Using Digital Communication for Transportation System in Smart Sustainable Cities

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Abstract

Smartphones today, which outnumber people worldwide in terms of accounts, do more than just connect people; they also serve as a practical tool for increasing the sustainability of cities. This research focuses on smartphone applications and their role in reducing transportation problems to form the ideal sustainable city. The problem found in the current transportation system in our cities reduces the sustainability of the city, and the questions of this study are: what is the effect of digital communication (smartphone applications) on the transportation system in the city? and can digital communication make cities more sustainable through its effect on transportation system? The methodology of this research is descriptive and analytical, through offering examples of smartphone applications and specified advantage and disadvantage of each example used in transportation system through reducing transportation problems to form the ideal sustainable city. The research concludes that digital communication has a positive impact on transportation system, in which it helps in reducing most transportation problems in our cities and contributes to sustainable cities.

Keywords: Digital communication; transportation system; sustainable city; smartphone applications

1. Introduction

Electronic devices are considered the most commonly used means of communication. It has been argued that the existing urban problems can be addressed using innovative and emerged digital communication (Lind, 2012). As cities strive to become more sustainable, municipalities seek to find out how Smartphone apps can change the way people move in cities. It is estimated that around 50% of the world's population live in cities and urban areas. To make cities more sustainable, city planning, urban design, and transportation systems, as well as perception and lifestyle, should embrace sustainability thinking (Bhatt, 2016). An ideal sustainable city is designed with consideration of environmental impact. People in sustainable cities consume less amount of energy, food, and water, thus the minimum amount of waste and pollutants are produced.

Transportation is a very important system in each city, and to promote cities toward sustainability, the transportation system should also become a sustainable transportation system in terms of environmental, social, and economic aspects (Mihyeon Jeon and Amekudzi, 2005). Nowadays, the everyday life is evolving due to digital communication, which combines digital communication with another device, such as a smartphone. Digital communication helps governments operate more intelligently (Bhatt, 2016).

The immense population growth in our cities makes the existing transportation system not meet the needs of all people, which leads to several problems in our mobility, including traffic jams, spending a lot of time in transportation, and consuming a great amount of energy in transportation that reduces the level of sustainability in cities. These confronted difficulties in the current transportation system in our cities challenge the notion of sustainable city.

This research focuses on the effect of digital communication, specifically smartphone applications, on the transportation system. Smartphones become the most usable devices in our daily life, thus this study attempts to forward their use to reduce some of our daily life problems related to transportation system. The main objectives of this research are:

- Highlighting the problems of transportation in the city.
- Identifying the positive and negative impact of digital communication on the transportation system.
- Implementing a method of using smartphones to reduce the transportation issues.
- Promoting the cities toward smart sustainable communities through solving transportation difficulties.

2. Theoretical Analysis

Numerous studies have been conducted on the role of technology and digital communication in improving the sustainability of urban transportation systems. A study by Lopez-Carreiro and Monzon (2018) assessed the concept of *smart urban mobility* as a combination of sustainability and innovation. It focuses on the growth and innovation in the concept of smart transportation in Spanish cities, by the factors of size and urban typologies, and they indicate the smartness dimension in the cities. The methodology of the research was the identification of quantitative indicators that assess urban transportation system through an artificial parameter known as the Smart Mobility index. It offers an overall framework for benchmarking cities by the smartness of their transportation systems. They highlight the features that most influence the smartness of a city's transportation system.

Other researchers focus on intelligent transportation systems such as (Sun, et al., 2016). They describe the system through an architecture viewpoint and its application in the transportation system. This study employed utilization of floating vehicles data and the methodology for introducing and analyzing architecture viewpoint. The authors describe the system from five points: functional, communication, enterprise, information and connectivity. Lind (2012)

highlights three ways of using communication technology that promotes sustainability, namely open access to data, the spatial information design lab, and community mapping.

Katiyar, et al. (2011) tried to solve the problem of the transportation system in cities, such as traffic crowding and overcome emergency conditions (i.e., accidents), by combining the transportation system with computer and information technology. The authors seek an intelligent system by using wireless sensors and Bluetooth technology networks, which are composed of small tiny devices that work in an autonomous method to sense the surroundings. They offer the question of how to obtain information about the roads? Focusing on the factor of safety in the roads by specifying the position and speed of the vehicles. The study focused on the payment system for transportation by using the mobile phone which can allow users to start and end the journey of a vehicle by specific application based on user inputs, acts as an electronic ticket for the payment. They described a toll road control and payment system by using toll policy through the factors of times and costs. The research discusses advantages, such as easy implementation in any urban context, and disadvantage of the system, and they argue that toll payments enclouding lower times and lower costs. The methodology used in this study was simulation analysis, and they concluded that sensor networks and Bluetooth can be used to increase the safety of road travel.

Other scholars studied sharing systems in cities, namely bike sharing and taxi sharing, and how these systems contribute to the quality and sustainability of the transportation system. Macioszek, et al. (2020) searched for bike sharing system as a common mean of eco-friendly, flexible, and suitable system in many cities. The management of these systems is through the use of smartphones due to the reason that the next-generation bikes will be smart and have the ability to communicate. They focused on analysis of the functioning of the bike-sharing system in Warsaw, Poland. Factors affecting bike-sharing system usage and the satisfaction level are studied. They found that there is a strong positive correlation between these variables.

d'Orey, et al. (2012) studied the taxi-sharing system in sustainable cities and its empirical evaluation of a dynamic and distributed to make transportation in cities economical and flexible. The objective of this system was to reduce the number of vehicles in the city and to increase the efficiency of use. The methodology employed was simulation analysis, for which the shared taxi service was evaluated in a real-city scenario using a realistic simulation program. They concluded that this system can increase average occupancy per traveled kilometer by 48% and it has benefits for both passengers and taxi drivers.

In recent years megacities have received more attention than medium- and small-sized cities regarding urban sustainability to accomplish basic development, since they present a strong opportunity for environmentally friendly transportation (Pojani and Stead, 2015). According to their analysis, medium-sized and small-sized cities have a great deal of potential for developing transportation systems. They refer to urban expansion, green travel modes, and the environment through flexibility, adaptation, and protection as sources for implementing new transportation measures, and it can be more vulnerable to fluctuations in the global economy by nine commonly considered options.

Another topic studied by scholars is the effect of online shopping on transportation in the cities. Giglierano and Roldan (2001) searched for the effects of online shopping on vehicular traffic. They mentioned that more people buying goods and services online will reduce short-distance traffic. The methodology of this study was personal interviews focused on consumers' shopping behaviors and the effects on short-distance traffic. The authors concluded that online shopping reduced total short-distance vehicle traffic by 0.31% in 2000 and he expected a reduction of 0.93% in 2004. Francke and Visser (2015) studied the effect of online shopping on both passenger and freight traffic in urban areas through the effects of time and financial passenger budgets. The paper discusses some facts about internet shopping and its impacts on mobility in city. It concluded that internet shopping has positive effect on mobility through time and financial budget.

The theoretical analysis demonstrate that researchers examine the impact of digital communication on cities from different angles and in light of various factors, such as the size, typology, and travel safety of cities. While some researchers offered the system of sharing taxis and their impact on transportation, others focused on a specific system to be used to reduce transportation systems, as well as the impact of online shopping on city transportation through time, money, and distance considerations was another topic of research. Table 1 outlines the summary of the theoretical analysis, highlighting the studied variables, factors, and their main findings.

Table 1. Analytical summary of the studied research.

Author/s	Publication year	Dependent variables	Independent variables	Factors	Findings
Lopez-Carreiro and Monzon	2018	Sustainable transport networks	Sustainability and innovation	Size and urban typology	Highlight the features that most influence the smartness of a city's mobility
Sun, Li, and Gao	2016	Cooperative intelligent transport	Architecture and Application	Utilization of floating	Describes the architecture of the system from five viewpoints
Katiyar, Kumar, and Chand	2011	Intelligent Transportation system	Wireless Sensor and Bluetooth technology	Safety of road travel	Blue tooth and sensor networks are used to increase the safety of road travel
Astarita, Giofrè, Guido, and Festa	2013	Road pricing	Mobile phone	Toll policy	Toll payments ensure lower access times and lower operating costs
Razzaque and Clarke	2015	Journey planning	Bike sharing system	Time and money	Bike-sharing system reduce the time and money of traveling
d'Orey, Fernandes, and Ferreira	2012	Empirical evaluation	Taxi-sharing system	Dynamic and distributed	Increase of %48 in the average occupancy per traveled kilometer with a taxi-sharing system
Pojani and Stead	2015	Sustainable urban transport	Nine commonly considered options	Urban expansion green travel modes, environment	Smaller and medium-sized cities have great potential to develop a sustainable transport system

Lind	2012	Information and communication	Technologies, sustainable cities	Livable and equitable	Open access to data, community mapping community watch
Giglierano and Roldan	2001	Vehicular traffic	Online shopping	Short distance traffic	Online shopping reduced total short-distance vehicle traffic by only 0.31 percent
Francke and Visser	2015	Mobility	Internet shopping	Time and financial budget	Internet shopping has a positive effect on mobility through time and functional budget

3. Methodology

The study employs descriptive and analytical methods to collect and analyze data through studying articles, books, and electronic documents. The theoretical analysis was presented in the previous section and the variables, factors and main findings of the studied body of knowledge were summarized in Table 1. The selected digital communication technologies include: applications for transport maps, bike-sharing system, online shopping applications, electronic ticketing applications and taxi calling applications.

The descriptive method was used to discuss the solutions of digital communication proposed in the theoretical analysis to address the transportation system problem and to promote the cities toward smart and sustainability qualities. Accordingly, advantages and disadvantages of these technologies are argued and their effects on the transportation system are described in the following sections. This is divided into three stages, as presented in Figure 1:

- Stage 1: Studying examples of innovation in digital communication through smartphone applications and how they are used in cities.
- Stage 2: Specifying the advantages and disadvantages of each example used in the transportation system.
- Stage 3: Identifying the effect of each example in the transportation system by reducing transportation problems to form the ideal sustainable city.

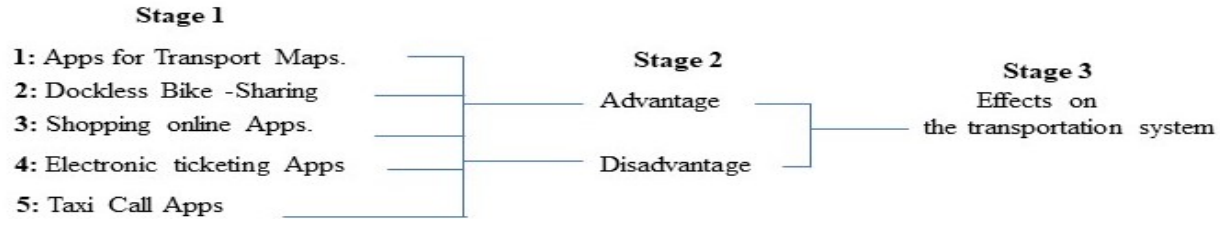

Figure 1. The structure of research methodology.

4. Digital Communication Using Smartphone Applications in Cities

4.1 Transportation-related Applications

Applications for transport maps are apps in smartphones that determine all public transportation systems such as trains, buses, and metro. They determine the place and time of each stopping station during the day in the city (Figures 2). Users can know the nearest station for each public transportation to reduce the time of waiting, using public transport apps are used in many countries, to change from cars use to trains, buses, and metro Systems, guided by apps on their smartphones. Smartphone apps are offering increasingly suitable ways to take journeys and away connections to other transport methods. (Lo, 2014).

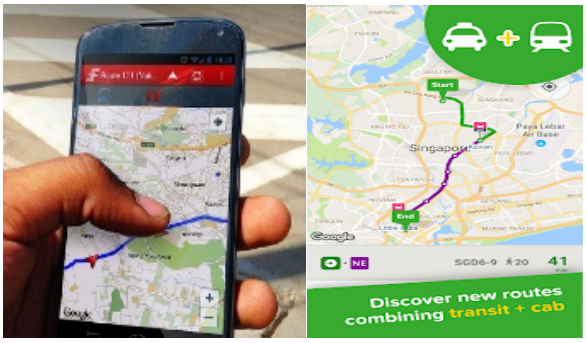

Figure 2. Strategy of transport maps apps. Source: authors based on (Lo, 2014).

4.2 Dockless Bike-Sharing

Dockless bike-sharing concepts (Figure 3) were originally offered by Davis Wang and they are serving in more than 200 cities across many countries. The main advantage that differentiates "dockless" systems from traditional bike-share is that riders can pick up and drop off the bicycles anywhere on the street rather than at a fixed station. This is made possible by a tiny connected device that is installed on each bike and enables users to quickly find and unlock the closest bike using their smartphone. Through the same smartphone app, the cost of trips is determined by their length and charged to the user's credit card. Dockless bikes are always distinguished by their vivid colors (Ji, et al., 2020).

Figure 3. Dockless bike-sharing concept. Source: authors based on (Ji, et al., 2020).

4.3 Online Shopping Applications

Online shopping contributes to make fewer trips, which will relieve traffic congestion, reduce air pollution, and reduce the need for retail space and parking. The internet has an impact on peoples' time and financial budgets. The quick growth of online shopping suggests that the real effects might start to be felt soon. In 2014, online retail sales totaled 1,552 billion euros, or 4.2% of all retail sales worldwide. From 2007 to 2012, the global online retail market grew by an average of 14.8% per year, while total retail growth was only 0.9% during that time (Giglierano and Roldan, 2001). Figure 4 shows the concept of dockless bike-sharing. The transport impacts of online shopping follow three different paths:

- Cancel a physical journey to a shop.
- Shopping online may save time and thus enable another activity.
- Traditional retail will be affected by the increase in internet the number of shops or their location, and thus, in turn, will affect consumer's shopping behavior (Francke and Visser, 2015)

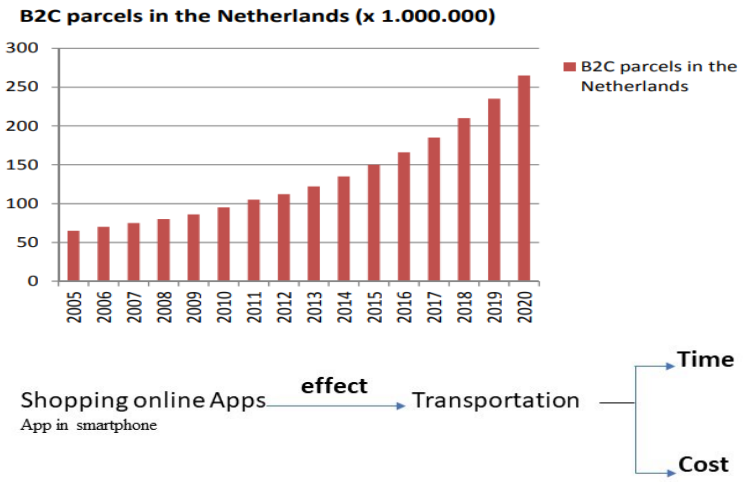

Figure 4. Dockless bike-sharing concept. Source: authors based on (Francke and Visser, 2015).

4.4 Electronic Ticketing Applications

Customers can now purchase tickets online and pay for them without having to visit a ticket office or machine by using the M-Ticketing app on their smartphones. Alternatively, M-Tickets can be ordered via the smartphone app's internet application; electronic ticketing is linked to place reservations to guarantee occupancy rates of less than 100%. Comparable advancements in long-distance rail transportation are evident. According to the Ticking office, this app has an impact on city planning by decreasing the number of trips made to purchase tickets and saving customers' time because doing so online is quicker than using more conventional methods (Ji, et al., 2020). Figure 5 outlines the percentage of respondents to purchasing a ticket for public transportation.

How easy is it to buy a ticket?	Buying a bus ticket, the regular way		Buying a train ticket, the regular way		Using the Ticket Website		Using the Ticket Voice - Portal	
	(%)	(cum)	(%)	(cum)	(%)	(cum)	(%)	(cum)
Very easy	7	7	6	6	47	47	41	41
Easy	56	63	69	75	53	100	56	97
Difficult	28	91	24	99	0	100	3	100
Very difficult	9	100	2	100	0	100	0	100

Figure 5. Strategy of taxi call apps. (Ji, et al., 2020).

4.5 Taxi Call Applications

With a better level of service than traditional taxis, customers can quickly and easily order a taxi from door to door using the "Taxi Call" smartphone app. In a short amount of time, the user can use the app to order a taxi from anywhere. It is necessary to weigh the benefits of the system for both taxi drivers and passengers. a 48% rise in the average occupancy per kilometer of travel

when the taxi-call application is fully implemented (d'Orey, et al., 2012). Figure 6 shows the strategy of taxi call applications.

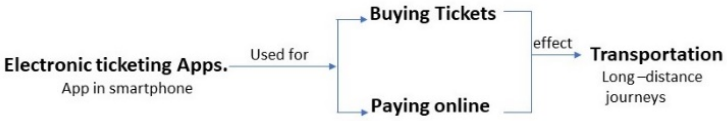

Figure 6. Strategy of taxi call apps. Source: authors based on (d'Orey, et al., 2012).

5. Discussion

5.1 Advantages and Disadvantages of Smartphone Applications for the Transportation System

Applications for transportation maps shorten the time spent waiting and looking for public transportation and encourage people to use public transportation more frequently than private vehicles. Identify the city's transportation system for the public. All citizens will be able to navigate the public transportation system with ease. By using a private car, this app will lessen crowds and traffic congestion at the urban level. This app's drawback is that not everyone will find it simple to use. Dockless bike sharing which makes bicycle use easier and encourages people to use bikes rather than other transportation methods has the advantage of ride can pick up and drop off the bicycle everywhere in the cities rather than at its specific station, reducing air pollution in the city that occurs in other transportation methods, bicycles itself is an environmentally friendlily device while this method has some other disadvantages such as it takes more time than other methods, riding bicycles need young and healthy people may it is difficult to old people and children to use it, bicycles cannot be used in difficult weather condition, and this method can be used only in short distance journeys.

Shopping online and using electronic tickets, which enable people to purchase goods and tickets using their phones instead of driving to a store or office, reduce pollution and energy used for driving and the need for parking. Saving time and eliminating the need to shop since all products are displayed online are two benefits of this type of app. The disadvantage of shopping online is buying goods without checking in reality and reducing the good effects of physical shopping on human psychology. While taxi call app makes asking for a taxi very easy and quick encouraging people to use taxi transportation more than private cars. The advantage is saving the time of waiting and searching for a taxi, saving extra trips for drivers, and reducing pollution and energy used for extra trips of drivers.

Based on the theoretical analysis, this research offered several examples of smartphone applications that may have an effect on the transportation system in the city. Each application technology has advantages and disadvantages in the transportation system, these summaries are outlined in Table 2.

Table 2. Advantages and disadvantages of the studied applications.

Apps	Type of the App	Advantages	Disadvantages
1	Applications for transport maps	Encouraging people to use public transportation more than private cars	Difficulty of use for some people
2	Dockless bike-sharing	A rider can pick up and drop off the bicycles everywhere Reduce air pollution Environment friendly Reduce energy	Take more time Need healthy people Cannot be used in difficult weather conditions Can be used only in short-distance journeys
3	Shopping online Applications	Cancel a physical journey to a shop Save time No need to shop Reduce pollution Reduce energy	Buying tools without checking in reality Negative effects on psychology
4	Electronic ticketing	Cancel a physical journey to a ticket office Save time No need ticket office Reduce pollution Reduce energy	Difficulty of use for some people
5	Taxi call applications	Save time Save extra trips for drivers Reduce pollution Reduce energy	Difficulty of use for some people

5.2 The Impact of Studied Applications on the Transportation System

According to previous offers, some smartphone applications that have been mentioned in this research have impacts on the transportation system by reducing transportation problems as using these applications save the time of each activity, reducing the main problem in our city transportation which is the traffic jam. In addition, reducing the general air pollution, energy, road area, and cost by minimizing requires daily physical journeys. These applications benefit people to spare time for other activities as shown in Figure 7.

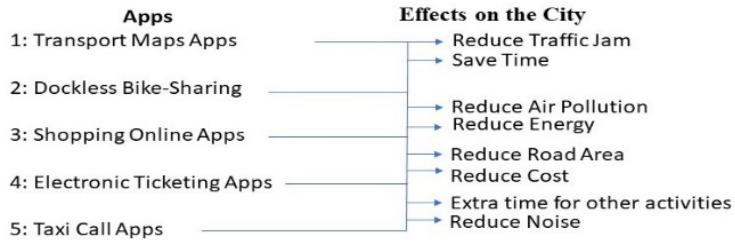

Figure 7. Effects of selected digital applications on the city. Source: authors.

6. Conclusion

This study highlighted the impact of digital communication, particularly smartphone applications, on the transportation system in smart and sustainable cities. Theoretical analysis was used to identify the emergent technologies and solutions proposed by the scholars in academia. Descriptive method was employed to describe the advantages and disadvantages of these solutions and the impact of the identified digital communication means on the cities are discussed.

This research concludes that digital communication (i.e., smartphone applications) have a positive impact on the transportation system, since they contribute in reducing most transportation problems in our cities, including traffic jams, time of use, energy consumption and environmental pollution. The use of digital communication facilitates the organization of mobility in the city, while it aids in choosing the most suitable method for each journey: choosing bicycles and walking for short-distance journeys and public transportation for long-distance journeys. Digital communication solutions guide people to recognize all transportation networks in the cities.

According to the analysis presented in this research digital communication can make the city more sustainable through its effects on transportation. Furthermore, using innovation in digital communication can reduce the negative environmental effects of transportation on the city by reducing air pollution and energy use.

Conflicts of Interest: The authors declare no conflict of interest.

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