TOWARDS SUSTAINABLE URBAN TRANSPORTATION PLANNING IN DEVELOPING COUNTRIES: "DRT" MOBILE APPS AS A CATALYST FOR BIG DATA-BASED DECISION SUPPORT SYSTEM

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ABSTRACT

The term big data refers to huge data sets which have high velocity, high volume and high variety. Using decision support system (DSS), big data can manage transportation demands, budgets, goals, and regulations. Moreover, it can manage different stakeholders and minority groups' needs and requirements, while adapting to environmental, economical and current social concerns. Transportation planning and decision-making faces rapid urbanization challenges in both developed and developing countries since urban planning process and decision makers depend essentially on data collection and analysis. This paper aims to discuss technological mutual line of big data, public transportation types, and DSS through transit mobile apps. The present paper discusses an assumption of reasons to explain why transit apps existed in both the developed and developing countries. It focuses on the developing countries, with a study on six demand responsive transit apps (DRT) used in Egypt to address the existing transit concerns. As a result, a comparison is drawn to comment on these apps' features and big data usage in enhancing transportation decision making in Egypt. Finally, the paper provides comments on still existing concerns and proposes recommendations for a new app development based on the previous apps, to sprint big data-based DSS.

Keywords: big data, urban planning, transportation planning, DRT, mobile apps, decision making, Paratransit, informal transportation.

1 INTRODUCTION

Big data (BD) is a broad range of observational or "naturally-occurring" data produced by transactional, operational, planning, and social activities that are not made for research by default. In general, the term BD refers to huge data sets which have high velocity, high volume and high variety, as well as a complicated structure that makes management, analysis, storage, and processing challenging. An emerging trend in information systems is the extraction of insights and hidden correlations from BD to improve citizen services and help decision-making. However, extracting valuable insights from developing smart cities necessitates generating datasets from various city domains to be integrated and analyzed. Common names for this procedure include BD analytics and BD value chain. Due to the complex, intricate, and multi-criteria character of urban concerns, decision-making in urban planning has generally become more and more challenging [1].

Urban growth in today's world is clearly hampered by poor decisions and citizens' discontent with the current developments. The citizens' contentment represents one of the prerequisite principles of sustainable development, which is still a big problem.

The problem of transportation has turned out to be is a worldwide concern. Nowadays, transit apps are used in both developed and developing countries with different reasons of establishing these apps. The present paper claims the relation between these apps and the country development level. Concerning developing countries, such as Egypt, transit concerns have a significant tangible impact on citizens' life. The present paper aims to draw a comparison between six different demand responsive transit apps (DRT) used in Egypt:

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Waslni app, Careem, Uber, Didi, inDriver, Dinamo apps, Swvl app, and Mwasalat Misr app. This leads the way to understanding and investigating how these apps fulfilled the market and solved the prevailing problems. Finally, the paper attempts to address the existing transit concerns and propose recommendations for a new app combing different stakeholders and sharing the solid background of previous app experiences.

2 DEFINITIONS

2.1 Big data

Kaisler mentioned "The collection of large and complicated datasets that are difficult to process using database management tools or typical data processing programs, including issues such as data capture, storage, search, sharing, transfer, analysis, and visualization" [2]. In 2012, Madden stated that "big data is data that is too large, too quick, or too difficult to process using current techniques" [3]. BD typologies can take many known basics forms that can blend with each other. BD characteristics are developing through time from just three Vs to eight, 12, 14Vs and one C in 2017. BDT sources are increasing each day in certain paths and classifications with different fields' usage; especially the field of urban planning [4]. This data ranges from user logging files on social networks, search engines, and email clients to machine-generated data such as real-time monitoring of sensor networks for dams or bridges (IOT), and various vehicles such as airplanes, cars, or ships. Furthermore, the sources of BD include traditional databases, sensors, log files, GPS systems, text and image files, audio and video files, and streaming data systems [5].

2.2 Smart cities

The term smart city has gained attraction in academia, business and government to describe cities that are increasingly composed of and monitored by pervasive and ubiquitous computing where economy and governance are driven by innovation, creativity and entrepreneurship enacted by smart people [6]. "A city that have digitally embedded devices everywhere built into the very fabric of urban environments", which are used to monitor, manage, and regulate city flows and processes, often in real-time. Many urban residents use mobile computing (such as smart phones) to interact with and navigate in the city, which generates data about its users [7]. "Smart city is found to refer more broadly to the growth of a knowledge economy within a city-region". From this perspective, a smart city is one whose economy and governance is being driven by innovation, creativity and entrepreneurship, enacted by smart people [2].

2.3 Decision making and decision support system (DSS)

The process of choosing a course of action involves identifying an option, acquiring data, and weighing potential courses of action. Using a step-by-step decision-making procedure, decisions can be made. By organizing pertinent information and defining options, this can assist in helping people make more careful, informed decisions. DSS is a computerized information system that uses BD analysis to support decision-making inside an organization or corporation. It gathers data that can be utilized to address issues and improve decisions. A DSS benefit is to increase the speed and efficiency of decision-making, improve the skills of employees to use a DSS, automate complicated managerial processes, free up the time of decision-makers, and improve interpersonal communication within an organization [8]–[10]. There are three main fundamental architectural components which are as follows: The user

interface, database management system (DBMS), model-based management system (MBMS) as shown in Fig. 1.

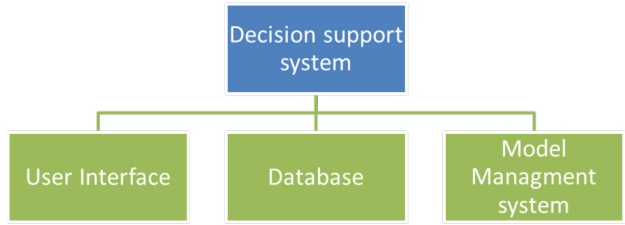

Figure 1: Data process in smart cities and its features.

3 METHODOLOGY AND HYPOTHESIS

The paper seeks to open a discussion in enhancing the decision-making qualities in transportation and urban planning by:

- Reviewing the modern approaches of incorporating BD through smart phones transit apps.
- Highlighting and promoting the importance of the relationship between recording human behaviour and efficient city planning as a catalyst for sustainability.
- Stating and comparing the different working apps in Egypt as an innovative solution made in the developing countries to address the lack of suitable formal transit.

The paper claims that public transit (PT) apps, in the developed countries, are well known and established as a reference to the relatively stable public transportation systems and authorities. As shown in Fig. 2, the sequence of developing needs of transit apps in the developed countries has started as a result of the need to digitize the system to coping with new technologies and serve citizens. These apps generated an important amount of data that would be considered as valuable data, especially in transportation and urban planning development recently. Data is then recognized, analyzed, and visualized to make a certain decision. At that time, developing PT apps is required for a more luxurious and healthier life. In addition, a human self-esteem is needed as Maslow's Hierarchy of Needs.

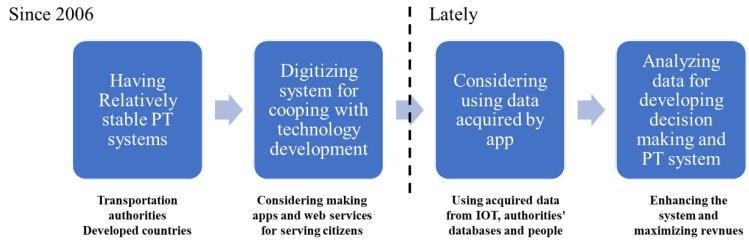

Figure 2: The process of creating transit app in developed countries.

On the other hand, developing countries experience a lake of structured computerized data. However, more and more citizens use technology everyday with their smartphones.

Smartphones are a good and cheap way of collecting data for decision making. Fig. 3 indicates the paper hypothesis about the need of developing countries to develop transit mobile apps. However, it belongs to safety needs and not to the self-esteem level. The needs in developing countries in the recent years belong to a lower level of Maslow's Hierarchy of Needs and not as the beginning of these apps in the developed countries in 2006.

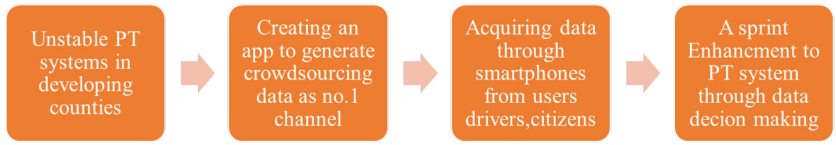

Figure 3: The process of creating transit app in developing countries.

4 LITERATURE REVIEW

The literature review is presented in three parts. The first part shows formal PT (transit) and informal PT (paratransit and DRT) as shown in Fig. 4. The second part reviews the different transit app types. The third part is a comparative analysis between different DRT apps worldwide.

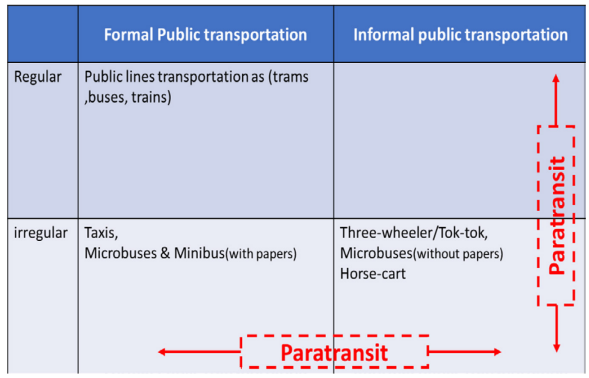

Figure 4: Formal, informal, paratransit in reference to transit types. Informal PT has no legal documents, while a paratransit is an informal PT with legal papers, irregular lines and timetable.

4.1 Formal PT (transit) and informal PT (paratransit and DRT)

The scale of metropolitan centres in developing nations has increased dramatically during the last forty years. In dense centres, low-income neighbourhoods, and congested streets, effective public transportation services are essential. These led to two main types of transit: formal and informal PT.

4.1.1 Formal PT (transit)

Formal public transportation can be defined as vehicle types supported or operated by governmental authorities as trains, buses, ferries, trams, and taxis. "Africa faces crucial challenges as it aims to generate an efficient inter-modal public transport sector that seeks to

enhance the lives of its citizens. Public transport is a challenge for the majority of users, but more so for the poor. More than 60% of households spend on average 20% of their income monthly on transport. It can be as high as 31% in rural areas". High operating and societal expenses, as well as inefficiencies in the various public transportation modes, are some of the difficulties the formal transportation sector is facing. Additionally, the layout of residential areas in pre-democracy times had a significant impact on the commute distance from homes to businesses (many people live far from their workplaces) [11].

4.1.2 Informal PT (paratransit and DRT)

Technically, informal PT services are those operating without official endorsement. This typically indicates that the vehicles and their owners lack the necessary licenses or registration documents from the government to offer the general public collective-ride services. A single person typically owns and operates small-sized vehicles that make up the informal transportation sector. The majority of drivers are young, low-skilled males who moved to the city from the countryside [12].

According to International Association of Public Transport (UITP), informal transport emerges in a context where:

- There is no service for some population because governments, civil servants and the upper classes do not notice this lack of supply, even if it is critical to the economy.
- There is a lack of investment in public services and utilities.
- The public realm and infrastructures are very much car oriented.
- There is fast urban sprawl and city development.
- There is a supply of vehicles that can be shared to transport people.
- Public transport is considered as a private business.
- Public transport is not centred on urban dwellers needs or on any public policy.
- There is potential provided by IT tools [13].

However, this is not always the case in all developing countries. In Egypt, informal PT operates inside cities main roads with official papers registered by government authority. While in Egyptian slums, low-density and dispersed settled areas, legal papers are absent. More than half of all public transportation trips in developing nations are provided by informal, often minor, companies. Based on market shares of travel between large-vehicle PT and small-vehicle paratransit, Godard stated in 2006 that 52% of transportation in Egypt is a paratransit model. In 2021, UITP stated that in many African cities up to 90% of the transport supply is informal [12], [14], [15].

4.1.3 Paratransit as a part of informal PT

In addition to the variability of prices, these services are either door-to-door or flexible enough to deviate from conventional routes. They contribute to optimizing traffic density by decreasing the use of private vehicles, meeting the demands and needs of passengers stemming from such traffic and transport problems. Operators of paratransit are remunerative because they can quickly adapt to shifting markets, are more aware of the needs of their customers, and have relatively minimal operating expenses. By organizing route associations and cooperatives, the present paper shows that they can lower per-seat costs to compete with larger companies. Other advantages of small vehicles are: more frequent headways, sense of passenger safety (due to the closer proximity of riders to drivers), better riding experience such as guaranteed seat, in addition to fleet-footedness as the ability to manoeuvre in crowded city streets compared to lumbering buses [16]. The different types of paratransit are shown in Table 1.

Table 1: Classes of paratransit vehicles and services that operate informally [17].

Class	Service features		Passenger		
	Routes	Schedules	Capacity	Service niche	Service coverage
Minibus/jitney	Fixed	Semi-fixed	12–24	Mixed	Subregion
Microbus/pick-up	Fixed	Semi-fixed	4–11	Distribution	Subregion
Three-wheeler/ motorcycle	Variable	Variable	1–4	Feeder	Neighbourhood
Pedicab/horse-cart	Variable	Variable	1–6	Feeder	Neighbourhood

4.1.4 Demand responsive transportation

It can be defined as a flexible service that provides shared transport to users who specify their desired location and time of pick-up and drop-off. This can be done by using different telematics tools. DRT is not a modern invention because the first formally recorded experiment was carried out in 1916 in Atlantic City. such as phone booking or smartphones. **DRT benefits** can make up for fixed public transport route services and improve mobility in low-density areas and at low-demand times of the day. While many DRT services are implemented primarily to improve social inclusivity and access to services, DRT can also contribute to de-carbonization by replacing private car journeys and facilitating multi-modal travel (for example, linking users to a train station or fixed route bus service). It is necessary to integrate DRT services into the local transport network to be effective. To reduce the carbon dioxide (CO_2) emissions for the passenger per kilometre from a DRT service, operators can optimize routes using the latest technology, select vehicles with lower or zero tailpipe emissions and increase passenger occupancy levels [18].

4.1.5 DRT as a paratransit mode

Traditional paratransit models provide fixed routes and frequency-based services to meet dynamic demands. DRT paratransit system, on the other hand, offers passengers flexibility in parameters like vehicle, route, schedule, and payment methods. It enables the passengers to prefer public transportation to private vehicles and other alternatives [12].

4.2 Types of public transportation apps

There are three major public transport app types in service. These three types include transport provider's apps, general-purpose transit apps, and hop-on hop-off tours apps.

4.2.1 Transport provider apps

These apps are developed for particular transport agencies. These apps only deliver information related to a specific company and have limited operating routes. They offer essential features to users according to a particular company's transportation such as: seat reservation and online ticket booking system for a particular ride in addition to route and schedule information for trip planning. These types of apps are used in bus companies like FlixBus in Europe, or GoBus and Bluebus in Egypt. Paratransit as microbus is operated within the intercity and regional routes as SWVL in Egypt and India [19], [20].

4.2.2 General-purpose transit apps

They come in the category of urban navigation applications. They have collaborations with various transport agencies and deliver information related to routes, ticket cost, time duration, live updates, and ticket booking system. These types of apps serve on a wide scale and operate

in more than a hundred cities or countries. These kinds of apps are on the top as far as the PT apps are concerned. For example, Moovit, Transit, and Citymapper are among the most popular apps of this type. They serve more than 250 million people in over 3,000 cities located in many countries [19].

4.2.3 Hop-on hop-off tour apps

These apps have a straightforward operating model. They are developed to ease sightseeing bus tours within a city or a country. Each tour is designed with multiple stops that are usually famous landmarks where one route covers one or several places of interest or tourist places. With the use of tour applications like Tuk-Tuk Hop and City Sightseeing Amsterdam, people may learn more about routes, stops, static schedules, the current location of vehicles, an offline city map, audio guides, and brief descriptions of well-known landmarks [19], [20].

4.3 DRT apps in developing countries, Egypt

In developing countries such as Egypt, governmental transportation systems suffer from overloading, crowding, and lake of system development as in infrastructure, assets and equipment, data analysis and decision making. Egypt is the Arab's largest market in ride hailing which led to informal transportation, paratransit, and DRT apps. Besides, individuals, start-ups and private entities started to address the problem, trying to solve, and even establish a business model from the solution to get good revenues. Among these initiatives are Waslni app, Careem/Uber/Didi/inDriver/Dinamo apps, Swvl app, and Mwasalat Misr app.

4.3.1 Waslni App

Waslni app was launched in 2017 from abstract developers. It acquired more than 100,000 users since its launch. Waslni was from the preliminary and primitive ideas to help in adjusting formal and informal public transport flow in Cairo and Giza provenance. As shown in Fig. 5 which represents the app UI, the app depended on a database pre-loaded with a description of all possible routes for each prime location loaded in the app.

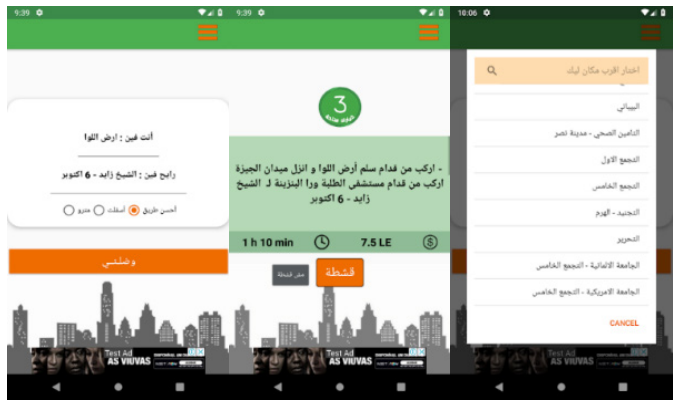

Figure 5: Waslni app UI [21].

The app business model was very simple depending on ads appearing by Google to users. The app has a score of 4.2 on Google Play store. Most of the comments affiliated with early

years are positive. Meanwhile, in the recent time comments are negative, due to new technologies introduced in the market without any update from the developer [21].

4.3.2 Uber, Careem, Didi, inDriver, Dinamo as DRT private cars hailing apps in Egypt

Undoubtedly, **Uber** has changed the way that Egyptians move. International Uber app introduced the car hailing to Egyptian citizens in Cairo since 2014. Uber operates now in five Egyptian cities. According to Hassanein, Uber claims to have 90,000 active drivers throughout Egypt, despite having previously claimed to have as many as 200,000 drivers there [22]–[24].

Careem is a Dubai-based super app with operations in over 100 cities, covering 12 countries across the Middle East, Africa, and South Asia. It works in 14 Egyptian cities. In January 2020, Uber Technologies Inc. spent $3.1 billion to acquire Middle East Careem, buying dominance in a competitive region ahead of a hotly anticipated initial public offering.

Didi is a Chinese ride sharing app, owned to Didi Chuxing Technology Company. It has been launched in the Egyptian market in 2021. The company started its operations in Alexandria (the second city in Egypt), as it is more limited compared to Cairo as the capital. Despite being founded in 2012, the business was able to purchase Uber in China in 2016. Didi is trying to acquire more users by offering free rides and cheap packages [25], [26].

inDriver is a global app with more than 100 million users in 45 countries. It is the second largest ridesharing and taxi app downloadable worldwide in 2020. inDriver model introduced a big different P2P business model than normal car hailing apps, as to request a ride; the user specifies the starting point and destination address of the ride. However, if the passengers have any suggestions for the driver about the price, they are willing to pay, the passenger's pricing offer may be countered by the driver. In many regions of the world, there is a high demand for a model like this [27]–[29].

Dinamo is a local car hailing company that works in specific Egyptian cities as Banha and Asuit. The Dinamo app which was previously named "waslni-banha" was launched in 2017 and was owned by Waslni Company. Dinamo acquired from 10,000 to 50,000 users in their first-and second-generation app. It is considered a very limited app. However, it has a progress in business rather than app or technological development as it is the only app operating in this geo-locations [30].

4.3.3 Swvl app the first DRT paratransit app

Swvl is a revolutionary tech-enabled mobility platform with a base in Dubai that supports mass transit in some of the most difficult and complicated emerging economies in the world. Intercity, B2B, and B2G transportation are all provided by Swvl. Swvl concentrates on mass transit, as opposed to ride-hailing services that concentrate on one-time and private rides. This lowers the price of a ride that might otherwise be unaffordable and lowers emissions. The company uses a unique algorithm to determine the quickest routes, including options for travelling to work or school [31], [32].

4.3.4 Mwasalat Misr app

Mwasalat Misr is a main investment from Emirates National Group. It is backed by the National Bank of Egypt. The company was firstly launched in 2014 and became a member of the UITP in 2016. The transport provider app launched in 2021 serves 32 million customers each year in 74 bus routes with 333 bus features such as accessibility, friendliness, and AC. The app has more than 100,000 users and features: easily track bus routes and stops, adding favourite locations and track buses' arrival time, access Mwasalat Misr routes and fares, planning trips from anywhere and to anywhere, notifications of the latest updates and

promotions; help and support around the clock. As shown in Fig. 6, the app is limited to the company buses only, as it is addressing a certain customer economical category [33].

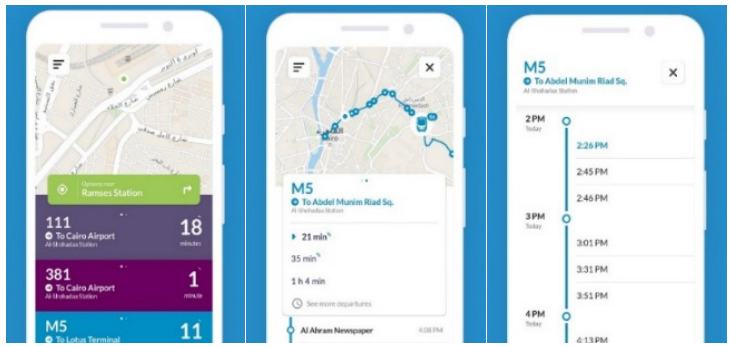

Figure 6: Mwasalat Misr app [33].

5 RESULTS

After discussing different apps in Egypt as a case for developing countries, the different apps were positioned in relation to formal, informal, and paratransit as shown in Fig. 7. All working apps are considered by default a demand responsive transportation (DRT). However, they all have a significant problem in considering the app as formal or informal. On one hand, the apps use licensed vehicles with legal papers. On the other hand, these vehicles are licensed as private, not legally considered for mass transportation, and do not pay taxes as conventional taxis or micro-buses. In addition, these companies operate as offshore companies in Egypt, which means that they do not pay taxes as local operating transit companies.

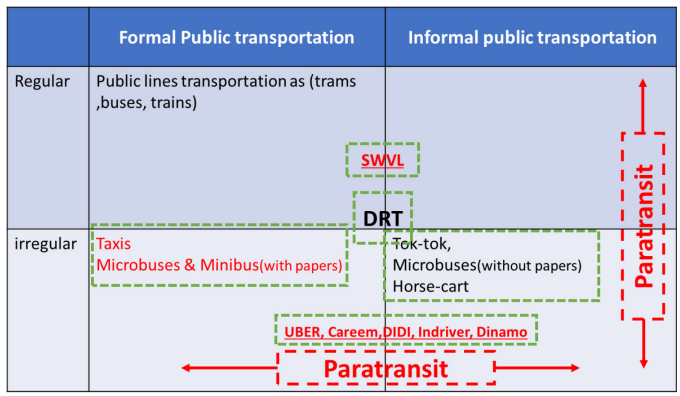

Figure 7: Positioning DRT apps in relation to formal, informal, and paratransit.

In May 2018, the government of Egypt approved a law governing ride hailing services. The country has two major ride-hailing apps, i.e., Uber and Careem. Both apps faced several legal disputes due to policies designed for conventional taxis. Thus, they are expected to create significant challenges for market growth [34].

Focusing on the Swvl app, it was initially developed for reducing chaotic traffic jams. However, the model evolved from organizing the existing paratransit micro-buses, to obtaining new vehicles which are owned by individuals, small bus traveling companies or even owned by the company. This led to a new category of paratransit vehicles which are more expensive than local existing micro-buses and cheaper than taxis and car sharing companies. This model addressed smartly wide customer categories in developing countries such as Egypt, especially from the youth and middle classes [35]. As shown in Table 2, mostly all apps in Egypt focus on one type, leaving the big market open in the other two types. Although Egypt is concerned with monuments and tourism, there is no app that provides this type of service. As a general-purpose app for formal and informal PT, yet no app meets this crucial demand.

Table 2: Comparative analysis between app types.

	Waslni app	Uber	Careem	Dinamo	Didi	inDriver	Swvl	Mwasalat Masr
Transport provider apps		✓	✓	✓	✓	✓	✓	✓
General purpose app								Somehow
Hop-on hop-off tour app								

A comparison is drawn between the different features of DRT apps, as shown in Table 3, to deduce different discussion points. Concerning apps different business models, mobility as a service (MaaS) and transport as a service (TaaS) apps have more features than normal DRT apps. In addition, the technology applied for newer apps offers more essential and friendly features compared to old existing ones. This shows that the very highly competitive market is generating more competitive features. However, disabled people are still not fully supported from all companies. Mwasalat Masr and Swvl are the best bidders in this

Table 3: Comparative analysis between features.

	Waslni app	Uber	Careem	Dinamo	Didi	inDriver	Swvl	Mwasalat Masr
Informative app	✓	✓	✓	✓	✓	✓	✓	✓
A to B route planning		✓	✓	✓	✓	✓	✓	✓
Real time departure and arrivals		✓	✓	✓	✓	✓	✓	✓
Alerts and safety					✓			
Notification		✓	✓	✓	✓	✓	✓	✓
Step by Step guide							✓	✓
Favourites							✓	✓
Trip cost estimation		✓	✓	✓	✓	✓	✓	✓
Ticket buying options							✓	✓
Nearest transport station information							✓	✓
Feature for disabled people			✓					✓
Offering and controlling prices						✓		
Multi modal app								
Using BD as a decision-making base		✓	✓		✓	✓	✓	

comparison. Yet, all apps do not seek to have a multi-modal app even those using with Maas and TaaS. Nonetheless, decision making upon BD for urban planning is not fully understandable by all national apps' decision makers as few research published in transit app impacts in Egypt. Thus, apps using BD are always updating their systems, UI/UX, developing more transit routes, and gaining more revenues.

6 CONCLUSION AND RECOMMENDATION

This paper discusses the concepts of BD, smart cities, and DSS. It highlights the types of public transportation as formal, informal, paratransit, and DRT. Furthermore, the paper claims the reasons of creating transit app in both the developed and developing countries. It scopes transit (DRT) mobile apps working in developing countries such as Egypt. Finally, the paper compares these apps in relation to transit app types, offers solutions, features, and BD usage for the decision making process.

The demand for ride-hailing services is expected to increase significantly in the coming years due to Egypt's increasing urbanization and continuously low automobile ownership rates. The pace of urban expansion in the nation is over 2%, according to Urbanet. This demonstrates that the cities of Egypt must make room for over a million new residents each year. The need for commute services in these recently growing cities has been driven by this.

New ride-sharing businesses in the country are concentrating on innovative techniques including long-distance services, cheaper average prices, and improved safety. Furthermore, newer modes of transportation have been developed as a result of rising fuel prices, the popularity of ride-sharing services, and greater environmental awareness. In order to reduce the ongoing traffic issues in Egypt's major cities, an increasing number of ride-hailing service providers are now offering their services to two-wheeler vehicles. These cars have more appeal in the online ride-hailing market thanks to their reduced prices. For instance, Careem offers metered scooter rides starting from USD 0.38 (6 EGP). The cheapest ride costs USD 0.50 (8 EGP), which is approximately 50% lower than regular car rides [34].

Yet, a one view solution is not the best-case scenario. Studying the Egyptian case, an incremental rational solution must be taken into consideration. A process of starting a national transport app in developing countries is essential to be shared between the government and the private sector. This app should start incrementally and decentralized from the capital, as more problems and complexes will appear in case of addressing the capital at first. This app should contain each legal public transportation and paratransit in one application to work as a multi-modal TaaS app. In addition, it should work as a middle mediator, launching with pre-acquired society knowledge of Swvl and Uber which can be a good start. This insures acceptance from various stakeholders as individuals, transportation authorities, policy makers and government.

This app can aid in facilitating a number of concerns such as:

- **Adopting citizens to chaotic PT schedules:** this could be achieved by real-time data getting from vehicles. Then, data can be accumulated and analyzed to be a real-time prediction tool for jams and conjunctions delay.
- **Wagons real-time crowdedness:** possible features and updates can state vehicle crowdedness, as data coming from smartphones and IOT devices can be analyzed.
- **Micro (citizen) decision making** from the previous features, any citizen can have the power to decide which transit type is acceptable. Citizens can make a decision upon crowdedness, times of arrival and departure, available alternatives and cost.
- **Enhancing dealing with traffic jams** can be achieved by analyzing the missing data of citizens take ins and outs.

- **Real-time info for governmental decision makers:** a control room can be fed with incoming analyzed data from servers to enhance instant decisions based on data.

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