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You have to drive: Impacts of planning policies on urban form and mobility behavior in Kuala Lumpur, Malaysia

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A R T I C L E I N F O

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A B S T R A C T

This article investigates how planning policies have shaped urban form and mobility behavior in the rapidly urbanized metropolitan area of Kuala Lumpur, Malaysia. We argue that the complex chain of consequences of previous policies and their implementation processes can be understood from the socio-spatial dynamics that result from the interaction between people and their built environment. Using the case of Kuala Lumpur, we provide empirical evidence of these socio-spatial dynamics through (1) the identification of key policies, (2) an understanding of Kuala Lumpur's spatial configuration using space syntax, and (3) in-depth interviews to reveal mobility behavior. Our findings suggest that Kuala Lumpur's previous road expansion policies, national car project, and fragmented new town development have created an urban form that encourages vehicular instead of pedestrian movement. Consequently, this has induced an automobile dependence and culture that conflicts with the country's current initiatives on sustainable development. For policymakers and planners, these findings provide awareness that policy impacts span across generations and scales, making them difficult to reverse and take a long time to be fixed. We conclude with practical insights on how to reverse the unsustainable path through socio-spatial innovations and research directions to address the ongoing vehicular dominance and automobile society in Kuala Lumpur.

1. Introduction

Rapid urbanization in metropolitan areas presents a challenge for urban management, especially concerning the understanding and management of the spatial and social consequences of planning policies. Planning policies, such as for transport and land use, have long-term impacts on the urban form, and in particular on the street network as the city's backbone that shapes the flow and pattern of movement. This influences people's behavior as they navigate and traverse the street network. Through land use and transport feedback cycle (Bertolini, 2017; Wegener & Fürst, 1999) for instance, road expansion and low-density development can lead to an unsustainable urban form and encourage an automobile culture. This culture creates a mobility behavior that prioritizes access to cars and penalizes those who are carless, such as captive pedestrians who symbolize the urban poor and the marginalized (Fischer, 2016; Urry, 2004). In this article, we investigate the chain of consequences in terms of how previous planning policies (i.e. transport and land use) affect

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mobility behavior (i.e. dependence on a particular mode) by analyzing the policy impacts on the urban form (i.e. focusing on the street network configuration), based on the premise that the street network configuration influences how people use and perceive space (Hillier, 2012; Hillier & Iida, 2005).

Over the past decades, the Kuala Lumpur Metropolitan Area (henceforth, Kuala Lumpur) has seen a number of changes in its planning directive: the massive road constructions in the 1960s, the national car project in the 1980s, the development of modern public transport infrastructure in the early 2000s, and the adoption of sustainable transport principles in the National Transport Policy 2019–2030 (Ministry of Transport, 2019). The influence of the previous policy of road expansion on Kuala Lumpur's urban form is evident from the enormous highway networks with a road density of 68 m/1000 people, which is similar to North American cities (Almselati et al., 2011; Bunnel et al., 2002). This policy is reflected in the current mobility behavior of Kuala Lumpur inhabitants, which represents a car-oriented profile with 80% of the mode share consisting of private motorized vehicles (Chuen et al., 2014; Land Public Transport Agency, 2013). The low share of public transport (i.e. commuter trains, mass rapid transits, monorails, buses) is attributed to the lack of integration between different modes and operators (Barter, 2008; Hamid, 2009). Non-motorized transport such as walking and cycling is almost non-existent, except in tourist areas, due to inadequate infrastructure (e.g. non-continuous sidewalks and cycling paths), humid weather, the negatively perceived image of pedestrian safety, and the deteriorating street livability (Mahmoudi et al., 2015; Rahman et al., 2015; Zakaria & Ujang, 2015).

For Kuala Lumpur, this interrelation of policy, spatial, and behavioral elements can pose a challenge for achieving the newly adopted sustainable transport policy (Ministry of Transport, 2019) and conflicts with the growing emphasis on sustainable development in Malaysia (Musa et al., 2019). Addressing this challenge requires a holistic understanding of the mechanism of how policy impacts the urban form (i.e. street network configuration) and people's behavior, thus allowing awareness-raising and a shift in planning practices to avoid an unsustainable trajectory of urban management that prioritizes an unsustainable transport mode. Against this background, this article sets out to answer the following research question: *How have planning policies over time shaped the urban form, which subsequently influences mobility behavior in Kuala Lumpur?*

The research question is linked to the argument that current urban transport challenges in Kuala Lumpur can be explained through an understanding of how previous planning policies have shaped a car-oriented urban form and car-dependent behavior. Therefore, this article builds on the literature concerning transport and urban form, especially on the relation between transport and land use (Bertolini, 2017; Chen & Felkner, 2019; Pflieger et al., 2009; Wegener & Fürst, 1999) and spatial configurations (Hillier, 2012; Hillier & Iida, 2005; van Nes & Yamu, 2018). These relations influence mobility behavior, leading to an automobile society (Urry, 2004; Williamson, 2003), indicating a path dependency (Low & Astle, 2009; Sorensen, 2015). To understand the local context of Kuala Lumpur's urban development and its related policies (Almselati et al., 2011; Barter, 2004; Bunnel et al., 2002; Mohamad & Kiggundu, 2007), we performed desk research on planning policies, which we later verified using empirical data of the street network configuration and mobility behavior.

We therefore employed a mixed method approach combining (1) a literature review on Kuala Lumpur's planning policies to identify key transport and land use policies linked to the evolution of the urban form, (2) space syntax analysis to understand how previous policies have manifested in the urban form through the proxy of street network configuration, and (3) in-depth interviews to confirm the space syntax findings and investigate mobility behavior. The use of a mixed method approach and multiple data sources provides a triangulation of the results. The findings can contribute to the discussion of sustainable cities (Newman & Kenworthy, 1999; Newman et al., 2016, 2019) by demonstrating the use of spatial analysis (i.e. space syntax) to visualize policy impacts, either as a postdiction to trace how current mobility behavior is manifested or as a prediction of how current policies can impact future mobility behavior as part of the urban management processes.

This article uses Kuala Lumpur as a case study. Following Lund (2014; see Table 1), the case study in a general sense is a case of the transport and urban form relation as people travel and navigate through the streets, whereby the flow and pattern of movement are influenced by land uses and street network configurations. In a conceptual sense, this article is a case of the production of an automobile society. In a theoretical sense, it is a case of path dependency depicting a chain of consequences of planning policy impacts on urban spatial configuration and mobility behavior. In addition, the selection of Kuala Lumpur as the case study provides insights into the socio-spatial implications of planning policies in the Southeast Asian context that are rarely featured in planning and transport literature. The case study covers the Kuala Lumpur Federal Territory and its agglomeration area as one spatial system of a metropolitan region.

2. Case study: Kuala Lumpur

Kuala Lumpur's development is shaped by trade (bottom-up) and political dynamics (top-down). Originating from tin mine settlements around the intersection of the Klang and Gombak Rivers in the 1850s, the area developed into a trading post and was later appointed as the state capital, the headquarters of British Malaya, in 1880 (Gullick, 1994; Jackson, 1963). In 1895, the population of

Table 1
Analytical matrix of the case study.

	Concrete	Abstract
Specific	Mobility behavior	Automobile society
General	Transport and urban form relation Transport and land use Spatial configuration	Path dependency

Kuala Lumpur was around 25,000 with an area of 0.65 km^2. Maps produced from cartographic surveys show that the urban area of Kuala Lumpur had expanded to 20 km^2 in 1903 and to 52 km^2 in 1924 (Aiken, 1981; Durand & Curtis, 2013). In 1957, Kuala Lumpur's urban area had extended to 93 km^2 with 320,000 inhabitants as it became the capital of the Independent Federation of Malaya (UN Habitat, 1999). From this time onwards, the urbanization process started to concentrate around Kuala Lumpur, while other historical Malaysian cities (e.g. Penang, Melaka) experienced slower urbanization rates (Masron et al., 2012). In 1974, Kuala Lumpur became a Federal Territory with an area of 243 km^2 (Fig. 1).

Nowadays, Kuala Lumpur Federal Territory is an administrative enclave located in Selangor State (Fig. 1). The urban agglomeration area is 2,843 km^2 and is referred to as the Kuala Lumpur Metropolitan Area, which includes the new towns of Petaling Jaya, Subang Jaya, and Putrajaya, and Kuala Lumpur International Airport (KLIA) (Kuala Lumpur City Hall, 2003, Fig. 1). In 2017, the population of Kuala Lumpur Federal Territory was 1.79 million (Department of Statistics Malaysia, 2019) while that of the Kuala Lumpur Metropolitan Area was estimated at 7.75 million (Aziz, 2018).

In terms of transportation, Kuala Lumpur is connected by extensive road network system (Sendut, 1965). Since the opening of the Federal Highway in 1957, 406 km of expressways have been built, in addition to the 108 km that are currently under construction (Malaysian Highway Authority, 2017). In line with this is the soaring use of private vehicles in the Federal Territory of Kuala Lumpur, which recorded on average an annual increase of 13.17% in motorization between 1984 and 2003 (Mohamad & Kiggundu, 2007). In 2017, the number of registered cars and motorcycles in Kuala Lumpur Federal Territory reached 3.9 million and 1.8 million respectively (Lee, 2017). Among other Southeast Asian countries, Malaysia has the highest percentage of car ownership with 82% of households owning a car (Lee, 2016).

Conversely, public transport development in Kuala Lumpur has been moderate. Prior to the 1990s, buses served as the main form of public transport (Wahab, 1990). By 2000, Kuala Lumpur had 209 km of electrified rail tracks for commuter trains (KTM) and light rail trains (LRT) (Bunnel et al., 2002). Since 2002, an express rail service has connected Kuala Lumpur with the airport (KLIA) and Putrajaya. In 2003, a monorail connecting commercial hubs in Kuala Lumpur city center started to operate. Despite these improvements, public transit ridership in Kuala Lumpur has remained around 20% (Chuen et al., 2014; Land Public Transport Agency, 2013). The public transit system is deemed to lack integration in terms of routes and intermodal changes (Hamid, 2009).

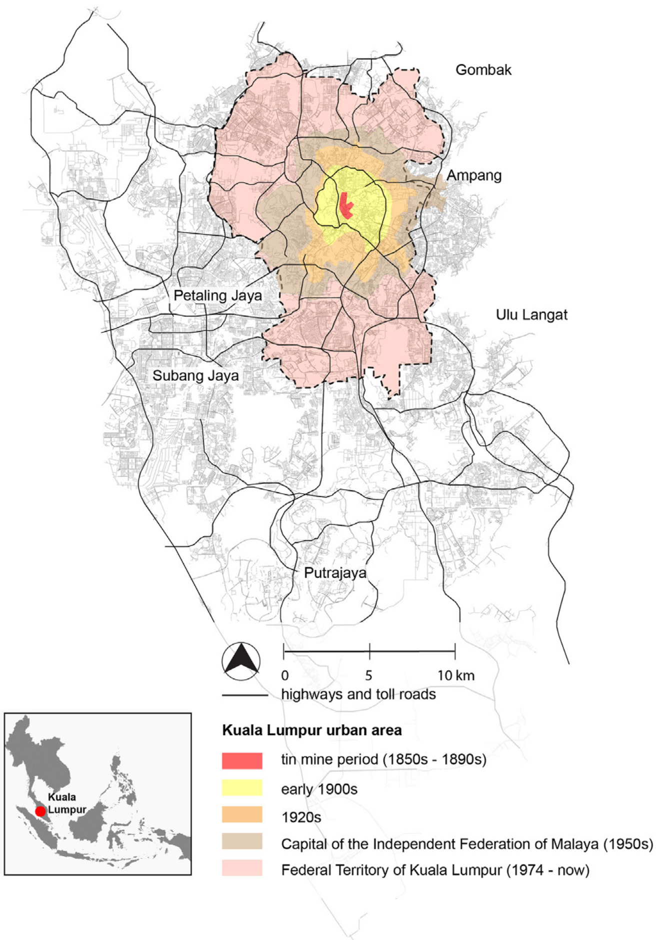

Fig. 1. Overview of Kuala Lumpur's urban development (adapted from Aiken, 1981).

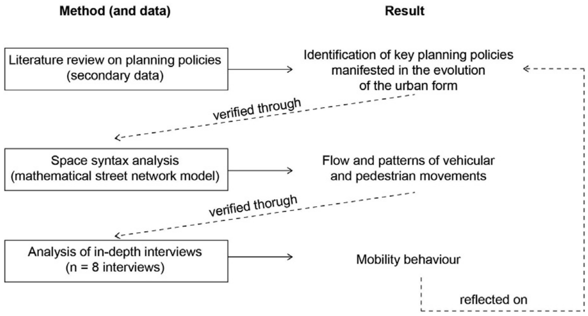

Fig. 2. Flow chart of the method and data analyses.

3. Method and data

To analyze the policy impacts on spatial configuration, which consequently influences mobility behavior in Kuala Lumpur, we employed a mixed method approach combining qualitative and quantitative analyses. This approach consisted of (1) a literature review of planning policies in Kuala Lumpur through desk research on books and journal articles, (2) space syntax analysis, and (3) the analysis of in-depth interviews. This mixed method was selected due to time efficiency, cost effectiveness, and limited data availability. Fig. 2 illustrates the flow chart of the method and data analyses, depicting how the mixed method provides a triangulation of the findings. The literature review of planning policies using secondary sources was convenient and less costly in terms of time, but the findings were at risk of a mismatch with actual conditions. To avoid this, we validated the literature review findings with the space syntax analysis, thus the evolution of the urban form shaped by the planning policies is triangulated by analyzing the street network configuration. Space syntax analysis, however, cannot depict perception and has to be interpreted with the understanding of local socio-cultural constructs (van Nes & Yamu, 2018). Thus, the findings from the space syntax analysis were confirmed through in-depth interviews. The findings from the in-depth interviews were then reflected back on the identification of key planning policies.

Departing from Fig. 2, details of the method and data are explained in the following sub-sections.

3.1. *Literature review of planning policies*

A literature review was conducted to identify key planning policies, their timelines and their interrelations, which provide information on Kuala Lumpur's urban form evolution over time. Sources were secondary data, consisting of books and journal articles (n = 16) published between 1963 and 2014 on Kuala Lumpur's urban development. Secondary data was used due to the limited accessibility to official planning documents across a long period of time, in particular the period prior to Malaysia's independence. The secondary sources included peer-reviewed articles to ensure data reliability. For the analysis, the historical periodization was divided into: the 1850s, when the city grew organically from tin mine settlements; the 1880s, when the city was appointed the state capital under British Malaya; the 1970s, when the city became a Federal Territory; and the 2000s-present to representing present day Kuala Lumpur. Findings from the literature review of planning policies were confirmed by the space syntax analysis (see Fig. 2).

3.2. *Space syntax analysis*

We applied space syntax theory and methodology to depict Kuala Lumpur's current urban form (through the proxy of street network configuration) in relation to previous planning policies. Space syntax analyzes the street network configuration to infer the flow and pattern of movements based on the logic that certain configurations influence people's perception and use of space (Hillier, 2012; Hillier & Iida, 2005; Hidayati et al., 2020a, 2020b). Since its development in the 1970s (Hillier & Hanson, 1984), studies have shown that space syntax measures are correlated with actual movements, and can therefore be used to identify vehicular and pedestrian movements (Hillier & Iida, 2005; van Nes & Yamu, 2018).

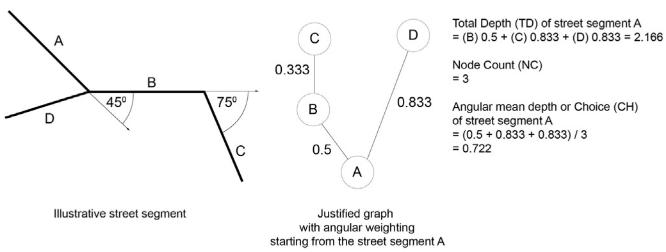

Fig. 3. Illustrative example of least angular deviation as the basis for normalized angular integration (NAIN) and normalized angular choice (NACH) computation in space syntax (source: Turner, 2007; van Nes & Yamu, 2020).

Table 2
Examples of coding for analyzing in-depth interviews.

Respondent ID	In-depth interviews transcription (keywords are italicized and numerically coded)	Code categorization	Related concepts (from the deductive phase)
Interviewee #1	If we use public transport, *it is difficult since we have to walk to the bus stop (2a)*. Our place is far from LRT, KTM, or MRT station. So, the only public transport is bus. [….] We do not use *bus and KTM because they are not reliable (2b)*. We have a choice to use personal transport. [author's note: LRT = light rail transit, KTM = commuter train, MRT = mass rapid transit]	(2a) Public transport difficulties (2b) Public transport stereotypes	
Interviewee #3	In 1980s, Malaysia was actually championing, they built the first *national car (4d)* [branded as Proton and Perodua, author's note]. When the whole *policy is about building a 'national car' (4d)*, they somehow directly and indirectly influence the transport and land use policies. Everything was about promoting the '*national car*' *(4d)*. So, the use of car has been glorified and popularized ever since in Malaysia.	(4d) Policy regarding national car	(4d) 'National car' policy (Athukorala, 2014; Barter, 2004; Mohamad & Kiggundu, 2007)
Interviewee #7	[…] *you have to drive (1)*. The weather and the roads are *not convenient and safe for you to walk (3a, 5)*.	(1) Private vehicle dependence (3a) Walking inconveniences (5) Safety	(1) Automobile dependence (Urry, 2004) (3a, 5) Transport and urban form relation (Bertolini, 2017; Pflieger et al., 2009)
Interviewee #4	[…] So, being a *pedestrian is the lowest social status (3b)*, whether it is discouraged or not, that is in our culture. Everyone strives to have our own car. Another related to institutional, the people who make decision tend to provide access, they strive to *expand the roads, build new roads (4b)*.	(3b) Walking stereotypes (4b) Policy regarding road expansion	(4b) Road expansion strategy (Almselati et al., 2011; Barter, 2004; Bunnel et al., 2002; Mohamad & Kiggundu, 2007)

Space syntax analysis is based on graph theory to depict the spatial structure and defines the relation between one street to other streets in a spatial system (Batty, 2004). It works with the concept of centrality, represented by accessibility with two main measures, namely *integration* and *choice*. *Integration* represents the ease of accessing a street segment in relation to other street segments in the system, while *choice* represents the likelihood that a street segment will be used as a route choice relative to all other street segments in the urban system, based on the shortest path between all possible pairs of origins and destinations (for an in-depth theoretical and technical explanation, see Al-Sayed et al., 2014; Hillier et al., 2012; van Nes & Yamu, 2018). *Integration* and *choice* are calculated in this article using least angular deviation, which has proven to be the most effective measure compared to the fewest turns and metric distances (Dalton, 2003; Hillier & Iida, 2005). The angular deviation is calculated as an angular turn from one segment to another segment, whereby 90° is counted as 1 (Fig. 3).

For Kuala Lumpur, both measures were normalized to avoid excessive dispersion in the calculations using normalized angular integration (NAIN) and normalized angular choice (NACH) equations (for an in-depth explanation, see Al-Sayed et al., 2014; Hillier et al., 2012; van Nes & Yamu, 2020):

$$\text{NACH} = (\log \text{CH} + 1) / (\log \text{TD} + 3)$$

where CH is computed as the number of shortest routes traversing a street segment and TD = total depth (see Fig. 3)

$$\text{NAIN} = (\text{NC}^{\wedge} 1.2) / (\text{TD} + 2)$$

where NC = node count and TD = total depth (see Fig. 3).

Here, NAIN depicts potential to-movements or street segments that are likely to become destinations (e.g. shopping streets), while NACH represents potential through-movements or route choices. In this article, both measures were calculated at the citywide (r = n) and local (r = 800 m) radius. The citywide radius infers the vehicular movement, while the 800-m radius represents a 10-min walking distance, and therefore infers the pedestrian movement.

To perform space syntax analysis, we generated a street network model of Kuala Lumpur with a diameter of 32 km and 328,514 street segments. The model was generated from OpenStreetMap using road center lines as a contemporary approach for drawing the axial map – a representation of a minimal set of sightlines indicating movement paths (Turner, 2007). The model was delineated using natural growth lines (e.g. roads, rivers) instead of administrative boundaries. The axial map was then converted into a segment map using Depthmap software, in which all the calculations were computed. The numerical results were visualized as color-coded maps, which were then manually simplified by only highlighting the 20% of street segments with the highest values (red and orange colors) and leaving the rest gray to maintain visual comprehensibility given the high street network density of Kuala Lumpur. Results from the space syntax analysis were confirmed through in-depth interviews.

3.3. In-depth interviews

Eight in-depth interviews were conducted to confirm the space syntax results regarding the flows and patterns of vehicular and pedestrian movement, leading to the identification of certain mobility behavior connected to planning policies and the urban form. We conducted semi-structured interviews with two citizens, three transport and urban planning lecturers, and three practitioners (one government officer, one transport consultant, and one employee of a non-governmental organization). The interview guide can be found in Appendix A and the list of interviewees in Appendix B. The interviewees were selected using the well-established snowball approach (Biernacki & Waldorf, 1981; Naderifar et al., 2017) while considering a wide range of perception and time constraints. Experts (i.e. lecturers and practitioners) were selected as they are considered to have prior knowledge concerning the spatial analysis, compared with general street users. Interviews with citizens functioned to confirm general remarks made by the experts. All the interviews were conducted in January and February 2019, and each took around 30–45 min. The interviews were transcribed by the authors and anonymized by only referring to the interviewee's position and organization. This is in accordance with research ethics, particularly on data protection (Parry & Mauthner, 2004; Saunders et al., 2015).

The transcriptions were coded in Atlas.ti software using a combination of deductive and inductive coding. The deductive phase was based on the literature review and was followed by the inductive phase to accommodate new codes emerging from the interviews (Campbell et al., 2013). The coding reliability was controlled by asking two academic colleagues to code the same transcript excerpt. Similar codes that emerged during the process were then used for the analysis (see Table 2 for coding examples from the interview transcriptions and Appendix C for the coding tree).

Codes from the interview transcriptions were analyzed for co-occurrences to identify potential correlations, where a higher number of co-occurrences between two codes indicates a stronger relationship (Friese, 2011; Paulus & Lester, 2016). The counting of co-occurrences and the visualization into a network of codes/keywords were performed in Atlas.ti software.

4. Results and discussion

4.1. Identification of key planning policies

Our review identified how planning policies in Kuala Lumpur, especially regarding transport and land use, have over time prioritized private vehicular movement (Fig. 4). In the era of the tin mine settlements, there was no proper transport planning and the streets developed organically to ease logistics (Sendut, 1965). During British colonization, road construction and maintenance were incorporated into town planning, but the implementation remained highly dependent on political and economic interests (Bristow, 2000). After Malaysia's independence, Kuala Lumpur's first transport study was conducted in 1964 by an Australian consultancy firm (Crooks Michell and Peacock) and the second transport study in 1974 by an American consultancy firm (Wilbur Smith and Associates). Both studies instilled car-oriented development and neglected local forms of transport, such as rickshaw and informal para-transit (Dick & Rimmer, 1986). The first study suggested a road expansion strategy, while the second study recommended an increase in bus fare as a strategy to provide a better service quality, which apparently did not work (Wahab, 1990). In the 1980s, the Malaysian government initiated the national car policy, which aimed to rationalize the automotive industry to decrease the influence of foreign investment (Athukorala, 2014; Milne, 1986). Tax incentives and low interest loans for the domestic market were launched to promote the sale of nationally produced cars, branded as Proton and Perodua. In 1985, national cars accounted for 12% of domestic car sales, and this peaked at 92.7% in 2000 (Athukorala, 2014). By 2005, the share of national car sales on the domestic market started to decline due to changes in import restrictions. In 2012, national car sales accounted for 52.6%, with the rest imported from Japan, Europe, and the

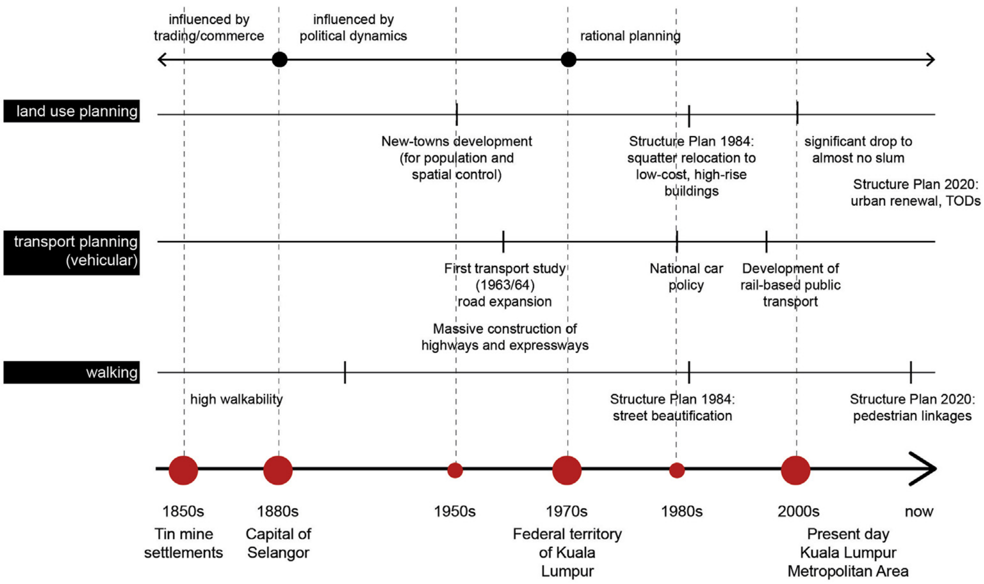

Fig. 4. Timeline of mobility-related planning policies in Kuala Lumpur.

United States (Athukorala, 2014). The increase in imported car sales was attributed to the higher socio-economic status attached to imported cars and the stereotype that imported cars perform better (Fischer, 2016; Letchumanan & Sam, 2016).

These policies have instilled and normalized the value of owning and using a car for daily mobility. Further developments in public transport services that took place in the latter half of the 1990s have been unable to shift the heavy reliance on the automobile.

In terms of walking, Kuala Lumpur was considered to be a highly walkable environment until the early 1900s. This was due to the city's size and its active land use, whereby shophouses with street-facing entrances along the main streets attracted social interactions while walking (Adam, 2013; Tate, 1987). Over time, vertical developments in the form of modern apartments and squatter resettlements replaced traditional shophouses, and the main streets lost their livability and walkability (Adam, 2013). Coupled with high motorization rates, this made walking unappealing. The Kuala Lumpur Structure Plan 1984 failed to improve walking conditions, as it focused mainly on physical beautification such as tree planting and the provision of street furniture, which often obstructed pedestrian movement (Adam, 2013). This deficiency in providing a walkable built environment is acknowledged in the Kuala Lumpur Structure Plan 2020, whereby one of its strategies is to promote pedestrian linkages. The effects of this structure plan, however, remain to be seen, as Althoff et al. (2017)'s study ranked Malaysia at 44th out of 46 countries in terms of walking activity.

Following the transport and land use interaction framework (Bertolini, 2017; Wegener & Fürst, 1999), we identified that the domination of vehicular over pedestrian movements is intertwined with land use planning, especially through suburbanization (Fig. 4). Between the 1950s and 1970s, low-cost flats were built to resettle squatters (Aiken & Leigh, 1975; Chee, 1991). In 1971, the Urban Development Authority was established and later the Kuala Lumpur Structure Plan 1984 was formulated to guide redevelopment projects to achieve a 'world class city' vision. This vision encompassed economic concentration in the urban areas, which often took the form of physical beautification such as slum demolition for the construction of modern apartments and infrastructure development (Bunnel & Nah, 2004; Douglass, 2017; Lo & Marcotullio, 2000). This resulted in intensified efforts to resettle squatters, which reduced the slum population in Kuala Lumpur from 21% in 1980 to 9.2% in 1997 (Bunnel et al., 2002). Due to land availability, several low-cost flats were built on the urban fringe, mostly to the south and southwest of Kuala Lumpur (Bunnel et al., 2002). This suburbanization has increased the number of commuters causing traffic congestion. It does not help that Kuala Lumpur set a high space allocation for car parking (Asian Development Bank, 2011), which has inadvertently promoted the car culture of its residents. In the Structure Plan 2020, urban renewal and transit-oriented development (TOD) are among the key strategies for urban development. However, as

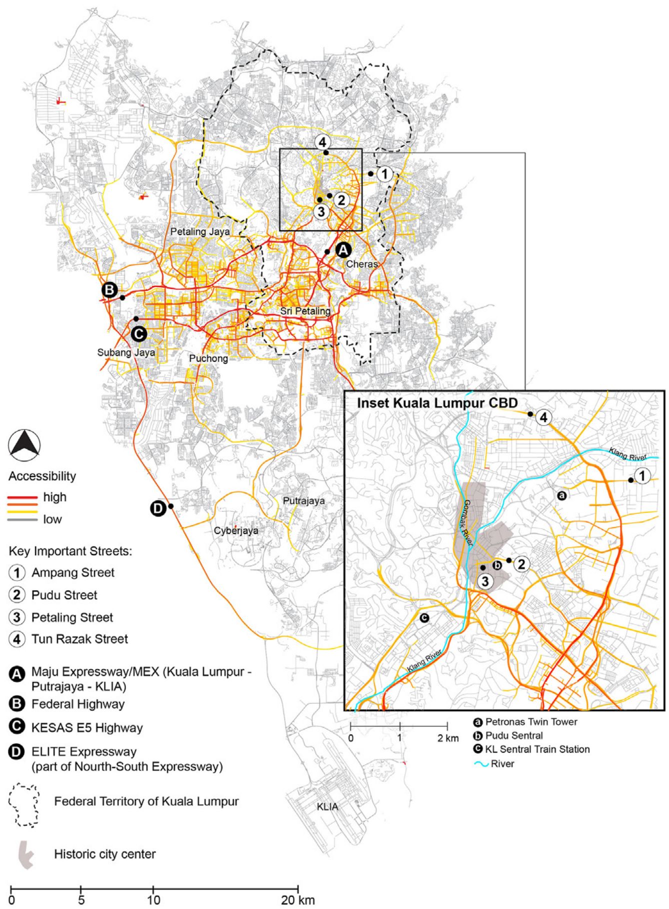

Fig. 5. NAIN citywide analysis of Kuala Lumpur.

implementations is still underway, their impacts on mobility behavior are yet to be seen.

4.2. Space syntax analysis of Kuala Lumpur's street network configuration

The space syntax analysis confirmed the findings from the literature review of planning policies, as Kuala Lumpur's street network configuration resembles a well-connected network of vehicular movements, in contrast to pedestrians. The normalized angular integration (NAIN) citywide analysis depicted how Kuala Lumpur's to-movement is centered on highways and roads in the southern part of Kuala Lumpur (Fig. 5). Unlike traditional European cities, where NAIN citywide analysis depicts the city's historic core (Hillier, 2012; Hillier et al., 2012), the analysis in Kuala Lumpur highlights new towns in the southern part that were massively developed between the 1950s and 1970s (refer to policies in Fig. 4). For instance, the new town of Sri Petaling was developed in the mid-1970s and consists of medium to low-cost housings as the area was located near a landfill. In the late 1990s, the opening of the KESAS Highway, followed by the MEX Expressway in 2007, improved Sri Petaling's accessibility (New Straits Times, 2015). Other new towns such as Petaling Jaya were developed in 1953 and Subang Jaya in 1974 to anticipate Kuala Lumpur's urban expansion (Ju et al., 2011, Fig. 5). These new towns are located 10–15 km from Kuala Lumpur's central business district (CBD). The high economic dependency of the new towns on the CBD has increased private vehicular traffic demands for commuting activities, especially in the absence of reliable public transport services.

Further, NAIN citywide analysis provided spatial evidence of the policy impacts of road expansion and new town developments (Fig. 4). Kuala Lumpur's aggressive development has shifted the urban centrality from a historically grown city center to highway-centered. This can be seen in the higher NAIN values of highways and expressways connecting new towns in the southern part compared to streets with historical importance in the CBD (Fig. 5; Table 3). Roads with high NAIN values include the Federal Highway, which connects Kuala Lumpur to Port Klang; the KESAS E5 highway, which leads to the new town of Shah Alam; the ELITE Expressway, which is part of the North South Expressway (NSE) connecting the northern and southern Malaysian peninsulas; and the Maju Expressway (MEX), which leads to the airport (KLIA).

By contrast, historically important streets have lower numerical values in the NAIN citywide analysis (Fig. 5; Table 3). Ampang Street, for instance, was the main street in the 1850s that connected Ampang, the former tin mine settlements in the east, to the city center. At that time, Pudu Street was also one of Kuala Lumpur's main streets and connected various tin mines in Kuala Lumpur. Now, Ampang Street houses Kuala Lumpur's landmarks, such as Petronas Twin Towers, while the city's main bus terminal is located in Pudu Street. In 1873, Petaling Street played a significant role in the urban economy because of the tapioca mill factory that was located on this street, which generated the city's main income when the tin mines were abandoned. Currently, Petaling Street is a tourist destination for culinary and shopping activities. An exception is Tun Razak Street, which has a relatively higher NAIN value than other streets with former historical importance. Formerly known as Jalan Pekeliling, Tun Razak Street was constructed as a ring road that encircled the city center during British rule; today, it is merged with the Kuala Lumpur middle ring road. While these streets remain important and have become major destinations in Kuala Lumpur, their importance is secondary from a citywide perspective compared to the highways and expressways.

The understanding of Kuala Lumpur's street network configuration is complemented by the normalized angular choice (NACH) analysis, which depicts a route hierarchy. The interpretation of the NACH analysis is linked to the interrelation between vehicular and pedestrian movements to confirm the tendency toward private vehicles and the neglect of pedestrians (refer to policies in Fig. 4). This is evidenced by superimposing NACH citywide and NACH local (800-m) analyses (Fig. 6). NACH citywide analysis highlights highways and expressways traversed by vehicular movements, thus depicting the foreground network that connects economic hubs at the metropolitan scale. Meanwhile, NACH 800-m analysis highlights streets that are likely to be traversed by pedestrians, thus depicting the background network that links socio-cultural hubs at the neighborhood scale.

The superimposition of the NACH citywide and 800-m analyses (Fig. 6) revealed how citywide policies of highways and new towns

Table 3
Syntactic values of NAIN citywide analysis for key streets and roads in Kuala Lumpur.

		NAIN
	The whole system	
	Minimum	0.237
	Average	0.564
	Maximum	3.215
	Historically important streets	
1	Ampang Street	0.678
2	Pudu Street	0.701
3	Petaling Street	0.678
4	Tun Razak Street	0.712
	Highways	
A	Maju Expressway (MEX)	0.748
B	Federal Highway	0.806
C	KESAS E5 Highway	0.787
D	ELITE Expressway	0.740

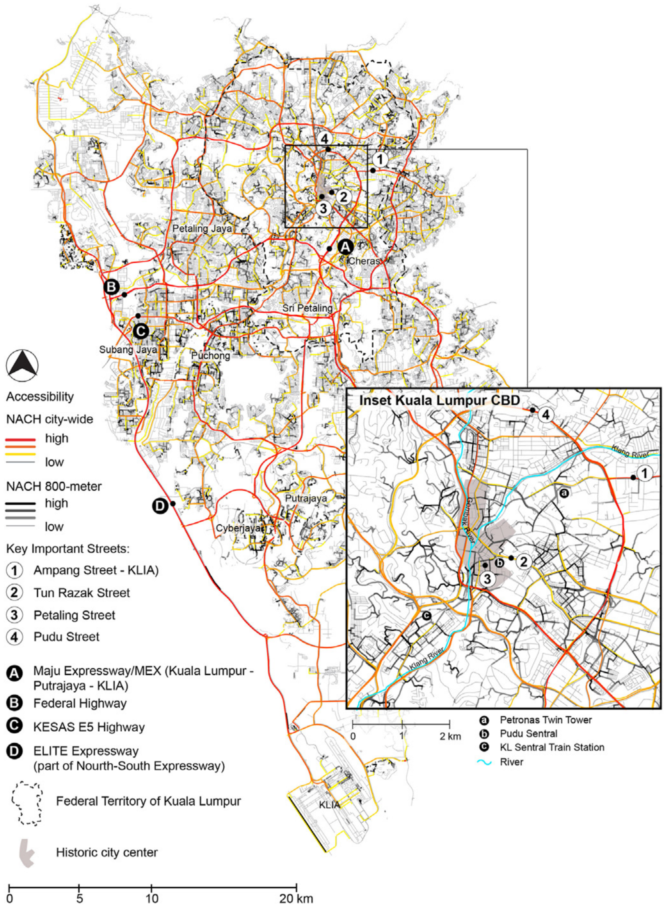

Fig. 6. Superimposing NACH citywide and 800-m analyses of Kuala Lumpur.

affect walkability. Here, the highways function as spatial barrier that isolate streets with high walkability potential, which are mostly shopping streets and residential streets in new towns. While the walkability potential of shopping streets is largely realized due to the construction of pedestrian linkages (e.g. pedestrian bridges and tunnels connecting one shopping mall to another), the potential of residential streets might not be realized due to the coarse urban grain generated by the upscale developments that reduce street livability and thus discourage people from walking (refer to policies in Fig. 4). This indicates that previous policies were implemented without considering the integration of developments at the metropolitan and neighborhood scales. Consequently, this resulted in vehicular networks that overruled the organically grown pedestrian networks.

4.3. Investigation of mobility behavior

In-depth interviews corroborated the findings from the spatial analyses: that the vehicular networks dominate and override the pedestrian networks. This confirmation can be seen in the mentioning of keywords during the in-depth interviews that indicate mobility behavior that glorifies car movement and marginalizes pedestrians. Such keywords included: private vehicle dependence, public transport difficulties and stereotypes, and walking inconveniences and stereotypes (Table 2). Keywords emerging from the in-depth interviews were registered as codes and analyzed for co-occurrences in Atlas.ti software (see Table 2 for coding examples and Appendix C for the coding tree). The co-occurrences of keywords or codes were visualized in a network diagram to infer their correlation (Fig. 7). A higher number of co-occurrences suggests a closer relationship between the keywords (Friese, 2011).

It can be inferred from Fig. 7 that Kuala Lumpur's dependence on private vehicles is closely related to direct and personal factors that reflect society's values of an automobile culture, such as public transport difficulties leading to negative stereotypes regarding its usage. In relation to key policies (Fig. 4), public transport difficulties and stereotypes are the result of the neglect of public transport in the planning process, as evidenced by the first transport study that focused on road expansion and the second study that suggested increasing public transport fares rather than using subsidies from other sources to improve its operation and service. These urban and transport planning practices are translated into personal values as individuals associate public transport with unreliability:

> "*If we use public transport, it is difficult since we have to walk to the bus stop. Our place is far from LRT, KTM, or MRT station. So, the only public transport is bus. [….] We do not use bus and KTM because they are not reliable. We have a choice to use personal transport.*"

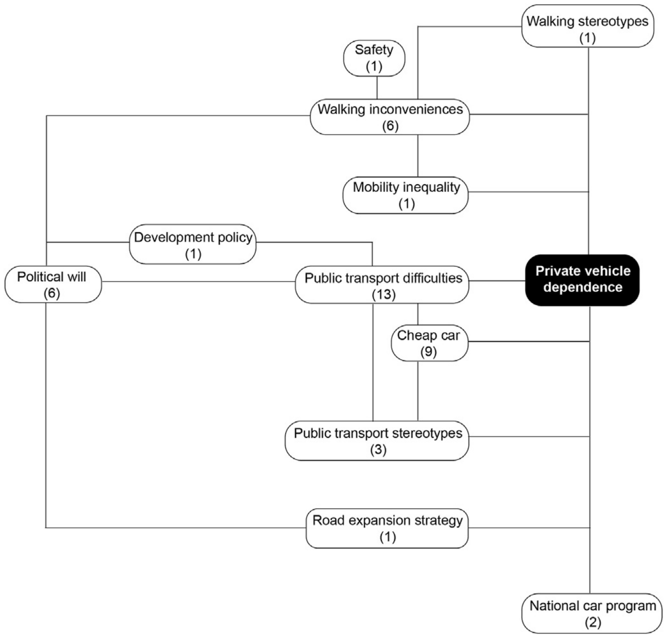

Fig. 7. Networks of frequently mentioned keywords from the in-depth interviews (note: the number in brackets indicates the co-occurrence frequency).

(Interviewee #1, citizen, translated from Malay by the authors, note: LRT refers to light rail transit, KTM refers to commuter train and MRT refers to mass rapid transit)

Contrary to public transport, cars are more preferred, both from an institutional and an individual perspective. Cheap cars are linked to the national car policy of the 1980s and the road expansion strategy, as expressed by one of the interviewees:

> *"In 1980s, Malaysia was actually championing, they built the first national car* [branded as Proton and Perodua, author's note]. *When the whole policy is about building a* 'national car', *they somehow directly and indirectly influence the transport and land use policies. Everything was about promoting the* 'national car'. *So, the use of car has been glorified and popularized ever since in Malaysia.*" (Interviewee #3, planning non-governmental organization)

Meanwhile, walking inconveniences are related to the decreasing safety caused by the road expansion strategy that prioritizes car traffic over pedestrians, thus forcing people to drive as they feel unsafe walking:

> "*[…] you have to drive. The weather and the roads are not convenient and safe for you to walk.*" (Interviewee #7, transport planning consultant)

Linking back to the key policies in Fig. 4, walking inconveniences are also connected to decreasing street livability due to the upscale constructions that took place from the 1950s onwards as part of new town developments and to the developments that took place in the 1990s as part of achieving the 'world class city' vision. This show how implemented policies on a citywide scale (e.g. new towns, road expansion) are detached from the local scale (e.g. walking conditions). In addition, it also confirms the spatial analyses that depict well-connected vehicular networks at the metropolitan scale compared with the fragmented pedestrian networks at the neighborhood scale.

Fig. 7 also reveals that walking inconveniences and public transport difficulties are related to political will that favors the road expansion strategy. However, although further investigation on what the political will encapsulates and the extent to which it influences other keywords is required, this is not within the scope of this article.

Furthermore, the in-depth interviews indicated the socio-spatial dynamics that lead to private vehicle dependence. Planning policies have shaped an urban form that supports vehicular dominance and, in turn, as people interact with their built environment, this dominance is internalized in socio-cultural values and reflected in how people use and appropriate the urban spaces. From an institutional perspective, this reflects a path dependency trajectory whereby previous policies create an organizational routine of prioritizing vehicular traffic in urban and transport planning practices (Low & Astle, 2009). This is later manifested in personal values as individuals associate walking with lower social status, in contrast to driving a car:

> "*[…] So, being a pedestrian is the lowest social status, whether it is discouraged or not, that is in our culture. Everyone strives to have our own car. Another related to institutional, the people who make decision tend to provide access, they strive to expand the roads, build new roads.*" (Interviewee #4, transport and urban planning lecturer)

This corroborates previous studies on the mobility behavior of Kuala Lumpur society, whereby car ownership symbolizes a high socio-economic status (Butler & Hannam, 2014; Fischer, 2016), therefore generating an automobile society (Urry, 2004). This behavior is also reflected in the use of car parking spaces, which are always full, even in the low-cost housing areas (Fig. 8a). Conversely, the low socio-cultural value attached to walking is manifested in disproportionate street profiles whereby the space dedicated to pedestrians is narrow compared to the enormous eight-lane roads for motorized traffic (Fig. 8b). This confirms Williamson's (2003) study on how Kuala Lumpur's road expansion strategy has produced a positive societal value of car ownership and car travel. Such value explains the current transport mobility condition in Kuala Lumpur, with a high share of cars compared with public transport and non-motorized transport (Almselati et al., 2011; Barter, 2004; Bunnel et al., 2002; Mohamad & Kiggundu, 2007).

5. Conclusion

Through the mixed method approach, this article contributes to providing an in-depth explanation of how planning policies and practices can shape a car-based urban form and automobile society. It therefore highlights the importance of an understanding of policy impacts across generations and spatial scales for formulating effective urban management strategies. Our analyses show that Kuala Lumpur's previous road expansion planning policies, national car project, and aggressive development of new towns have constructed a street network configuration that supports vehicular dominance, and consequently the use of and dependence on private vehicles. This chain of consequences involves long-term socio-spatial dynamics as people interact with and adapt to their built environment. Through space syntax analysis, we highlighted how highways and expressways dominate citywide access and override the accessibility of streets with former historical importance, which are likely to be more pedestrian-friendly. This is complemented by the in-depth interviews on

(a)

(b)

Fig. 8. (a) Garage of a dilapidated house full of cars, (b) Disproportionate street profile representing the marginalization of pedestrians compared with vehicular traffic.

mobility behavior, which confirm vehicular dominance and car dependence in Kuala Lumpur. This behavior has been formed across the whole mobility system, including the roads, the institutional system that formulates transport and planning strategies, the financial mechanism of owning a vehicle, and the socio-cultural values (e.g. how society perceives those who drive in comparison to those who walk).

To avoid or reverse car-oriented development, practical insights should include socio-spatial innovations to make walking and taking public transport more attractive and to dismantle the positive stereotypes attached to the use of private vehicles. Positive advertisements on walking and public transport coupled with discounted public transport fares, improved public transport services, pedestrian facilities and connectivity, and transit-oriented developments could be countermeasures to address the internalized automobile culture. In line with these efforts, urban planning and design should be directed to improving street livability and safety, for instance, by reducing street crime (Ghani, 2017) or by attracting more social and economic activities to the street. These efforts can help to achieve the newly adopted sustainable transport policy in Kuala Lumpur through the Kuala Lumpur Structure Plan 2020 and the National Transport Policy 2019–2030.

Moreover, as the car-oriented development trajectory is difficult to reverse, this article has demonstrated that the use of data-driven spatial analysis (e.g. space syntax) complemented with an understanding of the local context (e.g. through in-depth interviews) can support more effective urban management by visualizing the impacts of planning policies, thus providing a tool to perform both postdiction and prediction of the spatial impacts of planning policies. This resonates with Engin et al. (2020) regarding data-driven urban management. Our application of the mixed method can be performed in a context where data availability is limited and coupled with time and monetary constraints, which is often the case for cities in developing economic regions such as Southeast Asia. As Southeast Asian cities are starting to adopt a sustainable transport policy (ASEAN, 2019), it is important for planners and policymakers to consider how policy impacts infiltrate spatial and socio-cultural dimensions over generations. A similar trajectory is likely to apply in other Southeast Asian cities, such as Jakarta, Indonesia (Hidayati et al., 2019) or even medium-sized cities such as Chiang Mai in Thailand (Jittapirom & Jaensirisak, 2020). We therefore suggest future studies be conducted to investigate the spatial and behavioral consequences of planning policies in other cities to enhance the external validity.

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Declaration of interest

None.

Appendix A. IN-DEPTH INTERVIEW GUIDELINE

Before participating in the in-depth interview, potential interviewees are asked to read and sign the consent form.
Interviewer will briefly explain about the research and initial findings from the spatial analysis.
Key questions:

1. What do you think about the initial findings?

Hints to stimulate answer: looking at the result of the spatial analysis, do you agree that this part is more/less accessible by car? Do you think it is safe to drive or walk there? Under which condition you are willing to walk there? What do you think the most convenient mode (i.e. car, motorcycle, walk) to navigate through this street segment? Why?

2. What do you think are the reasons for such findings?

Hints to stimulate answer: Why do you think people use certain mode in this part of the neighborhood? What about your personal experience?

3. How do you describe current mobility conditions in Kuala Lumpur? What do you think influence them most? Why?

Hints to stimulate answer: try to relate to their personal experience, such as what mode do you usually travel, how often, where and when, the reason behind such pattern, their willingness to change the mode; current related policies or studies that they know about mobility and accessibility.

4. Can you associate certain mobility behavior to certain socio-economic group? Or certain places? Which one or where (refer to the spatial analysis)? Why?
5. What is your suggestion to improve the current mobility condition (refer to the spatial analysis)?

Appendix B. LIST OF INTERVIEWEES

Interviewee ID	Job category/Position	Organization	Date of interview
1	General citizen	Resident of Jinjang	January 25, 2020
2	General citizen	Resident of Kampung Baru	January 27, 2020
3	Member of non-government organization	Think City	January 28, 2020
4	Transport and urban planning lecturer	Universiti Teknologi MARA	January 29, 2020
5	Government officer	SEDA (Sustainable Energy Development Authority)	January 29, 2020
6	Transport planning lecturer	University of Malaya	January 31, 2020
7	Transport planning consultant	University of Malaya	February 1, 2020
8	Urban planning lecturer	University of Malaya	February 8, 2020

Appendix C. CODING TREE

The code tree is structured as follows:

1. Family code
   a. Sub-code

In-depth interviews transcription (further analyzed using Atlas.ti).

1. Private vehicle dependence
2. Public transport
   a. Difficulties
   b. Stereotypes
3. Walking
   a. Inconveniences
   b. Stereotypes
4. Policies
   a. Development policy
   b. Road expansion
   c. Financial (cheap car credit)
   d. National car
   e. Political will
5. Safety
6. Mobility inequality

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