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Sustainability of China's urban transport sector: a comparative case study analysis of Guiyang and Beijing

1.0 Executive summary

China has experienced a myriad of detrimental issues as a result of rapid urbanisation and economic growth over recent years. These include major traffic congestion, air pollution, alongside other environmental and social problems. This is largely documented in academic literature, with widespread belief that China's public transport is largely inefficient. Hence efforts have been taken by the government to address these challenges. This is highlighted by the shift in modes of transport used within cities. Informed by current literature, this report looks at two contrasting cities, Guiyang and Beijing. Specifically, the report analyses the current modes of transport used, their effectiveness, as well as their future plans in Guiyang and Beijing's bid to achieve the triple bottom line. Results conclude that each city has adopted transport systems which work to reduce heavy reliance upon private transport. This is done through investment in, and promotion of public transport, as well as alternative modes, for example walking and cycling. Yet there is much room for improvement. In consequence, both cities are now looking towards future plans to achieve sustainable transport systems. Ultimately, governance is highlighted as a key driver for sustainable urbanisation, as demonstrated with the case study of Guiyang's Masterplan which is largely government subsidised. In light of events, it should be suggested that other cities would be wise to follow similar footsteps in order to contribute to a safer, cleaner urbanised world.

2.0 Introduction

2.1 Air pollution in China

Despite the Chinese government deploying numerous policies which work to mitigate harmful emissions from the transport sector, China continues to be plagued with serious and increasingly challenging environmental issues (Qui and He, 2016). According to RSEC, China was the world's largest producer of CO_2 and SO_2, as well as the biggest energy consumer, accounting for 22.4% global consumption (BP, 2014). This is attributed to rapid economic growth, with twelve of the twenty most polluted cities in the world being located in China (World Bank, 2007). This is due to China's high car dependency, following a development trajectory similar to that of many other newly industrialised countries (Gan,

2011). This is reflected in China's passenger turnover which has increased from 1746.67 billion passenger-kilometres (pkm) in 2005, to 3009.74 billion pkm in 2014 (National Bureau of Statistics of China's, 2006-2015). Congestion and smog are thus widespread (Phipott, 1995), resulting in an increased risk of lung cancer, respiratory and cardiovascular diseases (Kunzi et al., 2000). Collectively, this brings both opportunities and challenges for China's integration into the global economy, whilst simultaneously placing efforts into protecting the environment.

With evermore public attention to air quality, the Chinese government are under increased pressure to devise feasible polices which balance economic development and environmental problems to produce a sustainable transport system (Qui and He, 2016). In 2017, China committed to strengthening cooperation with the EU to launch a nationwide carbon emission trading market (Spigarelli et al., 2016). While promoting internal change for environment protection, China sees this as an opportunity to learn and reaffirm its role in the global fight for a cleaner world (De Matteis, 2010). With EU's experience and China's need to implement more sustainable strategies, this proves to be a useful collaboration in achieving an effective and sustainable transport system (Gill and Murphy, 2008). This report has been produced to address China's bid for sustainable urbanisation in terms of green transport, set out by the organisation E-forum.

2.2 Sustainable transport

Sustainable transport incorporates a broad range of goals which consider economic, social and environmental factors (Litman, 2001), with the needs of the current generation being met without compromising the ability of future generations to meet their needs (Liu et al., 1999). Specifically, goals include meeting necessary demands for transport services, reducing the reliance on petroleum and non-renewable energy, avoiding negative environmental consequences and also reducing the cost of infrastructure construction (ibid). What is more, they must provide mobility and accessibility to urban residents in a safe and environmentally friendly way (Mohan and Tiwari, 2000).

2.3 Research questions

Informed by secondary data, this report will look at what is being done in Guiyang and Beijing, specifically answering these key questions:

1. What modes of transport are used?
2. How effective are they in terms of sustainability?
3. What are their future plans in achieving a sustainable transport system?

3.0 Methodology

Using online databases such as Google Scholar and the University of Manchester library service, a literature search was conducted to review published works on Guiyang and Beijing's current and future public transport infrastructure**.** Search engines such as Google were also used to find websites, newspaper articles and reports that could be used as a source of reference throughout the study. This proved successful in acquiring appropriate forms of literature to gain a comprehensive insight into the sustainability of China's urban transport system. In doing so, this indicated the extent to which Guiyang and Beijing's transport sector is sustainable, with particular reference as to how these have been governed. It is further worth noting that whilst undertaking this study, ethicalities were addressed and adhered to. Ethicalities included legally obtaining information and accurately documenting published works through Harvard referencing.

4.0 Discussion

4.1 Guiyang

Guiyang is the capital city of Guizhou Province, located to the east of Yungui Plateau, southwest China and covers 8,034 km^3 with a population of 3.448581 million people (UN-HABITATa, 2017). Like other Chinese cities, Guiyang has seen a rise of 81.6% in cars between 2008 and 2013 (Liao, 2008; Baidu.Net, 2014). Despite restrictive measures taken to control private car ownership, deteriorating traffic conditions, air pollution and noise nuisance have resulted in pressing concerns, both socially and environmentally (Wong et al., 2015). Hence Guiyang is argued to now be at a critical stage of environmental protection (UN-HABITATb, 2017). The Guiyang City Masterplan (2009-2020) is a case of point.

4.1.2 The Masterplan

Guiyang was selected as one of the demonstration cities to implement sustainable transport to compile and enhance “The Master Plan for Guiyang's Ecological Economy City”. In doing so, this aims to solve problems resulting from economic development and ultimately achieve the overall objective of sustainable urban development (UN-HABITATa, 2017).

Wei et al., (2013) compared thirty-four Chinese cities and found Guiyang, the beneficiary of national transport infrastructure development policy, ranked third in both sustainable and capacity efficiency. This demonstrates a paradigm shift Guiyang has made towards sustainable urban development which involves a triangular relationship between economic, environmental and social pursuits (Wong, et al., 2015). Since 2005, fuel taxation measures have aided in reducing fuel consumption by 15% within four years. By 2020, the Masterplan aims that no less than 45% of passenger trips will be made by public transit, whilst car commuting trips hope to be fewer than 25% (Li and Li, 2013). Specifically, the large focus of the Masterplan aims at decentralisation and control of urban sprawl through focus on its public transit system, with an allocated investment equivalent to 3-4% of the city’s GDP (Wong, et al., 2015). Hence the government’s role in implementing sustainable transport infrastructure through the supply of heavily subsidised transport is argued to be considered as a crucial factor to its success.

4.1.3 Rail Transit

Guiyang Rail Transit Line 1 is the first rail transport line in Guiyang, running through the northwest-southeast main passenger traffic corridor at a top speed of 80km/h (CREEC, 2014). To cater for Guiyang’s geological conditions, enclosure structure with nailing walls and soldier piles are adopted in the structure design, as well as shallow buried covered excavation (ibid). Therefore, advantages of the construction process are argued to be simple, safe and economical. What is more, passengers are able to transfer to the high-speed railway (ibid). Park and ride services also facilitate commuters to use connecting public transit, thus a comprehensive and accessible transport hub has formed (Wong et at., 2015).

Although rail transit aids in maintaining the smooth running of Guiyang’s production and consumption, promoting green urbanism has not come without its challenges. This is due to Guiyang’s karst hilly terrains conditions (Comtois, 1990) which pose as a dilemma to sustainable transport when considering its cost, feasibility and effective land use (Wong et al.,

2015). Guiyang has managed to overcome this, with rail transit gradually becoming the major source of mass transportation. This is due to its high efficiency, low consumption, low pollution, as well as its comfort, safety and flexibility (ibid). Hence rail transit is argued to provide positive contributions to the improvement of the ecological environment, urban development and the construction of the 21 century ecotype city.

4.1.4 Cycling

Cycling is promoted as an alternative mode of transport, aided through the opening of a 2.5m cycling track in 2013 (Li, 2013). By 2020, Guiyang will have five main cyclist tracks, with 500 parking spots in close proximity to local networks and services (Wong et at al., 2015). The return of cycling thus symbolises a renewed mind set in adapting to the new lifestyle of a fast moving city, in response to environmental and health awareness in the midst of Guiyang's increasingly congested urban environment (ibid). Therefore, cycling proves to successfully reinforce the triple bottom line.

4.1.5 Walking

Walking is also seen as a plausible mode of alternative transport as it not only strengthens connectivity, but also promotes health and a cleaner environment (Wong et al., 2015). Roads have therefore been widened as to make way for pedestrians and cyclists, overcoming safety barriers and making passages more attractive. In consequence, pedestrian behaviour is slowly being established, transitioning into a routine daily habit and practice (ibid). This also facilitates inter-modality mobility, contributing towards green urbanism.

Yet what persists to be a problem in Guiyang is the lack of consideration for pedestrians, as motorists do not respect their presence in street crossings. Moreover, in acknowledgement of the fact that a large proportion of the land is covered by hills and rugged terrain, this makes walking and cycling difficult (ibid). Further planning is therefore required in order to minimise conflicts with motorised transport. Ultimately, more serious consideration of facilities and safety measures are needed if cyclists are to be seen as shared road users.

4.1.6 Future plans

Guiyang Light Rail Transit (LRT) Construction Project is already underway and expected to be completed in 2019 (Wong et al., 2015). The basic target is to link key axial belts to key mass transit passengers' corridor, thus expanding the service range of the LRT system, with a

total length of approximately 177 kilometres (Travel China Guide, 2017). Phase one of subway line 1 started running in 2017, while the other four lines are expected to operate before 2020 (ibid). According to the long-range plan, Guiyang metro will include nine lines which will form a complete urban rail transit system, extending a distance of 467 kilometres (ibid). This will therefore make Guiyang's public transport system more interconnected, providing more incentive for commuters to make use of services, as opposed to heavy reliance upon car use.

4.2 Beijing

Beijing, the capital city and therefore the economic and political hub of China, has similarly seen a shift in the dominant types of mobility used, from cycling to car use, with the number of cars soaring from 494,000 in 2000 to 3.7million in 2010 (Chiu, 2012). Road transport alone accounts for 86% of CO_2 emissions and 57% of NOX emissions (Yang et al., 2015). This has direct impacts on city dwellers, causing health problems such as asthma and other respiratory problems. This shift in transport behaviour is largely due to rising affluence, with more people choosing cars as their primary mode of transport due to ease and flexibility. However, only the privileged are able to afford car ownership, forcing others to rely upon alternative forms of transport, which are often unreliable such as local buses (Lu, 2012). Increased government expenditure of 14.1 billion was spent during 1996 to 2003 on road infrastructure (Ahmed et al., 2008), resulting in urban sprawl. What is more, walking and cycling are not plausible due to Beijing's congested, unsafe roads (ibid).

In response to rising congestion, quotas on vehicle registration numbers were issued in 2011 which work to reduce the number of vehicles dominating the road (Pai and Gupte, 2014). The government further acknowledge public transport's role in reducing air pollution and congestion, hence increased investment and promotion of bus and rail services have been undertaken. This particularly comes in response to results showing that larger, more urbanised cities such as Beijing have the least sustainable transport systems. This can be contrasted with less affluent cities, such as Guiyang, which ranked third in comparison to Beijing which ranked thirty-third out of thirty-four Chinese cities (Table 1).

Table 1.
Urban transport sustainability efficiency (SE1) and ranking (R1) for selected Chinese cities, 2008.

R1	City	SE1	R1	City	SE1
1	Xining	1.8994	18	Taiyuan	0.3835
2	Hohhot	1.1847	19	Dalian	0.3790
3	Guiyang	1.1152	20	Shenzhen	0.3763
4	Lanzhou	1.0927	21	Harbin	0.3105
5	Haikou	1.0098	22	Jinan	0.3087
6	Zhengzhou	0.8297	23	Qingdao	0.2956
7	Changsha	0.6568	24	Hangzhou	0.2734
8	Fuzhou	0.6303	25	Chengdu	0.2629
9	Changchun	0.6203	26	Nanjing	0.2346
10	Ningbo	0.5808	27	Xi'an	0.2176
11	Hefei	0.5799	28	Shenyang	0.1788
12	Xiamen	0.5469	29	Wuhan	0.1731
13	Kunming	0.5310	30	Chongqing	0.1612
14	Nanchang	0.4666	31	Tianjin	0.1570
15	Shijiazhuang	0.4567	32	Guangzhou	0.1006
16	Nanning	0.4404	33	Beijing	0.0899
17	Urumqi	0.4073	34	Shanghai	0.0881

Table 1: urban transport efficiency and ranking for thirty-four Chinese cities. Source: Wei et al., (2013).

4.2.1 Bus Rapid Transit

Fiscal spending in bus infrastructure, as well as providing low fares at 2 RMB (22p) for the subway (Wang and Change, 2015) work to encourage people to make the switch from private to public transport (Mao et al., 2012). While buses are more energy efficient than cars, Xie (2012) indicates buses are accountable for high emissions due to gasoline being the main fuel type used. However, after the 2008 Beijing Olympics, the government mandated natural gas as a cleaner fuel in order to lower pollution levels, in their bid to develop a green transport system (Pojani and Stead, 2015). Havashi et al., (2004) further documents the use of GECAM, a water based diesel that produces less PM, CO and NOX emissions compared to standard diesel fuels. The government has also increased the number of 'clean fuel' buses, which if implemented at a larger scale than at present, will prove to be effective. These systems have been made cheaper to facilitate accessibility, thus bus transport is more socially sustainable.

4.2.2 Rail Transit

Beijing has been praised for its expansion of its rail transit system, with Chiu (2012) describing rail transit as the most environmentally friendly transport, reporting an exponential

rise in the length of lines built and use by population in volume. The shift from road to rail transport has therefore resulted in a fall in CO_2 emissions, relieving urban pressures both socially and environmentally. Having said this, Liu et al., (2015) acknowledge that whilst rail transit is effective, the volume of people still using the bus surpasses those using rail transit, accounting for 66.6% of public transport journeys in 2010 (ibid). Hence roads continue to be congested. Furthermore, Xie (2012) argues that whilst increased rail journeys have significant environmental benefits, these are likely to be offset by an increase in car use due to rising affluence. Although Beijing's rail system is presented as a sustainable transportation method, discrepancies in its use are revealed, specifically a lack of emphasis of rail use in government policy (ibid). This leads to the suggestion that a combination of promoting rail and de-incentivising car use is needed to improve the sustainability of Beijing's public transport system.

4.2.3 Future plans

Increased government investment on transit infrastructure is projected to occur in recent years to come (Shi et al., 2011; Deng and Nelson, 2010). As well as this, a shift towards cycling is expected to continue to take place (Phillips, 2016). Zhang et al., (2015) discuss the benefits of cycling. These include cycling being economically viable due to being relatively inexpensive, socially sound due to health benefits associated, as well as environmentally sustainable as no emissions are produced. As such, Beijing has directed efforts into implementing wide ranging bike-sharing schemes, restoring cycle lanes, as well as introducing rental programmes that will make 50,000 bikes available for hire (Zhang et al., 2015). The strategic placing of bike parks near bus and subway stations will also encourage people to cycle into the city (Watts, 2010). This is ultimately considered a largely sustainable strategy which could be used in conjunction with other public transport modes to improve sustainability (Banister, 2012).

5.0 Conclusion

It is therefore clear to see that China's transport sector is transitioning towards a more sustainable transport system (Jenks and Burton, 1996). This report highlights Beijing's adoption of bus and rail systems which have proved to reduce environmental problems and benefit inhabitants, hence is making progress in the city's attempt to be more sustainable. Likewise, Guiyang has invested in bus and rail transit in order to reach full capacity, as well as promoting alternative transport modes such as cycling and walking. This is contrasted with

Beijing which remains highly congested despite improved public transport networks. Beijing is now looking to reduce space currently used by public transport by similarly promoting slower modes of transport.

Yet it can be argued that ambitions remain a lip service due to ineffective implementations due to other political agendas ranking higher in importance (Hickman et al., 2013). Thus sustainable green urbanism requires strong confidence and financial support from national government in conjunction with local authorities if it is to succeed. Guiyang is a good example of this, with large government subsidy aiding in achieving the Masterplan for sustainable urbanism. Hence it would be wise for other Chinese cities to adopt a similar approach.

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References

Ahmed, Q et al. (2008) Urban transportation and equity: A case study of Beijing and Karachi, *Transportation Research Part A: Policy and Practice*, 42(1), pp.125-139.

Baidu.Net (2014) Vehicle numbers in the main cities of Western China, Available at: http://tieba.baidu.com/p/2702288217 (Accessed: 1st May 2017).

Banister, D. (2012). Viewpoint: Assessing the reality-Transport and land use planning to achieve sustainability, *The Journal of Transport and Land Use*, 5(3), pp.1-14.

BP. (2014) *Statistical review of world energy*, Available at: http://www.bp.com/statisticalreview

Chiu, R.L. (2012) Urban sustainability and the urban forms of China's leading mega cities: Beijing, Shanghai and Guangzhou, *Urban Policy and Research*, 30(4), pp.359-383.

Comtois, C. (1990) Transport and territorial development in China 1949–85, *Modern Asian Studies*,
24(4), pp. 777–818.

CREEC (2014) *Guiyang Rail Transit Line 1*, Available at:*http://www.creegc.com/en/tabid/187/InfoID/1521/frtid/190/Default.aspx* (Accessed: 7th May 2017).

De Matteis, P. (2010) EU-China cooperation in the field of energy, environment and climate change, *Journal of Contemporary European Research*, 6(4), pp. 449-477, Available at: http://www.jcer.net/ojs/index.php/jcer/article/view/242/223, (Accessed: 4th May 2017).

Deng, T. and Nelson, J.D. (2010). The impact of bus rapid transit on land development: A case study of Beijing, China. *World Academy of Science, Engineering and Technology*, 66, pp.1196-1206.

Gan, L. (2001) *Globalization of the automobile industry in China Dynamics and barriers in the greening of road transportation*, Norway: Center for International Climate and Environmental Research.

Gill, B., and Murphy, M. (2008) *China-Europe relations: Implications and policy responses for the United States.* A report of the CSIS freeman chair in China studies: CSIS, Available at: http://csis.org/files/media/csis/pubs/080507-gill-chinaeuroperelations-web.pdf

Hayashi, Y. et al. (2004) Urban transport sustainability: Asian trends, problems and policy practices, *European Journal of Transport and Infrastructure Research*, 4(1), pp.27-45.

Hickman, R. et al. (2013) Planning more for sustainable mobility, *Transport Geography*, (33), pp. 210–219.

Jenks, M. and Burton, E. (1996) The compact city – a sustainable urban form? Spon Press: London.

Kunzli, N. et al. (2000) Public health impact of outdoor and traffic-related air pollution: an European assessment, *The Lancet*, (356), pp. 795–801.

Li, L. et al. (2009) Bike Rental Station Deployment Planning in Wuhan, *Urban Transport of China*, 7(4), pp. 39-44.

Li, K. (2013) City slow system: green transport practice in Guiyang, Available at: http://www.gzcpc.
com/2013/06/09/88803.html, (Accessed: 2nd May 2017).

Li, C.H. and Li, J. (2013) Reply from the State Council on Guiyang City Masterplan (2009–2020).

Liu, X. et al. (2015) A system dynamics approach to scenario analysis for urban passenger transport energy consumption and CO 2 emissions: A case study of Beijing, *Energy Policy*, (85), pp.253-270.

Liao, Q. (2008) Motorized vehicles in Guiyang City has exceeded 38000, Available at: http://gzdsb.gog.com.cn/system/2008/12/24/010438244.shtml, (Accessed: 20th May 2017).

Lu, Q. C. (2012). China's public transportation: Problems, policies, and prospective of sustainability, *Institute of Transportation Engineers, ITE Journal*, 82(5), pp.36.

Litman, T. (2001) Transportation Cost Analysis for Sustainability, Victoria Transport Policy Institute.

Liu, D.Q. et al. (1999) Urban land use and sustainable urban transport development Chinese Population, *Resources and Environment*, 9(4), pp. 38-41.

Mao, X. et al. (2012). Achieving CO 2 emission reduction and the co-benefits of local air pollution abatement in the transportation sector of China, *Environmental Science & Policy*, (21), pp.1-13.

Mohan, D. and Tiwari, G. (2002) Sustainable Transport Systems: Linkages Between Environmental Issues, Public Transport, Non-Motorised Transport and Safety, Available at: http://www.vtpi.org.

National Bureau of Statistics of China. (2006–2015) China Statistical Yearbook, China Statistics Press: Beijing.

Pai, M. and Gupte, T. (2014) Next Generation Sustainable Transport Solutions in the Context of the post-2015 Development Agenda. In *Background Paper presented at the 8th Regional Environmentally Sustainable Transport Forum in Asia* (pp. 19-21). [online]. Available at: http://www.uncrd.or.jp/content/documents/22248EST-CRT-BGP_EMBARQ.pdf (Accessed: 2nd May 2017).

Phillips, T. (2016) 'Bike-sharing revolution aims to put China back on two wheels,' *The Guardian*, 28 December, Available at: https://www.theguardian.com/world/2016/dec/28/bike-sharing-revolution-aims-to-put-china-back-on-two-wheels (Accessed: 4th May 2017).

Phipott, J. (1995) ed. Transport Growth in Bangkok: Energy, Environment, and Traffic Congestion, Proceedings from November 1994 Workshop, Washington, DC: IIEC.

Pojani, D. and Stead, D. (2015) Sustainable urban transport in the developing world: beyond megacities, *Sustainability*, 7(6), pp.7784-7805.

Qui, L.Y. and He, L.Y. (2016) 'Are Chinese transport policies effective? A new perspective from direct pollution rebound effect, and empirical evidence from road transport sector', *Sustainability*, 9(3), pp. 1-15.

Shi, J. et al. (2011) Reform Beijing to a public transit oriented city–from the view of transportation equity, *Journal of Advanced Transportation*, 45(2), pp.96-106.

Spigarelli, F. et al. (2016) *China and Europe's Partnership for a More Sustainable World*, Emerald Group Publishing Limited.

Travel China Wide. (2017) *Guiyang Subway*, Available at:*https://www.travelchinaguide.com/cityguides/guizhou/guiyang/subway/* (Accessed: 7th May 2017).

UN-HABITATa. (2017) *Sustainable Guiyang Project*, Available at:*http://www.fukuoka.unhabitat.org/programmes/scp/china/detail04_en.html* (Accessed: 8th May 2017).

UN-HABITATb. (2017) *Urban Development Strategy in Guiyang* , Available at:*http://www.fukuoka.unhabitat.org/programmes/scp/china/pdf/Outline_for_the_Urban_Development_Strategy_in_Guiyang.pdf*(Accessed: 7th May 2017).

UN-HABITATc. (2017) *Priority Projects in Guiyang* , Available at:*http://www.fukuoka.unhabitat.org/programmes/scp/china/pdf/Priority_Projects_in_Guiyang_with_table.pdf*(Accessed: 7th May 2017).

Yang, Z. et al. (2015). Review of Beijing's Comprehensive motor vehicle emission Control programs, *Communications*, 49(30), pp.847129-102.

Wang, H. and Chang, D. (2015) Study of the impact of Beijing public transport subsidies on financial revenue under the public transport fare increase policy. In *Logistics, Informatics and Service Sciences (LISS), 2015 International Conference on* (pp. 1-6). IEEE. [Online]. Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7369794 (Accessed: 2nd May 2017).

Watts, J. (2010) 'Campaign to boost cycling in Beijing,' *The Guardian,* 24 January. Available at: https://www.theguardian.com/world/2010/jan/24/beijing-cycling-capital-plans (Accessed: 3rd May 2017)

Wei, J. et al. (2013) Urban transportation in Chinese cities: An efficiency assessment. *Transportation research part D: transport and environment*, (23), pp.20-24.

Wong, T.C. et al. (2015) *Population Mobility, Urban Planning and Management in China*, Springer.

World Bank. (2007) World development indicators 2007, Washington, DC: World Bank.

Xie, L. (2012) *Sustainability Implications of Mass Rapid Transit on the Built Environment and Human Travel Behavior in Suburban Neighborhoods: The Beijing Case* (Doctoral dissertation, Arizona State University). [Online]. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.661.2932&rep=rep1&type=pdf (Accessed: 4th May 2017).

Zhang, L. et al. (2015) Sustainable bike-sharing systems: characteristics and commonalities across cases in urban China, *Journal of Cleaner Production*, 97, pp.124-133.

Zhang, X.L. and Hu, X. (2003) *Enabling sustainable urban road transport in China: A policy and institutional perspective*, Norway: Center for International Climate and Environmental Research.