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PENN IUR **POLICY BRIEF**

#GalápagosGoesGreen: Galápagos Green Mobility Strategy

Resiliency and CO2 Emission Reduction Pathways via Green Transportation for Recovering the Tourist Industry in the Aftermath of COVID-19

EUGÉNIE L. BIRCH
Co-Director, Penn Institute for Urban Research
Lawrence C. Nussdorf Professor of Urban Research and Education, Department of City & Regional Planning, Weitzman School of Design
Contact Information: elbirch@pobox.upenn.edu

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Photo by Murray Foubister, via Flickr.

Executive Summary

Starting in the winter of 2020, University of Pennsylvania researchers from the City Climate-Resilient Infrastructure Financing Initiative (C2IFI) worked with planners and officials in Ecuador's Galápagos Islands to investigate sustainable transportation infrastructure investments focused mainly on the islands' two largest town centers, Puerto Ayora and Puerto Baquerizo Moreno, and the intra-island waters. This study is designed to support the islands' sustainability vision to transition from fossil fuel dependency to clean energy options expressed in its Zero Fossil Fuel Initiative (2007) as it works to preserve the archipelago's biosphere, protect it from the effects of climate change, and ensure healthy communities while maintaining its valuable tourism economy. The proposals align with the *Plan de Ordenamiento Territorial*, or Galápagos Plan for Land Use, and on-going planning efforts gleaned from extensive (Zoom) interviews over time.

This policy brief has six parts. Part One, Situation Analysis, sets the current geographic, demographic, governance, and economic scene. Part Two, Effects of Tourism on Energy Consumption, outlines the islands' fossil fuel dependency and efforts to reduce it. Part Three, The Pandemic Presents Opportunities, discusses the current mobility situation against the background of the *Corporación Andina de Fomento's* (CAF) proposed $100 million investment in grid improvement. It provides an overview of key areas in land and sea transport for consideration. Part Four, Elements of a Green Mobility Strategy, outlines suggestions for non-fossil-fuel-powered vehicles for land and sea, illustrating the solutions with case studies from places that have adopted them. Part Five, Investment Opportunities for the Initiative, provides an overview of possible national and international financial mechanisms to implement the Galápagos Green Mobility Strategy. Part Six is entitled Summary #GalápagosGoesGreen.

Part One: Situation Analysis

The Galápagos, a highly admired UNESCO World Heritage site, like all island economies around the world is highly dependent on imported fossil fuels to support its tourist economy and the livelihoods and lives of its residents.

GEOGRAPHY

The Galápagos consists of 19 highly protected islands; tourism is concentrated to the four inhabited ones: Santa Cruz, San Cristóbal, Isabela, and Floreana. The Ecuadorian government strictly controls the area through its designation of the Galápagos National Park (1968) encompassing 97 percent of the land and the Galápagos Marine Reserve (2001) including the intra-island waters and a 60-mile buffer. See Figure 1.

FIGURE 1

The Galápagos National Park, Marine Reserve, and Urban Areas

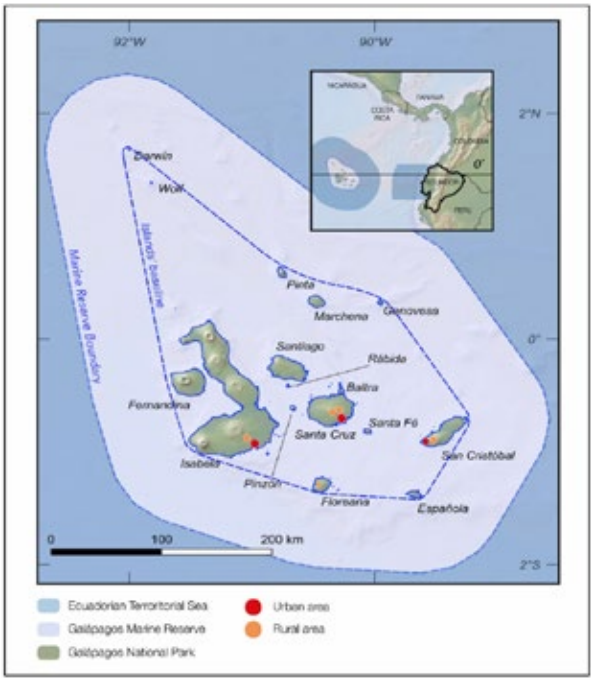


Figure 1. The Ecuadorian government protects 97 percent of the land; urban and rural settlements encompass the remaining 3 percent. In addition, it also has established maritime protections through a marine reserve.

(Source: Andrés Pazmiño, "Towards Comprehensive Policy Integration for the Sustainability of Small Islands: A Landscape-Scale Planning Approach for the Galápagos Islands," *Sustainability,* April, 2018. file:///Users/eugeniebirch/Desktop/Galápagos Policy brief/sustainability-10-01228.pdf

TOURISM AND ITS EFFECTS ON THE GALÁPAGOS

Over the past decades, tourism in the Galápagos Islands grew exponentially from 246,000 visitors between 1980-1989 to 2.2 million between 2010-2019.[1] In fact, in the 1980s tourism displaced fishing and agriculture as the islands' primary source of income.

As the islands are 600 miles from the mainland, tourists arrive by sea and air from either Quito or Guayaquil and an increasing number are choosing to stay on island rather than on cruise ships for the duration of their

1 Of note, the Galápagos were among the eight places that UNESCO recognized in this category in 1978. H. Lethier and P. Bueno, "Report on the Reactive Monitoring Mission of the Galápagos Islands World Heritage Site," UNESCO, August 21-25, 2017.

visits. As of 2016, at least 68 percent have had land-based experiences including overnight stays in hotels.[2] This number reflects visitors' changing tastes as well as the national government's strictly imposed limits on cruise ship berths.[3]

The growth in the number of visitors and the changing nature of tourism has put extreme pressure on the islands' basic services (fresh water, sanitation, waste), urban development, transportation, and ecosystem protection. It has resulted in a rise in greenhouse gas emissions mainly from air transportation, the increased demand for electricity, and land and marine transport.[4] Not only does the Galápagos have the second highest per capita electricity consumption in Ecuador but also its consumption is highly dependent on imported diesel.

THE COVID-19 PANDEMIC

The pandemic put a sharp halt to the islands' tourism: it dropped from 24,000 visitors in September 2020 to 1,000 five months later.[5] This devastating break has offered an opportunity to rethink the islands' energy consumption. But time is running out because the past few months have seen some changes. The cost of travel to the Galápagos has declined significantly, resulting in a boost to local tourism from the mainland. In addition, the government's management of public health on the islands has been successful. It is the country's province with the lowest number of infections and deaths per capita. As of August 2021, Galapagos had the highest percent of fully vaccinated population in the country, reaching 94 percent. These phenomena have alleviated the worst aspects of the pandemic-generated losses, bringing hope that tourism will recover soon. A key question is whether a business-as-usual situation will emerge or if the islands can position the tourist industry as being more ecologically friendly and therefore more protective of the area's rich biodiversity, their key asset.

GALÁPAGOS POPULATION

The islands' overall population is 27,000 people. The count is a bit confusing because the Ecuadorian government recognizes four types of residents (permanent, temporary, transient, and tourist), each with assigned rights and responsibilities. Table 1 provides data on the islands' urban population (2015) not disaggregated among the types of residents.

TABLE 1

Population of the Galápagos by Settlement

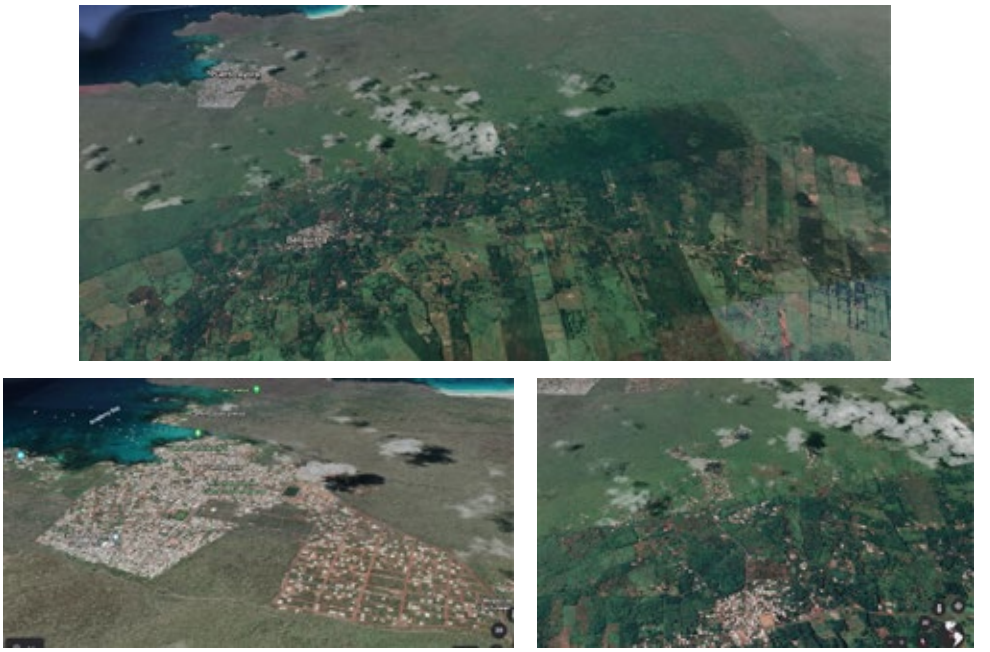
Island	City/town	Population 2015	% Total
Santa Cruz	Puerto Ayora	11,800	46.8%
	Bellavista	5,614	13.4
San Cristóbal	Puerto Baquerizo Moreno	6,500	26%
Isabela	Puerto Villamil	2,610	8.6%
Total		26,974	95%

Source: INEC. Principales resultados Censo de Población y Vivienda, Galápagos 2015. In: Censos INdEy, editor. Quito, Ecuador: Instituto Nacional de Estadísticas y Censos; 2016. pp. 22.

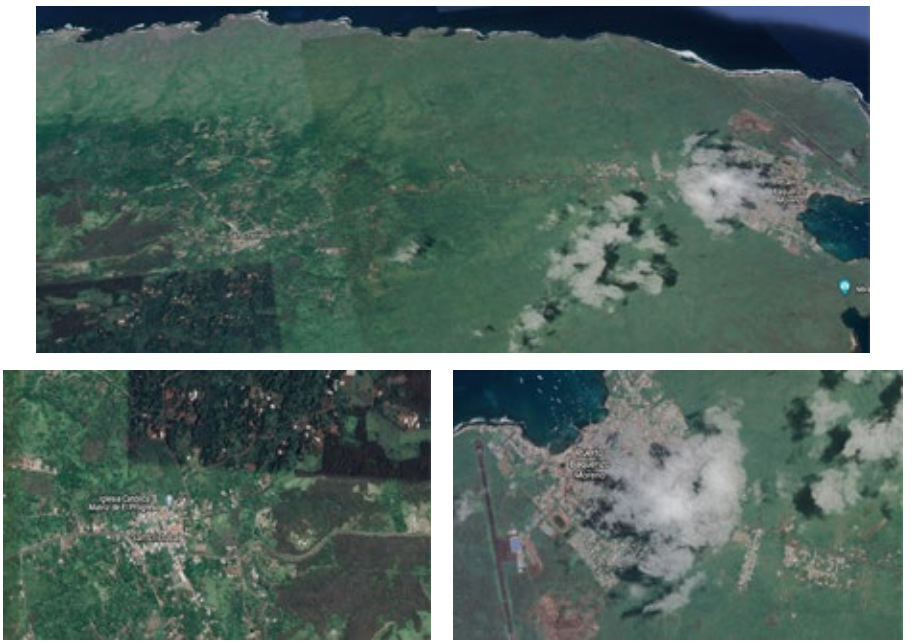
2 Izurieta J.C., 2017. Behavor and Trends in Tourism in the Galápagos between 2007-2015. in: Galápagos Report 2015-2016 GNPD, GCREG,CDF, and GC. Puerto Ayora, Galápagos, Ecuador.
3 Cajiao et al. 2020. Tourist Use and Impact Monitoring in the Galápagos: An Evolving Programme with Lessons Learned. Parks. 26 (2) November. https://parksjournal.com/wp-content/uploads/2020/11/10.2305-IUCN.CH_.2020PARKS-26-2en-Low-Res-1.pdf#page=89
4 Lethier and Bueno, op cit.
5 CAF. No date. Cambio climático: el nuevo desafío evolucionario para Galápagos (private communication).

FIGURE 2

Urban Settlements in the Galápagos



Urban settlements on Santa Cruz: Overview (top), close-ups of Puerto Aroya (right) and Bellavista (left) connected by a 6.4-kilometer road.



Urban settlements on San Cristóbal: Overview (top), close-ups of San Cristóbal also known as Progreso (right) and Puerto Baquerizo Moreno (left), connected by an 8-kilometer road (Source: Google Earth).

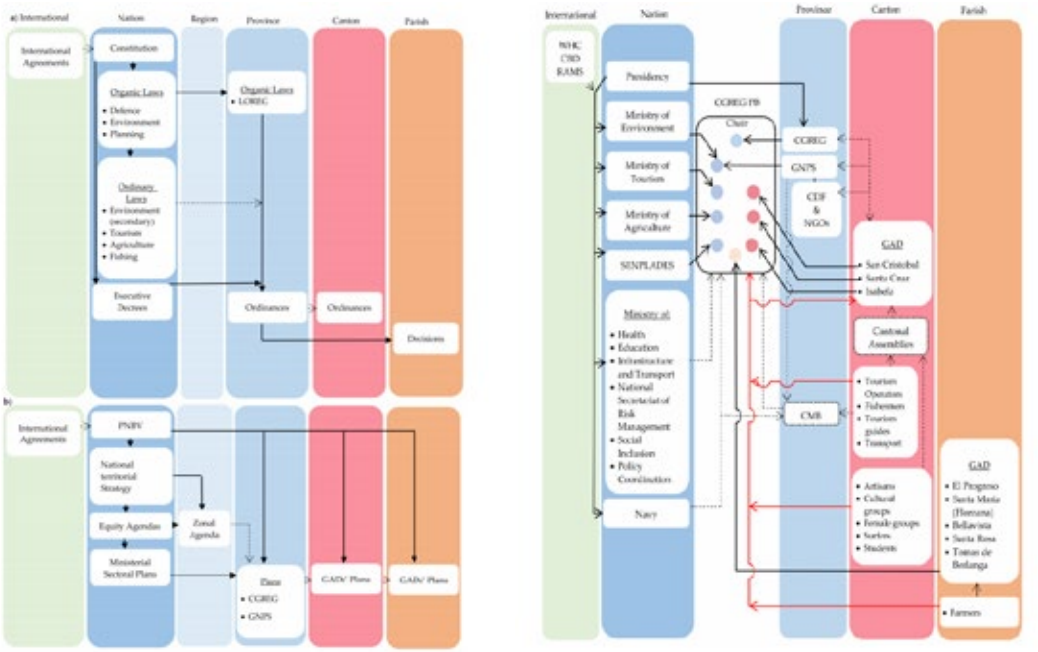
Santa Cruz island has two urban agglomerations, Puerto Aroya and a nearby settlement, Bellavista, that hold 60 percent of the islands' total population, and San Cristóbal island with Puerto Baquerizo Moreno and its satellite, San Cristóbal (also known as Progreso) that contribute another 20 percent of the total. Aerial maps of Puerto Aroya and Puerto Baquerizo Moreno and their surrounds demonstrate current development, suggesting some degree of sprawl despite government regulation. See Figure 2.

ECUADORIAN GOVERNMENTAL STRUCTURE AND THE GALÁPAGOS

The governance of the Galápagos is multi-layered, involving several national ministries (e.g. environment, tourism, fisheries, and navy) and four subnational levels (region, province, canton [municipality], parish) as specified by the Ecuadorian Constitution (2008) and subsequent legislative acts. The National Secretariat for Planning and Development (SENPLADES) oversees the nation's planning system. However, within this framework, the Government Council for the Special Regime of the Galápagos (CGREG), a provincial entity, has local jurisdiction over the planning and management of the islands. This Council has representatives from the president, ministries of environment, tourism, and agriculture, SENPLADES, the three municipal governments and Floreana parish. In 2015, the government strengthened the CGREG responsibilities with passage of the Galápagos Special Law (LOREG).[6] The President of CGREG, appointed by the President of the Republic, has ministerial status in the national government's cabinet.

FIGURE 3

Ecuadorian Governmental Structure in the Galápagos



This schematic outllines the government entities having jurisdiction over the Galápagos (right) and also shows the inter-relationships among them (left). (Source: Andrés Pazmiño, "Towards Comprehensive Policy Integration for the Sustainability of Small Islands: A Landscape-Scale Planning Approach for the Galápagos Islands," Sustainability, *April, 2018* file:///Users/eugeniebirch/Desktop/Galápagos Policy brief/sustainability-10-01228.pdf.

6 In 1998, the national government specified a management entity, the Galápagos National Institute (INGALA) for the planning and management of the islands. In 2008, it replaced INGALA with CGREG.

The Constitution delineates an intricate planning system that starts with the national government and runs through the subnational units. It requires local congruence with the national plans to gain access to any nationally sponsored funding. The central government oversees broad policy areas as encompassed in the *National Plan for Good Living* (adopted 2010), *National Strategy for Climate Change* (adopted 2012) and *National Territorial Strategy* (adopted 2013). Subnational governments align their plans relating to their respective responsibilities. See Figure 3.

In line with national planning directives, CGREG adopted the *Galápagos Territorial Land Use Plan 2015-2020* in 2015. It focuses on balancing environmental, social, and economic goals. Of note, it calls for:

- establishing optimal conditions for the well-being of residents without compromising the well-being of their natural surroundings or the ecological equilibrium;
- promoting tourism through sustainable practices;
- reducing energy dependency; and
- optimizing renewable electricity generation, transport, and connectivity.

While seemingly top-down, Galápagos is distinguished for being a space with a high level of community participation and involvement in the decision-making process. CGREG supports a plenary with representatives from several ministries and other public entities, the private sector, NGOs, and community leaders. It discusses and approves all plans and projects to be implemented on the islands. Cantonal assemblies also contribute to these deliberations. In addition, the national government has designated a Galápagos Marine Reserve Consultative Management Board but it is not yet fully operational.[7]

Part Two: Effects of Increased Tourism on Energy Consumption

To support its energy needs, Galápagos imports six million tons of diesel annually. Some 30 percent is used for electricity and 65 percent for mobility (passenger and cargo).[8] In 2010 (the most recent data available),the island emitted roughly 532,373 tons of CO2 equivalent (CO2 eq) per year, with 24 percent linked to electricity generation (18 percent) and a combination of local transportation of residents, tourists, and associated supplies (6 percent).[9] The remainder is allocated to international air travel to and from the islands. Of note, fossil fuel dependence poses other risks in addition to its threat to the climate. For example, in 2001, an oil tanker spill released nearly 150,000 gallons of fuel into the islands' waters resulting in the death of some 10,000 iguanas and other species.[10]

In 2007, the Ecuadorian government launched an ambitious Zero Fossil Fuel Initiative for the Galápagos. Resting on three pillars (eliminate diesel for electricity generation, gradual conversion to EV/hybrid vehicles and biofuel engines, and gradual conversion to biofuels for fishing and tourist boat engines), it aimed to transition completely to renewable by 2020, a target that has so far eluded it.

Nonetheless, the program has resulted in several investments in renewable energy for the production of electricity, primarily solar and wind to meet its first objective. By 2018, renewables fueled 16 percent of the islands' supply of electricity (57 GWh).[11] Little has been accomplished in the aspects of the initiative related to mobility. See Table 2..

7 Andrés Pazmiño, op cit. p.11.
8 Galápagos Conservation Trust, "A Sustainable Galápagos."
9 The majority of CO2-eq emanates from air travel. Ximena M Cordova-Vallejo, et al., "The Carbon Footprint of the Galápagos – Quantifying the Environmental Impacts of Tourism," MIT Engineering Systems Division, Working Papers, June 2012 https://dspace.mit.edu/bitstream/handle/1721.1/102930/esd-wp-2012-15.pdf?sequence=1&isAllowed=y.
10 Ministerio de Electricidad y Energia Renovable. No date. Galápagos Islands Zero Fuel Initiative. https://www.irena.org/-/media/Files/IRENA/Agency/Events/2012/Sep/6/Pablo_Carvajal.pdf?la=en&hash=C5DFD9860EB3EB3C4DD9BFD9EA3DB19A0C9ABB0E.
11 Omar R. Llerena-Pizarro, et.al. "Energy Sector in the Galápagos Islands: Current Status, Renewable Sources and Hybrid Power Generation System Proposal," *Renewable and Sustainable Energy Reviews*, Vol 108 (2019): 65-75

TABLE 2

Renewable Energy in the Galápagos

Island	Name	Solar	Wind	Biofuel jatropha curca plant	Units
Santa Cruz	Solar Puerto Aroya	x			1.52 MW
Baltra airport		x			
Baltra airport			x		2.25 MW
San Cristóbal	Proyecto Eólico	x			10 KW
San Cristóbal			x		
Floreana	Perla Solar	x			
Floreana	Biofuel (plus solar)			x plus solar	138 KW
Isabela	Biofuel (plus solar)			x plus solar	2.3 MW
Total		**2.6 MW**	**4.7 MW**		

Under the Zero Fossil Fuel Initiative, the Galápagos hosts almost 9 Gwh of electricity among four islands. With the exception of Santa Cruz-Baltra, the systems are not connected but operate separately. An underwater cable connects the Santa Cruz-Baltra system.

Source: Omar R. Llerena-Pizarro et.al. "Energy Sector in the Galápagos Islands: Current Status, Renewable Sources and Hybrid Power Generation System Proposal," Renewable and Sustainable Energy Reviews*, Vol 108 (2019): 65-75; Ecuador Energy Sector Assessment, Washington, DC: US AID, May 1920.*

In 2019, researchers at the University of Madrid published a ten-year assessment of the Zero Fossil fuel policy objectives. They revised the demand for energy, predicting a 30 percent rise (from 55 GWh to 74 GWh). They concluded that meeting the target (100 percent renewables by 2020) was not feasible. Moreover, they rejected the use of biofuels as ineffective after the failure of an experiment. However, they asserted that the islands could reduce dependency substantially through funding solar and storage batteries and roof top voltaics accompanied by consumer-based energy efficiency educational programs. They concluded that these efforts could result in increasing renewables to 39 percent of the islands' largest system by 2030.[12]

The program originally supported the import of EVs and hybrid vehicles, an effort that was stymied in 2019 when the government concluded that they stressed the electricity system. It has also supported modest experiments with green maritime boats, supporting solar-powered boats. Other energy-related efforts include the RENOVA project supporting energy efficiency that aims to replace residential and commercial refrigerators, air conditioners, and incandescent light bulbs and street lights.[13]

One of the more successful projects was rebuilding Baltra airport as the world's first green airport. Opened in 2012, this award-winning facility accommodates 300,000 passengers annually. Solar (35 percent) and wind (65 percent) power it. Its water comes from desalinization.

The management of the pandemic has shifted the previously established priorities including a temporary halt of planned renewable energy projects. However, in March 2021, the Ministry of Environment issued a request for proposals for the Conolophus Photovocaic project (15MW/41 MWh solar plus storage) for Santa Cruz. In early May, the Ministry suspended awarding the contract until the newly elected president could take office later in the month.

12 Andrea A. Eras-Almeida et al. "Decarbonizing the Galápagos Islands: Techno-Economic Perspectives for the Hybrid Renewable Mini-Grid Baltra-Santa Cruz," *Sustainability*, 12, March 14, 2020: 1-47.
13 Llernea-Pizarro, op cit. p. 69.

Part Three: The Pandemic Presents Opportunities: A Focus on Mobility

While the pandemic put a damper on tourism, the *Corporación Andina de Fomento* (CAF), the Latin American Development Bank, the World Wildlife Fund (WWF) and others were engaged in developing a $100 million proposal to the Green Climate Fund and additional funders for energy-related projects with a primary focus on grid improvements as well as a substantial citizen education program promoting energy efficiency and eco-tourism. The latter includes a proposal to credential or accredit activities that meet eco-tourism standards.[14] This proposal is currently making its way through myriad approval processes.

The University of Pennsylvania's City Climate Resilient Infrastructure Initiative (C2IFI) is developing a proposal for a program to promote the adoption and implementation of a green mobility strategy that would attract ecologically conscientious travelers while reducing GHG. This project focus responds to the fact that land and sea transport for tourism and fishing represent the highest local demand for fossil fuels, some 65 percent of the total.[15] The C2IFI leadership seek to align this work with the *Galápagos Territorial Land Use Plan 2015-2020* that called for: promoting tourism through sustainable practices and optimizing renewable electricity generation, *transport* and connectivity.

MOBILITY IN THE GALÁPAGOS

The transport sector has been subject to substantial but unsystematic and ineffective government policy. For example, the national government has restricted motorized vehicle imports since 1998. However, in 2016, it lifted the restrictions for EVs but in 2019, fearful of their draw on the grid, banned them.

As of 2018, 2,952 vehicles are registered to residents on the islands, up 53 percent since 2009. Nearly half are motorcycles (45 percent), with the remaining divided between pickup trucks (26 percent), cars (10 percent), and SUVs (9 percent). This amounts to one privately owned vehicle for every 2.9 households. By 2019, the island supported 36 privately owned electric cars (mostly KIA SUV's), and 10 hybrids, 6 of which are part of a government fleet.[16] See Table 3.

Both tourists and residents rely on a variety of fossil-fueled modes of transportation including bus, ferry, private land and water taxis, automobiles, *chivas* (truck converted to passenger transport), motorcycles and e-bicycles. Transportation is expensive. For example, private taxis cost three to seven times more than on the mainland. Tourists arriving by cruise ship have their land- and water-based transportation pre-arranged. Tourists arriving

TABLE 3

Land Vehicles in the Galápagos

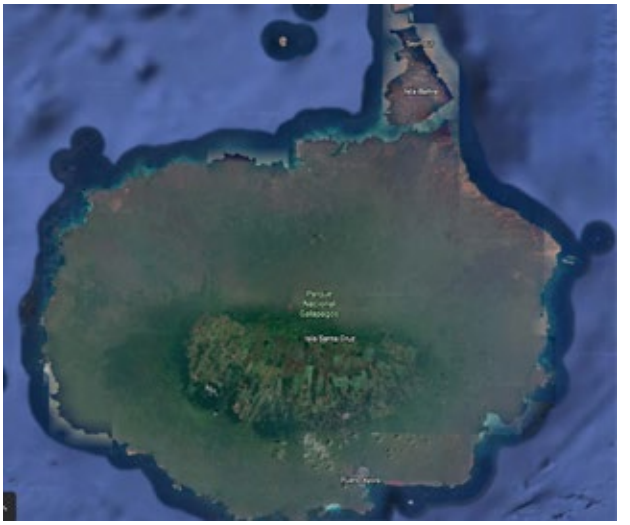
Island	# land vehicles 2009*	# land vehicles 2018	increase 2009-18 (%)
Santa Cruz	1, 074	na	na
San Cristóbal	699	na	na
Isabela	154	na	na
Total	**1,927**	**2,952**	**53%**

Source: These data come from the first vehicle survey undertaken in 2009. Marc Oviedo et all The First Complete Motorized Vehicle Census in Galápagos.

14 CAF op cit.
15 Héctor Iván Apolo, et al, "Santa Cruz, Galápagos Electricity Sector Towards a Zero Fossil Fuel Island," Conference paper, January 2019.
16 https://www.ecuadorencifras.gob.ec/documentos/web-inec/Estadisticas_Economicas/Estadistica percent20de percent20Transporte/2018/2018_ANET_TABULADOS.xlsx

FIGURE 4

Baltra/Santa Cruz



Tourist route from the Seymour Airport (Baltra) to Puerto Aroya (Santa Cruz) calls for three modes of transportation. Source: Google Earth.

by air to Baltra/ Santa Cruz usually take three forms of transportation if going to Puerto Ayora or its surrounds. They take a short taxi to a ferry that takes them across the Itabaca Channel separating the two islands, and then board a bus or private taxi to travel 40 minutes or so along the 42 kilometer roadway to the town. A few others take a catamaran or other marine vehicle for this part of the trip. See Figure 4.

In terms of public transport, the islands support five buses yet, according to the *Plan for Sustainable Development in the Galápagos 2015-2020,* a deficit in public transportation exists in rural areas and, within the existing urban areas, walking and biking is common. A new bike path from Puerto Ayora to Bellevista is popular with both locals and tourists. Santa Cruz's leading bike rental company, Bike-n-Smiles, offers customers Bosch e-bikes to explore Puerto Ayora and its surrounding area,[17] while other companies offer e-scooters.[18]

FIGURE 5

Boats in Two Harbors

Boats anchored in Puerto Ayora (right) and Puerto Baquerizo Moreno (left)

17 https://www.tripadvisor.com/Attraction_Review-g297533-d15523039-Reviews-Bike_and_Smile-Puerto_Ayora_Santa_Cruz_Galápagos_Islands.html
18 https://www.tripadvisor.com/AttractionProductReview-g297532-d17773077-E_scooter_for_Rent-Santa_Cruz_Galápagos_Islands.html

Maritime transportation for tourism, cargo transport, fishing, and personal travel around the islands is diesel-based. The main inter-island tourist sites are within a two-hour sea journey. The Ministry of Tourism requires registration of all tourism-related boats, recording five types: passenger yachts, passenger boats, daily tour boats, motorized sailboats, and motorboats. The 2017 UNESCO monitoring team reported 84 registered boats among Santa Cruz, San Cristobal, and Isabela.[19] However, as the photos below reveal, many more boats are anchored in the Galápagos's harbors but may not be registered.

Other marine transport includes cargo ships, strictly government-controlled to avoid importing invasive plants and species. Nearly 90 percent of the islands' supplies arrive by sea. In 2016, the government changed the system from pallets to containers in order to address efficiency and food safety issues. Two companies manage three containerships and a diesel tanker that service Santa Cruz and San Cristóbal. The ships visit the islands at regular two-week intervals. The containerships, anchoring at a distance from the docks, unload the containers onto a barge that transports the goods to the cities where it is unloaded onto small trucks for final delivery. See Table 4 and Figure 6.

While the worldwide ocean-going cargo industry is looking at ways to reduce emissions and clean up the fleets including sulfur emission standards, partial wind energy, and experiments with hydrogen fuel, improvements in this area are far into the future. So energy savings will have to be in the amelioration of the islands' port

TABLE 4

Marine Transport: Tourist and Cargo

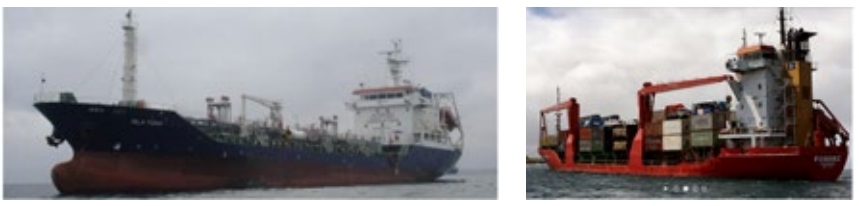
Type	Place	# marine vehicles 2017
Tourist	Santa Cruz	51
	San Cristóbal	22
	Isabela	11
Total		84

Cargo/Supply	Size (Weight)	Type
Paola	52x9 m (736)	Pallets/free cargo
Fusión 2	97x16m (5,125)	Containership
Isla de la Plata	91x16 m (3,477)	Containership
Isla Puná	88x14m 3,423)	Tanker

Source https://www.marinetraffic.com/en/users/my_account/payment/billing)

FIGURE 6

Cargo Ships



The Isla Puna tanker holds a million gallons of fuel (right); Fusion 2 (left) holds 373 containers
Source: https://sites.google.com/site/navieratransnave/jj

19 Lethier and Bueno, op cit.

facilities. In fact, the islands' lack modern energy-efficient port facilities that makes the delivery process inefficient, increases energy use, and risks accidents and environmental contamination. Today, when the container ships arrive, they offload their cargo onto barges that then go landside where small trucks take to the final delivery. Given this situation, CGREG and the national government are engaged in planning major port improvements.

This situation analysis reveals that much is happening to advance the Galápagos' ability to recover tourism post-pandemic, improve the lives of its residents, protect its remarkable biodiversity, and address climate change. The governance framework for the islands is strong:

- since the 1970s, it has been a UNESCO World Monument site with all the safeguards this status offers,
- it has extensive national parks that protect its land and sea,
- it has an up-to-date master plan,
- it is engaged in implementing an important Zero Fossil Fuel Initiative (albeit behind schedule) and
- it has gained national attention about the necessity of addressing its inefficient port facilities.

In addition, CAF and partners are preparing a substantial program for financing major electricity-system enhancements to improve its reliability and increase its use of renewables.

The time is ripe for rethinking the island's mobility system with the aim of transitioning to clean, green transport in many areas. In ordinary circumstances, such a change would be an essential component of the islands' economic development. It is even more critical now as the islands struggle to recover from the immediate effects of the pandemic while addressing the longer-term consequences of global warming. Based on the experience of other small island economies, micro-mobility solutions are uniquely suited to the Galápagos.

Part Four: Elements of a Green Mobility Strategy

The C2IFI program discusses a variety of policy choices for transportation aimed at incorporating electric land and sea vehicles for local resident and tourist use and targeting significant reductions in CO_2 eq/year. For land, they cover electric mopeds, e-bikes, electric cargo trucks, and electric buses. For sea, they include ferries to catamarans and various-sized boats used as water taxis. Case studies from similar places accompany the recommendations.

The program acknowledges that implementing such policies will require coordination with ongoing efforts to upgrade the islands' electricity and telecommunications infrastructure. In addition, all recommendations need to be implemented in a consultative stakeholder process and work in conjunction with the various planning documents governing the islands.

LAND TRANSPORTATION

The Galápagos could undertake a number of projects related to land transportation. Below are cases from around the world for electric mopeds, e-bikes, electric cargo trucks, electric trucks, and electric buses or shuttles that provide examples for the Galápagos replication.

ELECTRIC SCOOTERS/MOPEDS

Since motorcycles are the predominant form of transportation on the islands, migrating to a non-fossil fuel form, such as employed in Taiwan and other places, would be desirable. The Pengu, Taiwan example, using

battery powered scooters or mopeds, showcases how a program can successfully promote electric two-wheel transport transition quickly. To avoid up to two hour charge times and to address concerns about range, the program set up 24/7 access to battery swap services along roadsides and in convenience stores. Finally, it crafted incentives and subsidies to insure affordability. See Figure 7.

ELECTRIC SCOOTERS/MOPEDS IN PENGHU, TAIWAN

GDP per capita: $8,659

Geographic area: 141 km²

Main Industry: Tourism, Fishing

As part of the Official Penghu Low Carbon Island Project, from 2011 to 2013, the Taiwan government established subsidies to help replace gasoline motorcycles with 6,000 electric scooters. During this time, the government provided a $1,000 subsidy per unit. After subsidies, e-scooters cost around US$1,100 to $1,800 which is about the same as gasoline-powered scooters. Penghu was an ideal setting for Taiwan to test their e-scooter campaign because of both the residents' and visitors' daily short-distance commutes. As a result of the subsidies and public promotion, Penghu saw the number of e-scooters increase from 10 in 2010 to 3,464 by the end of 2013.

Currently, residents could receive up to NT$30,000 in subsidies from both the central and local government. On average, the combined subsidies save buyers about 35 percent of the price of mainstream electric scooters, which retail for about NT$70,000 ($2339.025 USD).The-scooters max out at 60km/hr and the island has 332 charging stations in 27 locations. In addition, Penghu has approximately 30 convenience stores and gas stations that provide a 24-hour battery-swap service to help riders cover more range on their scooters.

https://www.sciencedirect.com/science/article/pii/S0959652615010240
https://ir.nctu.edu.tw/bitstream/11536/15954/1/000303956700053.pdf
https://taiwantoday.tw/news.php?unit=8&post=14185
https://taiwantoday.tw/news.php?unit=7&post=129827

FIGURE 7

Mopeds and Solar-Powered Battery Exchange Stations

EV mopeds can carry a person and other things (left). Strategically-located battery exchange stations are solar-powered and easily accessed (center and right). (Source: https://www.theverge.com/2021/4/21/22394575/gogoro-india-hero-motorcorp-electric-scooters-battery-swap-stations, https://taiwantoday.tw/news.php?unit=7&post=129827)

ELECTRIC BIKES

E-bikes are a good alternative to mopeds due to lower costs, maintenance, and parking. With only one vehicle per three households (45 percent lower than national averages) in the Galápagos, programs designed to increase the affordability of e-bikes could help with local transportation needs without increasing fuel use. They have wide acceptance in Quito and Guayaquil and are available in small numbers on the Galápagos. Residents of Puerto Ayora are probably already familiar with them due to Smile e-bike rentals. Thus a more expansive

electric bike program could be an essential component of a smart pedestrian and bicycle planning strategy in and around Puerto Ayora and Puerto Baquerizo Moreno and the surrounding areas, especially the more rural settlements with irregular bus service.

With an average battery range of 20-35 miles, trips would not require large charging infrastructure. A few neighborhood stations could serve communities while tourist rentals remain in central areas. An additional benefit is that solar-powered stations can be designed to also power phones and other small electronic devices, lowering household energy requirements. Or, charging the small batteries can occur within a household.

E-bikes come with a range of designs and battery power, with their performance affected by such factors as terrain, wheel size, and speed. Market research could determine the different needs of residents and tourists in shaping a program. See Figure 8 and source video.

FIGURE 8

Electric Bikes

A tourist examines an electric bike with vendor demonstrating the controls and the small removable battery that can be charged at home. (Source: https://www.youtube.com/watch?v=LMZo_QULGDM (start at 4:04)

CARGO BIKES

In order to move goods from the ports and among businesses around the islands, islanders use pick-up trucks, accounting for 26 percent of the local vehicle fleet in the Galápagos. Electric or pedal, they come in many shapes. While cargo bikes would not replace the need for all trucks, their use could off-set small trip requirements for a wide range of island activities. See Figure 9.

CARGO BIKE USE AROUND THE WORLD

Cargo bikes come in many sizes, have many uses ranging from carrying groceries, tools, equipment and light deliveries to transporting children to and from school, and are ubiquitous around the world. Germany began a pilot program to support their use for personal and commercial transport with direct subsidies (E1,000 for electric and E500 for pedal powered ones and 2018, the country reported 39,200 were sold, out-performing EV auto sales (32,000). In March 2021, the German Ministry of Environment expanded the subsidy program to include a greater number of bikes and provide funding for micro-depots for storage and transfer of goods. Denmark's Copenhagen reports 40,000 cargo bikes while Rio has described 11,000 daily deliveries within the city. Kigali and Lagos also cite their use, also viewing them as a source of employment.

https://www.theguardian.com/world/2019/aug/25/cargo-bikes-berlin-four-wheels-bad-transport http://cccb.fgm.at/sites/default/files/downloads/Mayors%20Guide%20A5%20English.pdf
https://blogs.worldbank.org/transport/old-solution-new-challenges-rebirth-cargo-bike

FIGURE 9

Cargo Bikes

Cargo bikes can be pedal or electric-powered (left and center). Micro depots (right) can be deployed strategically for storage and transfer of goods.

Source: https://blogs.worldbank.org/transport/old-solution-new- challenges-rebirth-cargo-bike)

ELECTRIC TRUCKS

Cargo bikes carry light freight in limited areas. Trucks are also necessary. In fact, mini trucks and trucks are the second and fourth most popular mode of transportation on the islands. Transitioning to electric versions is a possibility. For example, the Chinese firm, Kaiyun Motors, produces a $5,000 electric pickup truck with a top speed of 45 km/h, a 500 kg cargo capacity, and a 121 km range and a more powerful one for $10,000. See Figure 10.

FIGURE 10

Two Types of Electric Trucks

These two electric trucks cost $5,000 and $10,000 respectively

*Source:*https://www.autoblog.com/2019/01/28/kaiyun-pickman-electric-truck-america/; https://www.motorbiscuit.com/the-pickman-is-a-10000-electric-truck-that-can-tow-4000-pounds/

ELECTRIC BUSES AND SHUTTLES

On both islands, some buses now operate to take tourists and residents from one destination to another. In San Cristobal, they travel 8 kilometers between Puerto Baquerizo Moreno to the small neighboring town of Progreso. In Santa Cruz, the most important route is the 42-kilometer trip between the airport in Baltra and Puerto Ayora. These routes hold possibilities for adopting electric buses or shuttles.

The bus routes on the islands are relatively short but the terrain is rugged, so key questions revolve around economics and performance. A standard 12-meter electric bus cost is about $750,000. Its battery life ranges from 250 km to 450 km depending on the terrain. Charging can be done with solar power, however a storage facility is essential. Using smaller EV shuttles is an alternative solution that might be more suitable for shorter, less-travelled routes. A case study from Martha's Vineyard, Massachusetts in the United States offers some ideas for the islands. See Figure 11.

ELECTRIC BUSES IN MARTHA'S VINEYARD

Population: 17,000
GDP per capita: $33,228
Geographic area: 96 square miles
Main Industry: Tourism

Like the Galápagos, Martha's Vineyard, an island off the coast of Massachusetts (USA), has a tourist-oriented economy. Its population grows from 17,000 to 100,000 during the summer season. It is highly dependent on imported fossil fuels for transportation and has a public transit system to assist with circulation. To reduce its fossil fuel dependency, its public transit authority is transitioning to electric buses. To date, it has purchased 16 (half its fleet), built an operations center with a solar roof that powers its 700kW charging station, and added a 1.5MWh battery storage facility. Maintenance and operating costs are less expensive than for diesel-operated buses.

https://cleantechnica.com/2021/05/26/electric-buses-get-solar-charging-battery-backup-on-marthas-vineyard/

FIGURE 11

Electric Buses and Shuttles

The Martha's Vineyard operations center with its solar panel roof that powers charging stations for the electric buses (left) and an example of a shuttle or minibus (right).

Source: https://cleantechnica.com/2021/05/26/electric-buses-get-solar-charging-battery-backup-on-marthas-vineyard/; https://en.wikipedia.org/wiki/Solar_bus#/media/File:Innotrans_2018,_Berlin_(P1070532).jpg

MARINE TRANSPORTATION

As with land transportation, many possibilities are available for adoption in the Galápagos, ranging from ferries and various-sized boats used as water taxis. The islands have already supported a limited number of solar powered boats such as the Solaris, a 10-passenger water taxi and the Genesis Solar, a 42-passenger catamaran. See Figure 12. How to scale up is an issue as these modes are more expensive than the current fossil-fueled fleet. Solar ferry services are in use in New Zealand, India, Norway, and other places. The Montenegro case study provides an example.

FIGURE 12

Solar Powered Boats

The Galápagos already has a few solar-powered boats. The Solaris (right) holds many passengers while the Genesis Solar (left) ferries tourists cross the Itabaca Channel.

Source: http://aboutGalápagos.nathab.com/blog/solar-powered-catamaran-service-arrives-in-the-Galápagos/; https://www.vice.com/en/article/3dk84n/this-solar-powered-boat-will-slowly-show-you-the-Galápagos

FERRIES IN THE BAY OF KOTOR, MONTENEGRO

Population: 67,456
GDP per capita: $8,846
Geographic Area: 107.3 km (shoreline)
Main Industry: Tourism

In 2019, Bella Boka company debuted two solar-powered ferries for public transportation. The two boats, *Elettra* and *Graciana*, operate on two separate lines and cover a total of seven stops. Elettra operates on two solar-powered electric motors and has a passenger capacity of 30 passengers while the hybrid Graciana operates on both an electric motor and has a capacity of 60 passengers. The investment was approximately E 4.26 million, 150,000 of which was financed by UNDP under the organization's broad "Towards Carbon Neutral Tourism in Montenegro Project." The Ministry of Tourism, The Chamber of Commerce, and the UNDP, and the GEF are all partners of this project. Another seven boats are expected to launch by the end of 2020, with a capacity of 35-60 passengers.

https://balkangreenenergynews.com/solar-powered-ferries-launched-in-montenegros-bay-of-kotor/
http://bellaboka.me/

A TRAINING PROGRAM

Human capacity is arguably the key underlying infrastructure as a plethora of workers will be needed for the operation and maintenance of any introduced electric vehicle. For this reason, the establishment of a training and maintenance center is recommended to educate interested local residents on how to market and service electric vehicles. Possible avenues of training include learning to convert gasoline vehicles to electric and, most important, servicing different types of electric motors. Fortunately, the maintenance of an electric motor is less complicated than a combustion engine, because an electric motor contains fewer parts that are easier to replace and more durable, so training both vehicle experts and people who are new to the automobile industry would be straightforward. Although focused on EV automobiles, the Hawaii case study below offers some replicable ideas.

EV TRAINING IN HAWAII, UNITED STATES

Population:1,415,872 (2019)
GDP per capita: $68,831
Geographic area: 28,311 square kilometers
Main Industry: Tourism

Sustainable Transportation Coalition Hawaii in partnership with the Blue Planet Foundation, operates an EV certification program that equips dealership sales associates with knowledge of EV technologies, infrastructure, incentives, and benefits in Hawaii. Dating from 2018, it has certified 41 automobile sales associates. In addition, Honolulu Community College offers non-credit courses in hybrid and electric vehicle automotive maintenance to technicians, sales people, and any interested residents.

https://www.stchawaii.org/programs/electric-vehicle-education/

Part Five: Investment Opportunities for the Initiative

In addition to the CAF/WWF $100 million proposal presented to the Green Climate Fund to finance clean energy-related projects, other interesting investment opportunities to support the design and implementation of climate-resilient projects on the Islands exist at the national and international levels. As Figure 13 below illustrates, the country's overall expenditure on green projects over five years is up to 2020. While the funds vary from year to year, the IDB and CAF are the largest contributors.

NATIONAL PROGRAMS

Ecuador has been more actively involved in improving access to finance for a number of mitigation and adaptation initiatives. In February 2021 it developed its comprehensive multi-level climate change policy in the *First National Climate Financing Strategy* (*Primera Estrategia Nacional de Financiamiento Climático*, EFIC).[20] The EFIC integrates the nation's financial and environmental efforts through three lines of action: 1) it mandates clear and effective governance of climate finance led cooperatively by two national ministries, the Ministry of Economy and Finance and Ministry of Environment and Water; 2) it consolidates funding from all sources into a single stream ; and 3) it outlines means for effective and efficient mobilization of climate finance through streamlined access, allocation, and management processes. These include 83 actions to be implemented in the short-term (until 2023), mid-term (until 2026) and in the long-term (until 2030) by public sector actors and institutions (national and subnational), the private sector, civil society, financial institutions, international cooperation, academia, and indigenous communities.[21]

In addition, since 2018, the Ecuadorian Development Bank (Banco de Desarrollo del Ecuador, BDE) has become a green bank that, in cooperation with intergovernmental organizations, has developed the CREDIBID program, which encompasses technical assistance and new climate resilient financial products targeted to municipal and provincial governments. It focuses on the following subsectors, which can be applied to the Galápagos Green Mobility Strategy outlined in this report:

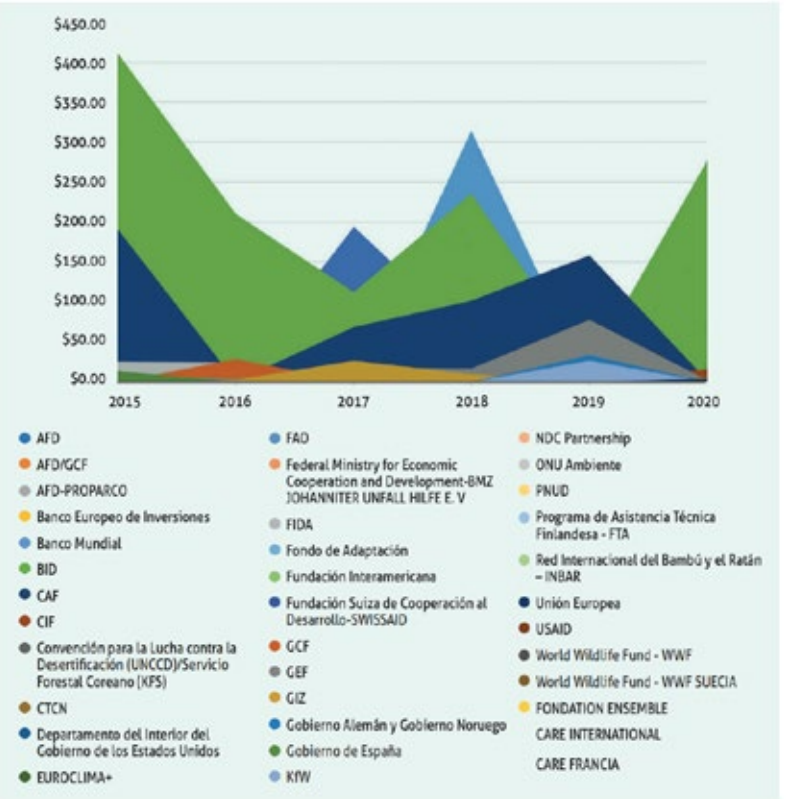
SUSTAINABLE TRANSPORTATION AND MOBILITY:

- Promotion of alternative transportation systems with an emphasis on non-motorized and public transit in conjunction with planning cities. The aim is to reduce auto-dependency, reduce GHG production and air pollution, and promote a healthy and safe habitat for citizens. By accommodating different levels of service

20 CEPAL. Presentación de la Primera Estrategia Nacional de Financiamiento Climático del Ecuador (EFIC). https://www.cepal.org/es/notas/presentacion-la-primera-estrategia-nacional-financiamiento-climatico-ecuador-efic
21 National Strategy of Climate Finance. Ministry of Economy and Finance. https://www.finanzas.gob.ec (accesed on September 19, 2021).

FIGURE 13

Climate Finance and their Sources in Ecuador 2015-2020 (in USD millions)



Source: National Climate Financing Strategy (EFIC)

ranging from comprehensive cycle routes through dedicated corridors to "smart" urban public transit systems that encompass technology and telecommunications modules.

- To date the CREDIBID has financed:
  - *Feasibility studies for the implementation of non-motorized transport systems.*
  - *Acquisition of electric bicycles and buses, among others, for sustainable public mobility.*
  - *Construction of infrastructure for the implementation of an integrated public transport system.*
  - *Supporting consulting for technology and financial management in transport systems*
  - *Technical assistance and capacity-building for improving BDE clients' efficiency and effectiveness in administration, finance, management and operations in order to guarantee the sustainability of the investments over time.*

TOURISM:

- In coordination with the Ministry of Tourism, provision of financial products for the execution of projects related to tourism.
- To date the CREDIBID has financed:
  - *Studies for the construction of tourist facilities or equipment near tourist attractions.*

- *Tourist road circuits:*
    - *Improvement of main, secondary, and pedestrian roads.*
    - *Connection to existing basic services, including water and sanitations.*
- *Urban commercial equipment to provide tourist services:*
    - *Rehabilitation of existing markets of artisanal, cultural and gastronomic goods.*
    - *Improvement of small squares or pedestrian paths as commercial areas.*
- *Signage.*
- *Accessibility infrastructure for persons with disabilities (e.g. elderly, parents with young children, and people with some type of permanent or temporary disability).*[22]

Furthermore, the National Finance Corporation (Corporación Financiera Nacional, CFN) supports small and medium-sized enterprises (SMEs), companies, and corporations and can finance the acquisition of fleets of electric vehicles for public or commercial transport (except taxis) of people and goods. It extends loans of up to 70 percent for new projects and up to 100 percent for the expansion of existing projects.

INTERNATIONAL PROGRAMS

During the last few years, the supply side of climate-resilient financing worldwide has increased. New players, funds, and financial facilities have entered the market, although much more needs to be done to meet the Paris Agreement goals. The urban areas of the Galápagos, being in the Islands, a world heritage site and a highly fragile ecosystem, are in a unique position to take advantage of these new opportunities as a way to foster sustainable tourism and economic recovery from the COVID-19 crisis.

The traditional funders, IDB and World Bank, have dedicated loans for a green and just recovery, while other entities have established city-focused lending opportunities in this arena. Germany and Luxembourg have initiated the $100 million City Climate Finance Gap Fund, administered by the World Bank and the European Investment Bank to support planning and early-stage project preparation activities, including aiding places building a pipeline of climate-resilient projects and connecting them to financing partners. [23] The United Nations Capital Development Fund (UNCDF) and United Cities and Local Governments (UCLG) in collaboration with the Global Fund for Cities Development (FMDV) have set up the International Municipal Investment Fund (IMIF) to aid cities and local governments in developing countries access to national and international capital markets for projects of less than $25 million. Private-sector Meridiam, with $70 billion invested in commercially viable infrastructure projects in mobility and energy transition, may be interested in any blended finance or public private partnership opportunities that the Galápagos Green Mobility Strategy might offer for large projects above $25 million.

BOLSTERING THE DEMAND SIDE

The above-mentioned sources are some of the existing opportunities to finance the Galápagos Green Mobility Strategy, yet important challenges remain on the demand side. The limited institutional and project preparation capacity, as well as the lack of creditworthiness from the Galápagos municipalities, makes them highly dependent on the national government. Political rivalries often impede proper coordination among the different levels of government needed to keep financial flows coming into cities. On the private-sector side, Ecuador has a regulatory framework that is difficult to navigate, especially for obtaining permits and the licenses required to implement projects, and even more so for developing public-private partnerships.

22 Ecuadorian Development Bank -BDE. https://bde.fin.ec/
23 City Climate Finance Gap Fund. www.citygapfund.org/

On a positive note, the government of the President Guillermo Lasso, former banker, elected April 2021, is keen on improving the business climate of the country as a clear signal for attracting national and international investment. There are expectations that the macroeconomic scenario will be more stable. The government has also announced much-needed tax and labor reform, which is already building confidence in the private sector and the international community. Hopefully all these positive changes will help improve the capacity of municipalities like the ones in Galápagos to have direct access to finance climate-resilient initiatives, such as the Galápagos Green Mobility Strategy.

Part Six: Summary #GalápagosGoesGreen

Being a World Heritage site affords the Galápagos certain environmental protections implemented by a multi-level governance structure guided by its master plan for 2015-2020 and other policies. The islands and their four cities, of which the largest, Puerto Ayora (population c. 12,000) and Puerto Baquerizo Moreno (population 6,500) and their immediate surrounds, are experiencing the growth of greenhouse gas emissions (GHG) due to an explosion in tourism that reached 2.2 million in the decade prior to the pandemic, sprawling settlement patterns and total dependance on imports for food and other goods. This phenomenon is contributing to rising sea levels and biodiversity losses threatening the island's tourist industry, the principle economic driver. While the pandemic decimated the burgeoning tourist industry, it also yielded the opportunity to reposition the islands as a leader in eco-tourism.

Such repositioning could focus on one of the major GHG contributors: transport. This report outlines a Green Mobility Strategy, premised on transforming current modes of fossil-fuel-dependent land and sea transportation to electric-powered bikes, trucks, cars, boats, and ferries. It provides examples of each mode as used in places around the world. It also outlines national and international sources of finance for the transition, inclusive of project preparation, capacity-building, and execution. A financing plan for this strategy is multipronged, employing partners from the national government, national and international finance institutions, and the private sector.

The effective implementation of these transport systems will require a combination of suitable policies, investment capacity, mechanisms, and business models, as well as local human resources and collective awareness about energy use. This means that in addition to technical feasibility and effective implementation it will also require policy revision and local capacity-building.