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Article

'Smart' Tools for Socially-sustainable Transport

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Abstract: In the smart city, information and communications technologies (ICTs) are proposed as solutions to urban challenges, including sustainability concerns. While sustainability commonly refers to economic and environmental dimensions, the concept also contains a social component. Our study asked how smartphone applications (apps) address social sustainability challenges in urban transport, if at all. We focused on transport disadvantages experienced due to low income, physical disability, and language barriers. A review of 60 apps showed that transport apps respond to these equity and inclusion issues in two ways: (a) by employing universal design in general-use apps; including cost-conscious features; and providing language options (b) by specifically developing smartphone apps for persons with disabilities. The article discusses the study by positioning it in the literature of smart cities as well as socially sustainable transport.

Keywords: Smart transport tools; 'smart' and sustainable; social-sustainability

1. Introduction

One of the primary concerns for urban areas in the 21st century is sustainability in using resources and in maintaining environmentally-conscious approaches to urban development. While not explicitly under the umbrella of sustainability, cities attempt to address issues of equity and inclusion as well. In the advent of the smart city[1] and its potential in solving urban problems, specifically in encouraging efficiencies in urban infrastructure and services, cities have been increasingly incorporating 'smart' technologies in their quest for sustainability. The important junction of smart technologies and sustainability has not been missed in the academic literature where the current debate explores the relationship between information and communications technologies and the concept of sustainability [1,2].

In his seminal work on smart cities, Townsend [3] highlighted that the application of information technologies has proliferated urban transportation systems more than other urban planning subfields. The use of smart city technologies in transportation systems includes smartphone applications (app) for various purposes ranging from real-time transit information, measurement of carbon dioxide emission, information about low-cost travel options, navigation information for people with accessibility needs, and many more.

In the academic debate, smart cities are criticized for their focus on the economic and environmental dimensions of sustainability while disregarding social dimensions e.g. [4]. In addition, our review of literature, indicated that in the academic discourse, the joint mention of smart city and social sustainability (equity) was not significant. This can partly be explained through the evolution of sustainability from an environmental concern and its historic focus on the economy and environment. To gain a better understanding of the reality outside the academic literature regarding

[1] "Places where information technology is combined with infrastructure, architecture and everyday objects, and even our bodies to address social, economic, and environmental problems" (Townsend, 2013, p.9).

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the application of smart technologies to social sustainability, we conducted a survey of 60 smartphone transport apps to assess the features they offer in light of equity and inclusion. We share the findings in this paper.

The paper first provides a background on sustainability and sustainable planning based on the definition in the 1987 *Brundtland Report*, highlighting the lack of clarity in the definition and in the meaning of social sustainability. The next section examines urban sustainability and transport equity and inclusion by delving into what constitutes sustainable transport and the impact of transport in shaping communities. Planners and citizens alike are looking to smart technologies as one of the tools for solving urban challenges. The concept of smart technologies is introduced following that and it focuses on what role they play, if any, in socially-sustainable transport. The findings from academic literature on their role is contrasted with the findings of our study, which we discuss in depth including the method of investigation and data collection used.

The overarching goal of the study is to contribute to research work at the intersection of socially-sustainable transport and technology. One of the objectives of the paper is to bring forth issues of social sustainability in the 'smart' discourse. In discussing the social aspect of sustainability in relation to an emerging technology, this paper will contribute to breaking the historical persistence of the focus of sustainability on the environment and economy only. The paper will also raise questions of equity and inclusion in urban transport and paint a realistic picture of the potential and limitations of smart technologies in contributing to these issues.

2. Sustainability and Sustainable Planning

Discourse on the topic of sustainability often references the vagueness of the concept and includes the frequently cited definition of the term put forth in 1987 by the *Brundtland Report*, entitled Our Common Future [5]. According to the report, "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [6] (p. 291). It is widely accepted in the literature about sustainability that the "needs" mentioned in the report are threefold: economic, ecological, and social [7,8] while [9] list four "needs": cultural, political, ecological, and economic. Social is a broad concept that includes both culture and politics; as such, the discussion in this paper will reference to the three needs, commonly referred as the 3Es (economy, environment, and equity).

The definition in the *Brundtland Report* has been adopted across various fields. It is especially relevant in urban planning; as [5] said, "Sustainability and planning have much in common." (P. 507). Sustainability has three aspects, namely economic, environmental, and social; so does urban planning according to [10, 11]. Moreover, planning and sustainable development are both future-oriented practices. Planning is inherently a sustainable practice in that it is a balancing act of competing needs, including that of future generations, which sustainable development stands to protect. Sustainable policies should include the preservation, maintenance and strengthening of all communities and their overall quality of life through a variety of community services and infrastructures. The three Es of sustainability are prosperous economy, quality environment, and social equity. The ethical principle of equity, particularly intergenerational equity, is central to the concept of sustainability.

The definition of sustainability in the *Brundtland Report*, despite creating the basis of most discussions on sustainability, is vague, an attribute that has made it open to various interpretations. We concur with [9] that there is a lack of precision in understanding exactly what sustainability is. This is problematic because misunderstanding the concept may lead to using ineffectual and incorrect methods which in turn may result in an inability to achieve the desired outcome. Unfortunately, the lack of precision also extended into the varying degree of attention the three "needs" receive, with the environment being at the top of the list. Partly this has to do with the evolving concept of sustainability in public policy. [5] said it originated and extended from environmental sciences. Similarly, [7] pointed out that the precedent to the *Brundtland Report* in sustainability research was the 1972 United Nations Conference on the Human Environment. In that conference, the organization decided that it was important to protect the environment for the well-being and economic prosperity of human beings. It sounded a warning alarm that the world had come to a juncture where

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environmental consequences of human actions could not be ignored anymore. It also laid out principles, action plan for implementation, recommendations, financial arrangements, and a multitude of miscellaneous resolutions to protect the environment. Partly as a result, the environment receives considerably more attention in the sustainability discourse. While such is the case, [12] said economic and social dimensions of sustainability are acknowledged but there is neither consensus nor clarity regarding the meaning of social sustainability. [13] agree with the lack of clarity in the meaning.

When the concept of sustainability is examined in the context of cities, the same emphasis on the economy and environment is observed. [7] said "Most of the definitions [of urban sustainability] are derivations from those of sustainability" (p. 1178). Similarly to sustainability, the concept of sustainable cities evolved from concerns that are mostly environmental [14] and from an interest to reduce the effects of climate change and urbanization [15]. While cities address equity and inclusion concerns through various avenues, (a) they do not address them as the social dimensions of sustainability or (b) they do not receive the same degree of attention as the economy and environment.

Consistent in various perspectives on cities is that they play a part in creating sustainability [8, 7, 9, 16, 17, 18]. Ensuring urban sustainability (which is the focus of our paper) then becomes of utmost importance. According to the European Environment Agency, one of the five goals that creates urban sustainability is "ensuring equal access to resources and services" [19]. This entails the provision of services and infrastructures to all members of the community, ensuring a level of affordability and access to service and removing barriers to service.

3. Social Sustainability in Urban Transport

While economic growth remains essential, development must not only meet present concerns for growth, it must do so in a context that includes the long term safeguarding of social and environmental resources. Sustainability policies should include the preservation, maintenance and strengthening of all communities and their overall quality of life through a variety of services and infrastructures. This will require significant changes in planning, lifestyles, population growth, and especially in technology. Overall, the concept of social sustainability can be defined according to two points:

- **Intergenerational equity**: the success of cities of the future will largely depend upon the legacy on current cities on resources and the environment. Capital assets passed on to the next generation must be at least of equal value.
- **Social equity**: implies a fair and equitable distribution of resources among the current generation. In terms of the built environment, the metropolitan area should provide a place of equal opportunity and not be an agent of segregation.

Plans for urban sustainability generally address transportation, housing, and employment and their effects on air quality, energy use, economic prosperity, and social equity. Recommended policies often include transit-oriented development; mixed-use developments; urban infill; brownfields redevelopment; more public transit use; active transportation; and better transportation information. This paper specifically examines social sustainability in transportation systems as they have far-reaching effects in social and economic opportunities, i.e. employment and prosperity, health and wellbeing, education, and access to information.

Transportation mobility is a hallmark of full membership in American society. The basic concept behind "sustainable transport" is to make transportation, land use, and resource decisions in a manner that does not preclude transportation options for current or future generations or any segment of populations. This is an initiative that broadens the scope of transportation decisions so that economic, environmental quality, and social equity considerations are balanced in the short and long term [20]. At the national policy level, the concept of sustainability including its applicability to communities, transportation, and the environment is quickly emerging as a key issue. As mentioned, sustainability is a frequently used concept whose exact meaning is not well established. An oft-quoted definition cited previously reads: "a sustainable condition for this planet is one in which there is

stability for both social and physical systems, achieved through meeting the needs of the present without compromising the ability of future generations to meet their own needs" [6] (p.41). However, this definition is difficult to express in objective terms, and there is no consensus on the specific policies that flow from it. Nevertheless, many advocates have determined that promoting a sustainable environment and sustainable communities is a key objective. Though its definition may vary from place to place, a sustainable transport system is one that:

- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy
- Is inclusive and provides options for persons of various abilities, financial as well as linguistic capabilities
- Saves in travel costs
- Ensures opportunities for meaningful public involvement in the transportation planning process, particularly for those communities that most directly feel the impact of projects or funding choices
- Distributes the benefits and burdens from transportation projects equally across all income levels and communities
- Provide high quality services—emphasizing access to economic opportunity and basic mobility—to all communities, but with an emphasis on transit-dependent populations
- Equally prioritize efforts both to revitalize poor and minority communities and to expand transportation infrastructure

Across the country, community-based organizations and low-income and minority residents that seek to improve their communities are recognizing the significant role played by transportation in shaping local opportunities. Efforts to challenge inequitable transport policies have become increasingly sophisticated to encompass a broad range of related social impacts. In the advent of the smart city, urban planners, governments, and citizens consider 'smart' solutions promising for solving urban challenges, including urban transport. Among these include incorporating ICTs to expand and increase participation in the planning process [21].

Rapid changes in technology and changing patterns in travel behavior are having significant impacts on urban transportation mobility. Because the ease of movement within and between urban places is a critical element of social, economic, and environmental vitality, the evolution of complex systems for moving people, goods, and information is the focus of considerable global attention. Modal options in the future will be different from those we experience today, perhaps in unexpected ways Cities will seek to implement "intelligent", "smart", and "sustainable" practices as they plan for and analyze the mobility needs of their populations. In the process, these practices will shape and reshape urban landscapes. History has shown that each era of transportation innovation has also coincided with cultural shifts. An interesting question is how or whether culture prompts technological change, especially relative to the "smart city" movement.

4. Smart and Sustainable

According to [3], the intent of smart cities, which he defines "as places where information technology is combined with infrastructure, architecture and everyday objects, and even our bodies" (p.9) is to solve problems of the economy, environment, and those of social nature. In that, the author implied that the purpose of smart cities is inherently to attain sustainability by addressing its three dimensions. A slightly different sentiment is reflected by [4] who highlights that the 'smart' concept merely encourages sustainable practices in the three dimensions of sustainability. However, the author argued that regardless of the technological affordances to advance sustainable practices in all dimensions, socially sustainable considerations are not optimized by the smart city. Similarly, [22] state that one of the challenges smart cities face is in developing technologies that work in the interest of fairness and equity. This reflects that the introduction of 'smart' in sustainability has followed the historical focus on the environment and economy.

The integration of ICTs and sustainability is gaining traction as a topic of discussion in the academic debate [2]. We found in our study that there is still less focus in the academic debate for

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smart solutions that create social sustainability. We examined approximately 90 sources on topics of smart cities and technology, sustainability, and equity and inclusion. There are certainly substantial bodies of literature on sustainability, social equity, and smart cities. We focused on recent sources that would be more likely to draw together these themes or at least include each as components of contemporary urban discourse. A keyword search of the selected documents resulted in 4,100 mentions of "smart" or "technology"; 2,197 mentions of "sustainability"; and 710 mentions of "equity" or "inclusion". This allowed us to get a general sense of topics being discussed by each, but we did not examine each of these 7,007 keyword mentions for context. The keyword search did allow us to identify documents that potentially included the three topics of interest (see Figure 1 – Venn diagram of topics/keywords).

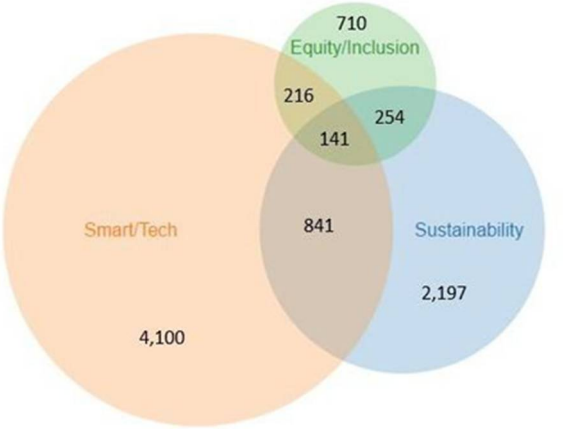

Figure 1. Document analysis and keyword co-mentions (note: numbers show frequency of (co)mentions)

The keyword scan resulted in 20 documents that along with sustainability and smart cities (or technology) also mentioned equity or inclusion. As shown in Figure 1, there were a small number of mentions of equity or inclusion related to smart cities or sustainability. It is interesting to note in these cases how equity was being connected to sustainability and also to technological aspects of cities (i.e., smart cities). There are many perspectives, applications, and implications of the concept of equity. Among those included equity as part of the planning process, as inputs and also as outcomes. Several authors acknowledged that social exclusion and inequity are critical problems to be addressed (e.g., Newton, 2012). Technologies as part of "smart cities," are sometimes seen as having the potential to increase citizen engagement (Allwinkle and Cruickshank 2011, Angelidou 2014) and having the potential to increase citizen engagement (Angelidou 2014, Redman 2014, Basiri et al 2016). These notions are common among planners who see information and communications technologies as removing barriers from government and public interaction and information exchange.

Overall, the joint mentions of sustainability, technology, and equity fell into six general categories. These include citizen engagement, citizen involvement in governance and planning process, digital divide/digital inclusion, detecting inequality and disadvantage, human and social capital, and general critiques about the ineffectiveness of technology in addressing social inequity. There is a notable void in the literature that explores the junction of technology and social sustainability.

5.'Smart' Beyond the 2Es?

The academic literature suggests that smart city technologies have not explored the social aspect of sustainability to address urban challenges as discussed previously. To compare that with the reality outside of it, we designed a study to examine the application of information and communications technology ('smart' tools) in addressing a social dimension of sustainability in transport. In our Section 3 we provide a list of what constitutes sustainable transport. For the purpose of the study, we focus on three issues in the list: affordability, access to transport for people of varying

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body abilities and language proficiency. We selected smartphone apps as the smart mobility tool of choice for this study as they have become ubiquitous in various aspects of urban living, with a high presence in transport-related functions.

Smartphone apps are "software programs for mobile device operating systems …" (Ahmad, Brauer-Rieke, & Newland, 2012, p.1). The use of smartphone apps for daily urban living is growing rapidly. In 2015, out of the 77% Americans who owned smartphones, 68% of them used apps, with 38% using 20 or more apps and 7% using 50 or more apps (Olmstead & Atkinson, 2015). The app technology notably enables the shared economy through platforms such as Uber, Airbnb; providing social connectivity - Facebook, Twitter; assisting navigation and travel - Waze, Google Maps; and providing essential assistive information for visually impaired persons - BlindWays, BlindSquare; and so on. The industry is also growing fast. According to the University of Alabama at Birmingham (2017), by 2017 the app market will be a $77 billion industry worldwide, with more than 268 billion app downloads. It is also estimated to have employed 1.729 million by December 2016 (Mandel, 2017). In the study, we asked: What role do ICTs play, if at all, in making urban transport socially sustainable, i.e. equitable and inclusive in relation to cost, disability, and language barriers? To investigate the state-of-the-art, we examined 60 smartphone transport apps.

6. Data Collection and Research Method

We collected data by replicating Google searches that people conduct to look for apps, and used the following keywords: transport apps, ridesharing apps, ridesharing services, carpooling apps, transport apps for people with disability, transport app for the visually impaired, transport apps for wheelchair users, transport app for low-income earners. Using terms such as transport apps, ridesharing apps, ridesharing services, carpooling apps, resulted in enough apps for our collection on the first pages of each Google search. However, when using terms like transport apps for people with disability, transport app for the visually impaired, transport apps for wheelchair users, transport app for low-income earners, we included the first, second, and third pages of the Google search results.

Our initial search resulted in a list of approximately 90 apps. We looked for these apps in the Apple Store and Google Play (initially depending on which one appeared first, but mostly on Apple for consistency and information on language options). Further exploration indicated that some of them were not available and did not have official websites, for example RideScout, Hopstop, and Way2ride. For some apps, we found media accounts that reported they no longer exist. With other apps, we identified that they were not exclusively for transport purposes but have a component of it. These include Looptivity and GoKid. We excluded AccessMap, Ridershare, and Kangaride as they are not smartphone apps but web-based platforms. This processes reduced the number of apps in our list to 60.

A content analysis was conducted on the descriptions of apps found on their respective official download pages from the Apple store, Google Play, and official websites. This research method was used for the following reasons: convenience to access websites at any time, accuracy of information regarding the apps' features, and efficiency in time used to gather data. We identified sample size (60 apps) to be a limitation of our data. The limitation in our research method is that we did not verify the functionality of the apps' features with users to compare with the official descriptions of the apps. In addition, in focusing on the official website descriptions of apps, the study might have missed app features not described there. The next phase of research will include interviews with app developers, app users, cities, and transport agencies to gather more data.

The data used for this study constitutes a list of apps for public transport, car sharing, carpooling, cycling, and walking. Most of the apps examined were for short, urban travel while a few of them were for longer-distance. Apps that have some component of travel such as Looptivity, Cozi, Carpool Party, and Carpooler were excluded in order to maintain consistency of the type of apps and the features for which they were assessed.

Our research question asked how smart tools respond to social sustainability concerns resulting from low-income and physical and financial barriers. To assess the apps for inclusivity and

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equitability, we looked for references of cost, wheelchair accessibility, accessibility to vision impairment, and availability of language options in the description of the apps. Terms used included save money, wheelchair accessible, share cost, accessibility feature for blind users, split cost, and so on.

7. Findings and Discussion

Based on the approach described above, our analysis produced the following findings.

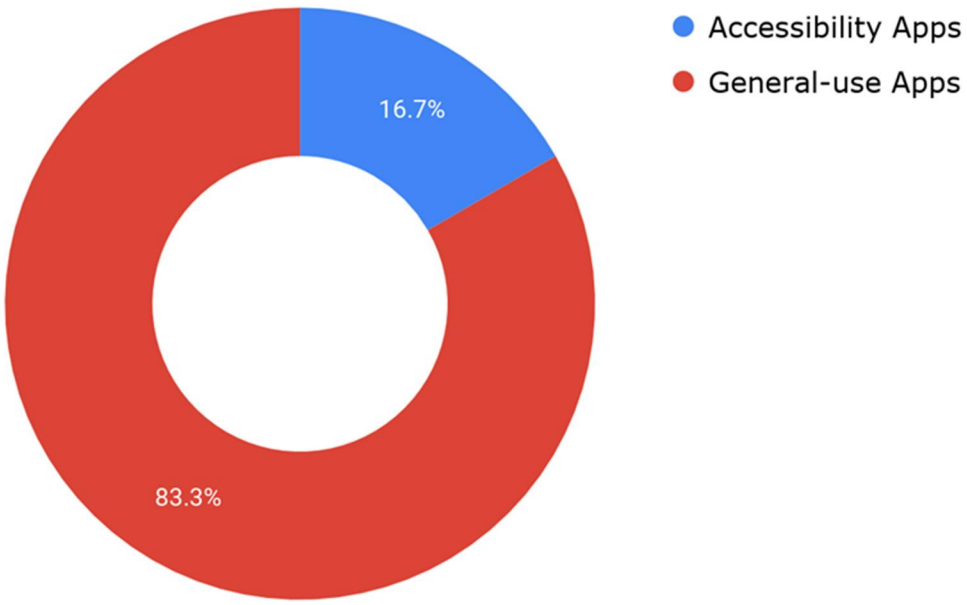

Figure 2: Out of the 60 apps reviewed, 16.7% of them were accessibility apps and 83.3% of were general-use

Google searches using generic terms like "transport apps" listed more on the first search page of results than using specific terms like "transport apps for the visually impaired". This indicates the proportion of apps for general use compared to those that encourage social sustainability in transport. This was not unexpected considering the fact that populations with transport disadvantage due to limited physical ability and language barriers are a minority and represent a smaller market for app developers. In the US, nearly 20% of the population have some form of disability (US Census Bureau, 2012).

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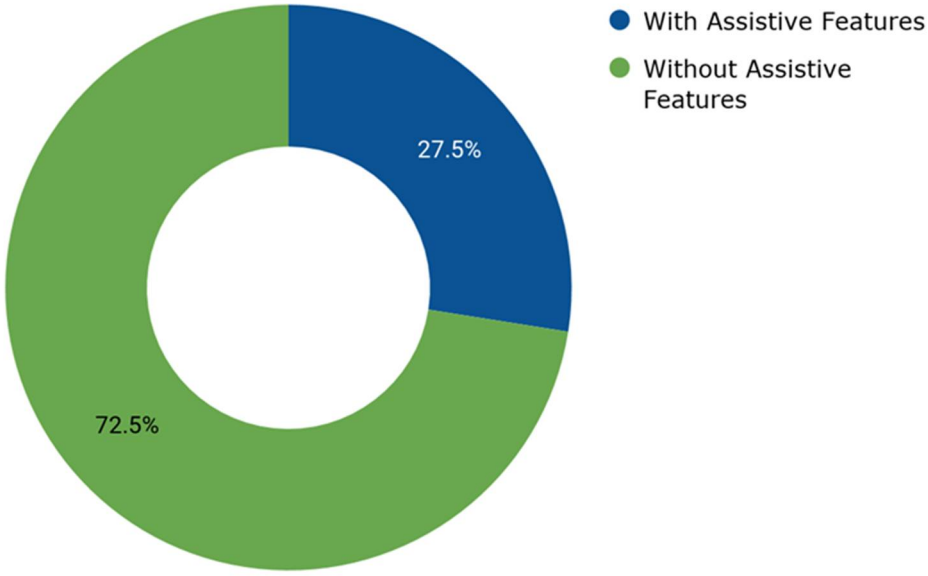

Figure 3: Percentage of general-use apps with and without assistive features

The apps we examined fall into two different categories in terms of the type of function they provide. In the first category the apps aggregate travel-related information to assist with navigation. Examples in this category include Google Maps, Bus Checker, Waze, and BlindSquare. The second category of apps enables travel service through car rental (e.g. Car2Go) or ridesharing services (e.g. Uber, Carma, Curb). Figure 4: Type of provision in all apps

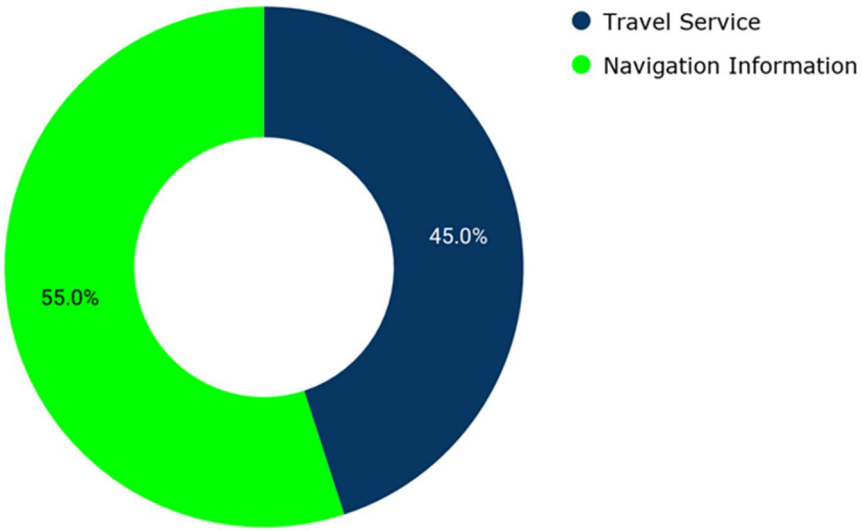

Figure 4: Type of provision in all apps

Another finding is that apps serve two different users: the general public and those that require special needs. The former group makes up most of the listed apps in our data and the later constitutes a quarter of the list. Out of the 60 apps examined, 18% of them were developed specifically for accessibility needs - for persons with limited mobility or visual impairment. Out of the 53 general-use apps, 21% included information about wheelchair accessibility or voice options for navigation. Language option was offered by 62%, varying from two to over fifteen language options and seventeen percent (17%) mentioned cost-conscious features. In other words, the apps responded to social sustainability in transport in two ways: (a) by employing universal design in general-use apps,

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including cost-conscious features, and providing language options (b) by specifically developing smartphone apps for persons with disabilities.

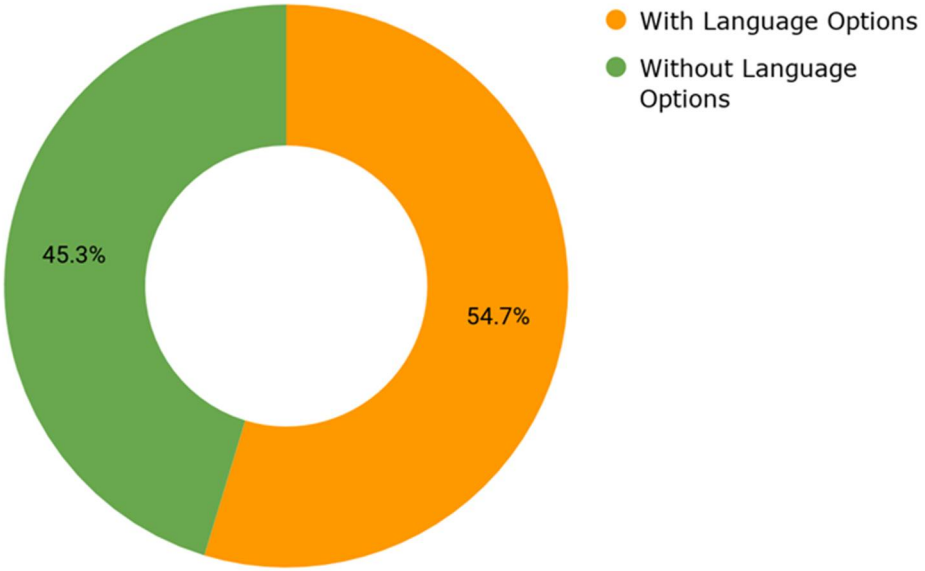

Figure 5: Language option in all 60 apps

Our finding that some of the most used general-use apps such as Waze, Uber, Google Maps are incorporating accessibility features indicates two things. That accessibility is a consideration for smartphone app developers and that ICTs can be used for socially sustainable practice in transport. Apps such as Waze are used by millions in many countries around the world and as such provide service in various languages. As a result, their language options address potential barriers in communities that are linguistically diverse. Some of the apps provide features that enable cost-sharing or cost-splitting indicating the technology's ability to respond to transport disadvantages that result from financial barriers.

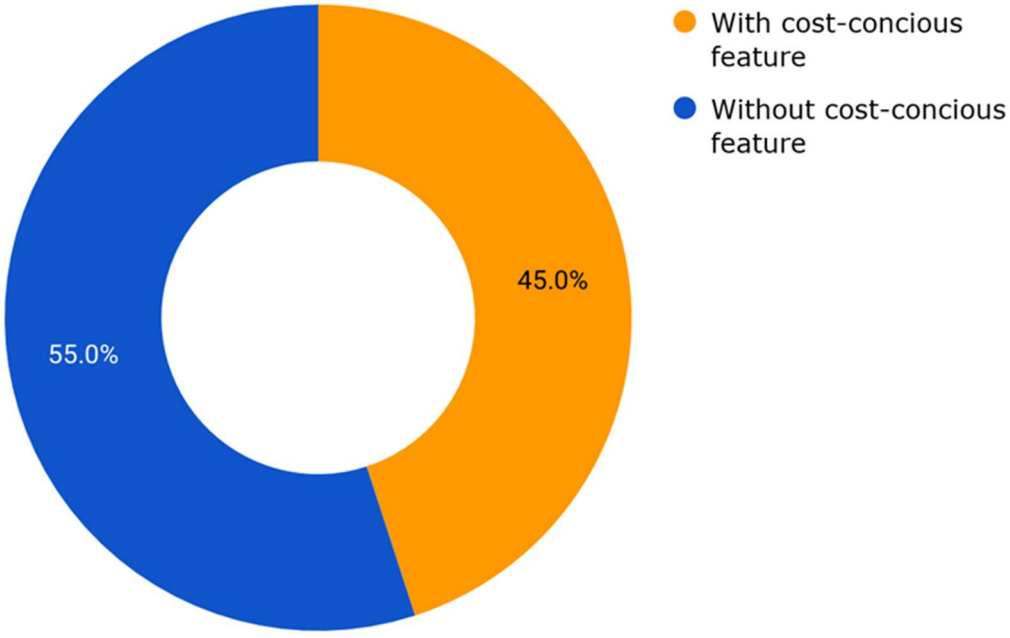

Figure 6: Apps with and without cost-conscious features

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8. Smart Tools, a Panacea?

In a report entitled, Technological Innovations in Transportation for People with Disabilities, the Federal Highway Administration (FHA) stated, "Technological advancements could help to empower people with disabilities by addressing their mobility needs, but the benefits of such advancement have not yet reached this segment of the traveling public" (FHA, 2011). The same demographic that can benefit from the technology have barriers to accessing it. Smart technologies have the ability to remedy digital divide but they might create other forms of polarization (Batty, 2012). A Pew report published recently highlighted the pronounced difference in smartphone ownership based on education, age, and income (Anderson, 2017). (See figure 7,8, and 9 below adopted from Anderson, 2017, Anderson & Perrin, 2017 (a); Anderson & Perrin, 2017 (b)).

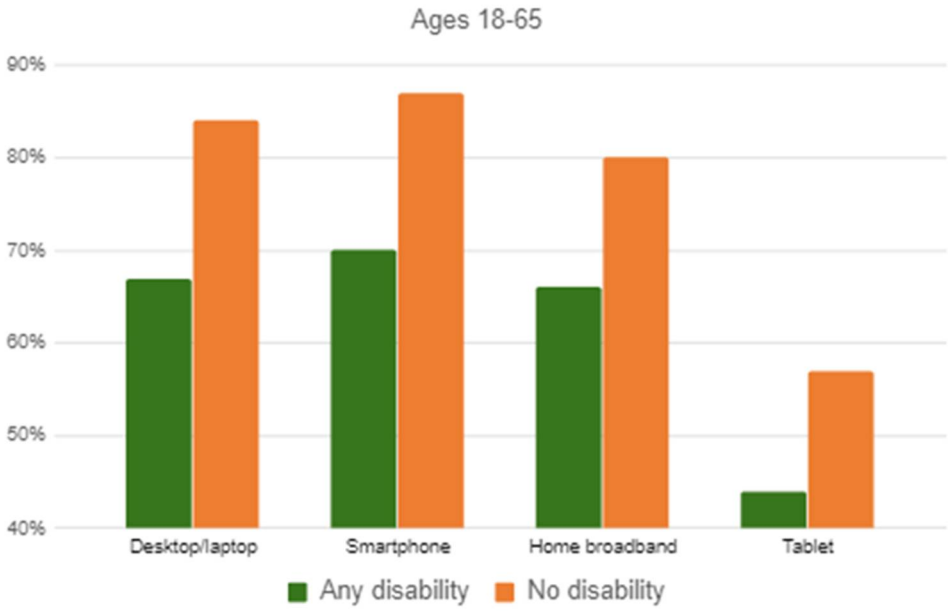

Figure 7: Technology usage and body ability for ages under 65

Figures 7 and 8 illustrate the consistent gap in technology adoption between those with disabilities and those without. As might be expected, the 18 to 65 age group has adopted technologies like computers, broadband, laptops, and tablets more rapidly than has the 65+ age group. It is interesting to note that between these age groups, the adoption gap by disability status is fairly similar averaging 15-16 percentage points. Also as expected, there is a significant adoption gap by income level (see Figure 7). For the technologies shown, the gap is between 30 and 40 percentage points, with an overall difference of almost 50 percentage points. A digital divide clearly present and looks to particularly disadvantage those with disabilities.

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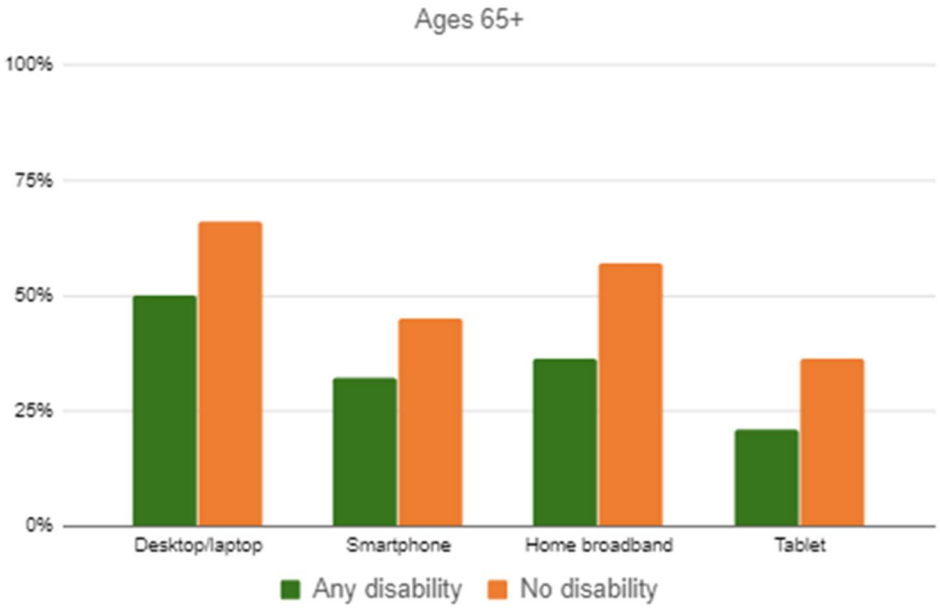

Figure 8: Technology usage and body ability for ages under 65

As shown in the above statistics, seniors, persons with disability, and low-income earners have a lower rate of adopting technology in general and smartphones in particular than their peers in other demographics. Developing technologies that consider equity and quality of life equally is challenging for those who create them (Batty, 2012). The challenge faced by users can be due to inequity in access to technology or a technology that address equity issues.

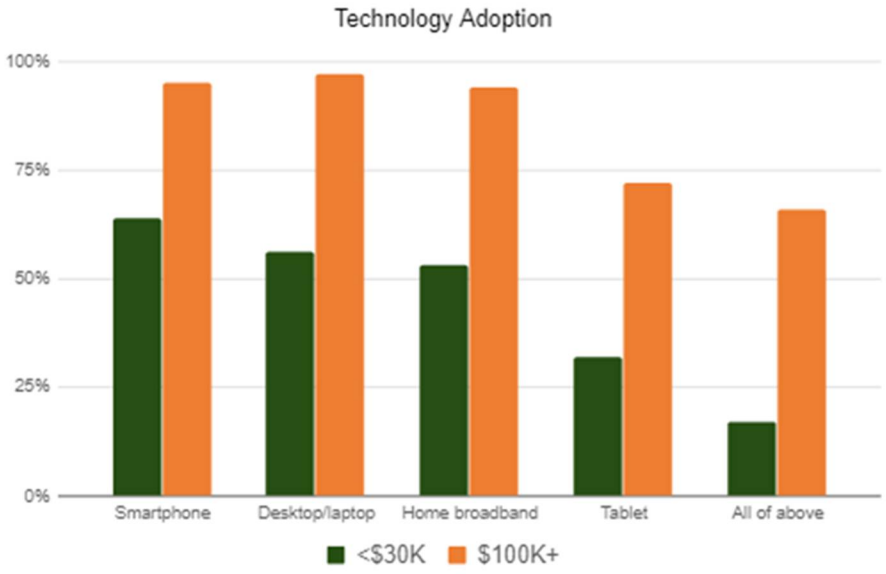

Figure 8: Technology usage and body ability for ages under 65

The objective of our study was to gain a better understanding of the application of smart tools for the purpose of socially-sustainable transport. While our list of apps was not exhaustive, the findings of our study indicate that smart technology has the potential to address equity and inclusion issues and play a role in creating social sustainability in urban transport. However, this is not to imply that technology is a panacea for equity issues; rather it is one of the tools that can be used to address

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them. In addition, regardless of the technological capabilities, socio-economic factors affect technology use. As discussed previously access to emerging technologies affects the same demographics whose transport disadvantage could be alleviated using advancement in ICTs. To fully optimize the technology's potential, these socio-economic factors need to be addressed. In other words, it is important to recognize that the ability of smart city technologies to play a part in contributing to sustainability is dependent on other socio economic factors. Batty (2012) said, "New technologies have a tendency to polarize and divide at many levels and we need to explore how new forms of regulation at the level of urban and transport planning, and economic and community development can be improved using future and emerging technologies"(p. 481). One way, he said, this can be accomplished is by balancing efficiency and equity.

9. Further Research

In this study, we examined equity and inclusion issues by focusing on cost, physical, and language barriers. We recognize that transport exclusion occurs as a result of other factors such as various forms of disabilities, race, gender (safety issues for women), level of literacy (specifically, in immigrant communities from countries with high illiteracy level), localities, and neighborhoods. The next phase of our study will exclusively focus on disability and explore the issue in depth. We will pay attention to development of new apps and assess their applicability to persons with disabilities. The Americans with Disabilities Act plays a role in accessible transit; our study will examine its role in regulating transport apps in general and those associated with travel service such as Uber, Lyft, Via, and others in particular. As one of the emerging information and communications technologies, transport apps have a communications aspect. Our study will examine the role of the Federal Communications Commission in relation to their regulation.

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