Understanding Railway Construction: The Future of Smart Transportation in the Greater Bay Area

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Abstract: By 2050, nearly 70% of the world population will live in urban areas. Urban development is a rapidly evolving problem that needs exploration. The notion of smart cities is becoming more and more popular in urban development. However, the inner nature of smart cities is quite controversial and has been interpreted differently in various fields. The Guangdong-Hongkong-Macau Greater Bay Area (GBA) is an ambitious blueprint of urban agglomeration in China. Transport planning is an essential part of urban infrastructure development, linking social life, urban infrastructure and economic development. The GBA development plan highlights the importance of high-speed rail construction and the whole connected transportation network. However, there is rare research on how an intelligent transportation network contributes to smart cities development. This article discusses the strength and weaknesses of the current high-speed rail construction in the GBA. This article briefly summarizes the notion of smart cities, smart transportations trying to picture the basic requirements of a resilient smart transportation system in urban agglomeration such as GBA. Hopefully, this article offers insight into future sustainable transportation planning and smart cities development.

1. Introduction

1.1 Urban Development and Smart Cities

Between 1950 and 2018, the world's total urban population increased from an estimated 0.8 billion to an estimated 4.2 billion. By 2050, 68 percent of the world's population will be living in cities [1]. The world's total urban population grew from an estimated 0.8 billion to an estimated 4.2 billion from 1950 to 2018. The average annual rate of urbanization reaches 0.92 percent a year which is proliferating [1]. China has one-third of the population live in urban area of Asia, and the urbanization rate has reached its peak at around 2005, and the rate is decreasing smoothly [1]. According to the National Seventh Population Census conducted in 2020, around 64 percent of the total population currently lives in cities in China [2]. The urbanization rate varies inside China, while six out of the ten largest Chinese cities are located in coastal regions in East and South China [2]. The Guangdong-Hong Kong-Macau Greater Bay Area (GBA) consists of two special administrative regions (SAR) - Hongkong and Macau, two megacities- Guangzhou and Shenzhen, and other seven medium-small size cities in Guangdong Province (see as Fig1). In 2020, the total area in the GBA is 56000km^2, and approximately 86 million population created GDP of USD1, 668.8billion [3].

Since the early twenty-first century, the notion of "smart city" has become popular in many disciplines regarding science, sociology, politics and urban planning. However, it changes through people's discussion of what is indeed a smart city. Nam and Pardo clarified smart cities ideology from different perspectives. In terms of technology, a smart city is the perfect combination of information and communication technology (ICT) and urban infrastructures such as smart homes and smart buildings [4]. Besides this, smart cities have requirements regarding fields that ICT plays as auxillary tools, such as education, policy innovations and social culture [5]. Overall, the ideology of smart cities has become a systematic development direction of future cities (see as Fig2). The GBA

outline precisely formulated future development as promoting smart cities cluster at the world-class level [6]. Therefore, exploring what a smart city is in nature is an urgent topic that needs addressing under scrutiny.

1.2 Smart Transportation in Urban Planning

Dirks and Keeling emphasized the significance of organic integration of a city's various systems to create smart cities, and transportation planning is an essential part of it [7]. High-speed rail is an essential part of transport infrastructure construction. The GBA development underlines the importance of developing smart cities while enhancing regional collaboration and urban agglomeration [6]. The National Development Reform Commission (2020) gives the Guangdong Provincial Development Reform Commission the consent of utilizing the formal Pearl River Delta (PRD) intercity rail transit network [7]. The aim is to build a transportation system connecting major cities in the GBA with major cities in one hour and mainland-level cities in Guangdong province in two hours and neighbouring provincial cities in three hours, building the GBA on rails, improving the modern comprehensive transportation system network. In the short run, the railway network in the GBA will be in operation and under construction for 4,700 kilometres, covering all the node cities in the central cities of the GBA and vital metropolitan areas such as Guangzhou and Shenzhen by 2050. In the long run, existed rail network and those under construction would exceeds 5,700 kilometers in GBA, covering 100% of cities at or above the county level by 2035. Conventional railways include locomotives and ordinary trains [8]. High-speed rail refers to the types of railway transportation with an initial operating peed greater than 200KM/h, designed driving speed above 250km/h, including high-speed train sets and intercity high-speed [8]. However, high-speed rail construction requires a high cost of labour and capital fund while cannot see immediate feedback in a short period. Moreover, smart transportation has higher expectations than traditional high-speed rail in automated data management platforms, smart emergency management systems, digitalized travel experience and environment protection.

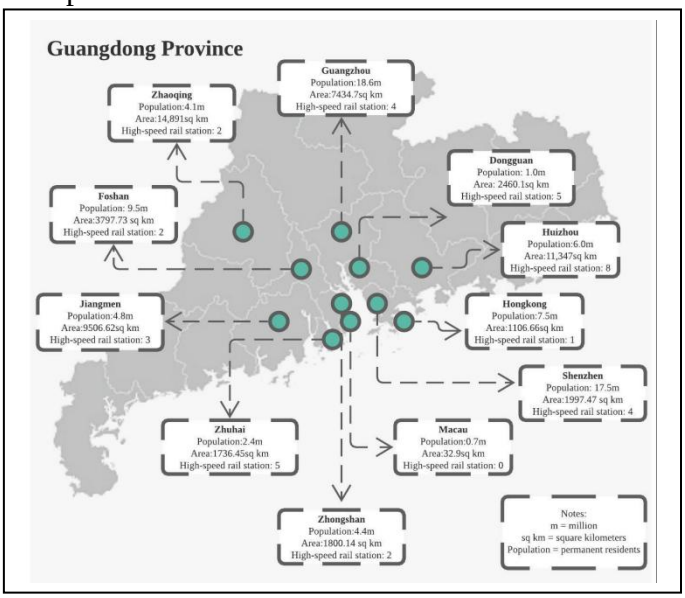

Figure 1. The Greater Bay Area High-speed Rail Station Distribution

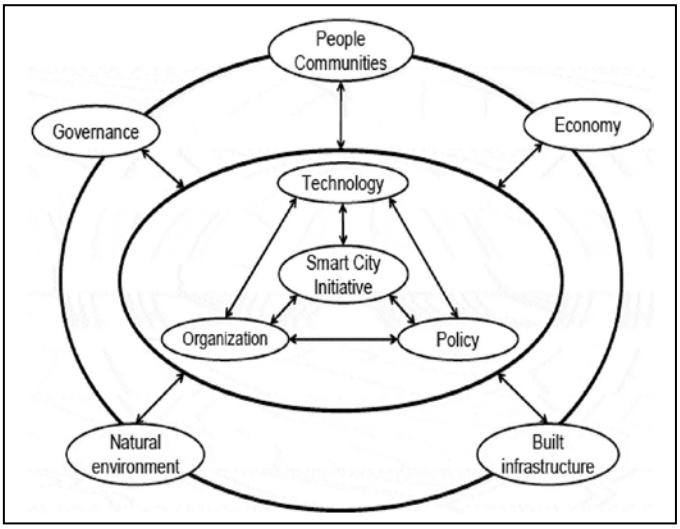

Figure 2. Smart City Initiative Framework by Chourabi et al., 2012

2. Methodology

2.1 Rationale

This article discusses how high-speed rail has integrated into smart cities development in the GBA in Guangdong Province, China. The author conducts this research by literature review, and the sources are from news reports, academic articles and authentic government reports, reliable statistical data. Academic articles reviewed under specific keywords such as "smart cities," "transport planning," "high-speed rail," "sustainable development," "the Greater Bay Area." Up to date transport planning news is collected from authentic government outlines and reports. Statistical data are collected and used as auxiliary analysis.

Firstly, the notion of smart cities is an ambiguous and fast-changed concept of urban development. Therefore, specialists from different fields interpret smart cities based on their specific subject acknowledgment. To minimize comprehension deviation, the notion of smart cities in this article is defined as highly digitalized, environmentally friendly and inclusive modern urban cities equipped with advanced information and communication technology (ICT). Furthermore, smart transportation is defined as a highly cost-efficient automatic digitalized transport network supporting various economic activities and people's daily needs, operating in an environmentally-friendly manner. Next, as transportation includes various modes, this article focuses on the construction of high-speed rail. However, as transport planning is complex and includes various modes, high-speed rail cannot be discussed separately. Therefore other closely connected transportation modes such as intercity rail and train are also be considered in an indispensable situation to understand the influence of high-speed rail adequately.

The fourth section discusses the potential risk factors of the GBA transport network, such as resilience and vulnerability. In addition, the influence of public anticipation on smart transportation has also been considered. Finally, in the fifth section, the article also provides suggestions for future high-speed rail network development to fit smart cities.

2.2 Literature Reiview

The main benefit of high-speed rail is stimulating regional economic activities. In the late 1990s, the high-speed train revealed its positive effect on reducing transport, both in time and distance, cost by linking cities to strengthen regional economic integration [9]. However, with the notion of smart cities, transport planning becomes a fundamental part of urban cities, connecting cities and further stimulating the radiation effect of core cities to peripheral medium-small size cities, forming large-scale urban agglomeration. Chen, Li and Wang traced the economic development of 11 cities located in GBA in a ten-year range from 2000 to 2016 [10]. By assessing the changes in accessibility

brought about by infrastructure development as well as changes in consumer policies. They looked at how different transportation modes affected different economic sectors like agriculture, transit, and industry. The positive economic impact is proven in sectors such as tourism and agriculture, but the industrial industry is significantly impacted due to higher operational expenses [10, 11].

Moreover, I compare the effect of high-speed rail development on different cities in a region. Some literature has concluded that while high-speed rail has economic benefits for core cities, but the growth is realized at the expense of pheripheral small cities [12, 13]. However, things are different in the GBA. Zheng et al., discussed the spillover effect of regions near high-speed rail stations in China [14]. They apply high-precision calibrated nighttime light satellite images by utilizing a difference-in-differences estimation. The findings demonstrates that the intensity of evening light images in areas near high-speed rail stations has increased by an average of 27%. The study also identifies a number of differences in these spillover effects between Chinese cities. It goes into great detail about the factors that could influence the performance of high-speed rail new towns. However, when it comes to spatial spillover advantages, there is a lot of variation between cities. The findings imply that building a solid high-speed rail new town in an urban-rural transition area requires more than just high-speed rail growth. Instead, the potential spillover effects of high-speed rail are contingent on supporting planning activities, such as high-speed rail and intra-city transportation network coordination, as well as offers great opportunities economic conditions. The result is consistent with Faber, Chen et al., which indicated that large-scale inter-regional transport infrastructure development could reduce industrial output growth, especially among connected peripheral regions [15, 10]. According to the findings, future transportation infrastructure investments in GBA should be conducted with greater caution in order to optimise the return on public infrastructure investment.

Nevertheless, smart transportation, on the other hand, necessitates the integration of dependable transportation systems [16]. The goal of smart cities is to connect human capital, infrastructure, and social capital in order to generate more sustainable economic development and a higher quality of life for citizens. Bhattacharya, Mclellan, and Tezuka specifically discussed smart cities development in developing countries [17]. The convergence of competitiveness, capital, and sustainability is a crucial component of a Smart city. They conducted a Smart Sustainable City Development Index (SSCDI)', and transportation is a vital variable under the social dimension [17]. The issue of associate public transport and personal mobility is a worth noticing point to improve overall transport network.

Xiong et al. focus on intelligent transportation systems (ITS) which focus on the technical aspect of smart transportation [18]. ITS develops based on better transportation infrastructure and advanced IT technology. ITS-related solutions consist of perception and convergence of traffic information, application support of transportation information, and urban transportation management. In the 12th Five-Year Plan, the Ministry of Transport introduces the plan's national highway traffic safety science and technology action [6]. The precisely put forward of concepts such as the "Internet of Things" major special project, "863" major special project "Smart City," contribute to the further development of ITS in China. The outline consists of active vehicle safety and intelligent vehicles, vehicle road network synergy, integrated traffic management and emergency systems. Mohanty et al. pointed out independent operation of each type of transportation is the feature of the traditional transportation system [19]. However, smart transportation includes various communication and navigation systems between vehicles and fixed locations. Smart transportation also covers the rail, water, and air transport systems and even their interactions. The smart transportation system optimizes the utilization of the vehicles used in the system. Passengers can choose from a variety of low-cost, short-distance, or faster transportation options. Increased safety secured by the sensor and anti-skidding technology, such as a radio frequency identification (RFID), to avoid collision and other risks. ICT is one of the primary enablers in the transformation of traditional cities into smart cities. The Internet of Things (IoT) and Big Data (BD), two closely related developing technology frameworks, make smart cities efficient and responsive. To enable improved decision making, insight finding, and process optimization, BD necessitates innovative processing approaches. To

explore and extract important patterns and knowledge from the BD of IoT smart cities, sophisticated data analysis mechanisms are required. Since natural resources are limited, the popularity of smart cities is growing on a daily basis.

Furthermore, sustainable transportation continues to be a major driver of global socioeconomic and environmental progress. Transport Canada sustainable transport has three core values: highest possible safety and security of life and property; efficient movement of people and goods to support economic prosperity and a sustainable quality of life; and respect for the environmental legacy of future generations of Canadians [20]. However, all the values are guided under the assessment of individual situation, government funding support, and environmental assessment.

On the environmental standpoint, smart city efforts are forward-thinking. The use of technology to promote sustainability and effectively preserve natural resources is central to the smart city concept. The IoT infrastructure dimension's issues are numerous. Government systems lack integration mechanism and have limitations on capabilities. High demand is needed on the software and systems application availability. The implementation of an ICT infrastructure is critical to the smart cities development. It encompasses a wide range of technologies, people, laws, practices, resources, social norms, and data that work together to enable municipal governance [21]. Kar et al. (2017), in the book Advances in Smart Cities, notably argued that smart cities are more than a simple implementation of ICT [22]. In the chapter on smart governance, the vision of e-governance calls for information sharing, transparent decision-making, and stakeholder participation to improve government services, all of which are crucial to attaining smart governance. A smart city would require smart mobility systems and infrastructure to meet the needs of its citizens. In this context, a smart mobility simulation analysis could assist policymakers in better planning for smart cities. The city's smart transportation criteria would also include national and international accessibility. It would also be critical to ensuring that ICTs were widely used in the creation and management of relevant facilities such as bridges, national roads, monorails, and metros.

3. Results

After investigating relevant sources, the author finds that little literature on smart cities addresses transport-related issues, especially high-speed rail construction, can be found in existing academic sources. The mind map shows the author's thoughts on smart transportation (see as Fig 3). Smart transportation emphasizes the interrelated function of both digitized infrastructure support and integrated smart governance. In Section Three, the author displays more details about the result. Hopefully, this can contribute to further study of smart transportation when policymakers or academia pursue smart cities development. The high-speed rail construction in GBA has apparent advantages and some risks. For example, it avoids the consumption of medium-small sized cities; in contrast, it boosts the flourishing of all cities inside GBA. However, the lack of resilience is a problem that needs detailed study, which will be discussed in the fourth section of this article. Moreover, more research is needed to show if high-speed rail in GBA falls in aspects such as environmentally-friendly (e.g. the before and after study of greenhouse gases emission and the burning of fossil fuels), easy accessibility (e.g. the comparison of the distance between high-speed rail stations and other vehicle locations), and smart traffic management systems (e.g. the integrated regulation of the vehicle movement state including location, speed, direction, acceleration, throttle and brake, numbers of passengers, maintenance status, prediction of driver behaviour).

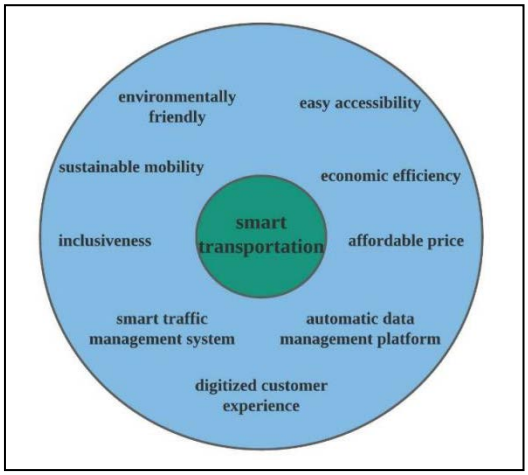

Figure 3. Smart Transportation features

3.1 Hardware Development of Smart Transportation

Zhong analyzed that intelligent transportation is the foundation of regional integration and the most direct manifestation of smart cities [23]. The GBA has the densest and busiest intercity railway network in China, providing strong technical support for promoting the integration of life in the GBA and building a quality living circle suitable for living, working and travelling. Furthermore, the extensive application of digital technology and the acceleration of the convergence of standards and mutual recognition rules have greatly improved the convenience of the GBA's transportation integration.

The Guangzhou-Shenzhen intercity railway is the first railway that achieved a paperless boarding experience in China, which significantly improved travel efficiency inside the GBA. In June 2020, the Guangzhou Railway Group announced that three railways had all launched Alipay. This payment app allows passengers to board the train by simply scanning a payment code instead of booking paper tickets [24]. These paperless experiences are expected to launch inside the Greater Bay Area.

As a pioneer city of artificial intelligence, Shenzhen continues carrying forward digitization construction. The idea of "one-yard pass" not only applies to people but also to import and export goods management. At airports, automatic passport control is a new technology that is being used in smart transportation. Passengers can use RFID-based passports or electronic passports for rapid and reliable entrance without a physical passport check in automatic passport control [19].

According to the GBA development outline, the national trunk railway market and urban rail transit integrate into four networks [3]. New-generation ICT, such as cloud computing, 5G, artificial intelligence and big data management, are used to efficiently link up passenger travel services, transport scheduling, command and train operation control, and adopt the European system of instant arrival, instant delivery. The aim is to gradually achieve the scientific planning and construction of the rail transit network and build a world-class rail transit network with reliable structure and efficient transfer construction and sharing. In the long term, the experience can move from cities to regions, from multi-network to integration, and from transportation coordination to leading the development of urban clusters into the new age. The future aim of the transport network in GBA is to promote the integration of rail transit networks, actualize cross-line transportation energy complementary and resource sharing, and improve the overall operational efficiency of rail transit.

3.2 Integrated Regional Railway Construction Planning

The National Development and Reform Commission has clearly outlined the importance of hub layout and bridging scheme [7]. Smart transportations emphasize the efficiency and mobility of the cooperation between each node of transport. The GBA inter-city railway and high-speed railway lines achieve connectivity through the hub transfer, and rural area railway operations transfer to the urban rail transit hub in cohesion. The rest of the operations between the hub within each implementation are connected by urban rail transit. Guangdong province will continue to strengthen

the internal interconnection of the GBA, building the main skeleton of the "A" glyph traffic in the GBA, improving the multi-level rapid transportation system with high-speed rail, intercity railway, and highway as the main body. In the short run, the aim is to fully actualize the one-hour transport circle among the three poles of Guangzhou-Foshan, Shenzhen, Hong Kong and Zhuhai. In the long run, the goal is to enhance the external radiation effect of the GBA, create the province's "three horizontal six vertical two-way" transport channel layout, and further promote Shantou, Zhanjiang Province, the sub-central city and the province's urban area traffic construction and development [25].

According to the Ministry of Transport of the People's Republic of China, the total high-speed railway construction in the GBA has exceeded 1200 kilometres [25]. Shenzhen and The Hong Kong and Macao Ports have recently been connected by the existing Beijing-Kowloon Railway, the Guangzhou-Shenzhen-Hong Kong High-speed railway. Zhuhai and the Macao SAR also have been connected by a high-speed railway at Zhuhai Hengqin Station. Hengqin New Area of Zhuhai has recently launched an individual business ledger filing system and a series of fast service channels such as cross-border one-station hand-held offices. The notarization service window for Macao investors in commercial registration has shortened from more than seven working days to less than two working days.

Another example is the iconic Guangdong-Shenzhen-Hongkong high-speed railway, supporting Alipay to board the train in any of its stations even when it crosses borders. The integrated high-speed rail experience benefits people who travel across borders daily due to work or study issues. The future aim of the transport network in GBA is to integrate the intercity (suburban) railway urban tracks of trunk railways, promote the integration of rail transit networks, actualize cross-line transportation energy complementary and resource sharing, and improve the overall operational efficiency of rail transit in the GBA.

4. Discussion

4.1 Smart Transportation Requires Smart Governance

According to Forrester, smart governance is the core of smart cities initiatives and a core challenge for smart cities initiatives [26]. Implementing the railway network in GBA requires cooperation between the national government, the provincial government and the local government due to historical reasons. The GBA consists of special administrative regions Hong Kong and Macau, one special economic zone Shenzhen. Promoting a convergence mechanism of Guangdong, Hong Kong, and Macao is the only way to break down current barriers. Although the mainland cities can copy the successful experience of urban governance and other things that Hongkong and Macao are leading, other fields, such as trade and investment liberalization and facilitation, should be addressed independently based on each case [27]. Moreover, the customs and border security checks under different political and economic systems can largely influence transportation accessibility.

Another important factor in smart governance is public participation. Li et al. discussed public participation in the urban planning process [28]. They pointed out that the enthusiasm and involvement of the public significantly influence the effectiveness of urban development projects. However, age, trust of government, and the level of education affected the degree of involvement of the public in the urban planning process. Thus, smart governance is an attempt to achieve socio-demographics in urban planning. As the development level varied across the GBA, the implementation of smart governance needs platform support and matching policies encouraging residents to participate in the decision-making process.

Moreover, New ICT may be able to compensate for the limitations of traditional forms of participation, including public hearings and citizen panels, which have been criticised for being time and money demanding because to their fixed location and time [29]. However, having access to modern ICT technology does not guarantee success. Smart governance necessitates greater public

participation, such as allowing citizens to advise or plan indefinitely while retaining the right for power holders to determine the legitimacy or practicality of the advice, which is strongly more than informing and consulting [30]. For the general public, ICT technology and production leads a straightforward, accessible, transparent, and engaging discourse. However, ICT tools may not be able to completely replace traditional participation techniques, especially for low-income or elderly people. Therefore, it is imperative to consider public involvement, especially for those GBA cities located in mainland China.

4.2 The Lack of Resilience of Transport Network in the GBA

Opschoor discusses the notion of 'climate change resilient and 'climate-friendly in the context of local, sustainable development [31]. The trade-off between agglomeration economies and dis-economies (e.g. population density and environmental decay). Supply of intermediate and final commodities has an impact on economic activity, which in turn has an impact on regional economic growth and urban agglomeration. Building a resilient transportation network in GBA is a necessary condition and driving factor for high-quality and sustainable development [32]. According to studies on the vulnerability and resilience of transportation networks, degree and betweenness attack drop rates were considerably faster than natural hazard and random attack drop rates, indicating that the GBA was more sensitive to targeted attacks. In terms of resilience, the GBA showed weak resilience in the face of focused attacks, owing to significant performance loss.

Meanwhile, the GBA had approximately the same resilience under natural hazards and random attacks. Moreover, the GBA has poor resilience when faced with targeted attacks, mainly due to the considerable performance loss [32]. Therefore, to enhance the transport network's reliability and secure the safety of drivers and passengers, further actions are required from relative departments from the government when making policies.

5. Conclusion

Overall, the GBA plan is an ambitious blueprint for creating a new spatial region to boost regional collaboration and the development of the smart cities cluster. After comparing the necessary factors of smart transportation planning and the current situation in the GBA, the author concludes that GBA has launched various ICT and IoT supporting the hardware infrastructure of smart transportation networks. Furthermore, positive economic effects such as stimulating regional collaboration, accelerating both human and business exchange have been reported. However, rare literature analyzes the effect of large amounts of railway construction and the following operation on the environment. Furthermore, the inclusiveness of the smart boarding system to different groups of people remains uninvestigated.

Nevertheless, this article has some limitations. Bias can occur in the planning, source collection, analysis phases of research. Spatial bias may occur as the GBA consists of cities in very different developing levels. Both hardware (e.g. big data collection, automatic emergency management, advanced sensor installment) and software (e.g. smart governance platform, inclusiveness justification, environmentally friendly transport network) development varies in each city in the GBA, which indicates the development speed of each city would be different. Moreover, many major projects in the GBA are currently under construction, which would have a significant influence on the point of view of this article.

Last but not least, carbon neutrality has become more and more critical in the global range. Transport as an essential part of the greenhouse gases emissions, the sustainability in transport planning needs further and precise research. Nowadays, smart cities require not only advanced digitization but also a kind of city that benefits the environment, humans and society. As Sennett illustrated in his book building and dwelling: ethics for the city, the ethical connection between urbanist and urbanite lie in practicing a certain kind of modesty: living one among many, engaged by a world that does not mirror oneself [33]. Understanding the ideology of smart transportation is critical to adjusting planning policies and promoting future urban growth.

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