Towards Sustainable Transport and Mobility

Edited by Julia R. Kotzebue

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Perspectives on Travelling and Commuting in Small Island States

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Abbreviations

AFV	Alternative Fuel Vehicles
BEVs	Battery Electric Vehicles
BOS	Bus-On-Shoulder
BRT	Bus Rapid Transit
CDF	Cumulative Distribution Function
CNG	Compressed Natural Gas
DSM	Demand Side Management
EIA	Energy Information Administration
EU	European Union
EV	Electric Vehicle
GHG	Greenhouse Gas
GIS	Geographic Information System
GoF	Goodness-of-Fit
GPS	Global Positioning System
HDV	Heavy Duty Vehicle
ICE	Internal Combustion Engine
ICT	Information and Communication Technology
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometres
K-S	Kolmogorov Smirnov Test
LCV	Light Commercial Vehicle
LDV	Light Duty Vehicle
MAB	Man and Biosphere
MDV	Medium Duty Vehicle
MLE	Maximum Likelihood Estimator
P&R	Park-and-Ride
PDF	Probability Density Function
PEVs	Plug-in Electric Vehicles
PHEV	Plug-in Hybrid Electric Vehicle
PHEVs	Plug-in Hybrid Electric Vehicles
PM	Particulate Matter
PTSC	Public Transport Service Corporation
RMSE	Root Mean Squared Error
SB	System of Distributions

SIDS	Small Island Developing States
SIS	Small Island State
TA	Transport Authority
TB	Transport Board
ToU	Time of Use
UN	United Nations
VIX	Vehicle-to-everything
WLTP	Worldwide Harmonised Test Procedure
ZR	Fix-Route taxis

1 Introduction

J. R. Kotzebue and T. Townsend

The idea for this book "Towards Sustainable Transport and Mobility: Perspectives on Travelling and Commuting in Small Island States" emerged from the interdisciplinary sustainable transport working group at The University of West Indies, St. Augustine, Trinidad and Tobago in collaboration with the Institute of Geography, University Hamburg. In discussions with practitioners, experts and students, we realised that the scientific literature rarely addresses travelling and commuting in Small Island States (SISs). Experts primarily focus on the economic-touristic aspects and change that heavily affect SISs, but publications on sustainable transport are relatively thin. A literature search with Google Scholar search engine shows that the number of scientific works related to the search keyword "sustainable transport" increased by over 1300 per cent from 2200 publications in the period 1990 to 2000 to over 34.300 in 2001 to 2020. The vast majority addresses sustainable transport in urban areas and barely less than one per cent (n 248) of the articles address it within SISs.

One can argue that SISs are insignificant, but the estimate is that they are home to over 63.2 million people (UN, 2014). Hence, United Nations (UN) the name SISs in an umbrella for a heterogeneous group of countries in the Caribbean, Mediterranean, Atlantic, Pacific and Indian Seas (Nurse et al., 2001). They share the following realities; they are relatively remotely located, have a small domestic market, small-scale enterprises and high cost for transportation, infrastructure, information and communication technology (ICT) development (Briguglio, 2018; UN, 2014). Partly inherited from a colonial past, SISs often have a single urban and economic centre around one major sea port (Allam & Jones, 2019).

This book aims to deal with the marginalised knowledge and provides insights on trends in sustainable transport transition, policies, practice examples, challenges and solutions of commuters and travellers in SISs. This is a necessity because the experiences and study resulting from continental urban and rural areas only partly fit with the spatial, social, economic and environmental conditions of the islands. Already the UN

Report of the World Commission on Environment and Development: Our Common Future called Brundtland Report (1987), placed sustainable transport on the international political agenda and warned that the transition to sustainable development needs informed choices and new policies for developing states, because copying energy patterns is undesirable and infeasible.

Sustainable Transport

The Brundtland Report does not define sustainable transport, but linked transport systems to land use and urban settlement patterns, air pollution, human health, consumption and food security. Although there is no agreed uniform definition, the UN Secretary General's High-Level Advisory Group on Sustainable Transport states that:

> "Sustainable transport is the provision of services and infrastructure for the mobility of people and goods advancing economic and social development to benefit today's and future generations in a manner that is safe, affordable, accessible, efficient, and resilient, while minimising carbon and other emissions and environmental impacts".(UN, 2016 p. 1)

The vague definition provides room for interpretations. By comparison, the World Bank Group's initiative Sustainable Mobility for All (SuM4All) (2019) developed a more concrete four-policy goal framework that is aligned to the UN's Sustainable Development Goals:

1. Universal access that refers to transportation for all at all geographical locations according to their social and economic needs.
2. Efficiency aims at predictable, reliable and cost-efficient mobility.
3. Safety deals with a reduction in crashes, injuries and fatalities.
4. Green relates to reduction of adverse environmental effects of transportation and mobility like (GHG), noise and other air pollution.

While the UN definition speaks about sustainable transport, the World Bank Group uses the term "mobility". The differentiation between transport and mobility is unclear, however, transport is traditionally linked to transport modes, sectors, the physical infrastructure, systems, networks, economic efficiency, and technical parameters (Barr, Prillwitz, Ryley, & Shaw, 2017).The purpose of transportation is to overcome space. This goal is attached to efficiency in terms of time and money (Rodrigue, Comtois, & Slack, 2016).

Crucial is the economy of scale, innovation, and technical diffusion to increase the efficiency (Holz-Rau, 2018).

By comparison, scholars associate the idea of mobility with the social and cultural aspects of travelling (Merriman, 2009, Urry, 2002). It is about the personal subjective experience, meaning, ethical and political perspectives. Mobility includes all forms of movement and all possibilities of moving individuals, objects, and ideas (Cresswell, 2011). The concept also includes the context, the spaces, how people move and rest (Adey, 2017). Therefore, the idea takes into consideration barriers and constraints of mobility. This includes the question of availability, accessibility and affordability. Virtual mobility is also part of the concept that increasingly becomes important, such as remote working, telemedicine, e-learning, e-government, and online shopping (Kenyon, Lyons, & Rafferty, 2002; Velaga, Beecroft, Nelson, Corsar, & Edwards, 2012).

Policy and planning

Although transport and mobility are crucial to the overall development, SISs consider transport policy seldom as an independent policy field. Other policies, such as land use, economic and tourism policy rather than transport policy, determine the transport development (Schwedes, 2016). Some SISs still have no national transport authorities. Planning can be outdated and deficient in key area. In some cases, there are no national or local-wide development strategies. This is partly because of high costs and inadequate resources and many depend on funding from governmental and non-governmental organisations like the European Union (EU), the World Bank Group (Attard, 2005; Fay, Andres, Fox, Narloch, & Slawson, 2017). The transportation system often emerged without systematic planning for the entire island. Instead, entrepreneurs and governments supported specific purposes like the former plantation-based economy in the colonial past and links to tourist resorts and shopping centres nowadays (Alberts & Baldacchino, 2017; GovTT, 1996).

Regarding the transport governance, many SISs have a centralistic or a poor planning culture, and limited inter-organisational communication is noted due to operating in silos. This is a major challenge for a sustainable transport development (Jordan, 2007). The continuing disunity about measuring and policy priorities hampers the systematic monitoring of the development, despite scholars and experts have recommended indicator sets and analytical frameworks (Dolcy & Townsend, 2020; Gudmundsson, 2004; Richardson, 2005). Lacking systematic traffic, commuter and travelling data, forecast and planning has led to reactionary and adaptive transport policies.

Accordingly, some governments and private actors make investments without little consciousness about the societal, economic and environmental interdependencies and adverse effects. The project-based approach is especially problematic regarding a resilient transport infrastructure, risk management, climate change mitigation and adaption. A resilient transport infrastructure is critical given the Climate Emergency. In many SISs hurricanes, heavy rains and landslides frequently damage the road infrastructure and disrupt transportation.

To that end, authors widely agree that a prerequisite for sustainable transport and mobility is an integrated policy and planning. The concept relates to management, physical elements, and operation of transport systems (Givoni & Banister, 2010). The integration can develop several dimensions. For instance, Carstensen and Holz-Rau (2020) identified (a) modal integration, (b) sectoral integration, and (c) vertical integration. Modal integration deals with the incorporating of all transport modes like walking, cycling, scooter, train, tram, bus, taxi, and car. The sectoral dimension refers to interdisciplinary approaches. The linkage of housing, transport and health policy exemplifies this type. Vertical integration deals with the governance aspect, the cooperation of international institutions, national, local authorities and stakeholders. Concerning the geographical situation of SIS, a fourth type, the spatial integration could be added. It refers to the even and just distribution of transport modes in areas, their connectivity and their access. For instance, urban areas often show a variety of transport modes while rural depend on one or two modes.

A Transition to Sustainable Transport

Inherent to an integrated transport approach is a goal-oriented or evolutionary transition to sustainable transport and mobility. Transitions include technological innovations and system improvements that create non-linear processes, which can also affect other sectors (Kemp & Rotmans, 2004). Part I of this book deals with the transition in personal transportation solutions. By addressing the energy and policy aspects in Chapter two (2), the authors King and Maharaj compare the transition to e-mobility in several SISs. They stress that governments should take a very proactive approach to encouraging the rapid adoption of Battery Electric Vehicle (EV) in tandem with a transition to renewable electrical energy to reap a wide swathe of economic and environmental benefits. Simultaneously, the authors highlight the need to invest in an environmentally friendly public bus system. However, they also address the economic challenges that could hamper the feasibility of the suggested transition despite the worldwide trend of decreasing battery and vehicle prices.

Linked to the preview chapter, Addison and colleagues bring the attention to the electricity distribution that needs to accommodate EVs in Chapter three (3). They argue that a management of EV penetration is necessary, since uncoordinated charging can produce load imbalances and sharp variations in current voltages and power. However, real data is insufficient in many SISs and, therefore, estimates of variables reflecting charging behaviour are necessary. The chapter provides an assessment of some probabilistic models based on weekday load curves derived from the charging data over one year, for a data-set consisting of 348 vehicles corresponding to 200 households in the Midwest region of the United States. The authors conclude that the data-driven approach will inform the decisions suitable for the local landscape. Still, there is the need to involve the many players and actors (public, private and non-profit), and to let them actively contribute to a successful EV adoption.

Because of its impact on the transport development, the book dedicates Part II to the digitalisation of transport and mobility. In Chapter four (4), Kotzebue and Bryan analysed the transport smartphone applications in Barbados. They investigated to what extent the apps address their target market and if they meet local transport needs and stated governmental goals. The analysis of the product descriptions and customer reviews revealed that most users are satisfied, but the apps poorly support government's goal to create a green and sustainable transport sector. Some apps provide wrong information, which discourages customers. Also, the partly insufficient ICT infrastructure hampers the proper function and use of apps. The authors recommend a supporting ICT policy to attract investments in the small market. The app market needs some guidance to exploit its potentials and to support government's goal.

In Chapter five (5) Kotzebue subsequently investigates the role of the digital capacity for the use of Participatory Geographic Information Systems in the North-East Tobago Man and Biosphere Reserve (MAB). The concept of digital capacity differs from the idea of digital literacy, which relies on the personal abilities. By comparison, digital capacity incorporates several kinds of input, including the ICT infrastructure and personal abilities. Additionally, the process, thus the interplay and collaboration, as well as the outcome, which must be beneficial for the community, are crucial. She concludes occasional, project-based use of digital tools will not empower the community to learn and to consider the tool as an opportunity for proactive behaviour. The author recommends integrating the use of such tool in the learning for sustainability in the MAB areas.

Although crucial, none of the chapters reflect on non-motorised mobility and its role in the transition to sustainable transport. Given the relevance, Part III of the book deals with non-motorised mobility. Non-motorised strongly relates to transport equity because pedestrian and bicycle infrastructure is often subordinated to the motorised transport system (Wigan, 1994). However, the collection of data is difficult because walking is a component of almost every travelling and commuting trip (Lee, Sener, & Jones, 2017).

Equity and Gender

Equity is associated with the distribution of the transport cost and benefits. Hence, an equal distribution is relative and must be socially acceptable (Cass, Shove, & Urry, 2005). However, the concept is hard to measure. For instance, the construction and maintenance of a highway creates working places and income, but it also generates a spatial inequity between users and non-users (Adey, 2017). Scholars differentiate between three types of inequality:

- Inequality of resources including, vehicle ownership, infrastructure and services:
- Inequality in travel behaviour, trip-frequency, travel time, travel distances, and needs.
- Inequality in the level of accessibility, which often refers to the easiness of reaching a location, the quality of mode and network, travel time, distance, and travel costs (Pereira, Schwanen, & Banister, 2017; Van Wee, Hagoort, & Annema, 2001).

The settlement structures, high costs of transport development and operation, low investments in public transport and state subsidies, encouraged in many SISs a relatively high car dependency and inequalities. Thus, commuters' and travellers' primary mode of transport is the car, or they consider the car as the only acceptable choice in terms of costs, time, safety and prestigious status (Wiersma, 2020). Some remote areas on the islands are only accessible by car, although in some islands the rural population depends on public transport or privately owned mini busses (Kotzebue, 2020). Studies showed that geographical remoteness can be a significant barrier to social inclusion (Cass, Shove, & Urry, 2005; Lucas, Mattioli, Verlinghieri, & Guzman, 2016).

In Chapter six (6) Attard, Maas, and Cañas highlight the challenges for active travel in the islands of Malta, the inequality of space and the prioritisation of the car. The authors provide insights and results from an activity workshop on walkability and cycling around the University of Malta, Msida Campus. Furthermore, they investigated the bicycle-sharing scheme in Malta. The study resulted in over 65 different environmental elements and characteristics of the public space that bear influence on the walking experience, such as the presence and quality of pavements and walkways, pedestrian crossings, street furniture, green urban areas, littering and weather. Concerns over road safety are, however, the main barrier to promoting cycling. Attard, Maas, and Cañas, conclude that the geographical characteristics of Malta create relatively short travelling distances and the good weather supports active mobility throughout the year. Some results also point towards specific policy and planning actions that would benefit and encourage more active travel on the islands.

Subsequently, Warren and his colleagues provide an additional perspective on walkability in Chapter seven (7) Walking in Havana, Cuba. The authors outline the results of a walkability audit for a selected area in a main shopping zone, which is adjacent to a multi-modal interchange for travellers. They discuss walkability with respect to the urban layout. The chapter also defines strengths and weakness of the current urban infrastructure, with conclusions focussed on making walking better for all stakeholders. The discussion highlights some of the inherent barriers found in many island situations and summarises some of the lessons learned which could be applied elsewhere to improve walkability as part of the overall island mobility and sustainability.

Inequalities are also evident between women and men. Compared to men, women frequently have a lower income; they have less access to private vehicles, shorter commuting times and travel distances, and depend more on public transport (Bamberger, Lebo, Gwilliam, & Gannon, 1999; Sánchez & González, 2016). Problematic is also the sexual and gender-based violence that travelling and commuting women are experiencing (ECLAC, 2019). Although the newspapers frequently report assaults, data is lacking in many SISs. As a result, many mothers connect the availability of a car to good parenting. They transfer negative mobility experiences to their children. Hence, children learn that walking and the use of public transport is riskier than using the private car. Additionally, non-drivers like non-car owners, children, the elderly and persons with disabilities become less mobile and increasingly dependent on a driver (Murray, 2009).

A reliable, accessible and sufficient public transport system, private or governmental owned, is therefore an essential for an inclusive and sustainable society. Part IV, the last section of the book, therefore, deals with planning and measuring public transport services and facilities. Bajada and Attard look back to Malta's major bus service reform in 2012. The authors explore people's attitudes regarding bus service quality characteristics and compared them through similar online surveys from 2012 to 2020. The results show that the attitudes changed from positive to negative within a decade. They conclude that the reform resulted in an improvement but did not attract potential users. Reforming through improvements to some of the bus service characteristics, such as quality of vehicles, route and schedule planning, are all a good start. However, this needs to be consistent and further supported with priority on the road. In conclusion, they highlight the issues with bus service delivery that are not solely borne by the operator, but have to also include a concerted effort by the authorities to prioritise the bus service and its quality.

Finally, in the closing Chapter nine (9), Furlonge and Cudjoe investigated the Park-and-Ride Accessibility and reported the experiences from the design of a pilot study for the island of Trinidad and Tobago. The study aimed at the identification of an appropriate location selection method for park-and-ride (P&R) lots. A major criterion for the lots was the accessibility to maximise the number of motorists who would use public transport. The authors identified through a literature review nine criteria for built-up areas to avoid the use of virgin areas. The analysis resulted in two potential sites. Given the lack of systematic transport data collection in Trinidad and Tobago, the authors conclude that most of the current methods for such require extensive data variables and apply complex computations, which would be prohibitive from the perspectives of data collection cost and analyses. The mixed qualitative and quantitative method proved to be a promising and effective method for site selection.

Conclusion and Perspectives Ahead

SISs have limited land availability for competing uses and limited financial resources for infrastructure and services. It is, therefore, an imperative that sustainable transportation development remains at the forefront when development plans and projects are being evaluated. The Climate Emergency makes this even more urgent since the effects of global warming, drought and mega-storms can create havoc on their economies, which often rely on single agricultural commodities or tourism.

"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987) p 41. Hence, sustainable transport development in SISs should be based at least on six pillars. These are (a) Integrated Land/Use Transportation Planning (b) Develop Clean, Safe, Efficient, Affordable Public Transportation Options (c) Ensure Access to Affordable Rural Transport Services (d) Address the mobility needs of special groups, e.g., elderly and disabled (e) Facilitate walking & non-motorised transport in urban centres (f) Reduce Air Pollution & Carbon Emissions.

For instance, researchers and practitioners at a recent Transportation Symposium 2021, hosted by the Department of Civil Engineering, Faculty of Engineering of The University of The West Indies, St. Augustine, Trinidad & Tobago, identified two of the key issues in creating sustainable "green transportation" development: (1) High demand for private transportation and (2) Low adoption of Alternative Fuel Vehicles (AFV). The high demand for private transportation is linked to (a) low adoption of public transport, (b) low use of walking & biking as modes of transport, and (c) infrastructure and systems that prioritise private vehicles above all alternatives. The low adoption of AFVs results from (a) high capital costs of acquisition, (b) low incentives and awareness for changing existing internal combustion engines to AFVs, and (c) low access to refuelling sites.

Our future perspective for significant change is that SISs need to develop and implement policies aimed at ensuring sustainable transportation service levels for both urban and rural dwellers without a debilitating drain on the state coffers. These policies need to be supported by strategic institutions with clear mandates, authority and accountability. What many SISs need is the will to take decisive action to change the tendency towards "laisez-faire" or "uniformed" policy making and replace it by scientific data-driven approaches utilising new tools and technologies and aimed at attaining measurable objectives that directly impact on the future lives of their citizens. The book offers some of these informed perspectives on sustainable transport development.

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Part I Transition in Personal Transportation Solutions

2 The Potential of e-Mobility in Small Island States: Energy and Policy Considerations

G. King and B. Maharaj

Populated islands with a small land area, such as many of those in the South Pacific, the Indian Ocean, the Mediterranean and the Caribbean regions, are generally well suited to the adoption of e-mobility (O'Neill-Carrillo, Lave, & Haines, 2021). It can form an important part of making transport more sustainable and accessible. Energy efficiency is particularly important in SISs, which often have vulnerable electricity grids with generation based on imported fuels (Mahadeo, G.; Bahadoorsingh, S.; Sharma, 2017).In the global phenomenon of vehicle electrification, SISs can benefit very significantly from the deployment of Battery Electric Vehicles (BEVs) and there are some different barriers to adoption. Most islands lag behind developed markets in the deployment of BEVs, with some notable exceptions such as Barbados (Sophie Hares, 2018) and Waiheke Island in Auckland (Dobson, 2018).

In this chapter, we aim to highlight the potential benefits that could be gained by accelerated deployment of e-mobility in SISs. We focus on Light Duty Vehicles (LDVs) and buses since space did not permit discussion of the potential of electric micro-transport or two- and three-wheeled vehicles. An overview of the world market sets the context; general opportunities and challenges that arise from the geo-political characteristics of SISs are surveyed; and suggestions for policy approaches are discussed. The chapter concludes with recommendations for an effective transition.

Global Trends and Issues in e-Mobility

Battery electric powertrains are more efficient, are quieter in operation, and can give better performance than internal combustion engines (ICE), all with zero harmful tailpipe exhaust emissions. Even when a BEV is charged on a grid that is powered by fossil fuels, the reduction in carbon emissions per km of travel can be significant, up to 60 % when combined cycle natural gas power generation is in use (Nealer, Reichmuth, & Anair, 2015). As the proportion of electricity is generated from renewable sources increases on a national grid, BEVs become relatively more carbon efficient (IEA, 2019).

The current global stock of passenger car BEVs is about 12 million, and there are about 600,000 buses. Around 44 % of global 2- and 3-wheeler vehicle sales are BEVs, with penetration reaching 25 % of the global fleet mostly in India and China. Aggressive growth is expected to continue, driven by government incentives and policy decisions; proliferation of BEV models available on the market; and the advance of battery technology and manufacturing economies of scale that improve performance and reduces cost.

Policy makers around the world are using legislative instruments to encourage and accelerate the transition to BEVs, with countries making policy commitments to phase out the sale of new combustion engine LDVs from as early as 2025. Many governments are offering cash incentives to customers buying new BEVs or attractive rates for the scrappage of old ICE vehicles. Support is being provided for charging infrastructure (Lieven, 2015).

Advances in battery technology, stabilised supply chains, and economies of scale have led to a nine-fold reduction in battery prices over the last 10 years (BloombergNEF, 2021). Batteries being the most expensive component in a BEV, this cost reduction has been germane to the growth in BEV sales.

BEV buses are growing in importance. China is the leading market with 27 % of new bus registrations being EVs in 2020 (IEA, 2021; Song, Liu, Gao, & Li, 2020). The global stock of BEV buses was approximately 600,000 in 2020, 99 % of which are in China. BEVs are ideally suited to start-stop duty cycles, with significant energy recovery through careful driving; reduced and simpler maintenance; and favourable vehicle architecture, improving the functionality of the bus. Heavy-duty vehicles (HDVs), using mainly compression ignition engines powered by diesel fuel, account for 24 % of GHGs in the US (US EPA, 2021) and up to 70 % of tailpipe emissions of NOx and PM pollutants. BEV HDVs can bring significant life cycle cost and environmental benefits (Sen, Ercan, & Tatari, 2017). The availability of electric heavy-duty vehicle models lags behind LDVs and buses, but models of different classes are gradually starting to appear on the market. Light and medium commercial vehicles sector, often used in urban areas for transporting equipment and materials and deliveries, are well suited to electrification. For instance, in the UK, over half of all panel vans remain within 24 km of their base on a typical day (UK Department of Transport, 2021), and have frequent stops and starts for deliveries. Most vans used for business purposes return to a base at the end of each day, and many return to base multiple times during the day. As a result, the range requirement for electric transport and delivery vans is lower than that for passenger cars, allowing them to use smaller batteries and making them more affordable.

Passenger cars, including SUVs and light duty electric pickup trucks, is the sector in which electrification has taken strongest hold. In 2019, there were 72 BEV models available in the US. Exponential growth in BEVs is expected in the coming decade. Only 2.3 % of LDV sales in the US in 2020 were BEVs, but global sales grew by 43 % year-on-year in 2020, and by 98 % year-on-year in 2021[1] (Figure 2.1).

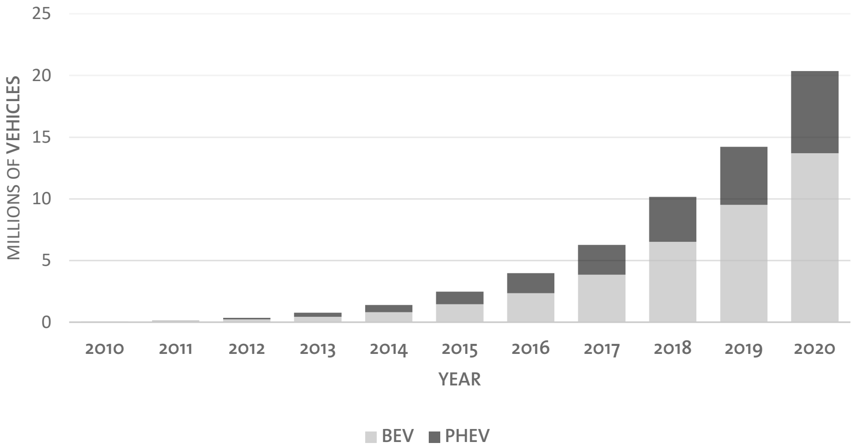

Figure 2.1 Global Electric Vehicle Stock by Powertrain Type 2010–2020
Note: Data Source IEA EV Global Outlook 2021. Compiled by authors

Supply of raw materials, such as cobalt and lithium, may prove to be a constraint on the growth of BEV sales. Production capacity will continue to expand as new supply sources are developed, but it is uncertain whether supply can meet demand (UNCTAD, 2020). Demand competition for battery raw materials is not only generated by BEVs but also by the burgeoning energy storage industry, in support of renewable energy installations. Supply constraints may cause BEV manufacturers to focus on products and markets that maximise returns.

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1 Estimated.

General Opportunities and Challenges for BEVs in SIS

Distinctive characteristics of SISs, and in particular SIDS, provide opportunities and challenges for EV deployment that are different from those of continental countries. This section identifies some key characteristics of an island context, and their implications for EV usage. A sample set of Caribbean SISs has been selected for analysis: Antigua; Aruba; Bahamas; Curaçao; Dominican Republic; Jamaica; Puerto Rico; St. Kitts; St. Lucia; St. Vincent; and Trinidad & Tobago. Additional more developed SISs were added to the analysis for comparison purposes: Cyprus; Malta; Mauritius; Singapore, and Taiwan. While not all the opportunities and challenges identified here are relevant to all islands, those discussed provide an important backdrop that can inform island-specific EV policy.

Low Point-to-Point Trip Lengths

In SISs, inter-city road trips are uncommon. Daily average trip distances can be similar to those in continental markets; for instance, survey results indicate that the average daily mileage in Trinidad and Tobago is 57 km[2]; but the frequency of longer drives will be much lower. Therefore, range anxiety that has historically slowed BEV adoption in larger markets is not a consideration in a SIS. Even though the daily journey of new light duty vehicle users is approximately 58 km in the UK[2] (UK Government: Department for Transport, 2020) 47 km in the Beijing area of China[2] (Cox, 2021) and 80 km in the US[2] (USOHP, 2020), range is a valid concern since longer road trips between cities are common. In a continental context, the range of a BEV is as important as other factors, such as performance or comfort to purchasers (Nie, Wang, Guo, & Shen, 2018). While high speed DC charging technologies, a growing charging infrastructure, and customer experience are helping to mitigate range anxiety in the major markets, they will remain very important factors that drive e-mobility policy.

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2 Calculated by dividing the average annual mileage for light vehicles by 282 days per year of usage.

Table 2.1 Examples of Small Island Maximum Point-to-Point Journey Distances and Estimated Travel Time

ISLAND	POINT A	POINT B	DISTANCE (KM)	TRAVEL TIME (HOURS)	AVERAGE SPEED (KM/H)	CHARGES ENROUTE	DESTINATION CHARGING FOR RETURN?
Antigua	Devil's Bridge National Park	Jolly Beach	29	0.82	36	0	N
Aruba	San Nicolas	Arashi Beach	35	0.75	47	0	N
Bahamas	Crown Haven	Sandy Point	171	2.15	80	0	Y
Curaçao	Newport	Sabana Westpunt	62	1.17	53	0	N
Dominican Republic	Punta Cana	Monte Cristi	457	6.05	76	2	Y
Jamaica	Negril	Happy Grove	309	6.48	48	1	Y
Malta	San Lawrenz	Birżebbuġa	54	1.12	48	0	N
Mauritus	Cap Malheureux	Souillac	77	1.30	59	0	N
Puerto Rico	Rincon	Ceiba	246	3.20	77	1	Y
Singapore	Singapore Changi Airport	Tuas	52	1.00	52	0	N
St. Kitts	Heldens	Banana Bay	38	0.77	50	0	N
St. Lucia	Gros Islet	Hewanorra Inter'l Airport	65	1.55	42	0	N
St. Vincent	Kingstown	Owia	46	1.47	31	0	N
Trinidad & Tobago	Matelot	Icacos	217	4.90	44	1	N

Note. Estimated travel time calculated by Google Maps Travel Planner. Charges required based on an estimated BEV driving range of 200 km. Malta travel time does not include ferry crossing. Compiled by authors

For most of the smaller islands in the sample set presented in Table 2.1, even a round trip between the farthest points on the island would require neither en-route nor destination charging. Minimal public charging networks in these islands would be sufficient for the use of private and light commercial vehicles. Larger islands such as Dominican Republic, Puerto Rico, Jamaica, and Trinidad and Tobago require strategically located public charging to support limit case longer journeys. A reasonable assumption is that most journeys on these small islands start and end at the same place, either a home or a workplace, and that charging is possible at that location.

Therefore, the low point-to-point distances on small islands lend themselves to the use of BEVs. Range anxiety should not be a factor in most cases. Minimal public charging infrastructure is needed, once home or workplace charging is possible.

Low Average Vehicle Speeds

Coupled with low average point-to-point distances, average vehicle speeds in SISs tend to be slow. The estimated journey times presented in Table 2.1 were calculated using the Google Maps using its journey planner feature. The corresponding calculated average speeds in many cases, are below 50 km/h. Except for highly urbanised Singapore, the routes plotted on these small islands are primarily rural and the journey times suggest winding, narrow and, in some cases, mountainous roads. Coastal roads pass through sporadic settlements, which will also require slower speeds.

Unlike ICE vehicles, BEVs are more efficient at variable low speeds than at highway speeds. Regenerative braking allows for the recovery of energy when slowing is required, improving efficiency and extending the range. When stopped in traffic or at a road junction, BEVs use minimal energy, unlike combustion engine vehicles that enter an idling cycle.

Therefore, low average vehicle speeds on small islands also lend themselves to the use of BEVs and the efficiency and range of these vehicles may even be greater than their published WLTP certification test results, since higher speed driving conditions are less common than represented in the certification test (UK Vehicle Certification Agency, 2021).

Concerted Efforts to Phase out Fossil Fuels

By their very nature, SISs must import any goods that cannot be extracted or produced domestically. Most SISs have no natural fossil fuel energy resources, yet historically they have relied on imported fossil fuels for their energy needs: smaller islands have relied on diesel generators for power generation (IRENA, 2018); larger islands have used a combination of coal, fuel oil, and natural gas. Some legacy coal power stations are still in operation. There are some notable exceptions, such as Trinidad and Tobago, which started transitioning to local natural gas power generation in 1976 and has been entirely reliant on natural gas since 1999 (Espinasa & Humpert, 2016).

Reliance on imported fossil fuels for transportation and electricity generation has several drawbacks for SISs:

High Cost of Importing Fossil Fuels, which Translates into Elevated Prices of Electricity and Transportation

SISs, being small markets, are often unable to command competitive pricing for fossil fuels and are subject to prevailing market rates. High energy prices increase industrial and commercial operating costs, increasing the cost of living and potentially elevating wages to compensate. Locally manufactured products can be more expensive than imported equivalents, and exports from the manufacturing sector will struggle with cost competitiveness in international markets (Briguglio, 1995).

Volatile Energy Costs Due to Fluctuations in Market Price of Key Fuels such as Oil

Not only do SISs have to deal with high energy costs, they also tend to be less able to finance hedging of fuel for stable internal pricing.

Air Pollution from Combustion

Many SISs lack the institutional robustness to regulate emissions from the power generation and transportation sectors. Particularly in SIDS, poor fuel quality, maintenance standards and vehicle roadworthiness testing can lead to some vehicles becoming highly polluting. Air quality is degraded in urban centres and in the proximity to roadways, a phenomenon that is exacerbated in islands that suffer from severe traffic congestion such as Barbados, Mauritius and Trinidad and Tobago.

Transportation Contributes to Greenhouse Gas Emissions

Transport tends to be the second highest contributor to CO_2e emissions in SISs, after electricity production. Table 2.2 shows the oil consumption and CO_2e from transportation, for example, SISs. Reducing transport CO_2 can have a significant impact on the national carbon emissions.

Table 2.2 Contribution of Transportation to Oil Consumption and CO_2e Emissions in Small Island Examples

COUNTRY	OIL CONSUMPTION FROM TRANSPORT (KTOE)	CO_2E FROM TRANSPORT (MILLION T)	TRANSPORT (KG CO_2E/ CAPITA)
Curaçao	355	1.09	6.90
Cyprus	665	2.04	2.33
Dominican Republic	2441	7.50	0.70
Haiti	487	1.50	0.13
Iceland	337	1.04	2.90
Jamaica	778	2.39	0.81
Malta	222	0.68	1.36
Mauritius	379	1.16	0.92
Singapore	2279	7.00	1.23
Taiwan	11964	36.7	1.56
Trinidad & Tobago	839	2.5	1.85

Note. Oil Consumption from Transportation Data Source IEA, https://www.iea.org/countries *(Accessed 18 Sept 2021). Compiled by authors*

Table 2.3 Examples of Small Island Electricity Production by Source

COUNTRY	COAL	OIL	NATURAL GAS	NUCLEAR	BIOFUELS	HYDRO	GEOTHERMAL	WIND	SOLAR PV	WASTE	RENEWABLES (%)
Curaçao		71 %						27 %	2 %		29.2 %
Cyprus		90 %			1 %			5 %	4 %		10.0 %
Dominican Republic	12 %	50 %	24 %		1 %	9 %		3 %	1 %		13.8 %
Haiti		81 %				19 %					18.9 %
Iceland						69 %	31 %				100.0 %
Jamaica		78 %	11 %			4 %		7 %			11.5 %
Malta		1 %	88 %						10 %		10.2 %
Mauritius	40 %	39 %			15 %	4 %			2 %		20.7 %
Singapore	1 %		95 %						1 %	2 %	5.1 %
Taiwan	46 %	2 %	33 %	12 %		3 %		1 %	2 %	1 %	8.1 %
Trinidad & Tobago			100 %								0.1 %

Note. Data for 2018–2019, Derived from IAE https://www.iea.org/countries *(Accessed 18 Sept 2021). Compiled by authors*

Sustainability Goals SDG7 (Affordable and Clean Energy) and SDG13 (Climate Action) are very relevant for SISs, and most are seeking to transition to an increased proportion of renewable electricity production; some such as Barbados, aggressively so (Government of Barbados, 2019). The current electricity generation mix for examples of SISs is shown in Table 2.3.

Efforts to replace fossil fuels with renewable energy synchronises with accelerating the adoption of BEVs. Combined with renewable electricity production, transitioning to BEVs multiplies any reduction in fossil fuel use. Table 2.4 illustrates this fact for four countries that rely heavily on oil for power generation. Substituting 10 % of the existing vehicle fleet with BEVs, assuming that the additional electrical energy demand came from oil electricity generation, yields a saving of 5 % on net oil demand. However, when 10 % of existing oil electricity generation capacity is substituted with renewable sources, a saving of 21 %-29 % is shown (Table 2.4). An exception is Curaçao, which has a surprisingly high oil consumption from transport: based on a national vehicle fleet of 80,000 vehicles, and assuming an average fuel consumption of 10 litres/100km, annual mileage per vehicle is more than 46,000 km, which is very unlikely for such a small island. As a result, the estimated incremental electrical power demand by adopting BEVs is higher than expected, exceeding what is produced by adding 10 % renewables in place of oil generation. It is possible that there is some confusion in the data reporting and that the oil consumption from transportation includes exported refined petroleum products.

Table 2.4 Savings from Combined Action of Introducing 10 % EVs and Increasing Renewable Power Generation 10 %

COUNTRY	OIL CONSUMPTION SAVED FROM TRANSPORT (KTOE)	TRANSPORT OIL SAVED (KTOE)	GENERATION OIL SAVED (KTOE)	TOTAL OIL SAVED (KTOE)	% OIL SAVED
Curaçao	355	36	8	43	12 %
Cyprus	665	67	113	180	27 %
Dominican Republic	2441	244	438	683	28 %
Jamaica	778	78	86	164	21 %
Mauritius	379	38	70	108	29 %

Note. Assuming: average combustion engine vehicle fuel consumption of 10 litres/100 km; average energy consumption of a BEV of 16 kWh/100 km; that renewable generation displaces 10 % of oil electricity generation; and a generation efficiency of 0.297 GWh/ktoe. Compiled by authors

For SISs that are making a strategic switch to renewable electricity generation, a complementary BEV adoption policy to accelerate uptake will have the effect of multiplying the potential savings in oil imports.

Vulnerability to Climate Change Effects Creating an Impetus to Exemplify Carbon Emissions Reduction Efforts

The contribution of SISs to global carbon emissions and climate change is negligible, but these nations number among its most severe victims. Sea level rise causes coastal erosion and increased instances of flooding threatening especially low-lying SISs such as The Maldives, Tuvalu and Kiribati. Hurricanes or cyclones to which SISs are periodically subjected are becoming more frequent and intense, an example being the destruction of the island of Barbuda by Hurricane Irma in 2017. Changing rainfall patterns are leading to regular drought and flooding, both of which undermine agricultural security.

Advocacy by political leaders of SISs for decisive global action on climate change can be effectively substantiated by demonstrating their own commitment to reduce carbon emissions (Roper, 2005; UNEP, 2021). The adoption of BEVs can form an important element of a carbon reduction strategy.

Table 2.5 Assumed Specific CO_2e Emissions for Power Generation with Various Energy Sources

ENERGY SOURCE	LIFECYCLE CO_2e (G/KWH)	FUEL ONLY CO_2e (G/KWH)
Coal	900	850
Oil	750	720
Natural gas	433	430
Nuclear	7	0
Biofuels	180	0
Hydro	10	0
Geothermal	35	0
Wind	10	0
Solar PV	75	0
Waste	100	0

Note. Compiled by authors

Table 2.6 Vehicle and Charging Energy Efficiency Assumptions

PARAMETER	ASSUMPTION	JUSTIFICATION
Grid Transmission Loss	12 %	
BEV Charging Loss	12 %	
BEV Operating Efficiency	160 Wh/km	WLTP Values
Real-world economy measurements	7	0
Gasoline Vehicle Fuel Consumption	10 litres/100km	Real-world economy measurements

Note. Compiled by authors

Based on the specific current energy mix for each island (Table 2.3), the specific CO_2e emissions from electricity generation with different energy sources (Table 2.5), and certain generalised assumptions (Table 2.6), the CO_2e savings from the introduction of BEVs are calculated in Table 2.7. The savings are higher in nations with a lower carbon electricity mix. At the extreme, the carbon savings in Iceland will be 100 % since all electricity is renewable. CO_2e savings in SISs with a heavy dependence on natural gas (Malta, Singapore and Trinidad and Tobago) is between 61 % and 65 %. The lowest savings will be yielded to Cyprus (oil dependent electricity) and Mauritius (coal and oil), but a CO_2e reduction of more than 40 % is still achieved.

Table 2.7 BEV Estimated g CO_2e/km Compared with an Equivalent Gasoline Vehicle for Example SISs

COUNTRY	AT PLUG g CO_2e/kWh	BEV IN BATTERY g CO_2e/kWh	BEV g CO_2e/kWh	GASOLINE g CO_2e/km	SAVING g CO_2e/km
Curaçao	510	658	105	229	54 %
Cyprus	648	837	134	229	42 %
Dominican Republic	566	730	117	229	49 %
Haiti	584	754	121	229	47 %
Iceland	0	0	0	229	100 %
Jamaica	606	782	125	229	45 %
Malta	390	504	81	229	65 %
Mauritius	623	805	129	229	44 %
Singapore	423	546	87	229	62 %
Taiwan	550	710	114	229	50 %
Trinidad & Tobago	431	556	89	229	61 %

Note. Compiled by authors

Therefore, implementing an accelerated BEV adoption strategy is fully aligned with, and supportive of, the efforts of SISs to exemplify carbon reduction actions.

Underdeveloped Public Transportation Systems

SIDS tend to suffer with weak public transportation infrastructure and organisation. In more developed SISs, such as Taiwan and Singapore, public transportation is very effective. Cause and effect are in operation here – a poorly organised or resourced public transport network increases the attractiveness of personal vehicle ownership and use. For instance, Cyprus, by the early 2010s, had seen a 93 % reduction in bus rides and a corresponding 300 % increase in private vehicle ownership over 30 years, leading to predictable traffic gridlocks (Papageorgiou, Maimaris, & Petros, 2015).

Electric buses provide an opportunity for SISs to upgrade their public transport infrastructure and marketing. Quiet, smooth, and comfortable, the passenger experience of an electric bus tends to be more pleasant than a diesel or CNG equivalent. Reducing tailpipe emissions and ambient noise in urban and suburban environments can help to improve quality of life, and the percentage of CO_2e reduction achieved by replacing a diesel or even CNG bus with a BEV equivalent is similar to what can be achieved by light BEVs. Modern BEV buses can be equipped with tracking software to allow centralised control of the fleet. Combining the introduction of BEV buses with a Rapid Bus Transit system can maximise the benefits of electrification and make public transport more attractive (Papageorgiou et al., 2015).

Commercial vehicles such as buses have much more demanding duty cycles than private vehicles, so get less benefit from the short point-to-point trips on SISs. Providing sufficient range for normal, unrestricted shift operations is a critical success factor for successful deployment of BEV buses. This might require capital investment in innovative charging solutions, such as overhead gantry charging or battery swapping, as has been demonstrated in China and the UK (Miles & Potter, 2014; Song et al., 2020). The large battery packs required by BEV buses make them a very expensive proposition but a lower total cost of operation over the lifecycle of the bus can help to mitigate the upfront cost (Burnham et al., 2021), as can creative financing plans and public-private partnerships for transportation solutions.

Discussion: Policies to Accelerate the Adoption of e-Mobility

In the previous section, it has been established that BEVs are particularly well suited to SISs, but their deployment is not without some challenges. They are beneficial economically, allowing for a reduction in fossil fuel imports; they improve energy security, especially when coupled with an increasing share of renewable energy for electricity generation; and they lead to a reduction in carbon emissions, especially when coupled to renewables. In this section, we provide perspectives on ways in which SISs could take decisive policy actions to overcome significant barriers to the rapid adoption of BEVs, increase their market penetration, and maximise the long-term benefits of electrification potential in their nations.

Availability of BEVs from Distributors

Vehicle models made available by manufacturers to small markets, such as SISs, have historically been limited. For SISs that use right-hand drive vehicles, model availability might be further limited. Distributors are mindful of their responsibility to provide technical and parts stock support for any models that they sell and can be reticent to import vehicles that they do not believe will sell in sufficient numbers to make support economically viable. Sending a strong, clear message about its intention to transition to BEVs will encourage manufacturers to supply BEVs to a SIS.

By proclaiming an approved policy to promote the sale and support of BEVs, a SIS will signal that it is committed to a transition to electrified transportation and give manufacturers and dealers the confidence to supply BEVs to the market and invest in supporting training and infrastructure. To strengthen this policy action, a clear date after which the import and sale of combustion engine vehicles will be prohibited can be declared. Barbados has led the way by declaring that by 2030, 100 % of its vehicles will be BEVs or run on alternative fuels (Lo, 2021). Barbados is also catalysing demand by immediately starting the process of electrifying the government fleet (Atwell, 2021). Simply making such declarations of intent can cause manufacturers to adjust their vehicle allocations and make more BEVs available to an SIS.

Scepticism Towards BEVs Among Vehicle Purchasers

Most customers have only had previous experience in purchasing an ICE new or used vehicle. Transitioning to a BEV is a step into the unknown. Reticence to take a ‘risk’ with a BEV is understandable since a vehicle is the second largest investment that householders make after property. For commercial purchasers, the practical business case for BEVs is usually untested. Apart from the high cost, primary concerns are about range and the ease and reliability of recharging (Rezvani, Jansson, & Bodin, 2015). Action is required to educate the public on the operation and benefits of BEVs.

Policy responses that can address scepticism towards BEVs can start with something as simple as a public information campaign to educate the public about BEVs. The media and local experts can be engaged in this activity. Commercial purchasers can be supported in their business planning for BEV purchases, in particular calculations of specific total cost of ownership for their use case. BEVs can be taught in the school curriculum along with science and geography topics such as climate change and renewable energy to sensitise young people to the importance of transport electrification.

Affordability of BEVs

It is still early in the adoption 'S-curve' of BEVs globally, with annual sales currently growing exponentially. Although the technology will gradually become affordable relative to ICE vehicles, BEVs currently have a substantial purchase price premium–about 30 %-40 % for buses and in the region of 20 %-50 % for light vehicles. However, total cost of ownership of a BEV in developed markets is expected to be lower than combustion engine vehicles by 2022 (Murray, 2019; Nunno, 2018). In some SISs, total cost of ownership for a small passenger BEV is lower than that for an equivalent ICE vehicle (Maharaj & King, 2020). An additional cost for a BEV is the home or base station-charging infrastructure. For commercial customers, this might be a significant outlay. In many countries, a cash rebate for the purchase of a BEV has been a favoured approach, but this is expensive and not found to be significantly more effective than other measures (Lieven, 2015).

Suggested policy responses to address the affordability of BEVs are generally fiscal and start with mitigating the taxation on the vehicles. SIS governments should ensure that the total amount of taxation applied to BEVs does not exceed the cash amount applied to an equivalent combustion engine vehicle and possibly provide short-term tax and duty relief on non-luxury BEVs to encourage accelerated adoption. Since the purchase price of BEVs is higher than equivalent ICE vehicles, fixed duty and VAT rates can multiply the tax paid, making these vehicles even more expensive in SIS markets. Purchase can be supported using financing schemes, underwritten by governments, for electric commercial vehicles, HDVs, and buses to make purchase more affordable. Tax incentives could be used to encourage financial institutions to offer favourable schemes for the purchase of BEVs; tax and duty relief can be offered on equipment for a charging infrastructure.

Technical Skills to Support BEV Service, Repair, and Emergency Response

Specific skills are required to maintain and repair BEVs. High voltage, high power systems pose safety challenges that are important for automotive technicians and emergency responders alike. Many vehicle manufacturers will not allow BEVs to be sold in a market unless technicians have received specific certification in EV technologies. It is important to encourage the acquisition of these skills in SISs to accelerate BEV adoption.

Therefore, government policy should ensure that technical standards for installation of EV chargers have been established. They should provide encouragement to automotive technical training colleges to start offering EV training courses, provide funding for this training, and set targets for the numbers of automotive technicians certified in the technology. Governments can also broker train-the-trainer arrangements to ensure that local skills training institutes are able to provide the training and certification.

Charging Infrastructure and Electrical Grid Robustness

While charging infrastructure is not the limiting factor for accelerated adoption of BEVs in SISs as it is in most other markets, a basic level of public charging infrastructure must be made available and home base charging supported by the electrical grid. Two elements of grid capacity must be considered: generation and distribution. Generation capacity must be expanded to account for additional demand from BEV charging. Distribution is important particularly at the neighbourhood level, where transformer capacity might be a limiting factor if several neighbours all purchase BEVs and charge at the same time (Meetoo, Bahadoorsingh, & Sharma, 2019).

Government policy support for the establishment of charging infrastructure can include enlisting electrical utility companies in planning for e-mobility. For the utilities, it should be a business development opportunity. Beyond planning, utilities should be actively involved in facilitating and promoting public and private charging (Viscidi, Graham, Madrigal, Masson, & Prado, 2020). Detailed studies should be commissioned to determine the optimum locations for high-speed pubic charging. Incentivises should be offered for the installation of off-grid solar charging parking garages at workplaces and shopping centres.

Loss of Tax Revenues from Fossil Fuel Sales

In some SISs, taxation from the sale of fossil fuels makes a significant contribution to the national purse. As these sales decline, that revenue stream will be lost, potentially causing some hesitancy from governments in accelerating the e-mobility transition.

Governments should respond by including the expected loss of revenue into their medium- and long-term budget planning. The formation of an e-mobility transition fund, financed by additional taxation on the purchase of ICE vehicles, can be considered. Alongside purchase taxes or duties, increasing taxation of fossil fuels, strategically and gradually during the transition period to mitigate the rate of revenue loss, can form part of the answer.

Stock of Legacy Combustion Engine Vehicles in the National Vehicle Stock

Even if BEV sales start to increase and ICE vehicle sales are entirely banned by, say, 2030, the legacy stock of ICE vehicles will remain. Equity of access to transport is an important consideration, as BEVs are currently expensive, reducing affordability.

Mitigating policy actions aimed at reducing the stock of legacy ICE vehicles can include investment in the public transportation system, focusing on increasing its attractiveness and accessibility, and finding solutions for the 'last mile' of journeys. Opportunities exist to promote conversion of legacy cars and buses to electric powertrains. This is a growing sector globally. Many countries around the world, at various times, have instituted a scrappage policy – for instance, that all vehicles more than 15 years old must be scrapped, exported, or converted to zero carbon energy – this could also be part of the solution. However, underpinning these actions is the setting of a date for the complete prohibition on the sale of fossil fuels in the public market. This will allow the free market to catalyse BEV sales.

Conclusion

At the start of this chapter, we hypothesised that SISs are generally well suited to the adoption of e-mobility and that it can help to make transport more sustainable and accessible. We have shown that the global trends in electrification of different classes of vehicles, supported by government policies and manufacturers' plans, present a tremendous opportunity for SISs to seize the benefits of the electrification of transport by accelerating the deployment of e-mobility.

There are several characteristics of SISs that would encourage accelerated deployment of BEVs: low point-to-point trip lengths; low average vehicle speeds; a concerted effort to eliminate the use of fossil fuels; their vulnerability to climate change that creates an impetus to exemplify an emphatic approach to reducing of carbon emissions; and underdeveloped public transportation systems that could be modernised using e-mobility.

Despite the opportunities that BEVs present to SISs, there are significant challenges in their deployment. These include the availability of BEVs, especially new cars; scepticism on the part of vehicle purchasers due to lack of knowledge and experience of BEVs; affordability; skilled technicians for maintenance and repair; a public charging infrastructure is needed; taxes may be lost from fossil fuel sales; and even if BEV sales grow, the stock of ICE vehicles will take years to deplete. Concerted policy actions from SIS governments are necessary if the challenges are to be overcome and the opportunities are to be realised.

A proactive approach to encouraging the rapid adoption of BEVs, in tandem with a transition to renewable electrical energy, can be achieved using a range of policy instruments. These should include tax relief on BEVs and equipment to support them, which could be paid for by incremental taxation on fossil fuels. Taxation incentives need only be transitional until mass-market dynamics predominate (IEA, 2020).

Encouraging an aggressive transition to e-mobility requires clear, strong, and consistent messaging from the governments of SISs. In the opinion of these authors, the most effective policy action to accelerate adoption of BEVs is to declare an early phase-out date for the sale of ICE vehicles, as is being done in a growing list of countries. Barbados stands out as a SIS having taken a particularly bold position, which can provide a benchmark for others.

Actions should be focused on the establishment of an organised, integrated e-mobility based transportation system using BEVs. A particular focus should be on buses for public transport, so that benefits can be maximised and to create an accessible transportation system that avoids the proliferation of private cars as the *de facto* preferred transport solution. Challenges in adoption of BEVs on a large scale are real but can be overcome by strategic and financed policy actions. Not all the policy responses suggested here will be politically feasible in every SIS, but they give some structure for policy planners.

Further investigation is warranted into the potential of electric micro-transport solutions, including two- and three-wheeled vehicles for SISs. These emergent vehicles could become increasingly important, especially in urban environments, offer greater energy savings than electrified cars and buses, and can be accessible a wider socio-economic spread.

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3 Goodness-of-Fit Probabilistic Models for EV Charging in Caribbean Small Island States

L. M. Addison, G. A. Hosein, S. Bahadoorsingh and C. Sharma

Globally, the impact of fossil fuel consumption on climate change has been an important topic of discussion in recent times. According to the IPCC (2019), the transportation sector accounted for 14 % of the global greenhouse emissions in 2014. In addition, the Energy Information Administration (EIA) (2019) reported that 28 % of the United States energy consumption was used for transportation, with 92 % of that being supplied by petroleum, while nearly 81 % of the energy supply of Caribbean states comes from oil products (FOCUS, 2016). Some estimates suggest Small Island Developing States (SIDS) globally would save around $3.3 billion annually if they switched all energy to renewable sources, especially in the Pacific and Indian Oceans (Atteridge & Savvidou, 2019). As a result, the use of electric vehicles (EVs) in communities is seen as a viable alternative in many regions worldwide, including the Caribbean.

Small islands are a prime market for EVs with limited road networks, high fuel costs and the need for direct grid storage solutions (Gay, Rogers, & Shirley, 2018). Many SISs also have favourable renewable energy resources, and renewable energy transition roadmaps are emerging. For instance, with minimal modifications to its infrastructure, the Caribbean island of Barbados can accommodate at least 20 % renewable energy penetration onto its grid (Gay et al., 2018). Since 2018, Barbados has been a regional leader in EV deployment in the Caribbean, where 1.28 % of their new car sales were electric, greater than in some higher-income countries, such as Canada (Prado, 2019).

Consequently, this reflects the need to adequately prepare electrical grids in SISs, based on driving patterns related to EVs. There are different types of EVs, classified by the amount of electricity used as the energy source. Battery Electric Vehicles (BEVs or most commonly EVs) and Plug-in Hybrid Electric Vehicles (PHEVs) are two main classifications of Plug-in Electric Vehicles (PEVs). In general, PEVs have been identified as the main future alternative to conventional automobiles powered by Internal Combustion Engines

(Almutairi, Alotaibi, & Salama, 2018). This is due to the fact that they are environmentally friendly and economically efficient, since they emit significantly fewer greenhouse gases (GHGs) per kilometre driven, as well as being less costly to operate (Almutairi et al., 2018).

Despite these advantages, the electrical power system would be directly impacted by the integration of such vehicles on the grid (Darabi & Ferdowsi, 2011). Power and energy consumed by these vehicles can be variable, and frequency of connection onto the grid depends on certain characteristics associated with driving behaviour and journey requirements. In order to analyse the impact of the EVs on the power system, models of charging curves are integral to the process. It is important to consider the aggregate effects of charging EVs on the electric power system infrastructure (Louie, 2015). As such, integration of EVs within the smart grid framework requires careful analysis.

SISs endeavouring to reduce their carbon footprints would need to extensively analyse the effects of EV charging as these grids are inherently small, and small disturbances can wreak havoc on the electricity supply quality. In the first instance, since there are no available data, the use of probabilistic models of charging station loads can assist greatly in this process and predict the expected impacts on the network's asset utilisation, health of the grid and overall success of the introduction of EVs.

As such, charging management is crucial since an increase in the number of EVs increases the additional loads. This can lead to a change in SISs daily load profiles and, subsequently, an increase in the demand peak. Any change in the daily load profile can subsequently affect a utility's ability to manage generation, supply and distribution, with respect to time and grid constraints, while increasing peak demand can put a strain on existing generating capacity (Dyke, Schofield, & Barnes, 2010). The uncoordinated charging of many EVs can compromise the grid in a number of ways. Hence, there is a need to assess the strategies to coordinate EV charging using available variables.

Management of EV penetration is necessary, since uncoordinated charging can produce an unbalanced distribution network of loads, possible overloads of distribution transformers, and cables/conductors, and sudden variations in the power quality of supply. Uncoordinated charging refers to the scenario where there is no control over when EVs are charged. This scenario significantly increases the peak demand and will require upgrades to the distribution grid, especially the upgrading of the distribution transformers. It can also lead to an increase in load imbalances, possible outages, as well as current and voltage variations. The research by Calearo, Thingvad, Suzuki, and Marinelli (2019) highlights how uncontrolled distribution of single-phase charging could be responsible for local voltage disturbances. These negative effects will increase if there are no Demand Side Management (DSM) schemes (Bahadoorsingh, Meetoo, Sharma, & Hosein, 2018) to reduce or shift energy consumption from peak hours to leaner demand periods.

On the other hand, a properly designed and well coordinated Time of Use (ToU) charging scheme can provide better flexibility and reliability to the entire electrical system (Flammini et al., 2019). According to Green, Wang, and Alam (2010), factors such as driving patterns, charging characteristics (vehicle demand profiles), charging timing (the magnitude and duration of charging cycle) and vehicle penetration impact the electric network. To demonstrate the capabilities of a coordination scheme, actual data and driver behaviours need to be available to perform simulations.

However, the scarcity of available real data regarding EVs and charging stations has forced researchers to first develop probability distributions for a number of variables (Flammini et al., 2019). Further to this, Almutairi et al. (2018) expressed the need to conduct a statistical evaluation among a wide range of available theoretical probability density functions (PDFs), in order to find the best model, to reflect the random characteristics of each driver behaviour variable. It should be noted that the driving behaviour of a typical SIS citizen is not necessarily the same as a driver resident in a metropolitan area. A metropolitan area has a significantly more complex and expansive transportation network. In a metropolitan area, driving patterns on the weekdays may include journeys from residences to transportation hubs before using mass transportation to commute into cities.

In some cases, residents may choose to commute daily with their own vehicles from their suburban residence to city workplace. In the metropolitan area, weekend journeys may be longer for leisure trips or shorter on domestic errands. In SISs, such as those in the Caribbean, citizens may have limited transportation options and so may have to rely on their own transportation for the convenience of all journeys. The total distance travelled by commuters in their vehicles in these different environments can vary from location to location and the peculiarities of the local transportation landscape.

With these nuances in mind, in an effort to derive variables for a probabilistic model, one must then consider the available data. Driving range of a typical domestic user can be treated as an estimation since the only data available are the sales of fuel. Fuel sales only may translate into an estimate of total distance travelled and it is very challenging to obtain driving route (freeways vs collector roads) and times (weekdays vs weekends, day vs night) as well as modes (eco-mode vs sport-mode) which are indicators of the energy consumed for individual users. In order to disaggregate this into the range of a typical driver, this can only be done in the first instance by using statistical inferences to determine when recharging should be required. Also, with the “novelty” of EVs in the market, it is postulated that most users would, in the first instance, plug on to recharge their EV once the user arrives home. As such, Louie (2015) and Flammini et al. (2019) use real transaction data, with probabilistic and statistical ideas, in order to assess the impact on the grids.

According to Ul-Haq, Azhar, Mahmoud, Perwaiz, and Al-Ammar (2017), addition of EVs would affect the overall load pattern of distribution networks, leading to power quality concerns such as voltage imbalances, depending on EV charging patterns over a day. The research in Ul-Haq et al. (2017) also discusses the complications in attempting to provide a deterministic quantification of the number of EV charging events per day and the associated load on the grid. The complete mobility pattern of the EV driver is an important factor, which is not always known. Hence, Yilmaz and Krein (2012) expressed that there is a need to develop a probabilistic model of EV charging to estimate an expected load in the system, leading to a power index, through which utilities can upgrade their infrastructure to support large penetration of EVs.

However, estimates of variables related to driver behaviour, such as arrival, departure times, daily mileage and so on, to characterise the PEV charging process are a challenge. Currently, there is a lack of sufficient actual data for this purpose, particularly in SISs. Therefore, the idea supported in larger countries is to use samples from transportation mobility data to estimate a PDF. The research by Almutairi et al. (2018) explains that the purpose is to not only preserve the characteristics of each variable, but to generate simulated data for further comparison. Hence, the use of PDFs is a useful way to reflect driver behaviour.

Additionally, Ul-Haq et al. (2017) develops a probabilistic model of the charging pattern for EVs associated with residential load profiles. The probabilistic model provides the activity for the residential load profiles and EV charging patterns over a period of twenty-four (24) hours. Other studies, such as Wang and Karki (2016) and Wang et al. (2015) use a theoretical PDF to provide a fit for the sample data. This gives a snapshot of the intrinsic randomness of driver behaviour variables, which is then used to generate synthetic data from the fitted PDFs. Thus, Normal and Lognormal PDFs are assumed for the variables arrival time and daily travel mileage respectively (Wang & Karki, 2016). Alternatively, Chi-square and Power law PDF are assumed for the aforementioned variables in other research (Wang, et al., 2015).

While many papers have fit PDFs for individual driver behaviour variables as previously indicated, most have not considered weekday load profiles. In order to assess the true impact of EV charging load on the local power grid, building these EV load profiles is crucial. Since the typical SIS distribution system is fed via pole-mounted transformers, the typical SIS utility maintenance procedure is to only upgrade the pole-mounted transformer after customers have complained of regular low voltage problems or if the transformer has failed. This has led to the norm being that most pole-mounted transformers are usually operating close to their nominal kVA ratings. So any step increase in loading (EV charging) would most likely drive the distribution transformer beyond its rating.

Therefore, different EV load profiles based on driver's behaviour and flexible EV charging needs can be used to analyse the effects of charging EVs on both the power grid's loading limits and voltage fluctuations. In addition, empirical load profiles for EVs using electric mobility data can provide a genuine depiction of EV loading for future planning mechanisms. This work attempts to assess which theoretical PDFs provide the best fit for weekday load curves based on aggregate residential and EV charging profiles. It provides a template for constructing and describing PDFs based on driver variables, which can be adopted in SISs. Following this overview of the current research, a brief methodology for such a scheme is also outlined.

Then, suitable Goodness-of-Fit (GoF) statistics and PDFs based on each of the load curves by day of the week are discussed. GoF implies a comparison of the observed data with the data expected under the model, using some fit statistic, or discrepancy measure, such as residuals, Chi-square or deviance (Kéry & Royle, 2016). GoF testing is a crucial element of this analysis since it assesses if the model "fits" the data in a statistical sense. These tests are used to select the best fit PDF from a list of candidate probability distributions, in order to describe the EV weekly charging data scenarios. Subsequently, the importance of such analysis for charging behaviour is discussed, followed by preliminary conclusions and recommendations. Overall, this research serves as a benchmark for future models, which can use these PDFs to assist with the implementation of EV charging control strategies for SISs, particularly in the Caribbean.

Method

The lack of actual databases of EV charging data in many regions, particularly in SISs, has been the motivation to start the first phase of a larger predictive model, for constructing various driving behaviour variable distributions from relevant travel data. This work is a PDF fitting case study using in-home plug-in EV recharging profiles for 348 vehicles. These are associated with 200 households randomly selected among those available in the 2009 Residential Consumption Survey (RECS, 2019) data for the Midwest region of the United States.

This probability sample survey enables statistical selection of households to collect energy-related data. The publicly available dataset accounts for user activity and appliance usage statistics from more than 12,000 households across the United States. These were statistically chosen to represent over 110 million household units, which included energy consumption details from each residence. Due to the lack of charging data for many SISs in the Caribbean, this methodology provides an experimental framework to generalise the weekly load scenarios, using previously existing data in the United States. This lays the groundwork for further studies in SISs to be conducted using their unique travel mobility data.

Power profiles which depict energy consumption patterns can fluctuate, and due to this randomness, the prediction of energy demand can be difficult. For these reasons, according to the work of Muratori, Moran, Serra, and Rizzoni (2013) and Muratori (2017), residential demand profiles are variable since individual household behaviour is stochastic in nature. Each PEV starts charging as soon as it is connected to the grid and remains a sink until the battery is fully charged. Therefore, there is no coordination scheme applied to the dataset. Simulation of the amount of electricity required to fully charge the battery depends on the previous trips and charging events, which are simulated using a personal energy consumption model (Muratori et al., 2013).

The profiles proposed realistic patterns of residential power consumption. These were validated using metered data, with a resolution of 10 minutes. This research also simulated various scenarios considering different PEV market shares (Muratori, 2017). In this dataset, vehicles were assumed to be 60 % BEVs with a 200-mile range and 40 % plug-in hybrid EVs PHEVs with a 40-mile all-electric range based on market trends. Both Level 1 charging (1.92 kW) and Level 2 charging (6.60 kW) were assumed in the aforementioned dataset, and the profiles represented total PEV charging demand.

In this chapter, the Level I charging dataset (PEV-L1) was used, since it is expected that most households would charge at this level. This data represented an uncoordinated charging scheme, where no control strategy was applied to deal with daily demand. The electricity demand profiles for the 200 households (without EV charging) were mapped to the total EV demand within the corresponding households (since some residences have more than one EV). Then, the aggregate household load was computed using the sum of the base load and the total EV load per household. The equation for this computation is expressed as:

$$PW_{Total\,Load,i} = PW_{Resid,i} + PW_{PEV,i} \tag{1}$$

where $PW_{Total\,Load,i}$ represents the total power demand for residential load, i, and $PW_{Resid,i}$ represents the power demand associated with the residential load, i and $PW_{PEV,i}$ is the corresponding total PEV-L1 load, for that household $(i = 1,2, \ldots, 200)$. The models applied here ignore seasonal variations, considering only weekday and weekend profiles.

These load profiles were used to construct weekday demand curves by time of day. Then, daily load curves were fitted using polynomial curves for each day of the week. In each case, a non-linear equation was obtained.

The form of this equation is:

$$f(x)_{fitted} = a_n x^n + \dots + a_2 x^2 + a_1 x + a_0 \quad (2)$$

where a_k represents the fitted model co-efficient of x_k, the variable ‘time of day (hrs.)’, for $k = 0,1, \dots , n$. In this work, a 5th order polynom‘al is used $(k = 5)$ ’or the best fit.

For each day of the week, GoF statistics‘were generated to ’escribe the overall fit of the model to the original data based on differences between observed and predicted values. The coefficient of determination, R^2, provides a measure of how well the fit explains the variation in the data. Root Mean Squared Error (RMSE) provides a relative measure of the fit, that is, how concentrated the data is around the line or curve of best fit. Let y_i be the true response for the i^{th} observation and $\hat{y}_i$ be the corresponding predicted response. The RMSE is defined as:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} \quad (3)$$

Lower values of the RMSE closer to 0 indicate a better fit.

Then, aggregate load curves categorised by weekday and weekend were examined in a probabilistic sense. Polynomial curve fitting was used to generate an estimated PDF for each load curve. XLSTAT 2019, the add-in package for Microsoft Excel, which uses maximum likelihood estimation (MLE) to derive the parameters of the probability distribution, provides the best-fitting theoretical PDF for each scenario. It should be noted that these distributions were chosen from a preset database of PDFs, but there may be others which can provide a better fit.

It is necessary to conduct a GoF test to check whether the observed data follows the specified distribution. The Kolmogorov-Smirnov (K-S) test is a nonparametric test which compares the empirical (actual) cumulative distribution function (CDF), say $G(x)$ to the theoretical CDF, say $F(x)$. The K-S Statistic (D) computes the largest difference between the two functions for all sample values x_i, $i = 1,2, \dots n$, using the equation:

$$D = max[G(x) - F(x)] \quad (4)$$

This statistic was used to determine if the hypothesis of interest “the observed data follow a specified distribution” was true when compared to a critical value. The significance level or p-value of this test was set to 0.05 or 5 %, and the original assertion was rejected if $p < 0.05$.

Results

The R Statistical Software (R Core Team, 2019) environment for statistical computing and graphics was used to match EVs to households to obtain the total load. Descriptive statistics, GoF, and probability plots were generated to reflect the load profiles by day of the week. These provide developers with tools for aggregate comparisons and to visualise the differences between datasets, respectively. Figure 3.1 shows the residential load without EV charging, classified by time of day and day of the week. Ignoring seasonal variations, the general trends for the days of the week were similar. Subsequently, load curves were generated to include EV charging and the GoF of these curves analysed.

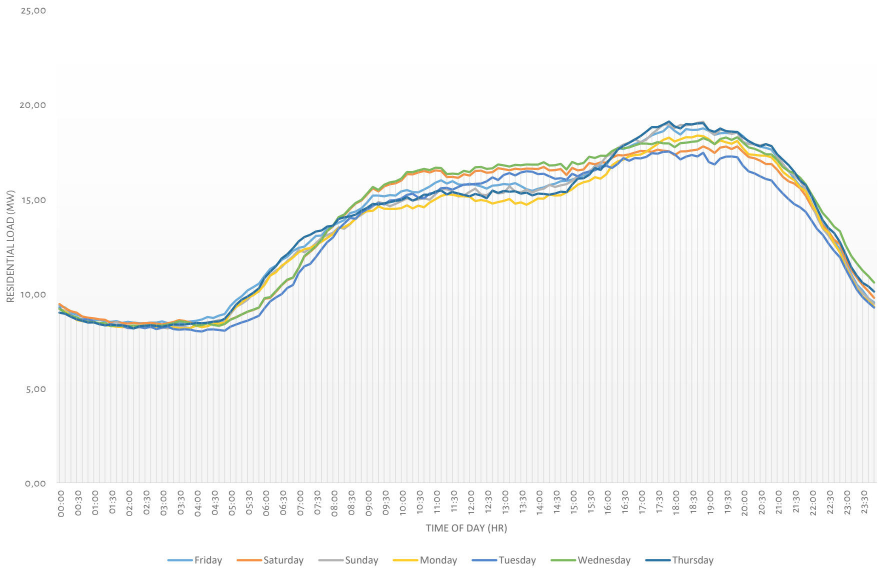

Figure 3.1 Residential Load Curves by Time of Day and Day of the Week (no EV Charging)
Note. From "Probabilistic Assessment of Electric Vehicle Charging Behaviour," by Hosein, Addison, Bahadoorsingh, and Sharma, 2020, Caribbean Electric Industry Journal, 16, 36–39. DOI:10.47412/QZWP9167, and "Goodness of Fit of Probabilistic Models for Electric Vehicle Charging Behaviour," by Addison, Hosein, and Bahadoorsingh, 2020, International Conference on Emerging Trends in Engineering and Technology, (http://conferences.sta.uwi.edu/iconetech2020/index.php)

Hourly Load Curves by Day of the Week

Load curves were generated for the original uncoordinated charging scheme by day of the week, in contrast to seasonal load variations, which are most commonly examined in the literature. In order to determine the charging behaviour on a weekly basis, total load curves based on the residential consumption and additional load from daily EV charging were constructed graphically.

These are shown in Figure 3.2 where, upon initial inspection, the peak demand occurred mainly between the hours of 4 p. m. (16:00 hrs) and 10 p. m. (22:00 hrs) daily. Descriptive statistics were generated as shown in Table 3.1. The mean, ***M*** (average) and standard deviation, ***SD*** (spread of data points about the mean) can later be used as estimates of shape and scale parameters in certain PDFs. Tuesdays experienced the highest average load (19.47 MW) while Thursdays experienced the lowest (18.35 MW). The standard deviations were similar for each day, ranging from 5.32 MW to 6.07 MW.

Each load curve was best fit to a polynomial to the 5^{th} degree. The overall fit for each curve was quite good based on the correlation coefficients, R^2 values (all close to 1) while the RMSE value was the lowest for Thursday (0.65), indicating this particular day had the best relative fit. Since the demand by day of the week was fairly similar, aggregate weekday and weekend load curves were generated and validated. The mean weekday load was 19.04 MW, slightly less than that of the weekend (19.12 MW). These load curves were examined further to find suitable theoretical PDFs to represent them.

Goodness-of-Fit to Polynomial Functions and Known PDFs

Non-linear polynomial equations were used to fit aggregate weekday and weekend load curves for this dataset. These can be used to estimate the probability of daily demand at a particular time of day. The weekend and weekday scenarios are both displayed in Figure 3.3. The PDFs of the load curves were best fit to polynomials to the 5^{th} degree. The coefficients of the two equations were close, which indicated that the demand for weekday and weekend, even with inclusion of the use of EVs on the grid, was quite similar for this particular region. The differences in demand here were reflective of their daily residential and EV charging behaviours.

Subsequently, standard PDFs were also used to determine the distributions with the best fit. EasyFit 5.6 Professional, an add-in package in Microsoft Excel, performs GoF tests and is used to evaluate the most appropriate distribution based on the smallest K-S value compared to the critical value, which is the best fit for the data. Figure 3.4 shows the best three PDFs for the weekday load curves. The histogram represents the spread of daily load over 24 hours. The PDF known as Johnson SB (System of Distributions) was found to be the best fit (K-S = 0.0162, $p > 0.05$), followed by the Generalised Gamma (K-S =0.0277, $p > 0.05$) and then the Dagum distribution (K-S = 0.0282, $p > 0.05$), as shown in Table 3.2.

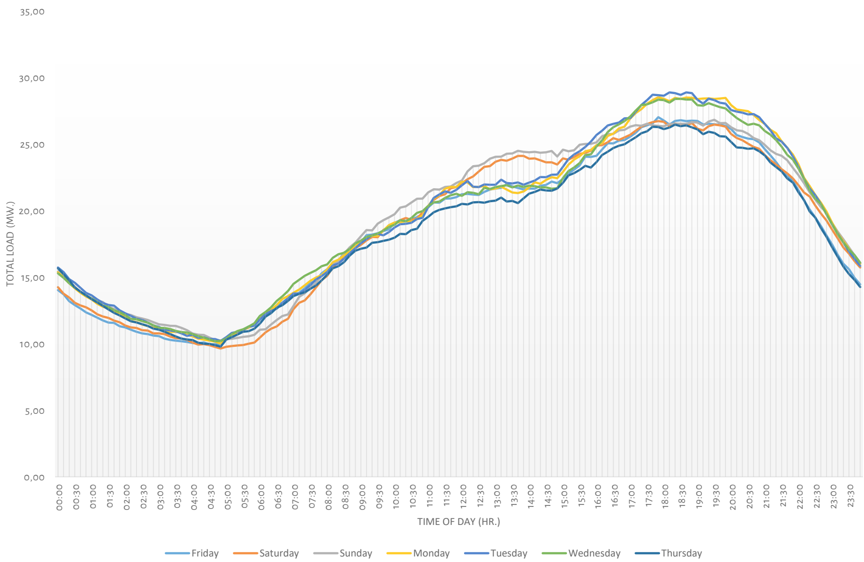

Figure 3.2 Total Load Curves by Time of Day and Day of the Week
Note. From "Probabilistic Assessment of Electric Vehicle Charging Behaviour," by Hosein et al., 2020, Caribbean Electric Industry Journal, 16, 36–39. DOI:10.47412/QZWP9167, and "Goodness of Fit of Probabilistic Models for Electric Vehicle Charging Behaviour," by Addison et al., 2020, International Conference on Emerging Trends in Engineering and Technology, (http://conferences.sta.uwi.edu/iconetech2020/index.php)

In Figure 3.4, the values of the parameters are γ=-0.441,δ=0.758 ,λ=26.639 and ξ=-2.564 for the Johnson SB distribution. The corresponding parameters for the Generalised Gamma are k=146.71,α=0.00917 and β=23.824, while those for the Dagum distribution are k=0.0068,α=198.62 and β=23.766. The shape parameters in the aforementioned distributions allow for flexibility which allows them to fit various real-life scenarios. This enables the realistic stochastic dynamics of EV charging profiles to be showcased.

Table 3.1 Descriptive and Goodness-of-Fit Statistics for Total Load Curves (MW) by Day of the Week

	MON	TUES	WED	THURS	FRI	SAT	SUN	WEEKDAY	WEEKEND
Mean	19.38	19.47	19.33	18.35	18.59	18.82	19.40	19.04	19.12
SD	6.03	6.07	5.84	5.32	5.67	5.94	5.83	5.76	5.87
Min	10.01	10.2	10.17	9.78	9.94	9.63	10.23	10.03	9.93
Max	28.50	28.86	28.37	26.44	27.00	26.70	26.80	27.75	26.62
R^2	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
RMSE	0.83	0.76	0.86	0.65	0.69	0.72	0.75	0.74	0.74
Total	0.83	0.76	0.86	0.65	0.69	0.72	0.75	0.74	0.74

Note. *From "Probabilistic Assessment of Electric Vehicle Charging Behaviour," by Hosein et al., 2020, Caribbean Electric Industry Journal, 16, 36–39. DOI:10.47412/QZWP9167, and "Goodness of Fit of Probabilistic Models for Electric Vehicle Charging Behaviour," by Addison et al., 2020, International Conference on Emerging Trends in Engineering and Technology,* (http://conferences.sta.uwi.edu/iconetech2020/index.php)

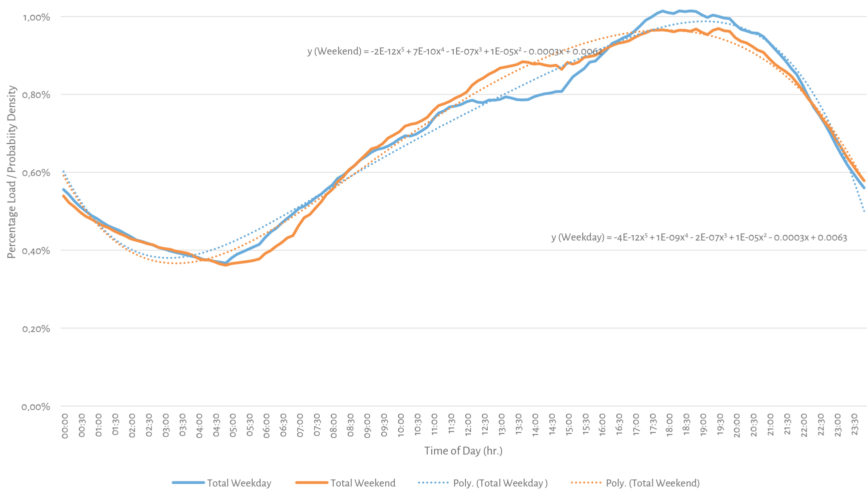

Figure 3.3 Probability Density Functions for Power Demand Curves by Weekday and Weekend

Note. From "Probabilistic Assessment of Electric Vehicle Charging Behaviour," by Hosein et al., 2020, Caribbean Electric Industry Journal, 16, 36–39. DOI:10.47412/QZWP9167, and "Goodness of Fit of Probabilistic Models for Electric Vehicle Charging Behaviour," by Addison et al., 2020, International Conference on Emerging Trends in Engineering and Technology, (http://conferences.sta.uwi.edu/iconetech2020/index.php)

The PDFs in Table 3.2 can be used to generate the uncoordinated charging power demand, ***f(x)***, at a certain charging time, ***x***. The advantage of these 'best' fitting PDFs is the additional shape parameters which provide a more realistic fit than popular PDFs such as the Normal and Weibull. This can be repeated for the weekend scenario also. In this way, random characteristics of the data can be preserved and EV charging load profiles can be easily estimated using these equations. Although known PDFs can be fitted as shown, polynomial curve fitting also provides a feasible technique to provide a close fit for such analysis. This flexibility is essential for further predictive demand analysis.

Table 3.2 Top Three Best Fitting PDFs for Weekday Load Curve

PROBABILITY DISTRIBUTION	PDF	K-S STATISTIC	P-VALUE
Johnson SB	$f(x) = \frac{\delta}{\lambda\sqrt{2\pi}z(1-z)} \exp\left(-\frac{1}{2}\left(\gamma + \delta \ln\left(\frac{z}{1-z}\right)\right)^2\right),$ $\xi < x < \xi + \lambda; \quad -\infty < \gamma, \xi < \infty; \delta > 0, \lambda > 0$	0.0162	1.0
Generalised Gamma	$f(x) = \frac{kx^{k\alpha-1}}{\beta^{k\alpha}\Gamma(\alpha)} \exp\left(-\left(\frac{x}{\beta}\right)^k\right),$ $x > 0, k > 0, \alpha > 0, \beta > 0, \Gamma(\alpha)$ is the Gamma function	0.0277	0.99
Dagum	$f(x) = \frac{\alpha k \left(\frac{x}{\beta}\right)^{k\alpha-1}}{\beta\left(1+\left(\frac{x}{\beta}\right)^{\alpha}\right)^{k+1}},$ $x > 0, k > 0, \alpha > 0, \beta > 0$	0.02821	0.99

*Note. From "Probabilistic Assessment of Electric Vehicle Charging Behaviour," by Hosein et al., 2020, Caribbean Electric Industry Journal, 16, 36–39. DOI:*10.47412/QZWP9167*, and "Goodness of Fit of Probabilistic Models for Electric Vehicle Charging Behaviour," by Addison et al., 2020, International Conference on Emerging Trends in Engineering and Technology, (*http://conferences.sta.uwi.edu/iconetech2020/index.php*)*

Discussion

It is evident that descriptive statistics and goodness-of-fit metrics are useful tools to investigate the nature of large datasets. In particular, maximum daily peak values are of significance to distribution grid protection schemes to predict system disturbances. The mean values can be used to demonstrate the percentage increase of daily demand compared to lower EV penetration scenarios, thereby considering suitable EV charging scheduling schemes.

In particular, the existing daily load pattern obtained can be used to estimate the coincidental demand with vehicle(s) charging. This can now be used to predict if distribution transformers will become overloaded, using the generated PDFs as a guide for predicted demand at a certain time in the week. In addition, this supports the development of a "rule of thumb" guide for the utility related to the maximum number of EVs that can be added to a circuit, before power quality issues would be experienced.

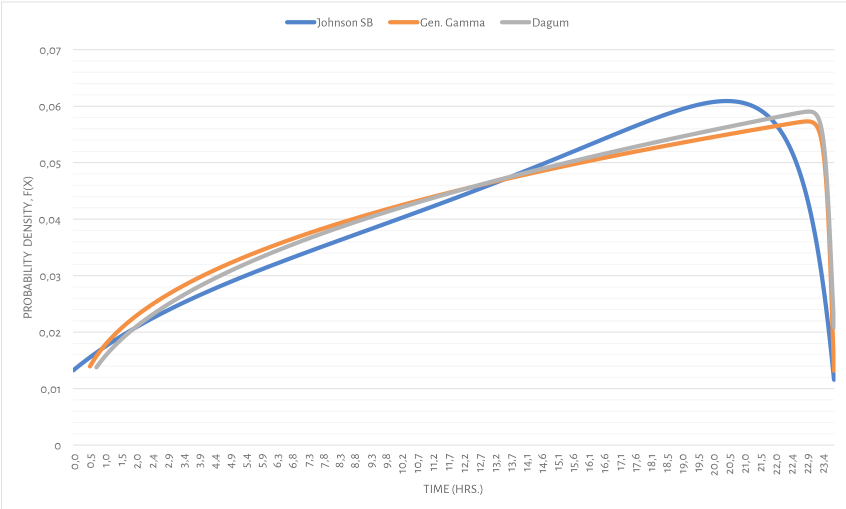

Figure 3.4 Probability Density Functions for the Weekday Load Curve
Note. From "Probabilistic Assessment of Electric Vehicle Charging Behaviour," by Hosein et al., 2020, *Caribbean Electric Industry Journal, 16*, 36–39. DOI:10.47412/QZWP9167, and "Goodness of Fit of Probabilistic Models for Electric Vehicle Charging Behaviour," by Addison et al., 2020, *International Conference on Emerging Trends in Engineering and Technology*, (http://conferences.sta.uwi.edu/iconetech2020/index.php)

In most SISs in the Caribbean, there is a need for a strategic EV infrastructure planning and likely upgrading of the supporting power system assets. This would also inform the utility/fleet owners as to where are the best location(s) to install public chargers and the expected impacts of those chargers on the grid. If these are not done concurrently, EV penetration can cause stability and power quality issues on these small island power systems. In this regard, GoF statistics can also provide key parameters which can encourage a more measured approach to compute the expected demand on the power system.

There is room for further work to generate more accurate PDFs for corresponding load curves, in order to subsequently predict EV demand, as well as feed into more complexed schemes. A limitation of typical theoretical PDFs used to model mobility data in larger countries is the inability to accurately describe the weekday demand at particular hours in the day for SISs, where climate and demand may also be vastly different. This may affect the accuracy of performance indicators and estimates at certain times. However, without actual local data, analogues of these PDFs modified to fit the location situation, are excellent starting points in the prediction of the effects of EV penetration on the health of the local grid.

Development of realistic PEV load profiles is essential for accurate determination of impacts on power system planning and operation applications (Almutairi et al., 2018). The aim is for system operators to have tools to evaluate uncoordinated systems properly in order to build coordination charging schemes based on EV demand. The outputs of this assessment can also be fed into DSM programmes to improve power consumption efficiencies. DSM plays an important role in the development of smart grids. This study provides key insights into estimation of PDFs based on EV charging behaviours, in order to build and assess models associated with transportation mobility data for SISs.

Hence, the real value in the methodology is the ability of the selected probabilistic model to provide the statistical representation of the power consumption at a particular time and location, based on the local users' driving behaviour and corresponding charging patterns. This can be superimposed on the existing power consumption requirements to determine the distribution network's transformers and cables capacity utilisation. Thus, any SIS can adopt a probabilistic approach to enhance the uniqueness of their EV demand, in contrast to larger countries.

Recommendations and Conclusion

This work presented an assessment of EV charging using goodness-of-fit of PDFs. These can then be utilised to build suitable PDFs to estimate country-specific metrics and enable forecasting models to be created for EV charging, using data-driven approaches. As EV penetration increases and charging coordination schemes are developed, power system planning is critical and generation expansion must continue to be ahead of the load growth. The adoption of renewable energy technology can play a role to potentially delay capital investment for power system upgrades at the transmission and distribution levels while developing prosumers that approach the adoption boundaries of various V2X options.

Undoubtedly, this data-driven approach will inform decisions suitable for the local landscape. Market readiness and progressive adoption in SISs, especially in the Caribbean, are faced with numerous unique policy, technical, infrastructural, legislative, and financial challenges, which may have stymied EV adoption. The holistic assessment using accurate and applicable transportation data of the existing state of play in any SIS must be performed. This will include public and private sector analyses to identify an all-inclusive path for EV adoption. This path must be made transparent and accessible to all stakeholders identifying the surrounding industries, which can be developed and sustained. There are many players and actors (public, private and non-profit) that need to participate and actively contribute for successful EV adoption. Stakeholder consultation is, therefore, critical and public awareness paramount.

Consideration of the importation process, applicable standards, standard development, tax exemptions and tariff considerations, suitable EV selections, licensing and insurance considerations, dealer, customer and utility responsibilities, safety aspects and vehicle-to-grid considerations have been documented (Meetoo et al., 2018). The reduction of GHGs and opportunities for improved health of the citizenry, linked to the sustainable development goals. National commitments will also influence policy development and possibly accelerate policy implementation. The development of an implementation plan requires a careful technical review of the technology available, ensuring applicability to the proposed plan.

Review of compliance, with existing local electrical and communication codes and standards is critical, especially if there is a long(er) term aspiration of integrating smart city measures. This can also initiate reviews of codes and standards. EVs can also provide an abundant supply of user data, and this introduces measures for privacy for big data collection and processing. Another such data-driven approach can also foster confidence for emerging urban mobility and ride sharing services, third party EV charging applications utilising Fintech and cryptocurrencies.

Therefore, it is recommended that the next step be to improve the goodness-of-fit of these probabilistic models for EV charging behaviour using real local transportation data. This can be extracted ideally from an EV pilot study or another hybrid approach, leveraging real local landscape commute data to produce revised probabilistic models. Future work should involve use of Monte Carlo simulation modelling techniques using predetermined PDFs for other mobility survey data variables such as home arrival times, home departure times, and daily mileage.

These models can then be incorporated into the real local power system models to perform sensitivity analyses and adequacy assessments at various penetration levels at strategic locations in the island power system. Such technical studies will further enhance the power system planning exercises. This is particularly important for SISs to maintain the integrity of the quality of the electricity supply, minimise outages, optimise the utilisation of the ageing electricity distribution networks and possibly delay capital asset investment(s).

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Part II Digitalisation of Transport and Mobility

4 Smart Public Transport in Barbados: Experiences with Smartphone Applications

J. R. Kotzebue and K. Bryan

Barbados has started to use ICTs to improve the mobility and services in public transport in the early 2010s. The small island state has a correspondingly small transport market because of its geographical position and size. The landmass of Barbados is approximately 430 square kilometres and approximately286,000 people inhabit the island, which is comparable to a medium-sized city in Europe (EB, 2020; GovBA, 2020). More than 1.5 million tourists visit the island every year. The economic development highly depends on the telecommunication and transport infrastructure (Nurse, Stephenson, & Mendez, 2016).

With introducing smartphone mobility application, Barbados is following a worldwide trend of increasing ICT use in public transport. ICT is regarded as a key resource in enhancing sustainability (Gebresselassie & Sanchez, 2018). For example, many cities around the world have introduced automated fare collection systems and automatic passenger counting systems that collect data when passengers use smart cards or credit cards for the payment when they enter or exit the bus (Yap & Munizaga, 2018). GPS bus-tracking systems provide real-time location data and are used to inform passengers about the position and arrival time of the next bus (Singla & Bhatia, 2015). The collected data is then used to improve the transport management, support the transport development and can contribute to an Intelligent Transport System, which ultimately leads to better time management and better lives for city residents (Davidsson, Hajinasab, Holmgren, Jevinger, & Persson, 2016; Mallik, 2014).

Despite the opportunities, the investment in ICT in transport in Barbados has been limited. Three major types of public transport operators operating on the market: state-owned public busses, private-owned minibuses and shared right fix-route taxis (ZR). The state-owned public transport provider, the Transport Board (TB), has introduced an online (WordPress and Google-maps based) bus-route finder that allows user to view bus schedules, routes and stops on a virtual map. Since 2010, four independently produced smartphone travel applications for passengers and tourists had been introduced on the market. However, the transport market in Barbados, and the Caribbean, differ significantly from established transport markets in the US, Europe, and Asia, and generally, in the Barbadian market there is little cohesive understanding of the specific needs of the customers, riders, operators and other stakeholders. Even more challenging, data about the use of the various transport modes are lacking. Therefore, this paper addresses two questions:

- First, to what degree do the public transport smartphone applications in Barbados address their target market?
- Second, to what extent do the applications address the transport needs, especially as it relates to the stated governmental goals?

In response to the questions, this examination identified major prospects through a literature review, analysed 87 customer reviews and the product descriptions. The book section starts with a brief description of the public transport policy and practice in Barbados, followed by an explanation of the analysis method. Subsequently, a presentation of the results, a discussion of the research question, and final recommendations for several measures for the further development of the use of mobility applications on Barbados' transport market will be made.

The Public Transport Policy and Practice

The Policy Framework

The public transport development in Barbados is based on a legal framework, but an overarching integrated and sustainable transport policy is lacking. Major policy guidance comes from transport-related strategic plans like the National Strategic Plan of Barbados, the Barbados Growth and Development Strategy and the Barbados Tourism Master Plan (table 4.1) (GovBar, 2007a, 2013a, 2014). The most recent direction concerning the digitalisation and the development of the public transport sector is provided in the "Barbados Energy Policy 2019–2030" that includes a strategic course for the development of the transport sector. The strategy focuses on the abolition of diesel and gasoline in the policy period, the reduction in the number of vehicles per capita, the improvement, convenience and attractiveness of public transport. A general goal is to promote the use of public transport. Moreover, the vision includes policy measures to "establish the use of management technology in public transit", e.g., using smartphone applications to verify arrival times of buses" (GovBar, 2019ap. 83).

Table 4.1 Major Policy Strategies and Public Transport Goals

AGENCY	STRATEGY	DURATION	MAIN GOALS
Ministry of Economic Affairs and Development Barbados	The National Strategic Plan of Barbados	2006–2025	+ Development of an efficient transport system and infrastructure. + Enhance access to public transportation, especially for persons with disabilities and higher age groups. + Reliable and adequate public transport system. + Private participation in provision of public transport. + Introduction of prepaid travel cards. + Exploring alternative fuels in public transport vehicles. + Implementation of appropriate traffic management systems and infrastructure. - Reduction of road fatalities.
Ministry of Economic Affairs and Development Barbados	Barbados Growth and Development Strategy	2013–2020	+ Development of an integrated public policy and investment programme. + Development of an efficient transport system and infrastructure + Development of reliable public transport system. + Encourage use of mass transportation system
Ministry of Tourism and International Transport	Barbados Tourism Master Plan	2014–2023	+ Comfortable waiting areas for public transport users at touristic transport hubs like airports. + Public transport facilities. + Improve and safety standards, organise and discipline minibus and route taxi service providers.
The Ministry of Energy, Small Business, and Entrepreneurship	Barbados National Energy Policy	2019–2030	+ Greater percentage of electric (EVs) and hybrid vehicles. + Use of bio- and alternative fuels in public transport. + Establish a transportation information system. + Introduction of a renewable and clean energy into the public transportation system. + Convenient and attractive public transport options.

Note. Compiled by J. R. Kotzebue

The central government had also commissioned several transport studies to prepare a National Transport Plan. For instance, the government received financial and technical assistance from the World Bank in the 1990s. The programme had the stated objective of improving the physical transport infrastructure and road network. Additionally, the government intended to use the assistance to:

- Reform the public transport sector
- Improve the regularity framework to initiate a sustainable road maintenance system
- Digitalise the financial system of the Ministry of Public Works, Transport and Housing
- Privatise the Barbados Transport Board and staff training

However, the programme implementation largely failed due to the lack of proper planning, evaluation, monitoring and control mechanisms (WB, 1999).

Goals from Barbados' Growth and Development Strategy 2013–2030

The Barbados Growth and Development Strategy 2013–2020 aims to develop an efficient transport system, infrastructure, an integrated public transport policy and investment programme. The strategy stresses sustainable green economic growth and development, which includes the transport sector (GovBar, 2013b). However, the strategy does not have a focus on transport, nor does it contain holistically clear strategic measures that address the entire public transport system and support the potentials of digitalisation. The Growth and Development strategy highlights the lack of mobile-internet penetration, though there is a robust internet infrastructure and high mobile and smartphone penetration. To address this, the government announced that it will develop a national ICT strategy, however, this still does not erase the concerns that policy guidance for application developers, especially as it relates to transportation application development, is still lacking (GovBar, 2013b, 2019b).

Transport institutions

Establishment of the Transport Board - 1955

Although the policy framework is in favour of public-private partnerships and power-sharing, the governance structure in the transport sector is highly centralised. The state-owned Transport Board (TB) – established in 1955 – is still the primary organisation for providing and maintaining the public transport facilities, including busses and terminals through the Transport Board Act. At the time of writing, it is evident that key suggestions from the reform programme hosted by the World Bank in the 1990s were not implemented. The bank had suggested the privatisation of the TB, to allow it to operate in part or wholly under the influence of the free market.

The TB has the power to transport goods and passengers, maintain and operate the bus service, provide amenities and facilities for public transport passengers (GovBar, 1978).

Though the TB is permitted to create programmes for reorganisation, they are subject to the direction of the Ministry and thus the minister of Transport and Works. The minister appoints the chair and can replace members of the board, which strengthens the central character of the system (GovBar, 1978). Currently, the TB continues to financially depend on governmental support and struggles with growing debt. Passengers are increasing according to the available annual reports, many of which, since 2014, are not publicly available (GovBTB, 2010).

Establishment of the Transport Authority - 2007

As the World Bank has recommended in the 1990s programme, the government established a Transport Authority (TA) in 2007. According to the Transport Authority Act, the major aim is the planning of a public transport system, monitoring and regulation of the public transport system, driver licencing as well as up-to-date information. This latter task includes the maintenance of a digital public transport database. Even though the authority advises the Ministry, the minister gives direction to the general policy of the Authority, approves the appointment of the director, the employment posts within and the Authority's finances (GovBar, 2007b). Whilst the law determines that the Authority has to develop a 5-year development plan for the public, the plans are not published on the TA's website.

The TA is also responsible for administering licenses routes and permissions to private operators who operate the privately owned ZR that can carry 5 to 15 passengers, and minibuses serving 11 to 24 passengers on fixed routes. Thus, the TA did not replace the Transport Board, which remained excursively responsible for providing bus terminals, operating and maintaining the public transport fleet, comprising 28- to 42-passenger busses (GovBA, 2021).

Despite the moderate reforms, Barbados has no free-transport market. The transport system and policy are centralised with little monitoring, evaluation, or control mechanisms. The transport market is non-transparent about the passenger numbers, the operating bus fleet and the number of vehicles. For instance, information about passenger numbers can be misleading, while the available interim reports of the TB state that the numbers of passengers are increasing in the state-owed public transport, an independent study states that passengers per vehicle are decreasing because of the increase of private operators (GovBA, 2009; Gwilliam, 1996). Anyway, up-to-date data is lacking. This situation creates uncertainties for application developers to invest in the Barbados transport market. A policy that supports, guides, and ensures collaboration and transparency in the transport sector would be central to encouraging the growth for application developers and transport-system providers.

Regardless of the lack of a national transport policy and ICT development guidance, the transport market could benefit from the further development of ICT use because private transport operators offer on-demand services and would allow commuters to have greater visibility into their (private operators) availability.

However, due to a lack of data, transport demand and supply is unclear to all parties involved, including public transport owners, operators and commuters. This results in an unsustainable situation, because frequently, operators run below their capacity or provide too little transport opportunities, which increases the waiting time of potential passengers. Furthermore, private transport providers run without a schedule and the busses of the TB merely have a fixed starting time and location, and no fixed times to reach designated stops. Due to many of these challenges, punctual transport planning and modal switching are nearly impossible. Hence, it is important to assess the opportunities for the mobility applications that have already been introduced.

Method

Defining Mobility Application

ICTs in mobility and transport have many dimensions, but a clear definition or criteria for mobility application are absent. Scholars used broad criteria to classify a mobility application, e.g., the relevance for transport behaviour and the need for making trips (Cohen-Blankshtain & Rotem-Mindali, 2016; Gössling, 2018). However, this definition allows for broad interpretation and can deliver an enormous number of applications. For instance, Gössling identified nine dimensions that define a transport application (Table 4.2) (Gössling, 2018).

Table 4.2 Nine Dimensions of Transport Applications

Travel Information	Remote working	Convenience
Planning and Routing	Payment & price comparison	Space and distribution
Sharing	Safety	Health and Mobility

Note. Adapted from Gössling, 2018

Smartphone applications can have relevance for almost all human behaviour like e.g., education, art, and culture. However, his study has a narrow perspective focusing on the following dimensions of transport applications:

1. Travel information
2. Planning and routing
3. Payment and price comparison
4. Multi-modality and sharing

Other criteria for inclusion into this study were:

1. Accessibility, which means the application had been offered on a smartphone through Google Play or Apple App Store.
2. The application must be in use.
3. It must address at least one of the highlighted dimensions, e.g., provide real-time traffic information, vehicle position, departure and arrival time, multi-modality, ridesharing, and is used for the organisation of demand transport.

Accordingly, four mobility applications were identified on the public transport market in Barbados. The first was introduced in 2016 and others followed in 2019. All apps were offered free to the user, but one application has in-app purchases that offer certain services for additional costs. All applications except for one are Barbadian companies. Currently, no international service provider is offering on-demand transport and ridesharing, but there is one local company offering both these services.

The Literature Review and Content Analysis

This section comprises two parts, a literature review and the content of the analyses of the customer reviews and product descriptions. The content analyses were conducted using MAXQDA, a qualitative data analysis program.

Literature Review

The review of literature from the field revealed that numerous empirical studies, which analysed smartphone applications, saw potentials in the three sustainability dimensions: social, economic, and environmental. The literature highlights the social potentials for travellers and public transport providers. For instance, a major potential is real-time information about traffic congestion, passenger numbers and occupancy rate (Nelson & Mulley, 2013; Simonyi, Fazekas, & Gáspár, 2014). Others include building and creating trust in the applications and supporting commuters' day-to-day activities (Schmitz, Bartsch, & Meyer, 2016).

From the economic perspective, experiences show transportation apps alter users' perception of transport costs and value (Shaheen, Cohen, Zohdy, & Kock, 2016). For instance, applications aim to attract car owners and older people to use public transport because of the cheaper or more economical cost of use (Hounsell, Shrestha, McDonald, & Wong, 2016; Schütze, Schmidt, Liimatainen, & Siefer, 2020). While it is frequently highlighted that the applications have a positive economic effect on the users, few empirical studies have been found that measure this effect on the public transport providers.

Notably, it has been shown that the choice of the transport mode has numerous environmental effects. For example, a positive effect on the overall carbon footprint as well as energy efficiency, since more users are using fewer vehicles to get from their places of origin to their destination (Singh, Gurtu, & Singh, 2020). Table 4.2 shows the general potentials taken from the reviewed literature. While the initial content analysis demonstrates the providers' perspective, a second content analysis was also carried out to examine the customers' perspective.

Customer Reviews and Product Descriptions

In this analysis, 87 customer reviews and the product descriptions were examined. These were published on the distribution platform, on other travelling platforms that inform customers about the apps, and the provider's social media site. Although the reviews give an opinion of customers, the results need verification by further research. A reason is that, e.g., the app providers could have manipulated the reviews. For instance, one of the providers only had positive reviews that were all published in the same month and year while another provider did not publish any reviews on the distribution platform. Table 4.3 shows the keywords that were used to analyse the application's information and customer reviews.

Table 4.3 Applications' Sustainability Dimension, Potentials and Keywords

SUSTAINABILITY DIMENSION	POTENTIAL	KEYWORDS
	+ increase, support / - reduce	
Social Travellers	+ Everyday activities + The willingness to travel + Journey planning, long, mid and long term + Self-determination + Informed choices + Orientation	Information, plan, useful, safe, easy, choice, good, nice, love it, helpful, ok, real time, life destination Wrong information, uncertain, not working, poor, bad, useless
Social Transport Providers	+ Real-time information, traffic, congestion, passengers, occupation rate + Route instruction + Announcement of service	Real time, life destination
Economic Travellers	+ Travel incentives + Price comparison + Switch of transport modes	Compare, price, bus, taxi, PSV
Economic Transport Providers	+ Ridership + Transport marketing + Fleet efficiency	Efficient, waiting time
Environment Travellers	- Carbon footprint	Environment, health
Environment Transport Providers	+ Fuel efficiency + Energy efficiency - Congestion	Energy, environment

Note. Compiled by J. R. Kotzebue

Results

The Product Descriptions

The content analysis of the application descriptions shows that all application providers offer supportive information for travelling and better planning. Three providers highlight the benefit of real-time information, like the vehicle location. Three applications' descriptions stress that transit across Barbados becomes better and easier to plan. Two providers state that the apps offer a more convenient way to get transport whilst another one advertises customer safety. One provider underlines the potential for taxi drivers to increase income. Other identified keywords as listed in Table 4.3, like environment, energy, efficiency, waiting time, real time, were not included in the analysed applications' descriptions (Table 4.4).

Table 4.4 Frequency of Keywords in the Product Descriptions

KEYWORDS	FREQUENCY
Information	10
Plan	7
Easy	5
Helps/better	3
Choice	3
Convenient	2
Safe	1
Income	1

Note. Compiled by J. R. Kotzebue

The Customers' Perspectives

Considering the customers' review of the applications, the content analysis shows that most customers experience the applications as good, helpful, and satisfying. Information being provided is often mentioned. At the same time, customers stressed in their review that some of the applications are not working properly, displayed wrong information, and create uncertainties (Table 4.5). Additionally, the analysis shows a divided picture. While some customers find the applications easy and useful, almost the same number of customers express disappointment and discouragement in their reviews.

Table 4.5 Frequency of Keywords in the Customers' Reviews

KEYWORDS	FREQUENCY
Good/helpful/satisfaction	17
Not working	10
Information	7
Easy	6
Discouraging	6
Wrong information	5
Disappointment	5
Useful	4
Uncertain	3
Plan	2
Choice	1

Note. Compiled by J. R. Kotzebue

Discussion

The Potentials

The study revealed several potentials for app developers to connect more deeply with sustainable three dimensions and with the Government's goals (Table 4.1). According to the literature review, mobility apps have potentials in all three dimensions of sustainable development, social, economic, and environmental. However, the literature reviews also showed that environmental potentials are presently less in the focus of the application developer and providers. For instance, a study highlighting the potentials of apps stresses their ability to enable social communication, foreseeing travel conditions, and locations (Wang & Fesenmaier, 2013). Other studies confirm that users utilise a travel app because they communicate, need information about the mode, time, conditions, and buying tickets. Users did not mention environmental information or reasons (Jamal & Habib, 2019; Meng, Kim, & Hwang, 2015).

The findings of this study reveal that the application providers mention the positive environmental effect of using public transport and shared mobility. However, applications often lack a function to inform users about the environmental effects of their behaviour. It is notable that none of the offered applications in Barbados includes a function that informs users about the carbon footprint or energy efficiency, for example. Also, the economic aspects are hardly addressed. Merely one provider highlighted that taxi drivers can generate extra income with the benefit of the app. No provider spoke about savings from taking public transport. We can therefore see that the application developers primarily focus on the social aspects in the use of their apps.

When we refer back to the Barbados Government's stated policy, one of the main development goals is to create a green and sustainable transport sector. According to this study, the apps support customers in their travel behaviour but they do not necessarily encourage them to change behaviour or to switch transport mode because of economic or environmental reasons. In this regard, the applications have further potentials for growth to align with the identified sustainable development goals and governmental goals.

The Challenges

The challenges mainly relate to in-app purchases and content biasing.From the analysis of the application product description, all providers highlight that the apps will inform the users and that the application will help to manage and to guide them. For instance, some applications provide background information about places of interest and offer live information about the vehicles. However, this study reveals that apps may also contain wrong information, which discourages customers and may create uncertainty or disappointment. Similarly, the apps' content can be biased and sometimes does not always have the goal to guide customers towards efficiency, informed choices, and self-determined outcomes, as highlighted by the literature. For example, one app mainly provides sponsored content, and crucial information is linked to in-app purchases. Here, the content mainly serves the so-called "behaviour targeting". The application generates data to identify the consumers' preferences, to display personalised promotional content and to sell certain products. This is opposed to providing robust transportation information (Mishra, 2020).

The study also reveals a difference in potential regarding the product's usefulness. While the literature and providers stress the benefits of travel planning, customers rarely mention this advantage explicitly. One reason could be that applications often allow and foster on-demand behaviour by providing information about real-time (actual) conditions. Therefore, users can freely decide and are not forced to pre-commit to a certain option, and this means that customers may plan less in advance and become discouraged when applications seem not to be working (Hey, 2005). The users may not recognise that the outcomes may be related to the time of day that the customer is searching and the actual availability at-the-moment in time.

Transparency

Generally, the bias in reviews does not allow for full transparency. Only one developer published all reviews, while others published reviews only in the beginning or just positive ones. However, it is important to note that scholars consider customer satisfaction, service reliability, information quality and responsiveness important factors for the trust of customers in any digital service (Cho, Yoo, Jeon, & Choi, 2019; Kim, Xu, & Koh, 2004). The factor of trust and credibility is also linked to the availability of customers' reviews, as they provide an important source of information about the service. Therefore, some transport applications in Barbados give little orientation. They, accordingly, limit customers' choice as they do not have a full overview of their options.

Other Limitations

Other app limitations are more structural in nature and rely on the deployment of required digital infra structure features. For instance, limited real-time data are rooted in the insufficient digital infrastructure. Another potential limiting aspect is that users' smartphones are sometimes the limiting factor. Some users also have smartphones with insufficient storage that create malfunctions of the application, or they have cell phone plans, which have limited or no-data access in the billing cycle. Additionally, the costs for the data use might exceed the personal benefits so that may cause users to rate apps in a negative way.

Many of the potentials that are mentioned in the literature are related to apps that are designed for a transport system with fixed time schedules and routes. This does not reflect the reality of the Barbadian transport system. One has to keep in mind that the Barbadian transport system functions mainly with unscheduled and variable routes. If app developers do not consider this aspect properly, this can reduce the usefulness of apps for customers and multi-modal transport users.

Finally, to enable the most useful outcome for the customers, there should be greater cooperation between transport providers and application providers. In the case of the state-owned TB busses, the government could consider collaborating in a public-private partnership.

Conclusion and Recommendations

The chapter questioned to what degree do the public transport smartphone applications in Barbados address their target market, and to what extent are the transport needs. When considering merely the results of the content analysis, it becomes clear that the smartphone applications in Barbados only partly match the highlighted opportunities. The identified opportunities have three dimensions: the social, economic and environmental, but in Barbados, the applications primarily focus on the social aspects. Nonetheless, most users are satisfied and find these apps helpful.

This work also discussed how the lack of transparency around customer reviews for some applications might lower the overall trust in all the applications. As shown, only one developer fully displays all of their reviews. We can see that opportunities, like applications, providing better detailed and informed options and opportunities to plan, can be greatly improved. In general, there is little guidance and consistency of reviews on the market, so customers are often on their own when they are searching to find appropriate smartphone applications.

Nonetheless, it may continue to prove difficult for the transport providers and application developers to come together when public transport largely depends on the government's policy. The TA regulates the number of vehicles through licences and the routes for private transport providers, like minibus owners and route taxi drivers. The state-owned TB runs and maintains the public busses. For both segments – privately owned or publicly operated – there is no mandate to install GPS devices, and there is little to any central coordination of routing and management. This makes it difficult for developers to invest in the market and to develop applications that largely fulfil the needs of the passengers. A holistic transport and ICT policy is lacking, and implementing this policy in the near term would streamline and enable the development of the transport application industry.

Based on the presented findings, we recommend that the government create more partnerships with transport operators and application developers who are focused on transport optimisation. The collaboration should be accompanied by studies and technologies that monitor and evaluate the development of the apps to create appropriate mobility applications. The study shows that the missing policy framework creates uncertainties in the small market so that international developers do not invest, and existing local and regional applications and application developers cannot fully develop their opportunities.

If the government has the goal to create a smart, green, and sustainable public transport system, it is necessary to create a supportive environment for public transport operators, application developers, and to steer applications so that all the social, economic, and environmental dimensions are realised.

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5 Digital Capacity in Community Transport Development

Experiences from the Man and the Biosphere Area Tobago

J. R. Kotzebue

In October 2020, the United Nations Educational, Scientific and Cultural Organization (UNESCO) declared the North-East region of Tobago a Man and the Biosphere (MAB) reserve. It became the largest MAB area in the Anglophone Caribbean Small Island Developing States (UNESCO, 2020). The UNESCO's three-zonation strategy focus on three key functions: conservation, sustainable development and logistic support. Protection and conservational activities characterise the core areas. In the surrounding buffer zone are activities permitted that are compatible with the core areas, like human settlement, tourism, research, and education. The program fosters sustainable resource management and development in the outer populated transition areas. The transition zone allows a smooth shift from the protected to the unprotected areas (Figure 5.1) (UNESCO, 1995). The collaboration with the stakeholder constitutes an essential element, and the roadmap for the MAB Programme encourages them to contribute to political decisions and to take part in implementing them (UNESCO, 2017).

The MAB reserve is located relatively far away from the main urban, touristic, cultural, and economic centres of Trinidad and Tobago. The fourteen villages that are included in the transition zone of the area are located along the two main roads that connect them with Tobago's economic and cultural centre, Scarborough. The inner transport system fully depends on motorised vehicles. The Tobago's local government, the Tobago House of Assembly Division of Infrastructure, Quarries and the Environment, as well as the Division of Tourism, Culture and Transportation are responsible for an adequate road system. However, the Ministry of Works and Transport that is located in the main island Trinidad is mainly responsible for the national transport planning. However, the transport development and planning is project based, because of a lacking in national transport strategy and integrated town and county planning. The planning process is centralised and gives no or little opportunities for citizens to participate. Accordingly, the close collaboration with citizens and stakeholders as required by the MAB programme is something new. Therefore, the village of Charlotteville has tested a (Public) Participatory Geographic Information Systems ((P)PGIS) to collaboratively develop a long-term sustainable transport strategy for the community in a pilot study.

Using ICT is becoming more important. An increasing trend emerges for Public Participatory Decision Support Systems (PSDSS), ((P)PGIS), and web-based Volunteered Geo-graphical Information (VGI) tools in many metropolises (Brown, 2017). Although the tools differ, geographic information and a participative process are core elements (Brown & Kyttä, 2014). Hence, these online tools could be considered as social-geo-communication tools (Brodersen, 2017; Vogler & Hennig, 2014). These tools offer the opportunity to strengthen the collaboration, but scholars also highlight the challenges like digital divide, poor geographical and socio-economic presentation, and biased results (Kahila-Tani, Kytta, & Geertman, 2019). The public still has often difficulties to understand the processes and results generated from digital planning tools (Geertman, 2006; Pelzer, 2017; te Brömmelstroet, 2017).

Studies show that the potential of the digital tools is context dependent. For instance, the character of the policy and planning processes, the digital literacy of participants, user- friendliness of the tools, and the communicative value of the output can be decisive (Geertman, 2006; Magee et al., 2020; te Brömmelstroet, 2017). These factors mainly stress upon the individual processes, single tools, individual and organisational capabilities. However, community and capacity-building literature highlights the importance of the community's capacities for sustainable development (Craig, 2007; Eade, 1997). Therefore, the question posed in this paper is: What role does the digital capacity of the community play in digital context-sensitive transport solution development?

To respond to the question, the first section describes the case study area and the web-based tool. The paper will continue by elaborating on the concept of digital capacity in the community's context and introducing a methodological framework. It allows assessing the role of the digital capacity in an ongoing process. The concluding section highlights some recommendations for the use of digital tools in MAB areas and transport planning.

The MAB Area

The core of the MAB area comprises the Main Ridge Forest Reserve that became protected in 1776. The area encompasses 3,937 ha with the ridge highest peak of 549m (GovTT, 2021b). Fourteen communities are part of the transition zone of area. The biggest communities are Moriha, Roxborough, Louis D'or and Charlotteville (Table 5.1) (CSOTT, 2011). Although Charlotteville is an important transport hub from a touristic point of view, because it has one of the two ports in Tobago for cruise ships, it is hardly accessible. The remoteness also affects the population growth as its population is declining (CSOTT, 2011). The village hosts the Environmental Research Institute Charlotteville (ERIC), which has successfully implemented community-based environmental and protected area management projects in the area. Therefore, the pilot study was conducted in Charlotteville (Figure 5.1).

Table 5.1 MAB Communities and Population

COMMUNITY	POPULATION
Moriha	2,151
Roxborough	2,089
Louis D'or	907
Charlotteville	863
Argye	625
Hermitage	609
Delford	594
Cascara	580
Belle Garden	544
Bellys Hope	492
L'anse Fourmi	273
Bloody Bay	144
Speyside	18

Note. Compiled by J. R.Kotzebue

The topography of the villages in the transition MAB area varies and changeover is from flat land near the coast to hilly terrain at the base of the core area, the Main Ridge Forest Reserve. Charlotteville developed in a sprawl like a network across the hillside near the forest reserve, partly because of the lacking in holistic land use planning. Two major roads, the Windward Road along the Atlantic Sea at the east coast and the Charlotteville – L'Anse Fourmi on the Caribbean Sea on the west coast connect the remote villages with Scarborough the main city of Tobago (Figure 5.1).

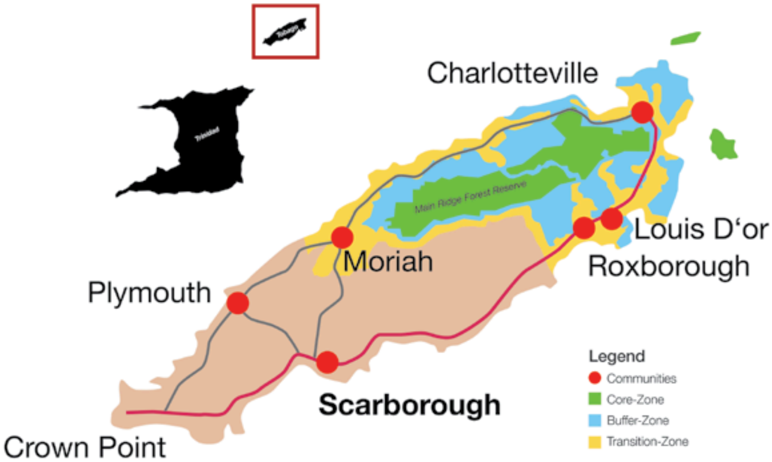

Figure 5.1 Tobago MAB Area with its Three Zones and the Major Communities
Note. Copyright by Göttsche (2021)

Both roads have narrow lanes, which allow, partly, only one vehicle to pass at a time in certain sections, and have many landslide occurrences. This results in challenges for the transport system that fully depends on motorised private cars (often shared), private-owed 9- to 25-seated minibuses on fixed routes (maxi-taxis), registered and unregistered taxis. The state owned Trinidad and Tobago Public Transportation Service (TTPS) that also provides a scheduled service is often unreliable (PAC, 2019). Although car ownership is increasing, the minority has a car in the remote areas and many non-drivers have to walk to the village centre or the main roads to get a transport opportunity.

PGIS and Digital Capacity

Participatory Geographic Information Systems

The pilot study introduced a type of Participatory Geographic Information Systems (PGIS), a web-based and social geo-communication platform that enables the participants to visualise transport ideas, discuss concerns, needs and solutions. The platform combined Google Maps mapping with an open-source content management system and social media. Participants could add a marker on the digital village map, upload descriptions, photos, videos, and rate and comment contributions.

PGIS aims at collaborative mapping in groups and is a reflective mapping to visualise, e.g., the community perspective (Brown & Kyttä, 2014). It combines community participation and geographic information systems (Weiner, Harris, & Craig, 2002). Community participation is contextual, with a diverse range of intensity, scope, and frequency (Sanoff, 1999). Arnstein's Ladder of Citizen Participation has illustrated this (Arnstein, 1969). Community control does not necessarily mean that the community takes over government tasks, but that the community becomes empowered to steer implementation (Sanoff, 1999).

Therefore, the approach differs from the computer-based tools that started in the 1960s in western countries (Klosterman, 1997). These early decision support systems (DSS) and planning support systems (PPS) were primarily designed for engineering, management, and planning experts (Batty, 2013; Eom & Kim, 2006). Meanwhile, Web 0.2 enhanced the options to involve the public, to generate and to share geospatial information like Volunteered Geo-graphical Information (VGI) (Goodchild, 2007; Rinner, Keßler, & Andrulis, 2008). A heterogeneous field of public participatory decision support systems (PSDSS) and (Public) Participatory Information System ((P)PGIS) increasing the opportunities to engage non-expert and the public in transport development (Keenan & Jankowski, 2019; Le Pira et al., 2017; Tulloch, 2007). However, to get people and a community engaged, they need the capacity to do so.

Digital Capacity

The Oxford Dictionaries define capacity as the amount of something that can be produced and that someone or something can contain (OUP, 2020). However, this definition proves not to be useful for the PGIS. In the field of community participation and public administration, the concept of capacity gained importance in the 1970s. Although debated, it had been defined as ability to anticipate and influence change, to make informed, intelligent decisions about policy, to develop programs, implement and evaluate applied actions, to attract, absorb and manage resources (Honadle, 1981). This definition implies that capacity has an input, a process, and an output aspect.

By comparison, the concept in the digital context shows an input and output logic. It refers "to the skills, competencies, attitudes, infrastructure and resources that enable people to work, live and learn in a world that is increasingly digital" (NFTL, 2015 p. 5). Another illustration of this type of definition is: "Digital capacities are users' abilities to mobilise material and symbolic resources to maximise benefits, opportunities and aspirations afforded by changing digital technologies and techniques". (Magee et al.,

2020) p. 1002. Hence, digital capacity is vital to being active in the physical and virtual world (Zhuang, Yang, Bo, Zhang, & Huang, 2016). Contrast these definitions with the digital literacy concept that describes "the ability to understand and to use information in multiple formats from a wide range of sources when it is presented via computers" (Gilster, 1997 p1) It highlights the cognition and the ability to understand information, and therefore, the process. The fast ICT development request that users must constantly advance their abilities and capabilities, which are part of the capacity (Bawden, 2008).

Regarding PGIS, digital capacity aims at community development, and capacity-building is a core concept. However, the capacity-building literature in this field draws on a diverse picture (Chaskin, 2001; Craig, 2007). Nonetheless, Morgan (2006) has distilled five characteristics of capacity that also shows input, process, and output aspects:

1. Capacity is related to empowerment and the identity of the community. This is linked to the capability e.g., assets, properties and power that contribute to sustaining and developing the community.
2. Capacity refers to the collective ability to establish relationships, mutual learning, that allows community groups, organisations, and individuals to sustain and develop the community.
3. Capacity is relational, and context-depended. One cannot build from a single aspect.
4. Capacity is about public values, and it contributes something to public life.
5. Capacity is a potential and involves many factors that can influence it.

In the light of the above digital capacity in the context of PGIS could be understood as the personal or community's ability and capability, like skills, soft and hardware, infrastructure to generate, employ, create relationships, opportunities and learning through ICTs that sustain and contribute to the community's development and values.

Method

A Digital Capacity Framework

To assess the role of digital capacity in the pilot study, the paper builds on Peter Morgens' capacity concept with its five characteristics, as explained. Accordingly, capacity can be viewed in an input (a), process (b), and outcome (c) framework (Figure 5.2). The input (a) refers to factors like digital skills, competencies, attitudes, digital infrastructure, and resources that can potentially empower the community. Also, digital accessibility that allows people with disabilities to employ technology, and the communities' motivations and goals can be input factors (Eade, 1997; Kulkarni, 2019). Examples of digital skills are information management, communication, collaboration, creativity, critical thinking and problem solving (Van Laar, Van Deursen, Van Dijk, & De Haan, 2017).

The process (b) includes the interaction of single actors, organisations, and the relationships that make a community. To improve the community in the digital and the physical world, it is crucial if and how a community uses its input to create or mobilise relationships. A critical dimension of relationships in a community is the sense of community, which implies that people feel like a community member, have an influence, feel integrated and share emotional connections like values, cultural events, and positive interaction (Abfalter, Zaglia, & Mueller, 2012; McMillan & Chavis, 1986). The process also includes contextual factors that influence the relationship like the socio-economic, the policy and governance, and the spatial context.

The output (c) relates to the results of the input and process. It is essential that the output match with the community's values and needs to contribute to the community buildup. Essential is that the outcome has the potential to create benefits and opportunities for the community. This aspect can be related to the time dimension because outputs can be beneficial in the short term, but might be meaningless in the long-term perception of the community (Craig, 2002; Mizrahi, 2009). Therefore, it is important that the outputs contribute to outcome that sustain the community.

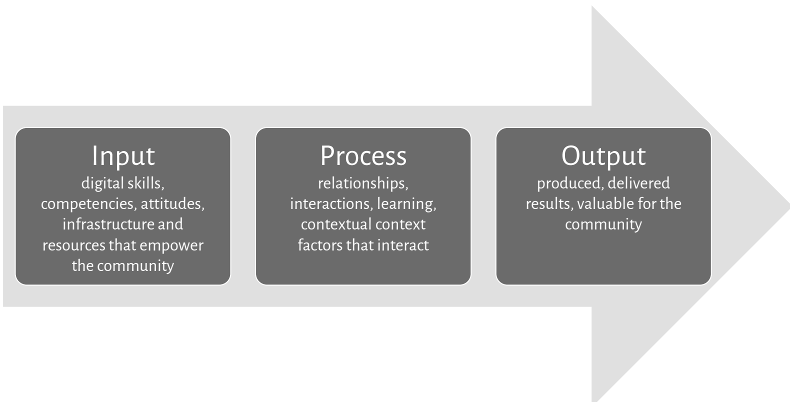

Figure 5.2 Digital Capacity Framework
Note. Copyright by J. R.Kotzebue (2020)

The Data Collection

The MAB's village, Charlotteville, functions in the pilot study as a Living Lab (Higgins & Klein, 2011). Together with the investigator, the community created sustainable and context-sensitive transport solutions as an experiment in a real-world context. In contrast to a real lab, the Living Lab is not a controlled setting and lacks a control group (Dekker, Franco Contreras, & Meijer, 2020; Higgins & Klein, 2011). This case-based learning includes trial and error, requires quantitative and qualitative research phases to identify and understand contextual factors (Johnson & Onwuegbuzie, 2004).

The collection of data included a survey that resulted in 108 valid responses (n 108). Although the response rate is low, the value of the research is not necessarily lowered because of the response representativeness (Cook, Heath, & Thompson, 2000). Baruch and Holtom (2008) confirm the importance that respondents are representatives of the population. In this light, there is little proof that a low response rate with high representativeness leads to selective reporting (Rutherford, O'Boyle, Miao, Goering, & Coombs, 2017). According to the demographic census of 2011, Charlotteville has 863 permanent residents, 51 % male and 49 % female. The survey corresponds to the gender relation, because 52 % female, 55 % male and 1 % other participants replied. In addition, the pilot study comprised seven structured interviews with key experts and stakeholders, and ten unstructured interviews with community members. A summary of the results is included in the communities' Sustainable Transport Strategy 2020–2030 (Kotzebue & Crichlow, 2020).

The fieldwork included analysing secondary data, observations, systematic descriptions of events, the behaviour, and the context. Extra observations help better to understand the phenomenon (Kawulich, 2005). The data collection occurred in a real-life setting, so that reliability can only be granted to the aspect of consistency of the responses and behaviour (Suen & Ary, 2014). The generalisation of the results is possible within the community, but needs more research to confirm the noted findings.

Results

The Input Factors

Specific data about the cell and smartphone subscribers in Charlotteville are not available. Therefore, the digital core skills and access are derived from the national market situation. The general trend shows that many people have one or more cell or smartphone subscriptions, 1.99 million (GovTT, 2021a). Currently, Trinidad and Tobago has a population of approximate 1.3 million (CSOTT, 2021). Merely 323.900 people have a landline phone by comparison. Regarding internet access, 770,200 subscribers have a mobile and 376.800 a fixed internet subscription (GovTT, 2021a). Most people have a cell phone, but many are not smartphones and internet access in remote areas is poor or variable. During the COVID- 19 pandemic, the mobile internet subscriptions increased by 17,9 % in one year (GovTT, 2021a).

The study's observations show that not all households have computers or tablets, but computers are accessible at the public library in the case study area Charlotteville. The most frequent users are children and teenagers. This age group also partly has access to computers in the schools. When addressed at the household, the majority refused to fill in an online survey and opted for the paper version when offered. Most participants also refused to map concerns or ideas with the PGIS tool individually. During the workshops, the participants refused to work with the tablet or laptop, even when they had the possibility to learn how to use the tool. Considering the geographical skills, e.g., many schoolchildren had difficulties orienting and to recognising cartographic symbols on a paper map. However, satellite photos helped most participants to orient themselves. Many participants knew Google maps and used it to advertise a touristic accommodation, restaurants and other businesses, but individually using it to think about context-sensitive transport solution-finding was new for many individuals.

The Process

The context- and community-sensitive transport solution development engages a geographically well-defined community. Considering the sense of community, the survey asked people about the core values of the community. Correspondents could either finish the sentence: "I get happy when people in my community" or could freely express themselves.

The survey showed that mutual aid is crucial for community members. The core values of the community are "respect" 20 %, "togetherness" 18 %, and "cooperation" 16 %. Additionally, 21 % of the participants indicated that the community helps and supports them. On the one hand, this signals a will of cooperation among community members. On the other hand, around 17 % of the participants indicated that the community is doing nothing for them. The picture shows a dichotomy between cooperation and exclusion.

The importance of collaboration also became visible while using the tool. Participants became active only when someone with technical skills or a respected person, like a family or community member, accompanied the participants. Community members needed not only to discuss the tool but more importantly the ideas and solutions. For instance, schoolchildren were constantly asking for teachers' feedback before they agreed on an idea. In the church, the discussion improved through the active involvement of the pastor. Many needed to discuss the transport issue with family members, neighbours, or friends at family level, before they responded to the survey or expressed ideas. A similar observation was noticed on the street. An exemption of this group had been community members who felt left out. They often used the opportunity to be contacted at the household level to express their needs. The individualistic participatory approach does not match the community's values and attitudes.

The desire for joint solution finding is part of the local community council, the voluntary associations, and non-profit organisations culture that are locally active. Charlotteville has several heritage protection groups and a police youth club. In addition, the Environment Research Institute Charlotteville (ERIC), a local non-profit organisation, collaboratively advocates for the protection of the marine and forest areas. The government demonstrates little participation in transport projects and community development. For instance, the community frequently reported collaborating in many surveys and assessment studies without follow-up and implementations.

Moreover, the structured interviews showed that most experts, leading stakeholders, and many community members regard the Tobago House of Assembly (THA) as responsible for sustainable transport development. At the same time, they simultaneously highlighted the weak political prioritisation of sustainable transport development. The political leaders pay little active attention to the subject and programmes. For instance, none of the authorities responded to survey requests or followed invitations to the workshops. The political system also provides insufficient finances, and human and technical resources for implementing and developing sustainable transport policies and practices.

The Outcome

The PGIS resulted in 29 ideas, 12 comments, and a long-term community-sustainable transport strategy. The strategy reflects, describes, and assesses the community transport solutions, and it stresses the community's transport needs. The satellite view of the virtual map supported the participants to locate the idea and their needs. However, the individual digital skills and merely the digital tool do not empower the community. The community needs feedback, mutual learning, the support of experts and community leaders. The tool should create collaborations, transparent and open discussions, but the community has little culture to use ICT for critical thinking and discussions. Social media platforms are mainly used to show, inform, and rate information, but not for policy issues and debate. Nonetheless, after the digital tool phase, 114 signatures for road safety and speed bumps were collected by the local police youth club. It is unclear if all supporters of the petition participated in workshops. However, the community could view the strategic community plan and it shows that the outcome of the PGIS and the workshops delivered valuable results for the community to enhance sustainable transport development.

Conclusion and Recommendation

The PGIS project in the MAB achieved numerous ideas and suggestions for the future that can be summarised in the vision: Reliable and safe transport opportunities that are available when needed to reach your destinations. A primary goal of the pilot project was to test digital tools for context-sensitive transport solution development in the MAB area and clarify the role of the digital capacity of the community.

Following the input, process, and output framework, the input showed community members generally have temporal internet access and depend on social institutions like the library and the school, which provide support, hardware, and software. In addition, the participants hesitated to use the tool independently. This phenomenon became clearly visible during the COVID-19 pandemic, which created an environment of social distance. During this time, the mapping platform remained unused. Further research is needed to explain the case-specific causes, but a principal reason for using online applications is their usefulness in personal life. The tools must fit into daily activities (Mehra, Paul, & Kaurav, 2020). Both the tool and the subject were new, not part of daily activity, so learning is required.

Concerning the process, many community members jointly mapped with the experts and expressed and visualise their needs and ideas. The interaction, collaboration, and mutual support of the community are essential. Studies confirm this finding that group discussion, interactive feedback and trust foster the use of PGIS tools (Brown & Kyttä, 2018; McCall, Martinez, & Verplanke, 2015). Nonetheless, the need for collaboration also creates dependencies. The online collaboration requires proficient facilitators and moderators (Šuklje Erjavec & Ruchinskaya, 2019). Increasingly, digital public engagement is outsourced to private profit-oriented platforms that filter information for the interest and goals of the contracting entity. The role of the facilitator, moderators and profit-oriented companies is still under-investigated, especially when concerning rural and peripheral areas.

Occasional, project-based use of digital tools will not empower the community to learn and to accept the tool as an opportunity for proactivity. The remote geographical location of the community influences the digital capacity. These areas have poorer digital infrastructure from the input perspective and strong collaborative needs. Compared to urban areas with an enhanced digital infrastructure, the web-based tools empower individuals that can collaborate without being aligned to local interest groups (Williamson & Ruming, 2019). Accordingly, users of these tools show an individualised collective behaviour in urban areas.

In conclusion, digital capacity is decisive for the use of digital tools in transport planning. However, the input, e.g., the improvement of individual digital skills and digital infrastructure, is insufficient for beneficial use. The process and the relationship with others are also crucial for digital capacity. Concerning the future use of digital tools in transport development, the study shows that tools and approaches must be adjusted to the context. If merely the experts, well-equipped, and skilled individuals understand the digital tools, it will empower the community insufficiently. Meaningful participation and learning are tightly linked, and therefore, it is recommended to conceive the understanding and use of these digital tools as learning for sustainability in the MAB areas.

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Part III Non-Motorised Mobility

6 The Challenges for Active Travel in the Islands of Malta

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There is now considerable evidence to support the claim that active travel (walking or cycling) can help tackle some of the concerns related to the climate crisis (Brand et al., 2021). Apart from this, walking and cycling have other well-documented benefits linked to public health, well-being, and the overall liveability in cities and urban areas (Frank et al., 2010; WHO, 2018). The current COVID-19 pandemic has also instigated a change in the way people view and experience public space, with more and more areas being dedicated to people walking and cycling in many cities around the world (Rhoads et al., 2021). Indeed, many more walkways and cycleways were created in the first months of the pandemic to cater for safe distances for those walking and cycling, and this at the expense of cars and other motor traffic. Lockdown restrictions have had a tremendous effect on urban areas, with many experiencing less traffic, less air pollution and more liveable environments (Popovich, 2020). There is some hope therefore that, as the world recovers from the pandemic and starts tackling the climate crisis more seriously, the effectiveness of active travel is valued and given the priority it deserves in urban transport policy and planning.

Small island states vary considerably in levels of economic development and, possibly as a result of this, in the development of their transport systems. A comparison of island states shows how diverse island states can be in terms of key socio-economic and transport characteristics. Table 6.1 ranks nine island states from various parts of the world in order of economic development. The strong relationship between GDP and rates of motorisation (vehicles per 1,000 persons) is only broken by the strong and restrictive policies implemented in Singapore aimed at curtailing the growth in motorisation and car dependence (Diao, 2019). The rest of the island states show a growing car dependence linked to increase in GDP and, in some cases, to per capita emissions.

Table 6.1 2019–2020 Key Socio-Economic and Environmental Characteristics for a Slection of Small Island States

COUNTRY	POPULATION (IN MIO)	AREA (KM²)	PER CAPITA CO_2 EMISSIONS (T)	PER CAPITA GDP ($)	VEHICLES/KM OF PAVED ROAD	VEHICLES/ 1,000 PERS
Haiti	11.4	27,750	0.29	2,773	23.5	7.1
Papua New Guinea	8.9	462,840	0.81	4,101	145.8	11.4
Jamaica	2.9	10,991	2.72	8,742	35.9	64.4
Maldives	0.5	300	3.14	13,049	753*	131.8
Mauritius	1.3	2,040	3.69	19,470	56.7	92.5
Trinidad & Tobago	1.4	5,131	27.14	23,728	120.2	714
Republic of Cyprus	1.21	5,527	6.10	37,655	105.7	1,023
Malta	0.5	316	3.53	39,222	148.8	804
Singapore	5.9	728	6.71	93,397	100.8	167.9

*Note. *Over 80 % of vehicles in the Maldives are motorcycles with under 6 % being cars. This figure represents the limited road network on the island. Compiled by author from ourworldindata.org, datacatalog.worldbank.org and other various internet sources.*

This chapter focuses on the Mediterranean islands of Malta. In 2018, the modal share of walking and cycling in the islands was less than 3 % of all trips (Project Aegle Foundation, 2018). The rise in car dependence since the 90s has seen a steady decline in non-car trips. This has resulted in a steady increase in congestion and traffic related pollution, and a decline in the urban space dedicated to pedestrians and cyclists and overall quality of the urban environment. With Malta having missed its 2020 climate change emission targets, the need to refocus policy on active travel is not only urgent but also necessary to promote sustainability. This chapter looks at the challenges for active travel in the islands through a review of the research conducted in Malta on walkability and bicycle sharing.

The Practice of Walking

The positive impacts of walking and walkable spaces have been documented in decades-long and multi-disciplinary research which claim benefits in socio-economic, environmental and even political arenas (Berg, Sharmeen and Weijs-Perree, 2017; Mackenbach et al., 2014). These impacts make the practice of walking and, therefore, walkability a key factor to address current challenges in the areas of public health, urban and transport planning, economic and social development, environmental sustainability, and cultural enrichment (Cañas and Attard, 2021).

A decline in walking was observed across the western world in the 1970s, mainly attributed to urban sprawl and the creation of car-oriented cities. However, in SISs, the shift to motorised travel happened later, with some being still in the process of developing chronic car dependence. This process can be easily observed in Malta, with the rise of car trips during the 1990s and 2000s (Figure 6.1), and the fast and steady decline in bus and coach trips and trips carried out on foot. The rise of the car and the decline in active travel in the islands has also led to other impacts on health, with high rates of obesity among the population, traffic-related injuries and fatalities, a reduction in social cohesion and overall environmental deterioration (Attard, 2020). All similar factors were trends observed in larger urban areas (Marshall, Brauer and Frank, 2009).

In view of this decline in active travel, some transport research focusing on walkability studied the role of the urban fabric characteristics and land use distribution in supporting and encouraging people to walk to certain destinations (Cervero and Kockelman, 1997), while urban research focused more on the role of streetscape in providing proper public space to pedestrians for their daily life (Gehl, 1987). Subsequently, health researchers interested in increasing walking to improve public health developed walkability indices based on transport and urban principles to study built environment correlates of walking (Frank et al., 2005).

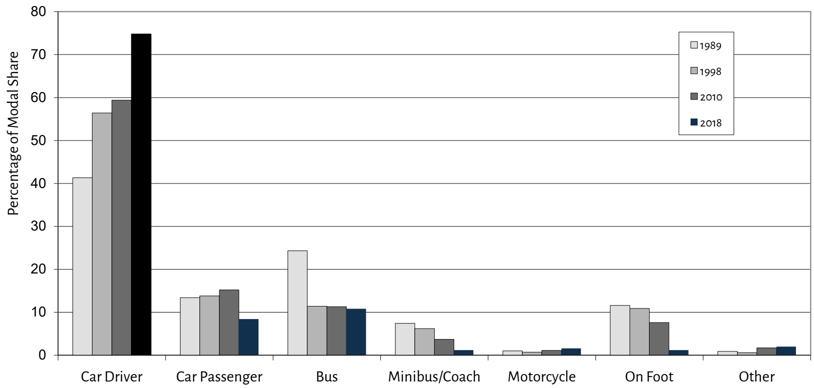

Figure 6.1 Malta's Modal Split 1989–2018
Note. Compiled by author from Transport Malta (2010) and Project Aegle Foundation (2018)

Walkability became a new measurable concept to investigate further implications of walking activity and pedestrian-friendly environments in different fields, such as economics and sociology (Litman, 2018; Greenberg and Renne, 2005). Currently, walkability is being increasingly included as a key component in urban liveability and sustainable development policies and research (Transport for London, 2018; Rafiemanzelat et al., 2017; Guzman and Douglas, 2015).

Using Citizen Science to Understand the Elements of Walkability

The first well-established walkability index was based on objective observations on some large-scale characteristic of the urban fabric and land use, which determine walking proximity to certain destinations (Frank et al., 2005). As more resources and data were made available, more ambitious walkability indices looked into elements and characteristics of the public space at street level, including pavements, crossings, street furniture, barriers and obstacles, the streetscape and so on (Park et al., 2015). The translation of the walkability of a place into certain elements and characteristics of the public space helped to empirically assess the relationships between the walkable environment and walking activity.

However, as walkability increasingly became linked to urban sustainability and liveability research with a strong social and cultural component, the more recent studies have shifted the focus from objective observations of the built environment and walking activity, towards pedestrian experiences of the public space, which requires a more subjective approach to assess what are rather ambiguous concepts, such as sense of safety, comfort, pleasantness or vibrancy. Having said that, both dimensions of the built environment should be taken into consideration, as different associations have been found between the objective and subjective dimensions of environmental features with walking behaviour (Chan et al., 2021).

In addition, because walking can be differently addressed from being just a means of transport to moderate physical exercise, as a recreational and cultural activity, or even a combination of all of them, the environmental determinants influencing walking may vary depending on the specific purpose of the walk (Gao et al., 2020). Furthermore, from a holistic perspective, walking can be seen as a behaviour rather than a specific activity. Consequently, the determinants that support and encourage people to walk span all levels of influence of the socio-ecological model, including personal, interpersonal, environmental, and policy factors (Sallis et al., 2011; Van Dyck et al., 2017).

A growing number of researchers have started to agree on the fact that there is neither 'one size fits all' walkability assessment (Moura et al., 2018), nor a unique desirable walkable environment that satisfies all pedestrians (Stafford and Baldwin, 2018). This context-specific nature of walkability points out the need to take into consideration the particularities of the place and people under study, as well as the purpose of each walkability research or policy. Faced with this reality, there are more and more participatory and pedestrian-centred walkability assessments, which try to better understand the underlying relationships between specific walkable environments and the pedestrians who experience them, so that specific policies and planning interventions can be proposed accordingly.

In order to support active travel policies in Malta, specific research into the elements of a walkable environment was necessary to encourage and enable walking. Cañas, Attard and Haklay (2020) have used a citizen science approach to assess the perceived walkable environment and identify the elements of that environment, which, in turn, affect walkability. This pedestrian-centred approach allows for the collection of georeferenced subjective and objective observations about the walkable environment as part of the participant daily routine, using existing social media platforms and smartphones. These observations create a subjective assessment, complemented by objective data that is very precise, reliable, and provides further insights into walkability.

This work is part of the WalkingMalta Project being undertaken at the Institute for Climate Change and Sustainable Development within the University of Malta, spearheaded by Carlos Cañas (www.walkingmalta.com). Participants in the study are encouraged to take photos of their walking environments and use predefined hashtags to rate their pedestrian experiences through the following opposing variables: #Safe or #Unsafe; #Comfortable or #Uncomfortable; #Pleasant or #Unpleasant; and #Vibrant or #Dull. Participants can also identify and list what influences the experience by including text about certain elements they notice which make an environment, for example, unsafe such as #nopavement or pleasant such as #trees or #greenery. These constructs of safety, comfort, pleasantness and vibrancy have been used in walkability research based on the theory of 'pedestrian needs' (Alfonzo, 2005) and others that have tried to define the walkable environment with a list of characteristics (e.g., Cambra, 2012).

As part of the active travel research projects, Attard, Cañas and Maas (2021) used an activity workshop, attracting a number of local stakeholders, to further engage with participants, and through the methods developed in the WalkingMalta project, collected further information concerning walkability and cycling around the University of Malta, Msida campus. The campus attracts over 11,000 students and 2,000 staff members and is surrounded by major roads that link the island's north and south, and west to east. Accessibility to the campus on foot or by bicycle is not that easy and, therefore, the campus was chosen for this initial workshop to address some of the concerns that hinder active travel.

An initial understanding of the data collected in the workshop paints a rather bleak and discouraging situation for those choosing to walk or cycle in the islands. Figure 6.2 shows how, out of 300 observations collected through the WalkingMalta methodology (Cañas, Attard and Haklay, 2020), many are negative and most are related to safety concerns. The lack of comfort and the many unpleasant experiences further demonstrate how the walkable environment in the islands requires substantial investment if it is to attract and encourage active travel. The elements associated with the experiences were also analysed (Figure 6.2). Pavements, greenery, obstacles and absence of supporting infrastructure are some of the more common elements, which lead pedestrians to enjoy or dislike the experience of walking in Malta's public roads and spaces.

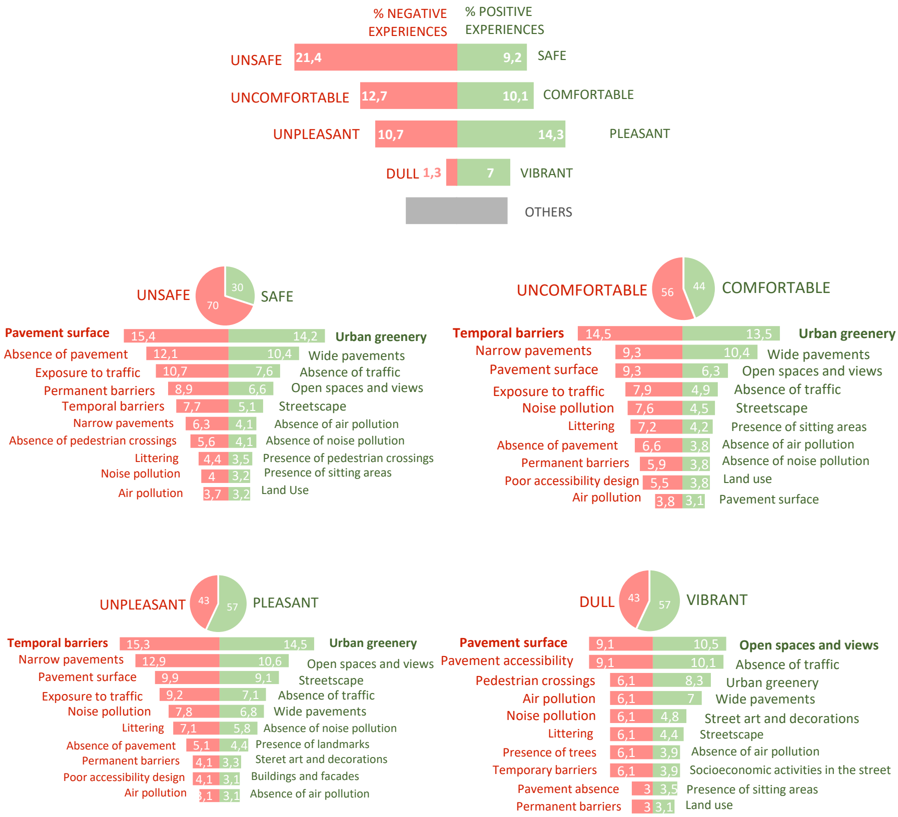

Figure 6.2 Percentage Distribution of Positive and Negative Experiences and Elements
Note. Compiled by authors

Outcomes and Further Research into Walkability

Research into the practice of walking in the island was not without challenge. Difficult public engagement, just representation of all pedestrians, cyclists and road users, and potential bias brought about by a culture of complaining influence the research and, potentially, the effectiveness of the methods to improve walkability. The need for better and safer infrastructure however is evident throughout the results of the research, and tangible outcomes, in the forms of reports and recommendations to local authorities to improve walkability have given the WalkingMalta project enough visibility and local public engagement (see, for example, Calleja, 2020). This has put the issue of walking on the national agenda. The research and subsequent workshop also produced a detailed report in 2020 on measures to improve local roads, starting from the roads leading to the University of Malta Msida Campus (Institute for Climate Change and Sustainable Development, 2020). Further research will go into the validation of the WalkingMalta methodology and the potential analysis techniques for understanding the experiences and elements that make up walkability.

Bicycle Sharing as Active Travel

Around the world, there are some 3,000 active BSSs. And although these schemes have been available since the late 1990s, many developed just over the last decade (Galatoulas et al, 2020; Fishman, 2016). Research into the systems have tried to establish their impact on cycling modal share and their potential to achieve urban mobility goals (Médard de Chardon, 2019). However, most of the research has focused on medium to large cities where cycling and cycling infrastructure was already established. Islands, on the other hand, alongside so-called 'starter' cycling cities with low to negligible cycling and infrastructure are still very much under-researched (Félix et al., 2019). The contribution of cycling, as part of active travel measures that promote healthier and cleaner travel, should be included in any island transport policy, and an understanding of how this can be affected by the introduction of BSSs adds to the current literature, especially when it focuses on islands.

Cycling in Malta has the lowest share in the islands' modal split, it accounts for less than 0.5 % of trips and cycling infrastructure is limited, fragmented and mostly located outside the urban area. Recent infrastructure interventions for cyclists on reconstructed and widened roads in the islands remain fragmented and inconsistent in style, from sharrows and 'share the road' signs to painted cycling lanes on the road and roundabouts, bridges and lifts to cross large junctions and arterial roads, as well as separated cycling paths in certain locations (Farrugia & Maas, 2020). According to studies carried out in the islands, cycling is perceived as dangerous and therefore not an alternative to the car or 'safer' modes of transport (Maas and Attard, 2020; Transport Malta, 2016). In addition, 34–49 % of the population does not know how to cycle (Maas and Attard, 2020). This has also been linked to the high rates of obesity among the population (58 % of adults) and the lack of walking/active lifestyles in general (Superintendence of Public Health, 2012).

The Characteristics of the Bicycle Sharing Scheme in Malta

Over the recent years Malta, like many other islands and cities worldwide, experienced the introduction of bicycle sharing. Despite the low use of bicycles, Nextbike Malta started operating shared bicycles in late 2016. It has now 60 stations and over 400 bicycles, and in 2019 it registered around 11,000 users. The majority of the stations are located around the central urban area, north of Valletta with other isolated clusters in other parts of the island. A second operator, Tallinja bikes started providing electric shared bicycles in Valletta and later in other locations including the University of Malta campus. A quick overview of the locations assigned for bicycle sharing stations shows how they are strongly linked to tourists, foreign residents and students (Maas et al., 2021; Maas, 2021).

The research into so called 'starter-cities' is very important to understand the role of bicycle sharing activities as a promoter of cycling. Maas et al. (2021) report on the reasons for using bicycle sharing and cycling as mode of transport in Malta, Limassol, and Las Palmas de Gran Canaria. There is significant association, by frequent shared bicycle users, with use of other 'alternative' modes of transport such as public transport and taxis, the provision of cycling paths and lanes, and improved (perceived) road safety, short distances to location and frequency of home and work destinations, and motivating factors such as money-saving and convenience.

The profile of shared bicycle users is also an important element to consider. Maas (2021) reports that in Malta some 73 % of the users are highly educated, employed or students. This is in line with the characteristics of other islands (Limassol and Gran Canaria), but also other shared bicycle systems where the majority of users are educated and employed (Fishman, 2016; Médard de Chardon et al., 2017). They also present interesting characteristics with regard to mobility options. Figure 6.3 shows what other modes of transport, bicycle sharing users have access to in Malta.

The potential to use multiple modes of transport when cycling, or using a bicycle sharing scheme (BSS) is another important element, and whilst in Malta many users do not combine modes (over 30 %), those that do, use walking (55 %) and public transport (20 %). The least used is the car (Maas, 2021).

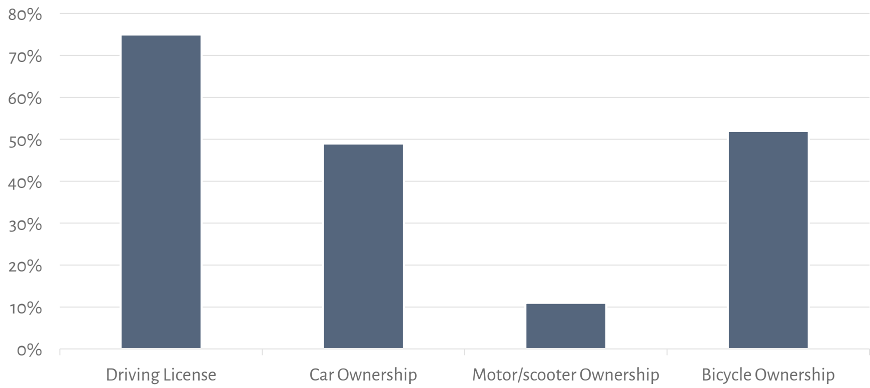

Figure 6.3 Access to Transport Modes by Bicycle Sharing Users in Malta
Note. Compiled by author based on Maas (2021)

Considering that the scheme in Malta is still relatively new, Maas (2021) also investigated previous travel behaviour among shared bicycle users in Malta in an attempt to establish possible modal shift. Whilst 11 % of trips were new trips made with shared bicycles, a considerable number of trips were shifted from walking (34 %) and the bus (18 %). This is not surprising given the convenience and speed which cycling offers when compared to both walking and using the public transport. A very positive 17 % of trips were shifted from the car whilst 10 % were already bicycle trips, carried out by personal bicycles. The remaining 10 % of trips were shifted from motorcycles and taxi, both positive shifts to cleaner modes of transport. Overall it becomes evident that some benefits can be accrued through the implementation of bicycle sharing, and that further investment in infrastructure, for example, would go a long way in attracting travellers from highly polluting modes to cleaner and healthier modes of transport.

Discussion

With the publication of the 6th Assessment Report by the IPCC in August of 2021, it is very clear that urgent action is required on all fronts to mitigate man-made emissions and adapt our cities to new realities of climate change. For many countries, including islands, transport remains a growing concern as emissions from increasing car use continue to rise. And as urban areas continue to attract more and more populations (and tourists), the growing need for sustainable urban transport solutions become more critical. This is also true for islands that are experiencing economic development, and as a consequence have struggled to control or contain the rise of the car over other, less environmentally damaging forms of urban transport.

As islands with unique geographies and socio-economic characteristics, there lies opportunities for leading the front towards more sustainable mobility, particularly on active travel. Malta, the case study showcased in this chapter, is one of those islands, which has developed economically over the last few decades, with negative consequences on its environment and public health. Despite the challenges of shifting more successfully to active travel modes, the island has many opportunities brought about by its geographic size, population density, climate and a relatively strong economy that is able to invest in the necessary infrastructure to support change.

Our research into walking and walkability provide some interesting preliminary research findings that point towards a complex relationship between the walkable environment and pedestrian experiences in the Maltese context. Over 65 different environmental elements and characteristics of the public space were identified by the participants in the WalkingMalta project so far, as relevant influences on their walking experience, either in a positive or negative way. These determinants arise out of the presence, absence, and characteristics of pavements and walkways, pedestrian crossings, street furniture, green urban areas, barriers and physical obstacles along the way, buildings, street art and decorations, open spaces and views, exposure to traffic, air and noise pollution, odour, littering, weather conditions, urban fabric and land use, outdoor activities, stray and wild animals, public transport and more.

Some of the elements and characteristics identified by the participants are in line with current research, such as the importance of green urban spaces for positive pedestrian experiences or the negative impact of the exposure to fast traffic. However, the context-specific nature of this participatory research has helped to find out the specific issues in the Maltese context. Some of these include architectural barriers from the construction of private steps or ramps on the public pavement, recurring temporal barriers from rubbish bags due to the daily day-to-day refuse pick up, or simply the many parked vehicles on the pavement. Ultimately many complain of poorly managed roadworks and building construction sites that negatively affect pedestrian experiences. Such observations can be of great help to identify specific measures to tackle these singular issues at a local scale.

The long list of determinants identified by the participants as relevant influences on their pedestrian experiences show a remarkable diversity of elements at different urban scales and temporal components. Pedestrians interact with different elements at the same time and, although some elements can play a significant role, their overall experience hardly ever comes from an isolated determinant, but from the combination of all of them together. This highlights the need for more comprehensive and multi-disciplinary policy and planning interventions to improve the walkable environment in Malta and beyond, in order to support and encourage more walking.

Investment in alternative modes of transport on its own does not bring about significant modal shift; effective change in mobility behaviour only occurs when there is a combination of 'carrots' and 'sticks' (Nikitas, 2018; Piatkowski et al., 2019). The combination of efforts to increase the safety, convenience, and feasibility of walking, cycling, and public transport, with policies to reduce and restrict car use has been shown to have the greatest positive impact on increasing liveability and sustainable mobility in cities and achieving modal shift towards active transport (Buehler et al., 2017; Oldenziel et al., 2016; Piatkowski et al., 2019).

Concerns over road safety are the main barrier to promoting cycling in starter cycling cities (Felix et al., 2019; Maas et al., 2021). The creation of an integrated cycling network, comprising segregated cycling paths along high-speed or high-volume roads, as well as traffic-calmed streets, connecting residential, employment and entertainment areas, could further promote cycling and BSS use. In the historic urban fabric with narrow streets, which are often one-way, there are opportunities for applying filtered permeability solutions (interventions allowing pedestrians and cyclists to pass, but not motorised vehicles) or contraflows for cyclists, allowing for more direct routes in the cycling network. The growth in cycling modal share in Seville (Marqués et al., 2015), a Southern European city that has promoted cycling in recent years through the creation of a connected network of separated bicycle infrastructure and the introduction of a BSS, highlights the potential for other 'starter' cycling cities like Malta and many other islands.

Enabling and promoting the complementary relationship between (shared) bicycle use and public transport have the potential to promote multimodal travel as an efficient alternative to private vehicle use. Using public transport for longer distances and (shared) bicycles to cover the first or last mile can provide an avenue for growth for cycling modal share and bicycle sharing use (Handy et al., 2014; Heinen & Bohte, 2014; Olafsson et al., 2016). And this has been the experience with the new mobility operators and services looking at extending the offer to users, from bicycle sharing to e-scooter sharing and other on-demand public transport services which have been implemented in Malta in the last decade.

Conclusions

The need for a modal shift to active travel in urban areas has become a priority for many cities looking at adopting sustainable mobility practices. This has been further encouraged by the recent COVID-19 pandemic through a mix of measures implemented in various parts of the world to provide more space for people to walk and cycle. The overall positive and swift reaction to changing behaviours and urban environments is testament to the opportunities that politicians and authorities have to take forward the necessary changes to urban transport systems. In islands, which are struggling with increasing car dependence and declining urban environments, the potential of active travel seems an obvious solution. Many are relatively small with short travelling distances, have good weather conditions that support active mobility throughout the year, and with benefits accrued from improving the quality of the environment that matches their dependence on a quality tourism product which, in turn, supports the growing tourist numbers.

Research into walking and cycling on islands is very important since there is a dearth of literature, which focuses on such island states and case studies. Urban areas in islands might be similar in size to small and medium cities in larger countries, however, their isolation, specific geographies, socio-economic and cultural characteristics, weather and governance structures make for unique micro urban areas that require specific attention. This chapter reviewed the work that is currently happening at the Institute for Climate Change and Sustainable Development at the University of Malta with respect to walking and cycling. Some of the results point towards specific policy and planning actions that would benefit and encourage more active travel in the islands.

It is hoped that this will instigate further research into active travel, and more evidence is produced in support of policies that seek to prioritise sustainable mobility. Ultimately, it is in the interest of local and national authorities to aim for more sustainable development, less emissions and improve well-being. Being islands, with many dependent on the tourism sector for economic growth, the interface with tourism travel is a key and important research area. Further work in this regard is required to establish best practices and measures to align more effectively with growth in tourism, active travel, and sustainable travel.

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7 Walking in Havana, Cuba

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Walking pedestrians account for nearly half of all daily trips in Havana. Walking provides many positive and sustainable benefits, including those linked with accessibility, health and energy conservation, but until recently, transport and urban planners have paid relatively little or less attention to the walking environment. Havana is an exceptional case among island cities in many ways and one outstanding feature is the high level of walking with 46 % of all trips carried out by pedestrians. The use of the bicycle accounts for another 1.8 % as a sustainable form of mobility. In six other Latin American cities walking and biking taken together account for many less trips resulting in a range of values from 32 % to 40 % of all trips, in Barranquilla, Curitiba, Guadalajara, Salvador, Recife and Belo Horizante, respectively (Hidalgo & Huizenga, 2013, figure 6, p 70). The high values of walking as a share of total trips means that more emphasis should be placed on creating better walking environments.

Good walkability depends on factors woven into the urban fabric, such as creating compact built-up areas and preventing city sprawl, increasing spatial accessibility through good street network design, creating public spaces as well as pedestrian and bicycle networks, stimulating walkability, creating mixed functions in the districts preventing social segregation, protecting green urban areas, and improving of public transport infrastructure (Telega et al., 2021, p 3). Both Telega (and CNC 2020) note that the Charter for New Urbanism is aligned "to growing the supply of neighbourhoods that are both walkable and affordable; work to change the codes and regulations blocking walkable urbanism; and advance design strategies that help communities adapt to climate change and mitigate its future impact"

The main objective in this study is to explore two methods called movement and place mapping maping, and walkability surveys (or audits), both of which can highlight issues around walkability and provide different types of data for Havana city. The movement and place mapping gives an overarching view of all movement and place for the entire city's needs by classifying streets leading to a greater consideration of the needs of people, rather than vehicles, in street planning and design (Jones et al., 2008). The movement and place method helps to determine the appropriate balance of street space and capacity to be allocated to different street user groups and can be used to place greater emphasis on walking and pedestrians. The walkability survey method focusses more on the street level, homing in on issues specific to that street by asking those who use the street where it works well and where it fails to meet the walkers' expectations (see Carmona et al., 2018 for examples). The study concludes with some recommendations for improving walkability.

There is widespread agreement (Fitzsimmons et al., 2010; Lo 2009; Carmona et al., 2018) that the presence of good local quality routes, accessibility to destinations, and perception of safety are three key features that contribute to 'walkability': a multidisciplinary concept describing the extent to which a place is conducive to walking. The definition of walkability has been contested, with debates about what are the best ways to measure it (Forsyth, 2015). In the case of London, a 'Living Streets' survey (Living Streets, 2017) that measured walkability in terms of responses to a few simple questions on a website app found that 72 % of respondents felt the streets were of good quality, 67 % felt the pavements (sidewalks) were good, 57 % said they felt safe walking, and more than 60 % said they could get to shops and parks easily. Measurements and surveys do not always translate well from place to place, and care is required in adapting experimental work for the context of the specific city. To understand the context for these studies, the next section describes the context of mobility and accessibility in Havana, and in particular, the role of walking in the capital city.

Mobility in Havana – the Importance of Walking

Understanding Havana's general transport situation and mobility patterns is essential for developing further sustainable policies for walking in the city. The most recent city mobility survey (Magdaleno et al., 2014), which covers all 15 municipalities of Havana, with 2.1 million inhabitants and an area of 728 km^2, was carried out in 2012. Figure 7.1 shows a map of Havana with the municipal boundaries shown and the main roads and routes into the historic city centre. Important destinations are labelled and shown with single line hatching. The survey, which defines a trip as any movement of more than 500 metres by any mobility mode, found that most trips were on foot. In second place was trips by bus, accounting for 21.1 % of daily trips, followed by cars (10.9 %) and taxis (4.7 %). A smaller number of trips are taken by ferry boat, truck and motorbikes. The key factors from the survey are in Table 7.1.

Table 7.1 Active Mobility, Havana, 2014

PARAMETER	MEASURED VALUE (UNITS)
Trips taken on foot, walking	46 % (of all daily trips)
Daily number of trips/person *	2.16 trips/person (all modes)
Walking trip distance *	1.0 km
Walking trip travel time *	17:34 minutes
Walking speed *	3.3 km/hour
Trips taken by bicycles	1.8 % (of all daily trips)
Bicycle trip distance *	2.1 km

*Note. * Indicates averages. Magdaleno et al. (2014), adapted by the authors*

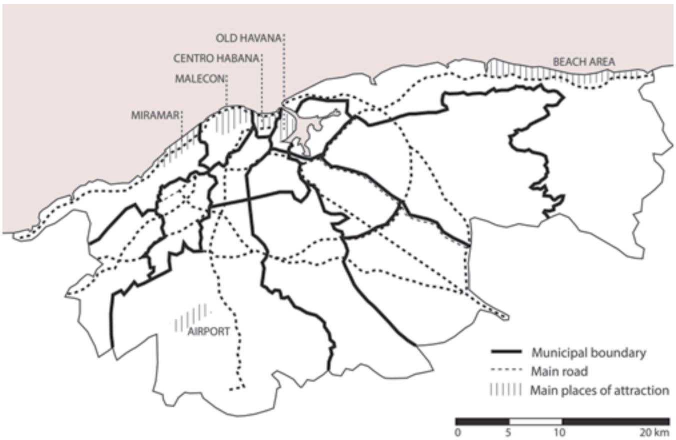

Figure 7.1 Map of Havana
Note. Compiled by authors

Many daily journeys in Havana are multimodal – in other words, passengers have to use multiple forms of transport, each one of them defined as a 'trip', to get to the final destination (Hotz, 2007). For example, one journey from home to work in the morning might involve 4–5 trips, starting with a walk to the bus stop (600 metres), then taking the first bus (5 km), then another (3 km), and finally walking the last 100 metres to the office. If each of these smaller trips take 10–15 minutes, then the overall travel time will be 45–65 minutes long. Rydin et al. (2012, p 2093) note "there is no doubting that walking and cycling are beneficial for health, the fact that poor people are often forced to walk long distances, especially those living in large cities, is not a good situation."

The relatively high dependence on walking and public transport is due to Havana's relatively low level of motorisation, low private car ownership (Enoch et al., 2004). The importance of active modes of travel is recognised by Havana's TA (Rodríguez & Campos Pompa, 2016), which is responsible for designing the city's overall transport strategy and implementing policy, but conditions for walking present challenges and difficulties for many users. This is particularly important for those with impaired mobility, who are a growing proportion of the population: in 2020, 22 % of Havana's citizens were 60 years or older (ADC, 2107). By 2030 the ratio is projected to increase to around 30 % (ADC, 2017; ONEI 2021). Those with mobility impairments or lower incomes often have lower mobilities, and need additional consideration for their walking needs (Rydin et al., 2012; Gehl 2010, Ardila-Gomez, 2012).

Havana is unique compared to other cities, as the motorisation levels are low currently, but the city was once more aligned to higher levels of automobile-centric practices (i.e., high car use and ownership) (Schmid & Peña 2008). This layout did create sprawl in the western zones, however, with the low car ownership levels of today this underlying layer of the city results in various disparities. Some areas have wide and pleasant boulevards and others are much more compact, offering less spaces for mobility – in general the older, more central parts of the city have less space for walking. When thinking about walkability it can be useful to consider the trajectory of automobile growth (and or decline) over time if this has had an effect on walking and pedestrianisation.

Another difference in Cuba is that whereas urbanisation in many island cities has been rapid (Pigou-Dennis & Grydehøj, 2014) in Havana the population has been relatively stable over several decades (ADC, 2017). The city has always been strongly internationally connected, and as the country's capital, it acts as a strong attractor, drawing in migrants from other parts of the island. The capital accounts for almost 20 % of the Cuban population. It is a relatively dense urban area, with a historic core and smaller sub-centres. In terms of mobility, the most recent survey confirms that walking accounts for the highest number of daily trips, not only in the centre, but also in peripheral neighbourhoods. It is, therefore, important to understand the walking conditions and the factors that might improve them, in order to improve the quality and performance of urban mobility in Havana. The next section will look at two tools that have been used to investigate conditions for walking in Havana in order to help shape more sustainable transport practices. The chapter then describes the results observed using both of these methods, and outlines some lessons which can be applied elsewhere.

Walkability Survey Methods

The two methods both involve auditing and classifying walking areas, in order to better understand and describe walking and walkability, with an ultimate goal of increasing and safeguarding walking and pedestrians. The first method of movement and place is most appropriate for large-scale mapping. The second method is more appropriate for smaller-scale districts or single streets. It would be possible to carry out, for example, a walking workshop or series of surveys across the city in different municipalities as well but in this study we focus on a single street (called *Galiano*) of importance for shopping which is also close to a major transport interchange.

Movement and place

Two main methods are described in this chapter, with their results. The first used the 'Link and place' approach (Jones et al., 2007; Jones et al., 2008), re-cast as 'movement and place': '*movimiento y lugar*' in Spanish. Using multi-stakeholder participatory workshops, the city of Havana was mapped using a set of criteria to describe the entire city network employing the method of link and place, whereby every street is characterised by the importance in terms of movement (M1 to M4) and place (P1 to P4). 'Movement' includes all movements of people, objects and services, and is not only motorised vehicles (bus, taxi, car, truck) but also all other forms of movement including walking, biking, strolling, skateboarding, etc. (Jones et al., 2008); and the 'Place' function describes the location's use as a destination itself, where people spend time to meet or socialise (Ortegón-Sanchez et al., 2022, Forsyth, 2015). The matrix of movement and place is shown in Table 7.2, with descriptors for each level: national, city, municipality, and neighbourhood (*barrio*).

Table 7.2 Movement and Place Criteria with Corresponding Strategic and Geographic Level

LEVEL	MOVEMENT DESCRIPTOR	PLACE DESCRIPTOR
National	M1 part of a national route, connects main cities (moving goods & people)	P1 places of national or international significance (tourism attraction, high historic or cultural value)
City	M2 part of the major routes in the city – key radial routes or strategic routes, connects municipalities, connects centres or subcentres	P2 places with high significance and value for the city (but not at the national level)
Municipal	M3 enabling movement of goods & people within the municipality	P3 Relevant places for the municipality (commercial centres, etc.) used mainly by those living nearby (often not frequented by those living outside that area)
Neighbourhood (Barrio)	M4 Local streets primarily for access, residential streets and service lanes	P4 Places of interest exclusively for the users or residents of the immediate area

Note. Adapted from Ortegón-Sanchez et al., 2022 and based on Jones et al., 2007

The main streets were coded in terms of m and P values on a 4× 4 matrix. About 2 % of all space is designated as M1–M3 and P1–P3 combinations, with the rest consisting of minor local (M4 and P4) thoroughfares. By identifying locations according to the categorisation on the Movement and Place matrix on the map of Havana, the survey reveals how streets are used for both transport routes and as destination-spaces, and so becomes a useful tool for transport planning.

Clearly, places that community participants designate as P1 and P2 need to be recognised as spaces of importance for the area's inhabitants, and this needs to be taken into account alongside the status of the road as a conduit for movement, so this mapping technique can help to identify the location's difficult discussions about levels of traffic, space for walking and many other facets of mobility can be explored. The street is called *Galiano*, a major shopping street in Central Havana that was categorised as M1 to M2, and P1 to P2, indicating national/high significance with critical/major flow of people and goods. It is here that the second type of spatial analysis was conducted. The position of *Galiano* street in Havana is shown in Figure 7.2. *Galiano* connects the sea front (the *Malecón*) to *Curita* Park, which is a busy interchange where many people change modes of transport from bus to taxi or vice versa. The *Capitolo* building is located north-east from *Curita* and Old Havana's pedestrianised area is approximately a 10-minute walk away, depending on walking speed and route taken.

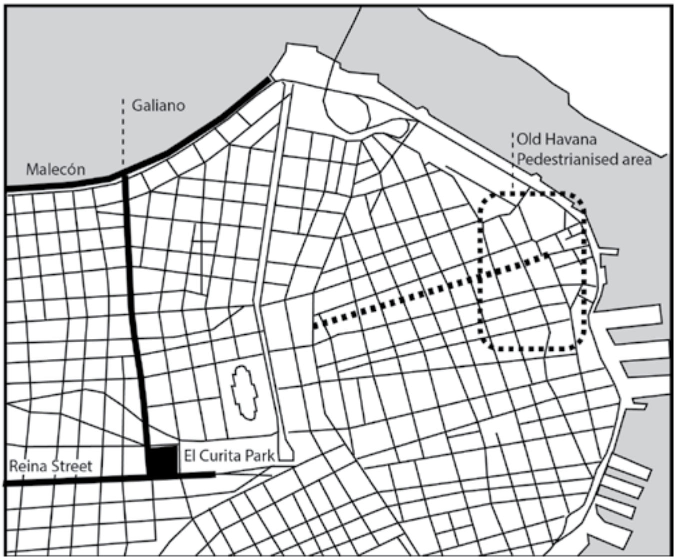

Figure 7.2 Map of Havana Showing *Galiano* street
Note. Compiled by authors

Auditing 'Walkability'

In the study of *Galiano* street, the focus was on the experience of walking in a specific location. Running from the seafront to the *Parque el Curita*, a city square, *Galiano* attracts many pedestrians, but suffers from poor infrastructure for walking. The research centres around a "walkshop" method, or "walking workshop" (Ortegón et al., 2022), carried out in the city street, with participants walking, rather than working in a studio or educational environment. In this way, the participants have direct connectivity to the street and those who use the streets.

A variety of surveys can be carried out by those undertaking a walkshop – the walkers themselves can complete the survey, or enlist others walking in that area to complete the survey (see Saunders 2021a and 2021b for a wide range of tools). Both sets of participants will yield meaningful results but, as highlighted by Fitzsimons et al., (2010) and Forsyth (2015), different stakeholders will have different perspectives on how walkable a route seems to be. These different sub-groups of walkers perceive different issues and problems with walkability and describe issues in subtly distinct ways that researchers need to be aware of, as they try to cater for different needs of all members of the community.

In the *Galiano* study, walkshop participants included 22 transport policy practitioners, local stakeholders, and researchers, supported by students studying architecture and the built environment who know *Galiano* well. Most of *Galiano's* pavements are protected from the traffic in the street by their colonnades – essentially large porches at the front of every building, supported by a series of columns at regular intervals. These areas provide shade and shelter for pedestrians. The buildings function as both housing and commercial, so some porches have a lot of activity, with customers waiting to be served from sales outlets, or people visiting friends or family.

The walking audit used a series of 20 questions based on the main themes, which comprise what constitutes walkability as perceived by the participants using three main areas of interest. These can be categorised as infrastructure quality, environmental quality, and subjective well-being (Ortegón et al., 2022 and Saunders 2021a). The infrastructure theme includes items such as seating, places to stop (and rest), crossings, shelter, width and surface of pavement, and obstacles in the way of the users. Environmental items include noise, air pollution, traffic levels, litter and safety of pedestrians. Subjective well-being includes whether users feel satisfied, relaxed, and if the surroundings are attractive and welcoming; these are also called alternatively global assessment of the street. Destinations need to be attractive in the sense that there needs to be things to see and do as well as being a destination in terms of why the person might be walking there (such as shopping, work, education, social visits, etc.). The questions were adapted slightly for the context of Cuba as the toolkits, has been devised for use in the UK and Australia. The UK and Australia studies tend to use complicated traffic counts and fine granularity to devise a final outcome or rating, which takes much longer to compile the data. In this instance, a basic set of 20 questions was utilised with a Likert scale. Not only was this more appropriate to the conditions in *Galiano*, but also the more simplified tool ensured that the results could be analysed, shared and discussed on the same day as the audit. Many other types of walking audits are possible to undertake using more complex methodologies (Adkins et al., 2012; Sallis 2021; Cain et al., 2017; TRL/Pers 2021; NACTO 2018).

Results

The results are presented firstly at the city scale level using movement and place to describe the findings for all fifteen municipalities across the entire road network. Secondly, walking survey results of *Galiano* street are explained in more detail, giving a closer view of what issues there are for pedestrians.

Movement and Place

The movement and place results are shown in Figure 7.3. Movement results map on to the traditional road classifications, with larger roads carrying more movement. The ring roads are clearly visible (as M1), and the *Malecón* along the sea front is also classed as M1. Smaller link roads are classed as M2 and M3, and the smallest levels of mobility are shown as M4 being local streets. In this map, for clarity, M4 roads are not shown but they are essentially all other very small roads and streets connecting larger M3 roads. With respect to 'place' (P1 to P3) allocations, the map in Figure 7.3 shows some of the disparities with movement – these are the areas, which could be considered to cause most friction between modes of transport (e. g., walkers and traffic). These areas are denoted by dark areas labelled P1, which are situated very near to M1 locations. It should be noted that P4 places are also not depicted directly in the map to improve clarity. The largest single designation is M4P4 at nearly 76 % of all areas, and this is expected, as the street network in Havana is dense and these streets tend to be used by locals with very little or no traffic. Other areas of interest are those which are M1P4 (6.8 %) and M4P1 (5.6 %).

Table 7.3 Movement and Place Portions Mapped on the Road Network.

	P1 (%)	P2 (%)	P3 (%)	P4 (%)
M1	0.3	0.2	0.2	6.8
M2	0.1	0.5	0.2	3.9
M3	*0.3*	0.1	0.1	3.8
M4	*5.6*	1.3	0.8	75.7

Note. Compiled by authors

M1P4 places an emphasis on movement (low place value) and is due in part to the actual main roads and arterial roads, and the vehicle-centric places nearby. Areas designated as M4P1 are observed mainly in the historical city centre or in pedestrian 'hot spots' in the periphery which correspond to specific places such as parks, the botanical garden, zoo, and the university campuses, and in total account for nearly 6 % of the city. The combination of low movement and high place means that these locations are subject to disturbance from any increase in traffic flows or changes in motorised mobility levels. Areas nominated as M4P2, which account for another 1.3 %, are also important place locations.

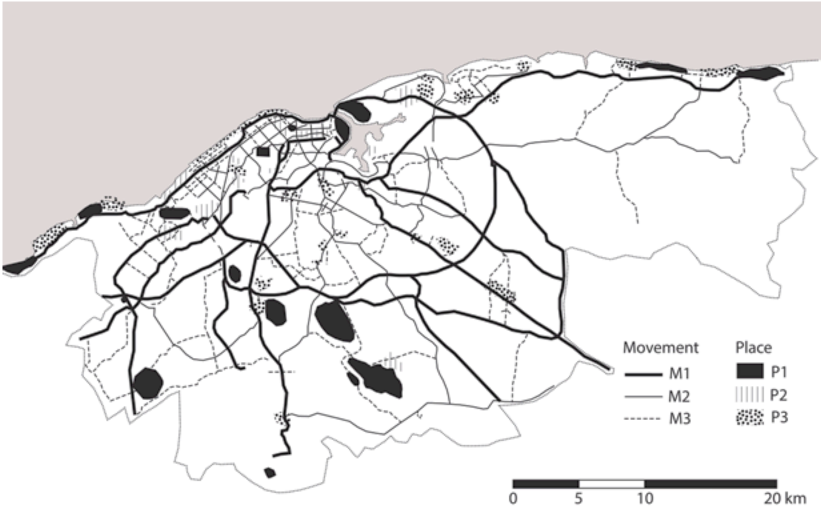

Figure 7.3 Movement and Place Classification of Havana
Note. Compiled by authors

Walkability and the Walking Environment

The walking for *Galiano* found that pedestrians placed high values on the width of the colonnaded area and the shade that the overhang provides (as shelter) was also noted. Other issues that were significant included: a positive environment, it was safe (no crime), attractive and interesting (Ortegón et al., 2022).

Areas for improvement included not having enough places to stop and rest, and issues with obstacles in the way of the walkers. Others noted issues with the colonnade surface, which can change from building to building, creating a walking flow which requires going up and down more frequently than a level surface. This motion, coupled with cracks or slippery surfaces due to water, dust or oil can create increased risk for walkers to fall. In some sections that were being refurbished, walkers had to deviate onto the street, which is only ideal when temporary and when the walking area is protected and well-signposted.

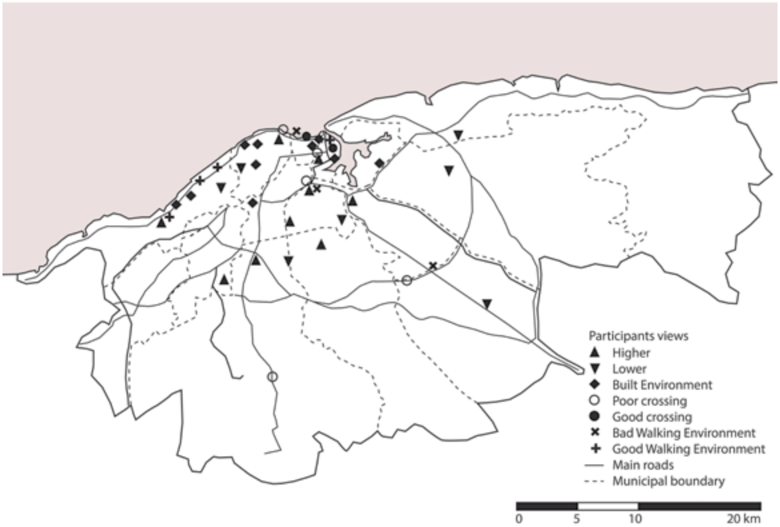

Figure 7.4 Community Views About Walking and Walking Environments in Havana
Note. Compiled by authors

Participants explained that in many instances in Havana at certain times of the day when traffic flows are lower, pedestrians take to the roads as it is sometimes easier (flatter) and more direct than on the pavement; sometimes in the evening the lighting is better in the street too. There is no quantitative measure on this behaviour to deviate into the road, but it tends to indicate a desire for walkers to find the best and most comfortable route. Clearly, walking on the street places pedestrians into traffic and increases the risk of accidents (Rydin et al., 2012).

The movement and place results were then discussed qualitatively, along with the results found by the walking audit. The team mapped their findings onto the movement and place map as an overlay highlighting specific issues that they observed with respect to the overall walking environment. These issues are shown in Figure 7.4. The ring roads and connectors are clearly observed as thin lines, usually as places with high movement being classed as M1 or M2. The participants rated the environments as having a good built environment, the conditions of specific crossings (and thus navigating their way through traffic), and the overall walking environment.

The walking environment, which was the focus of the walkability/walkshop process, is shown on this environmental map as one of the four poor walking environments - namely *Curita*, *Carretera Central* and two major junctions at the head of the *Malecón*.

These are all places that have high movement (M1) for both motorised vehicles as also for pedestrians sharing road space. Similar areas were noted to be places of poor crossings with insufficient space and time for pedestrians to cross streets and junctions. Many of the trips in Havana are multi-modal, as highlighted earlier, and tend to be polycentric, (Hotz, 2007). It is not surprising that places, which were found to be poor crossings– see the five open circles, or places ranked with lower rated environments– are somewhat isolated. These isolated destinations are important places for shopping, work or transport interchange and require further investigation to find out if it is possible to improve the walking environment. Figure 7.4 also shows two places that have good crossings, were deemed to be good environments in both their place and walkability, and these tend to be towards the western and northern edges of the city. These environments are important to city residents as many walk and, in particular, with an ageing population (ADC, 2017), walkers are very aware that falling and getting hurt can result in long recovery times. The elderly walkers try to minimise risk whenever possible. Many mobility studies have not yet considered trips taken by children directly, and with 14 % of the Havana city population being under 15 years of age (ADC, 2017) it is important to ensure this group has access to recreation, play and open spaces with fresh air. Considering subgroups within these studies is important and more work is needed in this area for many cities.

Discussion

This section outlines some of the lessons that have been learned by working with communities in neighbourhoods in Havana when using the various methods, such as link and place and walkability audits. The movement and place method allowed for the establishment of a new way of characterising roads and their associated places, which accounts for all movement – not just movement of vehicles. It reveals the differences between places and can be used to consider ways to make specific locations more 'place-oriented'. An example for Havana would be further investigations on areas deemed M4P2 to see if these places can be enhanced through interventions to make them even stronger destinations for those going there. Similarly, with zones of relatively high movement such as M2P4 and M3P4 (together account for nearly 8 % of Havana) one may want to consider if this movement is caused by too much traffic and if it interferes with the local neighbourhood in terms of difficult crossings, excessive traffic noise, dust, or other issues.

Although, to our knowledge, this is one of the first instances of these kinds of tools being used in the Caribbean and in the Cuban context, we suspect that further use of these tools in other parts of Cuba would be very useful. As one example, it would be useful to know how well these tools translate into other places, and it would be beneficial to compare and contrast certain places for their walking related issues. At the same time it is important to note the differences, for example, as Havana maintains a steady population over time, has low motorisation rates, and very high penetration of sustainable transport modes such as walking and bus use. A study in Jamaica to examine determinants of physical activity, adiposity and diabetes within a multilevel framework found that neighbourhoods with high disorder or areas with higher recreational space availability had significant positive associations with low/no levels of physical activity among women (Cunningham-Myrie et al., 2015). This recreational space availability was counterintuitive to their hypothesis that more space could result in higher levels of activity. It coud be that recreational spaces are associated with a low perceived level of public safety in poorer neighbourhoods.

More detailed work in this area is required and it would be very useful to ascertain if the position of green spaces nearby to neighbourhoods helps raise physical activity levels and/or increase overall happiness and well-being. In this case, the use of street measurement tools like movement and place or walkability surveys can be coupled with health statistics or other forms of data using GIS (geographic information system) to highlight issues of concern and potentially way to improve that environment (Telega et al., 2021; Abastante & Gaballo, 2021). One useful recommendation here is that it is important to understand the demographics of those doing the walking – for example, in Havana, the under 15-year-olds represent 14 % of the population (ADC, 2017). It is also important to provide places and space to play and engage in recreation, as this improves well-being and mental health (Roe & McCay, 2021; Gehl 2010). Rydin et al. (2012) emphasise that urban planners need to help promote a higher level of physical activity through interventions. Interventions include any actions which can help increase population density, diversify land uses, consider transport demands for all groups, and improve street connectivity overall. In general, any proactive action which attempts to change and improve the overall built environment can be considered to be an intervention. These can be as simple and inexpensive as line markings for crossing, or much more complicated as a series of planned actions. A series of twenty non-motorised policies which can support interventions that are more sustainable are summarised by Pojani and Stead (2015, p 7792, Box 2) based on work from Northern European cities.

The *Galiano* street audit found that certain factors were better than others – such as provision for shade, visual stimulation, and the utility of shopping, and accessing the interchange. Areas for improvement included those suggested by Gehl (2010) such as better surfaces, ramps, removal of irritating obstacles in order to provide a more disciplined pedestrian zone. Gehl also recommends that a physical distance of about 500 metres is found to be acceptable (p 127), and that when comfort is low, then sometimes the distance needs to be even shorter. *Galiano* appears to have segments, which help break up the route. This is an area that could be considered for future interventions to make this walking area more pleasurable. Considering the movement and place of each street in the network alongside of their respective local street audits would also yield useful results for future work.

In Praia (located on Santiago island and the largest city of Cabo Verde) the authors found that the higher the urbanisation level of a neighbourhood, the lower the provision of pedestrian space and the higher the proportion of "formal space" (Ancies et al., 2017). More urbanised areas also tend to have more crime and a higher collision risk. This kind of insight could be very useful for other cities attempting to rethink their transport planning and policies and place in order to increase walking and enhance walkability. Havana, however, unlike Praia, has good coverage for the public transport system and also has high levels of access in most areas for shops and recreation and leisure. A useful tool from the Cabo Verde case study is the use of photographs to document and share different perspectives and aspects of walking in the city. This study found the use of physical maps, which the participants could interact with and discuss, very useful, and Jones et al. (2008), use maps in the local community with good results. Overall, the use of movement and place as a systematic method to characterise the city proved to be very useful for raising the awareness of the importance of place. Coupled with a street survey, this provided more local and detailed information which can be considered if interventions or changes are being considered.

Conclusion and Recommendations

This chapter started with some overarching aims encapsulated by the following questions: What lessons have been learned by working with communities in neighbourhoods in Havana and from the two methods applied? This summary will help address both of these questions and outline some ideas for other communities and places to test and learn in their own island situation.

For Havana, it was observed that tools and toolkits (and their associated methodologies mainly from the UK) could be utilised to map movement and location at both an overarching city-wide level and also at the municipality. The process worked best when a previous example of city mapping was outlined, and for local mapping the survey was adapted to appropriate culture and linguistic terminology. More work is required in this area with further detailed mapping and checking, with local partners needed at each municipality. Municipalities could also share the results. For example, some of the largest mobility flows in Havana between *Plaza de la Revolución* and *Centro Habana* have been captured in the mobility survey, but these should be viewed along with movement and place maps to gain further insights. For walking surveys, further testing should be carried out in order to ensure that appropriate questions and metrics are being used for the city's context and the place being measured for walkability. Street audits at the street level are highly useful and will result in many useful outcomes: different streets in different municipalities can be compared/contrasted, suggestions for improvements to place can be made; 'hot spots' of poor environments can be made transparent, and key factors can be combined statistically to see what factors correlate with one another. However, as noted by Arellana et al., (2020), care must be used with walkability indexing, especially with weighting of the factors and how those being surveyed interpret the questions but also how those carry out the work interpret them. It is also worth noting that many city visions that frame the city as a liveable place (see, for example, those from Roe & McCay, or Gehl, 2010, Ortegón & Tyler, 2016) can be coupled with street audits and other mapping methods. Using a vision such as 'design approaches for an active city' (Roe & McCay, 2021) can help align these methods with the overarching needs for, and the requirements of the people. These frameworks or visions allow the community and facilitators to ask open questions such as 'how much green space is required to ensure our city has good mental health?' Ultimately, it is the people that make up the city, and by concentrating on them as a focal point, our hope is that better urban environments which suit city dwellers can be achieved. By using and combining multiple techniques and then summarising the findings through a series of workshops, events, working papers and/or published papers over time, the city can use these results to test their interventions as part of the larger strategy to promote more sustainable transport options.

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Part IV Planning and Measuring Public Transport

8 A Decade Following the Malta Bus Reform: Attitudes Towards Service Quality

T. Bajada and M. Attard

Malta, an island state in the Mediterranean and an EU member since 2004, has an area of 316 km² (National Statistics Office 2017). The archipelago made up of three main islands, two of which are inhabited, has a population of around half a million and with 1,867 persons per km² is one of the densest countries in the EU (National Statistics Office 2019a). Malta is composed of six districts, these being the Northern Harbour, Southern Harbour, North, South Eastern, Western and Gozo and Comino, the latter being two separate islands. Most of the population is concentrated on the main island, Malta, with the urban area stretching from the eastern side of the island covering primarily the Northern Harbour, Southern Harbour, Western and South-Eastern districts. A car-oriented culture predominates in this small island state. Car ownership and associated car use has been increasing steadily with economic growth since the early 1990s (80 % of trips are done by car). In 2018, there were 608 cars per 1,000 inhabitants in Malta, placing it sixth in rank within the EU. Luxembourg was first with 676 cars per 1,000 inhabitants (European Commission 2021). One of the main reasons for this dependence is the priority given to cars in the design of the urban environment. Priority to other modes of transport, such as the bus, is negligible. Bus priority lanes, which were included and shared with other modes of transport such as EVs and motorcycles are often used illegally also by other vehicles and cars. Enforcement is lacking, leading the bus to struggle with car traffic at the detriment of its passengers. The recent road infrastructure projects that took place all over Malta led to the majority of the bus lanes - eight in all - being reduced or removed to cater for the car.

In the Maltese transport system, the modal share for bus is 10 %, while walking is only 2 % and cycling is negligible (Attard 2020). In this past decade, other modes of transport were introduced, in particular shared cars, bicycles, scooters and other micro-mobility options. Figure 8.1 shows the sharp rise of car ownership since the late

1980s, the subsequent decline in public transport patronage until 2010, and the increase in overall mobility following the bus reform. The increase in bus use was also triggered by an increase in the temporary foreign population which migrated to Malta following a rapid increase in GDP and economic activity.

Until 2011, Malta's bus service was operated by around 400 bus owners and operators who formed the Public Transport Association. The bus service was in dire need of change; service quality was low, the fleet was old contributing to air pollution, the fare structure needed a revision, as well as the drivers' conditions to align with EU law on employment. The routes needed to reflect a more integrated service network that removed the burden on Valletta as the primary hub and included several interchanges around Malta (Childs and Sutton 2008). These issues and the relevant proposed changes were all put forward in a Government White Paper in 2008 (Ministry of Infrastructure Transport and Communications 2008). Following nearly three years of discussions with stakeholders, the 2011 bus service reform was set to change the service overnight and with it instil a modal shift from car to bus use. The changes essentially reflected the issues that needed to be addressed, including: a new, air-conditioned bus fleet, new routes, improved working hours for bus drivers, a service delivery bound by a contract and maximum waiting times, amongst others. Further details about the bus reform are available in the works by Attard (2012), Bajada (2015), Bajada and Titheridge (2016), Bajada and Titheridge (2017), and Bajada (2017).

The reformed bus service started operating on the 3rd July 2011 following a competitive tender issued by the Government. The new operator was bound by a ten-year contract that included a detailed service level agreement for the provision of the bus service network in Malta and Gozo. A consortium led by international operator Arriva won the bid, however, this was short-lived because of a series of events and failures in the system delivery, leading the operator to default in many aspects of the contract (Bajada & Titheridge, 2016). Punctuality and service unreliability were reported to be the major issues (Bajada & Titheridge, 2016).

Following the buy-out at a nominal fee of €1 in 2014, the Government nationalised the service and took over both the operations and regulation of public transport. This gave the opportunity to Government to issue once again an expression of interest for operators to run the national service. Only two submissions were received, one being a local consortium of public transport operators and a second one from Spanish Bus Operator ALSA (Autobuses de León). Negotiations were conducted behind closed doors between Government and ALSA who subsequently took over the service in July 2015. The company running the bus service locally is called Malta Public Transport (Malta Public Transport 2021).

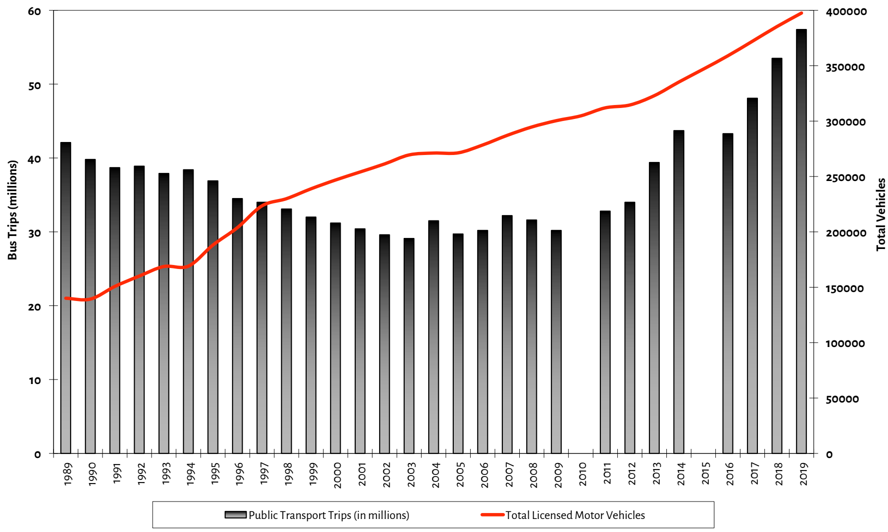

Figure 8.1 Car Ownership and Bus Usage Trends in Malta 1989–2019
Note. Compiled from the National Statistics Office. Public transport data for 2010 and 2015 are missing or incomplete

This chapter aims to evaluate the attitudes of the population toward bus service quality characteristics over the past 10 years and compare them over time. To do this, we use data obtained from Bajada (2017) in which attitude data from both Maltese resident bus users and non-bus users was collected before and after the bus service reform. Another dataset was collected in 2021, which provides the data on attitudes towards the bus service before the reform and today for both bus and non-bus users. The chapter proceeds with a literature review regarding attitudes, bus service quality characteristics, factors that influence bus use, and the evolution of the bus industry over the past decade. The research methodology follows next, after which one finds the results, discussion, and conclusion. We conclude with a reflection on the bus service quality in Malta and associated recommendations for the coming decade.

Literature Review

A sustainable public transport system has a working bus service that serves as its backbone (May, 2004), as in the cases of Singapore (Menon & Kuang, 2015) and Curitiba, Brazil (Goodman, Laube, and Schwenk 2006). Indeed, buses are the most basic form of public transport and have been described as a representation of democracy through which every segment of society is mobile and can reach goods, services and activities (Peñalosa, 2013; Litman, 2012). When a good bus service is in operation it also contributes to a healthy, sustainable land transport system (Ibrahim 2003).

A good bus service is measured by the quality of service that it delivers. Service quality is defined as a measure of the level of service that is performed, and the extent to which it meets customer expectations (Parasuraman, Zelthami, and Berry 1985). In the bus industry, service quality is an important component that influences bus use and encompasses a number of characteristics (Wall & McDonald, 2007, dell'Olio et al., 2011, Rohani et al., 2013). Bajada (2017) summarises the common bus service quality characteristics explored in research, amongst which accessibility, information, time, customer experience, comfort, security, fare structure and environmental impact (Andreassen, 1995, Balcombe et al., 2004, Paulley et al., 2006, and Joewono & Kubota, 2007). More recent research has focused on accessibility (Lionjanga and Venter 2018), customer experience (Currie and Fournier 2020), and satisfaction (Mokonyama and Venter 2018).

When evaluating bus service quality, research generally focuses on attitudes (e.g.,Beirão & Sarsfield Cabral, 2007). Attitudes are an important measure because they have often been linked with the intention or the actual use of a bus service (de Oña 2020), although positive attitudes do not always mean that people would shift modes to use the bus (Pronello and Camusso 2011). The attitudes towards a service can be influenced by psychological (Choo and Mokhtarian 2004), demographic (Lyons et al., 2008), socio-economic factors (Shiftan, Outwater, and Zhou 2008) and mode use (Anable 2005). Bajada and Titheridge (2017) add hearsay to the list of factors that influence attitudes; it can have an indirect role in influencing attitudes because it does not come from experience. Consequently, similar attitudes can still result in different behaviour. Furthermore, Murray et al. (2010) found that an improved bus service quality is not directly related to improved attitudes towards the service.

Bus use is influenced by factors such as age, gender, and income (Balcombe et al., 2004). Teenagers below the driving age and senior citizens are more likely to use the bus (Enoch et al., 2003 and Goodwin & Lyons, 2010), whilst females are dependent on buses more than males (Simma & Axhausen, 2001 and Enoch et al., 2003). The fact that females use buses more than males is associated with three aspects. The first is psychological, females are able to process and obtain more information than men (Beale and Bonsall, 2007); the second is geographic, they travel shorter distances than men; the third is socio-cultural, they are the main carers in a household with children and, consequently, they travel less (Axisa et al., 2012 and McQuaid & Chen, 2012). Other factors that influence bus use include income, car ownership and availability, parking availability and policy integration. People with low incomes are more likely to use the bus, which is cheaper (Balcombe et al., 2004 and Beirão & Sarsfield Cabral, 2007). Conversely, the higher a person's income is, the more likely it is that they own a car (Dargay, Gately, and Sommer 2007). Car availability is, however, different from car ownership. In a household, there could be one car but more than one adult with a driver's license. Consequently, if one adult uses the car, the other is left without it and would still need to resort to another means of transport, such as the bus to travel.

Over the years, the bus industry has continued to evolve. We are now seeing technologies applied to efficient payment systems for seamless interchanging (Osemwegie et al., 2017) and the further integration of multi-modal systems including the use of buses through mobility as a service (MaaS), and service automation (Hensher, 2017). Furthermore, Demand Responsive Transport using mobile applications is growing in many cities (Oh et al., 2020). All these developments aim to increase patronage and concurrently, trying to maintain and improving service quality. These are, however, difficult times for the bus industry because the various lockdowns and mobility restrictions brought about by the COVID-19 pandemic has meant less patronage and less revenues for operators worldwide (Orro et al., 2020 and Jenelius & Cebecauer, 2020). Hence, the bus industry has had to reinvent itself in response to the pandemic, and at the same time, prepare for the post-pandemic future.

Method

The research takes an empirical approach and uses three datasets. Consequently, this work is a cross-sectional study of attitudes towards the bus service, and although the participants are different, attitudes of users and non-users are measured and analysed across time.

The first dataset originates from a questionnaire survey collected in May 2011, just two months before the bus reform in Malta. The second dataset is collected in July 2012, one year after the reform. For these two datasets, the sampling population was obtained from the 2007 Electoral Register (Department of Information 2007). A stratified random sampling strategy was used and participants were randomly selected from the six districts of Malta and Gozo. In this manner, the sample population was representative of the enumerated population distribution by district (Bajada, 2015). The questionnaires were conducted via telephone to a target population of 385. In the end, four hundred questionnaires were collected in each year. In 2011, 390 of these questionnaires were valid and in 2012, 398 were suitable for analysis.

Table 8.1 Data Collected from the Three Datasets

VARIABLE DESCRIPTION	VARIABLE	MEASURE	AVAILABLE IN THE QUESTIONNAIRES OF 2011 AND 2012	AVAILABLE IN THE QUESTIONNAIRE OF 2021
Socio-Demographic	Gender	Nominal	x	X
	Age	Nominal	x	X
	Occupation	Nominal	x	X
	Nationality	Nominal	x	X
Geographic	Locality of residence	Nominal	x	X
	Locality travelled to mostly	Nominal	x	X
	Ownership of driving license	Nominal	-	X
Mobility	Vehicle ownership	Nominal	-	X
	Mode of transport used mostly	Nominal	x	X
	Usage of the bus service before the reform (2011)	Nominal	-	X
Bus service related	Rating of the service quality characteristics before the reform	Ordinal	x	X
	Usage of the current bus service	Nominal	-	X
	Rating of the service quality of the current bus service	Ordinal	-	X

Note. Compiled by authors

The third dataset was collected between May and June 2021, a decade after the reform. The questionnaire survey was held online, using snowball sampling. In this case, key persons were identified and asked to forward the questionnaire to people they knew. The target population sample was 385, which was rounded up to 400; in all 424 valid responses were recorded. In total, this study will analyse data from 1,212 participants.

The 2021 questionnaire applied similar questions to the survey of 2011 and 2012. The consistency between questionnaires would allow for an easier analysis. Table 8.1 provides the list of questions. The variables are grouped by the general description of the variables e.g., gender is under demographic. The measures indicate that only two variables were ordinal because they were the ratings assigned to the attitudes towards the bus service; the other variables were nominal.

In the datasets for 2011 and 2012 the assigned Likert Scale was from one to five, where one was the worst and five the best, an additional number, six was assigned to the option ‘Don’t know’. The middle number on the scale, three, meant that the participant was unsure of the service quality characteristic.

Table 8.2 An Explanation of the Key Used in the Scatter Graphs

DATASET	YEAR COLLECTED	LABEL	EXPLANATION
First dataset	(May) 2011	2010	Participants would refer to the old bus service, referring to the previous year, including 2010
Second dataset	(June/July) 2012	2012	This is the dataset that was collected exactly one year after the bus service reform
Third dataset	(May/June) 2021	2020	The year 2021 was not complete at the time of the data collection, so 2020 is used as a reference year here. Moreover, one question had asked the participants to state how many times did they use the bus in the previous year, which was 2020.

Note. Compiled by authors

In the case of the dataset for 2021, the Likert Scale was the same from one to five, the numbers meaning the same as those in the older datasets. In this new dataset, the participants also had the option 'Don't know' (six) and another option 'I don't remember the old bus service', which was coded with a number seven. The reason for including 'Don't know' is that the participants included both bus and non-bus users, and the attitudes of both were collected. The option 'I don't remember the old bus service' was particularly targeted to foreigners who moved to Malta after 2011.

Due to the fact that the first two datasets were collected as part of a PhD study, the ethics procedure followed that of the UCL Research Ethics Committee. The research was exempt from acquiring explicit approval. The third dataset was carried out by the Institute for Climate Change and Sustainable Development at the University of Malta (UM); hence, the UM Research Ethics Committee procedure was applied. Following a self-assessment, it transpired that no specific approval was required. In both cases, it was sufficient to keep the participants anonymous by assigning a unique identifier.

The analytical methodology involved descriptive statistics of the socio-demographic, geographic, mobility and bus service related variables. The focus of the analysis was mainly on the attitude ratings of the combined bus and non-bus users. Scatter graphs were used to show the attitude ratings on the eight service quality characteristics as identified in the literature review (accessibility, information, time, fare, customer experience, comfort, security, and impact on the environment). Each scatter graph is dedicated to the service quality characteristic and shows the attitudes of the datasets labeled as indicated in Table 8.2. The Table explains the keys used in the scatter graphs.

Results

Table 8.3 illustrates the demographic characteristics of the survey participants in comparison to the national statistics. It is worth noting that at a national level, the Maltese population has an equal balance of genders. Generally, the questionnaire participants included a higher percentage of females with a striking difference in the post-reform dataset (2012). The age groups collected for 2020 were slightly different from those collected in the first two datasets. This is possibly due to the different method of data collection. With regard to age, the national data did not change with regard to percentages per cohort (Table 8.3).

In the datasets, the groups for the years 2010 and 2020 were very similar for the 30–49 years age groups, which included the major percentage of participants (Table 8.3). The year 2012 shows a difference in the age group that participated the most, which was 36 % of the 60+ age group in this case (Table 8.3).

The category 'other' groups together elementary occupations, craft and related, and unemployed. The reason for this was that the percentages were relatively small when compared to the other categories (Table 8.3). For the unemployed, it is worth noting that the unemployment decreased by 1 % from 6 % to 5 % over the decade. The percentages from the questionnaires tally with the national data 6 % (2011), 4 % (2012); only the 2020 data shows a drastic difference from the national data – 0.5 % (Table 8.3).

Unsurprisingly, given that in 2012, most of the participants were 60+, most of them were retired (25 %) and housekeepers (33 %) (Table 8.3). Professionals always formed part of a large percentage of the occupation category (even in the case of the national data), particularly for the 2020 dataset (71 %) (Table 8.3).

The majority of the Maltese population live in the Northern Harbour and Southern Harbour districts, and most employment and educational facilities are located there. It is unsurprising therefore, that most of the origin and destination trips of the participants occur within these two districts. This was the case in all the datasets, the district of origin was mostly the Northern Harbour (30 % in 2010 and 2020, and 31 % in 2012). The Northern Harbour district was the most travelled destination in 2010 and 2020, 33 % and 44 %, respectively; in 2012, the destination changed to the Southern Harbour district 38 %.

Table 8.3 Demographic Characteristics of the Questionnaire Participants in Comparison to the National Statistics

		NATIONAL DATA CENSUS (2011) (POPULATION = 416,055) %	PRE-BUS SERVICE REFORM (2010) (N=390) %	POST-BUS SERVICE REFORM (2012) (N=398) %		NATIONAL DATA (POPULATION = 460,297*) %	BUS SERVICE IN OPERATION (2020) (N=424) %
Gender	Male	50	45	33	Male	50*	44
	Female	50	55	67	Female	50*	56
	Non-binary	n/a	n/a	n/a	Non-binary	n/a	1
Age Groups	11–20	13	9	7			
	21–30	15	16	8	18–29	17*	18
	31–40	13	22	14	30–39	15*	29
	41–50	13	21	17	40–49	13*	33
	51–60	14	9	17	50–59	13*	12
	60+	21	23	36	60+	25*	8
Occupation	Housekeeper	n/a	28	33	Housekeeper	n/a	2
	Retired	9	12	25	Retired	14**	4
	Professional	10	12	12	Professional	46a***	71
	Service worker	2	12	8	Service worker	20***	2
	Student	11	11	6	Student	6****	8
	Clerk	2	6	6	Clerk	11	9
	Other	13	21	10	Other	22	3

*NSO (2019a), **NSO (2019b), ***NSO (2020), ****NSO (2021)
[a]includes Professionals (21 %) + Managers (11 %) + Technicians & Associate Professionals (14 %)

Note. Percentages have been rounded to the nearest whole number. Professional includes: Professionals, Legislators & Senior Officials, Technicians & Associate Professionals. Other includes: Elementary occupation, craft and related and unemployed. Compiled by authors

The mode choice of the 2010 and 2012 datasets was divided namely by bus, car and other. The 2020 dataset was divided between bus, car, motorbike, personal bicycle/e-bike, walk and other. In all cases, the car is the dominant mode of transport (2010:49 %, 2012:65 %, 2020:68 %), which is expected in a car-oriented society. The bus is the second mostly used mode of transport (2011:31 %, 2012:33 %, 2021:10 %). For 2020, this was equivalent to walking (10 %). In the datasets representing the years 2010 and 2012, the category 'other' modes of transport included motorbike, walking, cycling and ferry. The shared percentage in mobility for the category 'other' was 20 % in 2010 and 3 % in 2012. In 2020, 2 % used the motorbike and 7 % the personal bike/e-bike. The other modes of transport in the 2020 dataset referred to the ferry service and micro-mobility; 3 % of the participants used other modes of transport. Furthermore, in 2020, 92 % of the participants had a driving license, 88 % owned a vehicle, and 86 % used the bus service before the reform. Interestingly, 47 % of the participants did not use the bus service in 2020/2021.

The attitudes of the participants are shown in Figure 8.2. The dataset referring to the bus service before the reform (2010) had quite negative remarks about the service quality (Figure 8.2). Similarly, the attitudes towards the existing bus service (year 2020) are relatively negative. Even when the participants rated the best (5) e.g., for 'accessibility', the percentage was low (13 %). Information and comfort are the only two service quality characteristics that were rated 4 (nearly the best), with 39 % and 40 %, respectively. The dataset that showed the most positive attitudes was the one collected in 2012. This was also the case for 'time', which was known to be a major problem with the service, was rated the best (5) by 13 % of the participants.

Discussion

The pandemic has surely left a negative impact on bus services worldwide (Orro et al., 2020 and Jenelius & Cebecauer, 2020). This is evident also in Malta with the 2020 survey, conducted as part of this study, which showed 47 % of the participants not using the bus during that year. Literature shows that the higher the income among a population, the more cars they own and drive (Dargay et al., 2007), as was the case from the findings in this research – 71 % of the participants were professionals, therefore, having higher income than the other occupations such as students and clerks.

When compared over time, the attitudes measured in this research show that the bus service quality improved one year after the reform. This finding resonates with the literature, which states that attitudes are influenced by several factors that are not directly related to service quality characteristics, including demographic, socio-economic factors and mode use (Anable, 2005; Lyons et al., 2008; Shiftan et al., 2008). In fact, the 2012 dataset had more elderly and retired participants, as well as more females than any other category. These were also the groups that tended to use the bus most, which also conforms to the literature (Enoch et al., 2003, and Goodwin & Lyons, 2010). Consequently, these attitudes were based on actual experience and use of the bus, making them more realistic than the attitudes of car users that might be based on perception and hearsay (Bajada & Titheridge 2017). The 2020 survey participants were mostly professionals and car users, furthermore, 47 % of the participants did not use the bus. From this we have to conclude that the attitude ratings of the 2020 participants were primarily based on perception and hearsay, rather than experience.

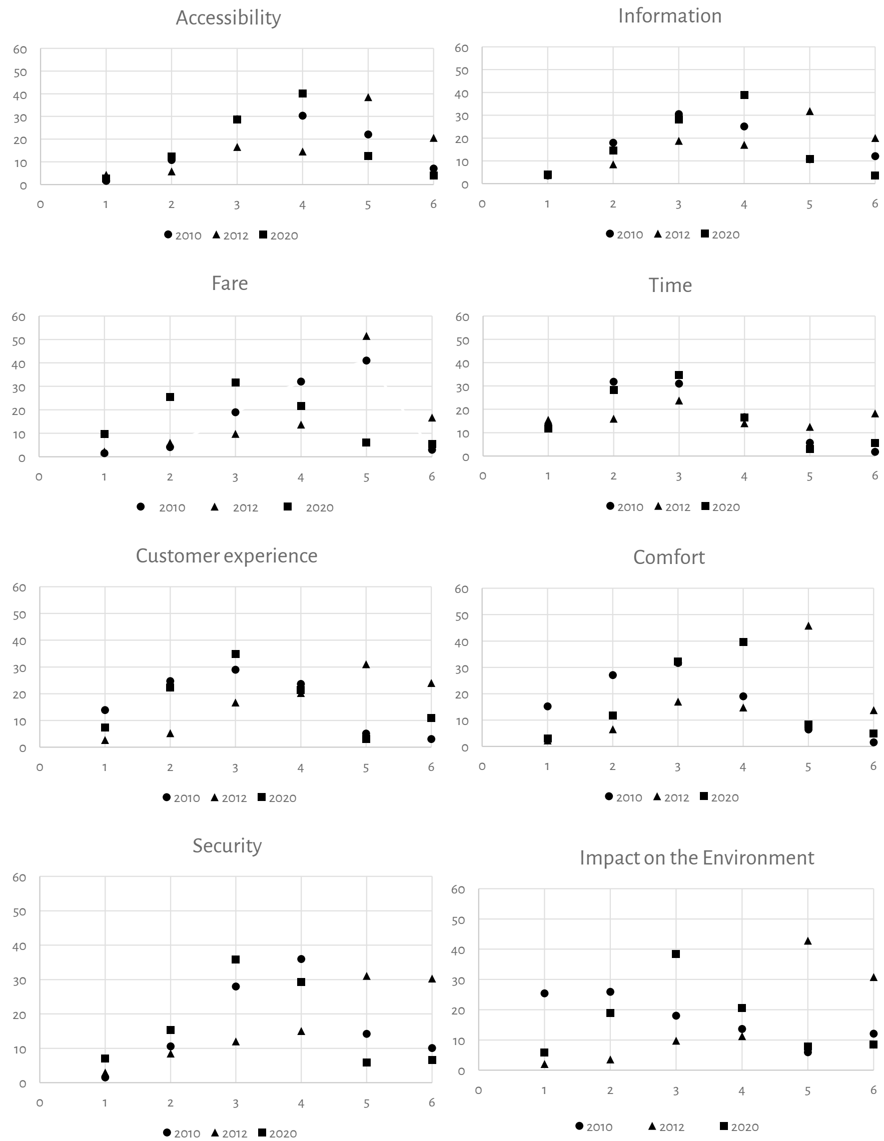

Figure 8.2 Scatter Graphs Showing the Attitudes of the Participants Towards the Bus Service Quality Characteristics Over Time
Note. Compiled by authors

Conclusion and Recommendation

This chapter focuses on the bus service in Malta, a service that has been in direct competition with the car for more than four decades. This research refers particularly to the past decade, a time during which several changes were implemented. These included a major reform in the sector, followed by a government buy-out from the operator who failed to abide by the service level agreement. This was followed by service nationalisation for a year, after which a new operator was awarded the contract of operation following a public expression of interest. Malta Public Transport, the new operator, has now been delivering the service since 2015 (six years).

The fact that the bus service reform was much needed is undeniable. The old bus service had several flaws that were improved following the reform. However, the much-enhanced service, even a decade later still needs further improvement. It is true that the attitude ratings are at times influenced by non-bus users, however, it is necessary to also identify these attitudes if the aim is to improve a bus service that might attract potential users. Shifting modes from single user vehicles that run on fossil fuels to sustainable modes of transport is now a must, given the 'code red' warning issued by the IPCC in August 2021. Consequently, focusing on providing a good quality and attractive bus service should be a priority even more so because it needs to be considered as the backbone of an integrated and sustainable public transport system.

This chapter has highlighted the challenges for the bus service in Malta, and a set of recommendations is being put forward to further improve it:

Shift the Maltese car-oriented culture: The car-oriented culture in Malta needs to change and this can only happen with the participation of all stakeholders (the general population, operators, regulators, government and politicians).

Keep consistent with service quality improvements and ensure proper enforcement: The reform of key bus service characteristics such as the quality of vehicles and the coverage and scheduling of routes are all indeed good, however, the operation needs to be further supported with proper enforcement of traffic rules and priority over private cars on the road. Reliability, efficiency, and a concern for the environment need to be reflected upon in a more sustainable service quality.

Ensure that monitoring and benchmarking are implemented and maintained: Monitoring and benchmarking are imperative to gauging the bus service quality. It is also evident that the issues with bus service delivery are not solely a responsibility of the operator, but have to also include a concerted effort by the authorities to prioritise the bus service and its quality.

These recommendations are critical for a successful bus service operation over the next five to ten years. Success for a bus service means having a reliable service that retains and attracts patrons, especially private car users. A successful bus service should score high in all its service quality characteristics. On the other hand, there should be deterrents to the use of less sustainable modes of transport.

Additionally, two key issues which might influence the bus use now and in future are the current and future pandemic events and climate change. The pandemic brought about a fear of contagion from public transport use and thus affected patronage worldwide. Proper aeration and cleanliness on board the vehicles and bus stops, together with social distancing measures have shown that contagion can be controlled. Furthermore, the fact that we are in a climate emergency means that buses should be promoted as sustainable, environmentally friendly mass transport modes that serve as alternatives to cars or any other single-user polluting vehicle.

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9 Park-and-Ride Accessibility

Experience from a Pilot Study for the Island of Trinidad

R. J. Furlonge and M. Cudjoe

Background

The twin-island Republic of Trinidad and Tobago is a Small Island Developing State. It is the leading Caribbean producer of oil and gas and the highest consumer of fossil fuel. Its relatively small economy accounts for less than 1 % of global GHGs. However, the country ranks among the top five emitters per capita. The current dominance of private transportation confirms that any effective strategy to reduce GHGs from the transportation sector must include efforts to decarbonise private transportation, in addition to reducing the kilometres travelled. Public transportation has become far less attractive to middle- and upper-class riders, and as a result, the Public Transport Service Corporation (PTSC), which is the Government-owned public transport provider, experiences very low ridership among segments of the population that prefer travel by automobile to using any public transportation mode. Very high traffic densities are a serious and worsening problem and cause increases in both GHGs and traffic congestion and can be improved by provision of transit incentives and simultaneous auto disincentives. Therefore, it is not only important to decrease carbon emission but also to reduce vehicle traffic densities while maximising human densities on the roadways.

The Government is pursuing services to design, operationalise, and evaluate a demonstration pilot project of a P&R initiative for the capital, Port of Spain's (POS) greater area along the main East-West and North-South transport corridors using parking infrastructure (such as, sporting stadia facilities) and tools of behavioural economics in order to modify commuter choices. The objective of this project is to test a specific strategy to provide support to long-term goals for transit that can contribute to reducing congestion and air pollution and increasing the use of public transportation systems. The pilot is expected to provide a reliable, convenient, and enjoyable public transportation experience to both users and shuttle drivers alike. This will be achieved through the use of GPS and data-enabled smartphones that will allow a high level of automatic coordination between users and transit shuttle drivers. The target market would be (a) users with smartphones who are making use of the P&R facilities being established by this endeavour, and (b) transit shuttle drivers with smartphones providing services to the P&R users.

Critical Issues in Developing Transportation in Trinidad and Tobago

There is currently no agency of the Government responsible for national transportation planning and administration (APDSL, 2010, pp. 8–12). There is a division of the Ministry of Works and Transport responsible for highways, including a special project unit for new and upgrading of highways and bridges; there is another division for licensing vehicles; and there is a Government-owned company for operating buses (PTSC). There is a need for a road transportation authority charged with responsibility for planning, administering and developing the transportation system for the nation. This authority would conduct planning and analysis to meet short-, medium-, and long-term mobility needs. It would formulate policies and implement public involvement programmes to secure public understanding and support. It would be responsible for building, expanding, and maintaining the road network and improving transportation infrastructure. It would also undertake traffic surveys and data collection and reporting, and road safety education and accident reduction schemes. Future mobility improvements in Trinidad and Tobago must consider managing vehicle ownership. The demand for personal vehicle ownership needs to be balanced with the number of vehicles using the roads. If these two competing demands are not managed properly, the result would be continued traffic congestion and increases in GHGs.

Another critical component in the transport sector not being addressed is in the domain of public transportation (APDSL, 2010, pp. 19–20). There is no coordination and monitoring of the planning for locations of public buildings, housing communities, schools, etc., with respect to the transportation needs of the users. At present, no single agency of the Government is responsible for monitoring, controlling or coordinating the operations of the public transportation industry. The Public Transport Service Act, which created the PTSC in 1965, does not give them responsibility for regulating taxis or maxi-taxis (minibuses). The Transport Division of the Ministry of Works and Transport is responsible for the licensing and inspection of taxis and maxi-taxis. In other words, PTSC is a publicly owned bus operator governed by its Act, while other privately supplied public transport services (taxis and maxi-taxis) are effectively deregulated and operate on their own. So, there is a critical need for the administration, rationalisation, and control of the industry. This would include planning, organising, and administering services, routes, and terminals, collection and analysis of data pertaining to passenger demand and potential suppliers, and an ongoing monitoring of the industry, including vehicle standards.

Decision makers need to carefully consider who they are providing these components for. They need to determine the following: (a) What are we trying to achieve, and why; and (b) How do we coordinate this information. The answers to these questions would involve the planning and administration of transport services, routes, and terminals and parking facilities; collection and analysis of data pertaining to the persons desiring to travel, where they are coming from, and where they are going; and what are the accessibility needs of the travellers.

The country has been desperately in need of continued transportation planning and policies to guide sustainability ever since the first and only national transportation plan was completed in 1967. Many were elated with the award of the Government commissioned Comprehensive National Transport Study in February 2005, and this was to be completed by September 2006. A report was submitted in November 2006, but it was not accepted by the Government. Thus, there is a long outstanding need for a comprehensive national transport plan and associated policies, and consequently there is a severe shortage of data for transportation decisionmaking.

Purpose of this Work

The pilot study included the following activities, and this chapter focusses on them:

- Rapid diagnosis of the current situation related to transit in the Greater POS area, establishing a baseline situation of traffic volumes, and public transit usage and characteristics.
- Identification and prioritisation of two feasible sites for implementing the pilot project, preferably State-owned, as this is a pilot project, one in the East-West Corridor and the other in the North-South Corridor. The sites identified should generate the highest potential impact on expected outcomes as attraction of users, good connectivity, and travel times and congestion reductions in POS.

Baseline Situation of Traffic Volumes and Public Transit Usage

The information in this section was taken from the Trinidad Rapid Rail Project: Traffic Study Final Report (Steer Davies Gleave, 2008). This secondary data was used because no new data was collected since that time, and it was not possible to arrange primary traffic data during the Covid-19 Pandemic. The East-West Corridor is made up of the Eastern Main Road, the Priority Bus Route (PBR) and the Churchill Roosevelt; and the North-South Corridor comprises the Southern Main Road and the Solomon Hochoy Highway and the Uriah Butler Highway. The PBR was created as a busway; it was conceived as dedicating its two lanes for the exclusive use of buses. Cars account for 39 % of the total traffic on the PBR, which is a significant number using a road for buses only. Most of these cars are understood to be military vehicles or government officials with special licenses, but some are also illegal drivers who use the PBR as a quick alternative to avoid congestion. Table 9.1 gives the key transportation information for the East-West and North-South Corridors. Nearly 200,000 vehicles transported 344,000 persons on weekdays to and from POS, and the modal split was just over 60 % cars. Fifty Percent travelled for work and about 30 % went for business. The average travel speed during the peak periods ranged from about 20 to 30 kmph (32 to 41 kmph on the PBR).

Table 9.1 East-West and North-South Corridors Key Transportation Information

NO.	ACTIVITY	EAST-WEST CORRIDOR	NORTH-SOUTH CORRIDOR
1	Total No. of Vehicles (weekday)	95.000	104.000
2	Cars (weekday)	60.000	63.000
3	Passengers (weekday)	191.000	153.000
4	Trip Purpose (Work) %	52	47
5	Trip Purpose (Business) %	25	31
6	Journey Speed to POS (AM)	20-39	29-32
7	Journey Speed from POS (PM)	21-31	18-23

Note. Compiled by R. J. Furlonge

Identification and Justification of Two Sites for the Pilot Project

The nation of Trinidad and Tobago has never had official P&R services. Prior to the Covid-19 pandemic, a large number of motorists were making use of the shopping malls (because they are usually located in suburban centres) to safely park and use easily accessed legal and illegal taxi shuttle service to the nearby urban centres to get to work or conduct business in POS. Identification of an appropriate methodology for site selection methodology will result in a more efficient and inexpensive planning process for selecting P&R facilities.

Methodology

The objective of this Pilot Study was the identification and prioritisation of two feasible sites along the main East-West and North-South transit corridors of the island of Trinidad. Therefore, only one site was sought in the East-West Corridor and another in the North-South Corridor. The research sought a simple yet effective method for site selection.

Site selection should give priority to (1) Land currently in parking use; (2) Undeveloped or unused land in public ownership; (3) Undeveloped private land; and (4) Developed private land (Coffel et al., 2012). This Pilot Study focussed on the first two only because the Government is interested in state-owned properties for P&R development, as this is a demonstration pilot project and it would not like to acquire or rent property for operation.

Potential Park-and-Ride Sites

Six sites were identified as having potential for investigation as P&R sites for the Pilot Study:

1. Ato Boldon Stadium in Couva
2. Brian Lara Cricket Academy in Tarouba
3. Centre of Excellence in Macoya
4. Eddie Hart Facilities in Tacarigua
5. Larry Gomes Stadium in Arima, and
6. Trincity Mall, Trincity

These sites are shown in Figure 9.1.

Ato Boldon Stadium

The Ato Boldon Stadium for football and athletics is visible from the Solomon Hochoy Highway and has an access gate located about 900 metres west of the Couva-Preysal Interchange on the Couva Main Road. The site is located at the beginning of the morning peak period highway traffic queues from the south and is 35 km from downtown POS.

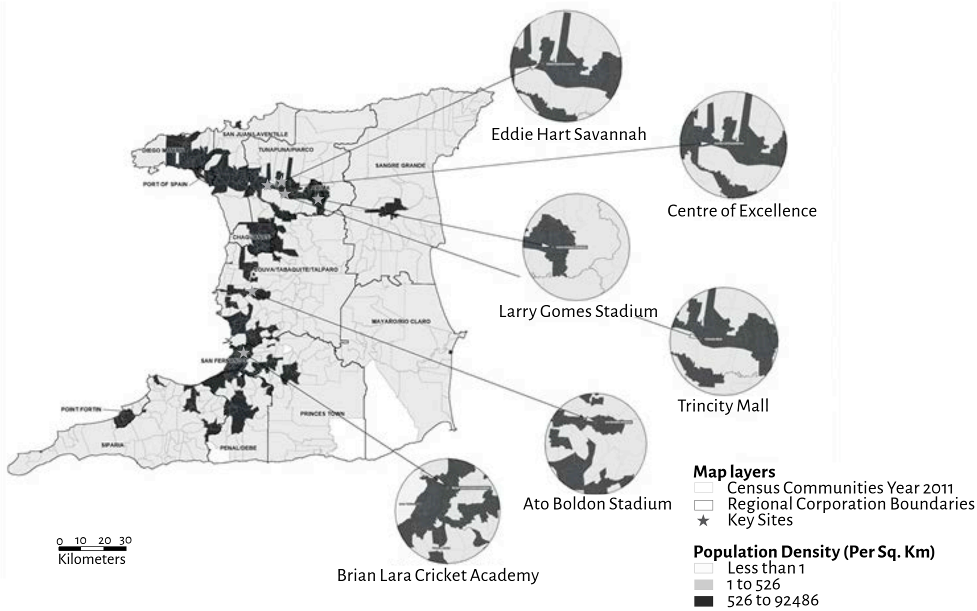

Figure 9.1 Potential Catchment Areas and Their Residential Densities
Note. Copyrights by R. J. Furlonge

Brian Lara Cricket Academy

The Brian Lara Cricket Academy (BLCA) is a multi-purpose stadium in Tarouba, Trinidad and Tobago, used mostly for cricket matches. The site is located just east of the Solomon Hochoy Highway between Gasparillo Bypass Road in the north and the Tarouba Interchange on the Tarouba Link Road in the south. Access is primarily via the Gasparillo Bypass Road, but vehicles may also exit on the Tarouba Link Road. The site is located outside of the morning peak period highway traffic queues from the south and is 52 km from downtown POS.

Centre of Excellence, Macoya

The Centre of Excellence is situated on the Macoya Road, just off the Churchill Roosevelt Highway. The complex consists of a hotel, a swimming pool, a stadium, a fitness centre and sports clinic, including event indoor and outdoor spaces for rent. The site is located in the midst of the morning peak period highway traffic queues from the east but is less than 400 metres away from the PBR. It is 15 km from downtown POS.

Eddie Hart Savannah

The Eddie Hart Savannah in Tacarigua can also be considered as a P&R lot in the east. Apart from the now popular car park food court with its hard surface carpark, there appears to be some parking space at the National Racquet Centre, Eastern Regional Indoor Sport Arena, and the National Hockey Centre areas. The site is located next to the PBR, with its access less than 150 metres south of the PBR and in the midst of the morning peak period highway traffic queues from the east. It is 17 km from downtown POS.

Larry Gomes Stadium

The Larry Gomes Stadium for football and athletics is not visible from the Churchill-Roosevelt Highway (CRH) and its access is located about 1.7 km northeast of the intersection of CRH and O'Meara Road in Arima, via O'Meara Road and Lennox Yearwood Expressway. The site is located at the beginning of the morning peak period highway traffic queues from the east and is only 2.5 km away from the PBR. It is 27 km from downtown POS.

Trincity Mall

Trincity Mall is visible from the Churchill-Roosevelt Highway (CRH) and its access is located on Trincity Central Road in Trincity. A Government financial bailout caused it to be operated by the Government, and there is good vehicle ingress and egress. The site is located near the beginning of the morning peak period highway traffic queues from the east, and is only 1.5 kilometres away from the PBR. It is 19 km from downtown POS.

Literature Review

Studies have been done over the years to plan for the optimal location of P&R facilities, such as, geographic information system (GIS), multi-criteria method, multi-objective spatial optimisation modelling methods, mixed linear programming formulation, and minimising the operating deficit while adding decision variables such as transit and parking fees. Also, there have been studies of catchment areas for P&R, such as hyperbola method; parabola method; circle method; GIS, and dynamic approaches using GIS as well as user navigation data such as costs, travel time. (Ortega et al., 2021). All of these methods require extensive data variables and apply complex computations, and are likely to encounter difficulty in procurement of funding for data collection, as well as expertise for analyses.

Parking lots should have convenient access, and thus should be near arterial roadways, and preferably upstream of major congestion points. (Transportation Research Board, 2004; Vermont Agency of Transportation, 2015A; Coffel et al., 2012). The Vermont Agency of Transportation (2015B) further stated that a site should be within 0.4 km of a major commuter corridor, defined as connecting major employment centres; also, the site should be able to be seen from the road. Ukkusuri et al. (2010) advised that the location should be visible from important highways with clear signage. P&R lots should be near to home relative to the overall trip. (Transportation Research Board, 2004).

The road capacity (that is, the maximum number of vehicles that can pass a point on the road per unit of time) of access points should be adequate. Parking accesses should be set back at least 45 m (preferably 75 m) from nearby intersections and spaced at least 105 m apart and at least two combined entrances and exits should be provided for facilities with more than 500 spaces (Coffel et al., 2012). The location should be able to accommodate most of the parking demand (Cornejo, 2014).

P&R facilities should be located at least 8 to 13 km from the city centre and should be far enough away to compensate for the time spent changing travel modes (Coffel et al., 2012). It should also be placed near the trip origins (residential areas) and far from the trips destinations (employment areas) (Cornejo, 2014); Greater than 6 to 8 km, preferably 16 km from CBD (Ukkusuri et al., 2010). Coffel et al. (2012, p. 100) recommended that population densities in P&R catchment areas should be less than 1,600 to 2,400 persons per square km.

Personal safety and protection of automobiles left in the lot are important commuter concerns. These include lighting, fencing and gates, security monitoring booths, cameras and surveillance equipment, signing, and ensuring adequate visibility from all parts of the facility. (Turnbull, 1995, p. 24). The site should be secure both by being visible and by providing safety amenities such as lighting. Being proximate to a populated area such as a shopping centre is also helpful (Vermont Agency of Transportation, 2015A). The quantity and quality of facilities provided are important factors in P&R site selection, such as toilets, telephones, tourist information, small convenience store, parking for differently abled and cycle parking/lockers (Higginson, 2001).

Selection should consider sites that are likely to have to share activities (Higginson, 2001). A shared lot is the available portion of an existing parking lot for P&R service. The following should be included when considering shared lots: (a) Availability of parking spaces on a weekday basis, (b) Adequacy of the amenities, and (c) During peak periods, the access points are not impacted by traffic generated by adjacent land use activities (Christiansen and Rathbone, 1978).

Site Selection Criteria

The criteria were adopted from the literature review for the site selection process. The potential catchment areas were determined based on computation applied in the literature. The following criteria have been adopted for the site selection process. The individual factors applied to the relevant components were 1- lowest, 2 - medium, and 3–highest.

1. Property Ownership and Operation Type: Government-owned and operated; or, Government-owned but Private-operated; or, Private-owned; Private-operated.
2. Ease of Access: Good proximity to expressway/highway; Upstream of major congestion points; Good access and egress; Visible from important highways.
3. Facility Access Travel Distance: Proximity to home relative to the length of the overall trip.
4. Adequacy of Capacity of Ingress and Egress Points: Parking entrances and exit locations should be set back at least 45 m (preferably 75 m) from nearby intersections and spaced at least 105 m apart.
5. Facility Number of Parking Spaces: At least 250 spaces (150–200 equal to 2 points; more than 250 equal to 3).
6. Distance of P&R Facility from Destination: At least 8 to 13 km from the city centre.
7. Residential Population Density: Population densities in P&R catchment areas should be less than 1,600 to 2,400 persons per square km.
8. Safety and Security: Provision of Security and Monitoring.
9. Amenities: Comprehensive facilities, including toilets, telephones, tourist information, small convenience store, and parking for differently-abled.
10. Shared Lots: Assurance that a certain number of parking spaces will be available on a weekday basis; adequacy of the amenities provided; and, during peak periods, especially the evening peak, congestion within the lot and at the access points not intensified due to traffic generated by the shared use.
11. Potential Catchment Area: Catchment area population is large.

Potential Catchment Areas and their Residential Densities

P&R facilities should be located to serve the best possible population base and population densities. Table 9.2 gives the population and residential density of the potential P&R sites.

Table 9.2 Population and Residential Density of the Potential P&R Sites

NO.	POTENTIAL CATCHMENT AREAS	POPULATION	RESIDENTIAL DENSITY (PER SQ. KM)
1	Ato Boldon Stadium	40.454	252
2	Brian Lara Cricket Academy	108.594	679
3	Centre of Excellence	111.644	697
4	Eddie Hart Savannah	110.095	688
5	Larry Gomes Stadium	83.940	524
6	Trincity Mall	105.966	662

Note. Compiled by R. J. Furlonge

Research has shown that 90 % of a P&R facility's demand will come from an area defined by a circle formed by extending 4 kilometres downstream of the lot and with a chord of 6.4 kilometres either side of the P&R lot, as shown in Figure 9.2 (Spillar, 1997, p. 35).

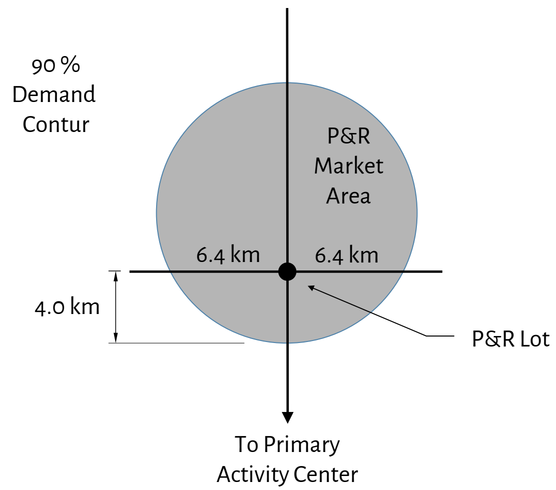

Figure 9.2 Potential Catchment Area Determination
Note. Park-and-Ride Planning and Design Guidelines, by: Spillar (1997)

Figure 9.1 also gives the Potential Catchment Areas and their Residential Densities for the potential sites. It also shows the following:

- Census Community boundaries (light colour, with white representing forest reserves)
- Regional Corporation boundaries, including their names
- The two cities (capital POS and San Fernando)
- Population Density, with the darkest areas representing and range of 526 to 92,486 persons per sq. km.

Site Evaluation

Table 9.3 gives the Site Selection Criteria and Evaluation. The maximum value available from application of the individual factors was 48 points. The ranking was as follows:

a) Brian Lara Cricket Academy–North-South Corridor–43 points (90 %)
b) Trincity Mall–East-West Corridor–39 points (81 %)
c) Larry Gomes Stadium–East-West Corridor–38 points (79 %)
d) Centre of Excellence–East-West Corridor–37 points (77 %)
e) Ato Boldon Stadium–North-South Corridor–35 points (73 %)
f) Eddie Hart Savannah–East-West Corridor–32 points (67 %)

All of these sites have good potential, with the few shortcomings being mainly with amenities and safety and security. Since only two sites are to be selected for the Pilot Study, one each from the east and south, the following were selected:

- From the east, Larry Gomes Stadium
- From the south, Brian Lara Cricket Academy

Table 9.3 Site Selection Criteria and Evaluation

NO.	SELECTION CRITERIA	SELECTION CRITERIA COMPONENTS	SITES A	B	C	D	E	F
1	Property Ownership and Operation Type	Government-owned; Government-operated	✓	✓		✓	✓	
		Government-owned; Private-operated						✓
		Private-owned; Private-operated			✓			
2	Ease of Access	Good proximity to expressway/highway	3	3	3	3	3	3
		Upstream of major congestion points.	3	3	2	3	3	3
		Good access and egress	3	3	3	3	3	3
		Visible from important highways	3	3	3	3	3	3
3	Facility Access Travel Distance	Proximity to home relative to the length of the overall trip	1	2	2	2	2	2
4	Adequacy of Capacity of Ingress and Egress Points	Parking entrances and exit locations should be set back at least 45 m (preferably 75 m) from nearby intersections and spaced at least 105 m apart	2	3	3	1	3	3
		At least two combined entrances and exits should be provided for facilities with more than 500 spaces	-	3	2	-	3	3
5	Facility Number of Parking Spaces	At least 250 spaces	3	3	3	2	3	3
6	Distance of P&R Facility from Destination	At least 8 to 13 km from the city centre	3	3	3	3	3	3
7	Residential Population Density	Population densities in P&R catchment areas should be less than 1,600 to 2,400 persons per square km	3	2	2	2	2	2
8	Safety and Security	Provision of Security and Monitoring	2	2	2	2	1	2
9	Amenities	Comprehensive facilities, including toilets, telephones, tourist information, small convenience store, and parking for differently-abled	2	2	2	1	1	2
10	Shared Lots	Assurance that a certain number of parking spaces will be available on a weekday basis	2	3	1	2	2	1
		Adequacy of the amenities provided	2	2	2	1	1	2
		During peak periods, especially the evening peak, conge-stion within the lot and at the access points not intensified due to traffic generated by the shared use	2	3	1	1	3	1
11	Potential Catchment Area	Catchment area population is large.	1	3	3	3	2	3
	TOTAL		**35**	**43**	**37**	**32**	**38**	**39**
	%		**73**	**90**	**77**	**67**	**79**	**81**
	RANK		**5**	**1**	**4**	**6**	**3**	**2**

A: Ato Boldon Stadium; B: Brian Lara Cricket Academy; C: Centre of Excellence; D: Eddie Hart Facilities; E: Larry Gomes Stadium; F: Trincity Mall

Note. Individual Applicability Factors are 1- lowest, 2 - medium, and 3—highest.
Compiled by R. J. Furlonge

Discussion

Most people in Trinidad and Tobago still mistakenly believe that public transport is the responsibility of the PTSC. The PTSC is simply a Government-owned bus company. Public transportation is required by everybody at one time or the other and is essential for more than 60 % of the population in Trinidad and Tobago. Public transportation cannot be effectively developed and managed without a well-planned transit administration. A properly organised public-transport sector could make a large difference, especially to the peak-hour traffic congestion and to accessibility in many areas. The necessary first step to organising public transport is to place control of the sector in a single dedicated agency—a transit authority (Furlonge, 2011, January 20, p. 16).

The PBR is an extremely valuable asset whose capacity should not be jeopardised by illegal or inappropriate use. Since its primary function is to move people, other non-public transport uses should be prioritised and only be granted a pass when they will not impact on the primary function. In 1974, a decision was taken to convert the abandoned railway lines to exclusive busways. The PBR was created from a railway to an extensive 26-km busway. This means it was conceived as dedicating its two lanes for the exclusive use of buses and other high-capacity road-passenger vehicles. The PBR was completed around 1990 between POS and Arima and was once the longest exclusive busway in the world. The Government was quite futuristic in its thinking in seeking to develop this route as part of a bus rapid transit (BRT) system. A BRT system provides a high quality of service along dedicated or close-to dedicated routes, with increased service frequency, capacity, and speed. Unfortunately, the PBR has never functioned as a rapid bus transit route (Furlonge, 2014).

Studies have shown that transit travel time is competitive with auto travel time, and transit fare is competitive with the cost of driving (Connetics, 2014). Lower public transport travel time increases the probability of choosing public transport while lower transfer time convinces travellers to choose P&R mode over public transport (Islam et al., 2015). The PBR provides an opportunity for an exclusive busway in the East-West Corridor, and thus an improvement in transit travel times. There is no busway in the North-South Corridor. There is potential for a Bus-On-Shoulder (BOS) facility on North-South highway system (that is, on the Uriah Butler Highway and Solomon Hochoy Highway). The BOS concept is the allowing of buses to use shoulders on freeways and major arterial streets during peak congestion periods to bypass congestion in the general purpose traffic lanes. BOS differs from shoulders that are open to high-occupancy vehicle (HOV) and general traffic during peak congestion hours. BOS applications carry much lower volumes of traffic than HOVs and general traffic use of shoulders. Typically, the BOS projects limit buses using the shoulder to times when traffic on the highway is congested and moving very slowly, and they cap the speed buses are allowed to operate on the shoulder. BOS applications minimise congestion-related schedule reliability problems; they improve the competitive travel times for buses versus cars; they reduce bus running times; they are low cost and easy to implement; they do not require new rights-of-way; and they are not obtrusive (Martin et al., 2012).

Customer Amenities at the two selected pilot sites have need for tent shelters. Partially enclosed tent shelters should be provided for passengers. A separate enclosed tent shelter should be provided for the customer information and ticketing staff, and another for security staff. Trash receptacles would also need to be suitably placed. Portable toilets and hand-washing facilities would have to be provided. Concessions for food vendors could be considered, but patrons would have to be advised that food and drink would not be allowed on transit vehicles.

Concerning safety and security at the two selected sites, it has to be recognised that both personal safety and protection of automobiles left in its slot all day are important commuter concerns that must be addressed for the P&R pilot. These would include lighting, security personnel, and ensuring adequate visibility from all parts of the facility. If it is assumed that P&R services for the Pilot would be expected to operate from 5:00 am to 8:00 pm, then the facilities would need to be open from 4:00 am to 9:00 pm, and thus lighting would be required. Lighting is already available at the BLCA, and so temporary lighting would have to be provided at the Larry Gomes Stadium external carpark. Suitable numbers of security personnel would have to be worked out for both facilities.

Conclusion and Recommendations

Trinidad is about to develop official P&R services. It is critical to optimise the location of the P&R lots and maximise the size of the associated catchment areas. All of the current methods for such require extensive data variables and apply complex computations, which would be prohibitive from the perspectives of data collection cost and analyses. This article has attempted to provide a simple yet effective method for site selection. The two Government-owned sites recommended are Larry Gomes Stadium in the east, and the BLCA in the south. The likely patrons of the P&R Pilot will compare the cost of commuting to work using a personal auto and paying for parking at the destination with the transit fare and cost of parking at the P&R lot. P&R will only be attractive to them if the latter overall cost is lower.

There is a weekday transient population to POS from the East and South of Trinidad of 344,000 persons transported in 200,000 vehicles, inclusive of 80,000 public transport. Of these persons, 172,000 travelled for work and about 103,200 went on business.

The following are the suggested system objectives to provide the conceptual design of the P&R Pilot Project, considering user equity in a car-dependent society:

- overcome the shortcomings in transit administration and management
- provide reliable transit services
- provide adequate service frequencies
- provide sufficient services in the off-peak
- provide dedicated bus lanes
- provide adequate passenger information systems
- provide sufficient marketing and awareness of transit services
- provide high-quality waiting environments in terms of cleanliness, lighting, furniture, shelters, safety, toilets, Wi-Fi and phones, trash receptacles, and commercial or service opportunities.

The PBR should be given priority for High Occupancy Transit Vehicles, such as PTSC Buses and Maxi-Taxis, with a heavy emphasis on very large buses such as articulated, accordion-types. Traffic signals would be coordinated along the PBR to emphasise its priority, with pre-emption signal control at intersections favouring transit. This would be the beginning of the functioning of the PBR as a BRT System. The Ministry of Works and Transport should implement a BOS system for the Uriah Butler Highway and Solomon Hochoy highway (North-South highway system) as dedicated bus lanes in order to improve the transit travel times.

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