regularly monitor the operational performance of the e-handcycles, measure their usability and accessibility for people with disabilities, and assess their positive impact on the environment in terms of energy consumption and reduction of pollutant emissions. Additionally, these indicators serve as a methodological monitoring tool for evaluating other last-mile passenger micro-mobility systems in Bogotá and other cities with similar systems.
4. **Enable and improve the process and interface of requesting and renting the handcycle in the Tembici app:** Currently, Tembici's cell phone application is the main tool for the localization and loan of its bicycles. In the case of the handcycles, the loan of this vehicle is not enabled by the mobile application and requires an unfriendly process for the user with physical disabilities in which they have to go directly to one of the offices of the company, fill out and sign a commitment and responsibility document for the use of the handcycle and agree on the time and place for the use of

this e-handbike[1]. We suggest that this process can be done through the mobile application, avoiding the previous steps and giving information to the user about the location and availability of these vehicles in real-time.

5. **Develop the communication and dissemination strategy, focusing on users with physical disabilities and reduced mobility**: Developing this communication strategy by Tembici is crucial to promoting e-handbikes and creating more options for PWD mobility in the city. This should start with:
    a. Publicizing these vehicles' development and improving access, rental, and location of e-handcycles in the system through the mobile application.
    b. Inform the users about the steps to access and use the e-bikes in the places where they are located.
    c. Design pedagogical and virtual guides for the proper management and operation of the e-handcycles by the PWDs, focusing on road safety.
    d. Define and publicize the schedules and costs of weekly, monthly, or per-trip rentals of the e-bikes.
    e. Articulate the promotion and use of these vehicles with the information systems of the District Mobility Secretariat and TransMilenio as an alternative for PWDs to mobilize and access these systems. Also, this action can be developed by messages in social media networks, POP material, and information at TransMilenio and SITP stations and routes or at PWD trip attraction sites, such as medical and health centers.
    f. Develop guided and promotional tours that explain the use of e-Handcycles, where they can be rented, and how to use them properly.
    g. Train operational personnel at locations where e-Handcycles will be available for rental to explain and inform the use and location of these vehicles and to assist PWDs or persons with reduced mobility in using these vehicles.
6. **Incorporate the handcycles and start the operation and lending of the handcycles, Model 1**: For the development of this stage, it is suggested that it be done in two parts, one in which an operational test is performed and the other that covers the development of the full implementation of e-handcycles in the five proposed points.
    a. *Operational test:* Operational tests will involve installing e-handbikes at five designated loan points, testing safe driving with PWD in Tembici's area of influence, making necessary physical adaptations for their use, finding parking spaces for overnight storage of these vehicles, developing and implementing the mobile application that will allow the loan and tracking of the handbikes, and integrating and testing the information from the monitoring indicators defined in this project into Tembici's operational monitoring platform.
    b. *Operations development*: The operations implementation will require periodic monitoring of the e-bikes and preventive maintenance of their electro-mechanical operation.
7. **Periodic monitoring and evaluation of the implementation of the e-handcycles operation**: The performance monitoring results, and user perception indicators should be followed up at least every two months. Additionally, it is crucial to monitor the communication and information strategies

[1] The process can be checked here: https://tembici.com.co/vehiculos-especiales/#alquilar

related to e-handbikes, as they are essential for individuals with physical disabilities and reduced mobility to adopt and use these vehicles.

Table 2 summarizes the duration of each stage described. This timeline suggests a three-month preparation and readiness period for implementing the public loan of e-handcycles in the SBS of Bogota, followed by a nine-month implementation period. Prior to implementation, there will be two months of testing or pre-operational activities to directly test the e-handbikes in public spaces, reduce safety risks for users, and test the monitoring, communication, and tracking tools of these vehicles. Additionally, it is recommended to review the performance indicators, usability, and user perception of the e-handbikes, as well as the progress of communication strategies every two months once they are in operation.

Table 2. Scale-up timeline for the first year.

	ACTIVITY	TIME OF EXECUTION IN MONTHS											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Electrification of handcycles/ design of the handcycles (model 1)												
2	Identifying and defining the locations or stations where the handcycles will be made available for use in the bike sharing system												
3	Integration of the indicators proposed in this project for the tracking and monitoring of the handcycles in the Tembici platform												
4	Enable and improve the process and interface of requesting and renting the handcycle in the Tembici app.												
5	Develop the communication and dissemination strategy, focusing on users with physical disabilities or reduced mobility												
6	Incorporate the handcycles and start the operation and lending of the handcycles, model 1.												
6.1.	Operational tests												
6.2.	Operations development												
7	Periodic monitoring and evaluation of the implementation of the e-handcycles operation												
	Activity												
	Milestones												

Source: Despacio

3.3. Stakeholder engagement

For the scalability of the project, it is important to consider the following key actors of the city government:

- **The District Secretariat of Mobility**, which oversees the operation of Bogota's SBS and establishes criteria for monitoring and tracking the bicycles used in the system, particularly the special ones such as handcycles. This institution will endorse the operational use of handcycles and their location in the five strategic points suggested by this project within the area of influence of the SBS. Additionally, the institution will provide an endorsement of the results obtained from the monitoring indicators of these vehicles.
- **The District Secretary of Social Integration**. It is responsible for defining, supervising, and developing projects that promote universal accessibility. Their goal is to ensure that people with disabilities have access to goods, services, and programs that improve their quality of life. In this case, this entity will allow the liaising of groups and people with physical disabilities so that they

can access and use the handbikes, as well as may propose plans or programs or sujects sources for subsidies for this population to use the e-handbikes.

- **Transmilenio SA**. It is the management and supervision entity for the operation of the city's BRT system (TransMilenio) and the Integrated Public Transportation System (SITP) of Bogota. This organization can promote the use of e-handikes as a complementary mode of transportation for the first and last mile. In this sense, it will be key to develop communication and dissemination activities with Transmilenio SA, since PWD use this mode as the main means of transportation in the city. The SITP routes supervised by Transmilenio SA serve as a means of connecting PWDs with e-handcycles and informing them of the possibility of accessing these vehicles.
- **Private actors.** Tembici currently has three private companies (Enel, Vanti, and Mastercard) that pay for advertising in the Bogotá SBS, covering the system's operational costs. These companies can play a crucial role in allocating resources for the incorporation of e-handbikes, either by providing economic resources in kind or in capital for CAPEX or OPEX. Companies may be motivated to allocate resources to this project by the management of corporate reputation strategies that they have developed or intend to develop in order to promote and strengthen the inclusion of people with disabilities. However, the involvement of private companies or private capital for the scalability of the project should not be limited to these organization. Tembici can develop a reputational strategy that will allow them to attract and invite more private organizations to help them jointly to continue strengthening themselves as a company that promotes universal accessibility in sustainable mobility.
- **International cooperation and multilateral agencies**. In this case, international multilateral organizations such as the Inter-American Development Bank (IADB) with its transport observatory and accessibility programs, the World Bank Group with the ESMAP fund aimed at promoting equity and electric mobility, or programs such as C40, UEMI-UNEP-UITP and cooperation agencies such as the German GIZ and the French Afd, may provide resources or grants for the development and scalability of this project. It is important to note that while the resources from these organizations can help kick-start and support scalability, they cannot provide a constant flow to ensure the continuity and development of this project in the short and medium term.

3.4. Budget

With the purpose of carrying out the project's scalability, the capital expenditures (CAPEX) required for the implementation and start-up of the e-handcycles in the Bogota SBS have been estimated. Two scenarios have been calculated for this purpose. The first scenario relates to the adaptation of the handcycle in Model 1, and the second to the modification of this vehicle in Model 2. Table 3 shows the cost of every scenario. However, as stated before, Tembici has opted to consider the development of Scenario No. 1, given the cost, time, and feasibility of adapting the mechanical handbike into an electro-assisted vehicle. Scenario No. 2 still presents a factor of uncertainty for Tembici, given the problems presented in the adaptations performed in the handcycle. Therefore, Scenario No. 1 is the better choice for developing the scale-up of this project. However, the estimated cost of Scenario No. 2 can serve as a benchmark for similar adaptations or as a starting point for developing a new e-handcycle, whether for Tembici or other companies.

Table 3. CAPEX cost for scalability scenarios

CAPEX*				
Scenarios	**Value COP**	**Quantity**	**Electrification cost COP**	**Electrification cost USD**
I. Model 1 located in top 5 Tembici stations	$ 5.082.013	8	$ 40.656.104,00	$ 10.207,41
II. Model 2 located in top 5 Tembici stations	$ 14.833.287	8	$ 118.666.296,00	$ 29.793,20

Source: Despacio *OPEX cost is the same for scenarios 1 or 2

Regarding the Operational Expenditures (OPEX), they have been estimated for both scenarios, since the values considered for their operation are indifferent to the adaptations that will be incorporated in the handcycles and that will be carried out in the first year of implementation of the e-handcycles in the Bogotá SBS. Only the first year has been considered because Tembici will use the experience and operational information of the adapted vehicles to determine if any OPEX costs can be changed, optimized, or modified. For these operational estimates, we have considered having five (5) people or operators on the street who will prepare and supervise the delivery of the e-handbike to the users and assist them in attaching and detaching the vehicle.

Other costs, such as preventive and corrective maintenance by the external supplier who adapted the handbikes for this project, Pargal, have also been considered. The estimated cost of this maintenance is to be carried out for six months by Pargal, and the corrective maintenance is to be carried out during the first six months of operation. During the first six months of the e-handcycles implementation in the SBS of Bogota, Tembici is expected to learn from Pargal how to perform corrective maintenance on the e-handbikes. After this period, Tembici will be assumed to continue with this maintenance in the second semester of the project scale-up development.

Also, we have considered other items, such as renting a space for overnight storage of the e-handbikes near the five designated stations. Additionally, we have allocated 10% of the total implementation cost to cover any unforeseen events that may arise during the implementation of the e-handbikes. However, it is important to keep in mind that the OPEX estimates have been made with the Tembici team and so far require further review by the company's financial team so that they can be revised in light of the other operational costs of the SBS. All OPEX costs can be viewed in Table 4

Finally, Tembici cannot currently assume the estimated OPEX and CAPEX costs because the resources obtained from rent, maintenance, and advertising are not yet sufficient to cover them. Therefore, these costs will need to be covered by donations from sponsors of private companies or international loans or grants from international cooperation funds, which will allow the scalability of the e-bikes in the SBS of Bogota.

Table 4. OPEX cost for scalability of e-handcycle Model 1 in Bogota SBC

OPEX (First year)*								
Expenditure	**Unit**	**Quantity**	**Per e-handcycle / Tembici dock**	**Value COP**	**Total cost COP monthly**	**Total cost USD monthly**	**Total cost COP year**	**Total cost USD**
Tembici operator	Monthly	12	5	$1.800.000	$ 9.000.000	$ 2.260	$ 108.000.000	$ 27.115

OPEX (First year)*								
Expenditure	Unit	Quantity	Per e-handcycle / Tembici dock	Value COP	Total cost COP monthly	Total cost USD monthly	Total cost COP year	Total cost USD
Preventive maintenance (VAT included)	Bimonthly	6	6	$ 120.000	$ 720.000	$ 90	$ 4.320.000	$ 1.085
Corrective maintenance (VAT included)	Bimonthly	6	8	$ 100.000	$ 800.000	$ 100	$ 4.800.000	$ 1.205
e-handcycle storage	Monthly	12	3	$ 500.000	$ 1.500.000	$ 377	$ 18.000.000	$ 4.519
UIA	Global	12	10%	$ 252.000	$ 25.200	$ 63	$ 3.024.000	$ 759
Total					**$ 11.512.000**	**$ 2.890**	**$ 138.144.000**	**$ 34.683**

Source: Despacio. * OPEX cost is the same for scenarios 1 or 2

3.5. Replicability in other cities

For the replicability of this project, we have identified several cities in which the process can be scaled and replicated considering the following features:

a) **Geographic context and demographic size:** we consider only cities located in Latin America based on their population size, with a similar population to Bogota.
b) **Existence of public or shared bicycle systems:** only cities with at least one public or shared bicycle system were considered.
c) **Existence of bicycle infrastructure:** It was essential to consider the kilometers of bicycle paths in the selected cities, having in mind Bogota's progress in providing infrastructures for this purpose.

In this sense, we set a points system to select these cities which are explained in the following table:

Table 5. Criteria and scores set for selecting potential cities for replicating the project in Latin America.

Criteria	Assesment features	Score
Demographic criteria	Less than 499.999 people	1
	500.000- 999.999 people	6
	1 million- 4.999.999 people	8
	5 million- 9.999.999 people	10
	More than 10 million people	8
Existence of public or shared bicycle systems.	The city does not have a public or shared bicycle system	1
	The city has a public bicycle system	6
	The city has a shared bicycle system	8
	The city has a shared bicycle system managed by Tembici	10
Existence of bicycle path networks	The city does not have bicycle path networks	1
	The city has less than 100km bicycle path networks	4
	The city has more than 100km bicycle path networks	6
	The city has more than 200km bicycle path networks	8

Criteria	Assesment features	Score
	The city has more than 500km bicycle path networks	10

Source: Despacio.

Based on the criteria of the Table 5, a final selection and mapping of cities in which the project can be replicated is presented in Table 6, the scores obtained in each of the four previously established criteria are added. The complete assessment of theses cities can be found in the Annex "Mapping of cities with potential replicability". The table below shows the results and final score for each of the 30 preselected cities:

Table 6. Complete list of assessed cities with potential of the project replicability.

N°	City	Located in Latin America? (score)	Demographic size range (score)	Does the city have a public or shared bicycle system? (score)	Does the city have bicycle path networks? (score)	Final score (location + demographic size + bicycle system + bicycle paths)
1	São Paulo	10	8	10	10	38
2	Lima	10	8	8	8	34
3	Mexico City	10	10	5	8	33
4	Bogota	10	10	10	10	40
5	Santiago	10	10	10	8	38
6	Rio de Janeiro	10	10	10	8	38
7	Caracas	10	8	5	4	27
8	Buenos Aires	10	8	10	8	36
9	Ciudad de Guatemala	10	8	5	4	27
10	Brasilia	10	8	10	10	38
11	Guayaquil	10	8	1	4	23
12	Medellin	10	8	5	6	29
13	Fortaleza	10	8	8	8	34
14	Salvador de Bahía	10	8	10	8	36
15	Belo Horizonte	10	8	8	4	30
16	Santiago de Cali	10	8	8	6	32
17	Havana	10	8	5	4	27
18	Córdoba	10	8	5	6	29
19	Manaos	10	8	8	4	30
20	Quito	10	8	5	6	29
21	Maracaibo	10	8	1	1	20
22	Santa Cruz de la Sierra	10	8	1	4	23
23	Tijuana	10	8	1	4	23
24	Curitiba	10	8	10	8	36
25	Ecatepec de Morelos	10	8	1	4	23
26	León	10	8	5	8	31
27	Puebla	10	8	8	6	32
28	Belem	10	8	8	6	32
29	Ciudad Juárez	10	8	1	4	23
30	Recife	10	8	10	6	34

Source: Despacio

In summary, four cities scored 38 out of 40 and three cities scored 36 out of 40. These 7 cities, therefore, are considered the most suitable to scale and replicate the project (see table below).

Table 7. Final selection of cities with potential replicability.

N°	City	Located in Latin America?	Range	Public or shared bicycle system?	Bicycle path networks length	Total score
1	Bogota, Colombia	Yes	5 million- 9.999.999 people	Tembici	608 Km	40
2	São Paulo, Brazil	Yes	More than 10 million people	Bikesampa-Tembici	722,1 Km	38
3	Santiago, Chile	Yes	5 million- 9.999.999 people	Tembici/ Bikesantiago	369 Km	38
4	Rio de Janeiro, Brazil	Yes	5 million- 9.999.999 people	Bike Rio- Tembici	457 Km	38
5	Brasilia, Brazil	Yes	1 million- 4.999.999 people	Tembici	664 Km	38
6	Buenos Aires, Argentina	Yes	1 million- 4.999.999 people	EcoBici/ Tembici	270 Km	36
7	Salvador de Bahía, Brazil	Yes	1 million- 4.999.999 people	Tembici	310 Km	36

8	Curitiba, Brazil	Yes	1 million- 4.999.999 people	Tembici	208,5 Km	36

Source: Despacio

As seen below, the five of the selected cities are located in Brazil, 1 in Chile, and 1 in Argentina:

Figure 3. Cities with potential replicability. Source: Despacio

3.6 Public policy framework

Accordingly, this project aligns with Bogota's local policies, considered the Universal accessibility aspect in each of the following policies:

- Plan de Ordenamiento Territorial Bogotá Reverdece 2022-2035 (Decreto 555 de 2021)
  - Along with inclusion, care, and active transportation modes, this aspect is central to sustainable and decarbonized mobility policy.
  - Also it is a key component when prioritizing clean and sustainable transportation modes (Articles 3 and 95). (Alcaldía Mayor de Bogotá DC, 2021). and should be considered when promoting the creation of infrastructure and mobility networks (including pedestrian and cycling networks);
  - In the implementation of multimodal and low-emission transportation modes, these networks must be inclusive and efficient when providing public transportation services in Bogotá (Articles 159 and 161). (Alcaldía Mayor de Bogotá DC, 2021).

- Additionally, universal accessibility is one of the strategies that will allow the implementation of the Care and Social Services System. This system is based on gender, inclusion, and universal design approaches, which will address the needs of different population segments (such as women, children, the elderly, people with disabilities, homeless people, and vulnerable populations) (Articles 88 and 92). (Alcaldía Mayor de Bogotá DC, 2021)
- Finally, this aspect it is the main criterion for designing the public space system to guarantee an adequate pedestrian mobility throughout the city (Articles 122, 133, 137, and 150). (Alcaldía Mayor de Bogotá DC, 2021).

- Plan de Movilidad Sostenible y Segura (Decreto 497 de 2023)
  - Universal accessibility should be promoted in public spaces and in public transportation systems. To this end, special attention should be paid to active mobility (pedestrians and cyclists), considering multimodality, inclusion, safety, sustainability approaches, and infrastructure components and transportation services (Articles 13, 16, 57). (Alcaldía Mayor de Bogotá DC, 2023)
  - Bogota should incorporate universal accessibility approaches to ensure people's mobility, taking into account infrastructure components and transportation services (article 77). (Alcaldía Mayor de Bogotá DC, 2023)
- Política Pública de la Bicicleta 2021-2039 (CONPES D.C. 15 de 2023)
  - Universal accessibility is considered as a strategy to promote equitable access to cycling infrastructure (including its planning and construction). This should be achieved through a gender approach that guarantees "care trips" (*viajes de cuidado*) under road safety parameters for cyclists and bicycle passengers (such as children) (Secretaría Distrital de Movilidad, 2021)
  - In addition, this document proposes to strengthen the participation of people with disabilities in policies that promote bicycle use. To this end, it should be taken into account that, by 2017, only 0.6% of persons with disabilities residing in Bogota traveled by bicycle (Secretaría Distrital de Movilidad, 2021).

- Política Pública de Acción Climática 2023-2035 (CONPES D.C. 31 de 2023)
  - People with disabilities are among the population groups that, according to the WHO, are most vulnerable to climate change. Therefore, one of the main strategies to address this phenomenon is promoting the decarbonization of urban mobility, giving priority to pedestrian and sustainable mobility modes (Secretaría Distrital de Ambiente, 2023).
- Política pública del Peatón, en Bogotá Primero el peatón 2023-2035 (CONPES D.C. 36 de 2023)
  - One of the main criteria that, along with sustainability, quality, efficiency, safety, equity, and inclusion approaches, is universal access. That will be possible by creating a mobility system in which priority is given to clean and sustainable transportation modes. This implies promoting

short trips by public transport or non-motorized vehicles, taking into account that urban environments should be accessible to all people (Secretaría Distrital de Movilidad, 2023b).

- It is essential to improve the infrastructure for pedestrian mobility of citizens, under parameters of accessibility, comfort, and safety in travel. Special attention should be paid to vulnerable populations (e.g. people with disabilities and/or reduced mobility, children, and the elderly) (Secretaría Distrital de Movilidad, 2023b).
- It is also important to create public spaces that, under parameters of universal accessibility, allow people to move between sustainable modes of transportation, thus connecting with their points of origin and destination (Secretaría Distrital de Movilidad, 2023b).

In sum, these policies constitute the framework of action for the territorial implementation and encouragement of sustainable mobility that promote the use and incorporation of clean technologies in the city by public and private actors with an inclusion and accessibility approach.

Also, it is noteworthy that this project is a private endeavor with significant public ramifications for the mobility of individuals with disabilities. It should not necessarily be restricted to the city's public policies. Nevertheless, Tembici's initiatives aim to contribute to the development of these policies in order to promote and improve the mobility options of the city's population.

4.6 Final considerations and recommendations.

- The methodology and data collection strategies developed in this project for the monitoring and assessment of the operational performance of handbikes, as well as their environmental impacts, road safety, and user accessibility, become a tool for the evaluation of vehicles designed for people with disabilities. But this methodology is also useful for any passenger using a micromobility vehicle for first and last mile transportation, as this is based on the principles of universal design and accessibility. In this sense, it is recommended that these indicators be included in the Tembici monitoring platform for tracking its bicycles or considered as a public policy strategy for tracking the activities of operators of similar systems.
- Tembici's mechanical handcycles have several technical, operational, and universal design aspects that need to be improved if Tembici wants to make them fully operational. In this sense, this project developed a series of methodological strategies that made it possible to identify improvement opportunities for these vehicles, by the hand of PWD and users with reduced mobility. In this way, adaptations have been achieved in the handbikes Models 1 and 2 that have improved the usability of the handbikes, incorporating the modifications of the electric motor, but which can also cover other aspects that improve the design and operation of these vehicles. Hence, this is the reason for developing Model 2 of the handcycle. However, Despacio recommends that these handbikes not be put into operation without first improving the road safety aspects related to the anchorage of the wheelchairs, the braking system, and the maneuverability of the vehicle, as this could lead to risks for the users who operate them and generate adverse effects for Tembici.
- Regarding the results of the indicators obtained, it is worth highlighting the findings on the willingness of the users with physical disabilities to pay for the use of the handbike. On the results of this indicator, the declared willingness to pay ranged between COP 15,000 and COP 25,000 (USD 3.75- USD 6.26) for a weekly cost lower than the COP 29,990 (USD 7.51) set by Tembici to rent the mechanical handbike. This value set by Tembici is in a range of 16% to 93%

above what PWD would be willing to pay for the rental of the e-handcycle. Therefore, this result raises the question of whether the rental value should be adjusted so that users with physical disabilities can access these e-handbikes. Also, this aspect raises a question about how to finance the operational expenses of these bicycles. Although the monthly cost for eight e-handbikes is COP 11,252,000 (USD 2,890) and is not related to the monthly rental fee, it could be reviewed whether these values could be leveraged through the participation of private companies willing to subsidize or pay for this operation, through advertising or an intensive social responsibility strategy.

- Concerning the monthly savings that PWD can have when using the e-handbike as their primary mode of transportation on the first and last mile, users of the Model 1 e-handcycle can save COP 115,372 per month, which is approximately USD 29. This translates into a total savings of COP 1,384,480 or USD 348 annually. This value is relevant because the disabled population has a low monthly income. According to the project's baseline data, 52% have an income below approximately COP 750,000 (USD 19). In this sense, a monthly saving of COP 115,372 in transportation costs is crucial for this population. Therefore, this indicates that the city government can subsidize the use of special micro-mobility vehicles so that these populations can have affordable options to mobilize themselves. This subsidy should be studied with more detail and information than what is collected in this project. While these values are meaningful, a transportation economics study needs to be conducted with more PWD to determine these monthly savings, as well as strategies to make them a reality for this population.
- Finally, although the electrification of e-handbikes brings improvements to this vehicle, it is necessary to improve the lending scheme and communication of the availability of these vehicles. Some of these recommendations are already described in the scalability section of this report. But, complementary to the abovementioned, it is suggested to develop tours or rides to make e-handbikes more visible. For example, Bogota's "Car Free Day," an event every first Thursday of February, is an opportunity and a scenario for demonstrating these vehicles.

4. Annexes

Annex 1 Baseline project

Annex 2 Deliverable 2

Annex 3 Scale-up cost OPEX-CAPEX and timeline

Annex 4 Mapping of cities with potential replicability

Annex 5 Indicators Battery e-handcycles project

5. References

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