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Potentials and Challenges of The Connected Autonomous Shared Electric Vehicle (CASE) from Urban Geography Perspective in Southeast Asia Mega-Urban Regions

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Potentials and Challenges of The Connected Autonomous Shared Electric Vehicle (CASE) from Urban Geography Perspective in Southeast Asia Mega-Urban Regions

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Abstract

This study aims to raise awareness of a viable collective transportation concept that yields the most sustainable and inclusive outcomes. The connected autonomous shared electric vehicle (CASE) has been proposed as a future enabler of collective mobility that emphasizes sharing vehicles among numerous passengers and endorses multi-modal public transportation. This study demonstrates the application of an integrated scenario building approach at both the generic and place-specific levels. Then, the plausible scenarios were developed that best fit the area-based context. The scientific research trends in bibliometric analysis and the discussion on urbanization problems in spatial analysis were synergized to identify critical uncertainties, which are the input in scenario building. The discussion on urbanization problems of mega-urban regions in the SEA context captures additional challenges from a compound of mobility inequalities such as limited accessibility and fragmented paratransit, which could fuel the ignorance of collective urban mobility usage. The plausible scenario quadrants shed light on long-term strategy planning requirements in response to various autonomous mobility deployments and their consequence on urban dynamics.

Keyword: Autonomous Vehicles, The Connected Autonomous Shared Electric Vehicle, CASE, Scenario Building, Mega-Urban Regions, Southeast Asia, Bangkok, Ho Chi Minh City

1. Introduction

The introduction of autonomous vehicles (AVs) is predicted to potentially improve both transportation capacities and stimulate the worst impacts of car dependency. This research aims to introduce a concrete concept of collective transport to counterbalance negative impacts from private ownership of an autonomous vehicle to avoid pessimistic scenarios. This study focuses on ubiquitous self-driving mobility with optional human attention, which is in line with level 4 and above, determined by the Society of Automotive Engineers International.

The connected autonomous shared electric vehicle (CASE) is a collective mobility solution that prioritizes sharing vehicles between multiple users and promotes multi-modal sharing with public transportation. CASE has the potential to interweave and be compatible with various mobility modes, including Private autonomous vehicles (PAVs), connected vehicles (CVs), shared AVs (SAVs), and electrification vehicles (EVs). The connectivity in CASE overarches connected the multi-modal transportation system and CVs' features of real-time information exchange with other vehicles, roadside infrastructure, and everything with compatible networks and devices. Moreover, the combination of the CASE mobility solution and the mobility as a service (MaaS) mobility service offers an individual tailoring service to commuters (Coppola & Silvestri, 2019), which eventually persuades a commuter to use alternative transportation modes rather than an individual ride.

The CASE concept is grounded and expected the positive effect within a context of long-term well-planned public policies (Adler et al., 2019). The cities with underdeveloped infrastructures are challenged to prepare high-cost new infrastructures that incorporate emerging technologies. The divergence between slow institutional response to regulate and provide infrastructures during the rapid technological change is critical in technologies adopters like most Southeast Asia countries. Indeed, most of the capital cities in Southeast Asia are well recognized for their world-ranking traffic congestion problems, a long period of urban problems, and inadequate transportation infrastructures. Moreover, the research on shared-autonomous urban mobility concept and AVs deployment are notable geographical imbalance upon contexts of the Global North (Thomopoulos et al., 2021). These research gaps indicate the need for new related research to mitigate an insufficient theoretical contribution. Therefore, this research intends to serve as the stage zero study in the long-term implication of CASE through a case of Bangkok (BKK) and Ho Chi Minh City (HCM), which have been selected due to their urban dynamics of rapid expansion of urbanization areas. The question has been raised that how CASE should be governed to promote a collective transport system?

2. Literature review

2.1 Unfolding Shared Autonomous Vehicles Prophecies

The blooming of mobility on demand follows the user-centric approach, which offers individuals varying transportation modes to complete door-to-door trips through a digital platform including ride-hailing taxis and ride-sharing shuttles. These features become more important in the matter of deployment between an individual or collective forms of mobility than the ownership type (Mitchell et al., 2016). Some scholars envision the combination of AVs and collective transport as opportunities in sharing economy (Adler et al., 2019; Grush & Niles, 2018c; Krueger et al., 2016; Mouratidis et al., 2021; Stead & Vaddadi, 2019; Tsigidinos et al., 2021). The sharing concept is

much anticipated to mitigate the negative impact of private AVs ownership. Various scholars point Shared Autonomous Vehicles (SAVs) are more suitable for AVs ownership due to price and cost dimensions (Adler et al., 2019; Hörl et al., 2016; Mohammadzadeh, 2021). Moreover, the mobility on-demand service with automation technologies will decrease the operation cost, such as the driver cost. Therefore, SAVs in fleet mobility services are expected to be more affordable, convenient, and attractive to a mass of users.

At the time of writing, the discussion on Shared Autonomous Vehicles (SAVs) is referred to both ride-hailing and ride-sharing services interchangeably. Moreno et al. (2018) highlights the importance of distinguishing SAVs terms explicitly. These two services offer different kinds of services, which will have divergence path dependence on social, economic, and environment. Ride-sharing service serves multiple riders that share a single-vehicle. The service may make multiple picks up and drop off for passengers along a route. Ride-sharing is likely to reduce the number of cars on the road to serve the same travel demand.

In contrast, ride-hailing is a mobility service without car sharing among multiple riders. The ghost trip or the trip with zero-passenger will occur to get the next passenger or from AVs self-park in less-expensive urban areas. These assumptions expect vehicle-miles traveled (VMT) to increase after full automation deployment (Fagnant & Kockelman, 2015). Meanwhile, the VMT reduction mission is important to reduce gas emission, local economic boost, and place-making. Moreover, the AVs technologies deployment in fleet operation could disrupt public transportation by offering a great supply of door-to-door service, which is more comfortable and flexible.

To this end, the diffusion of SAVs on urban mobility is critical to the sustainability transition. SAVs can only help achieve the private ownership reduction targets, the ignorance of mass public transport usage and ride-sharing orientation may worsen a situation. Hence, the adoption of SAVs should concern multi-modal share mobility schematic, in which public transportation is prioritized as the backbone of urban mobility (Papa & Ferreira, 2018; Stead & Vaddadi, 2019).

2.2 Governancing the city toward the CASE adoption

The emerging integrated multi-modal mobility system will be engaged with a diverse range of stakeholders on a national, regional, and local scale (Fenton et al., 2020). The challenge will depend on the institutional capacity of certain governments to mobilize the political process in dealing with multi-stakeholders, planning policies and regulations, and implementation (Cohen & Cavoli, 2019; Marsden & Reardon, 2021; Nikitas et al., 2017; von Mörner, 2019).

The government interventions are constrained to the place-specific contexts as a self-evidence, where political territory and market operation are located, such as ticket distribution, pricing system, and institutional structure (Smith et al., 2019). It is important to recognize that the introduction of new mobility cannot be independent of urban form and vice versa.

González-González et al. (2019) suggest the need of policy in urban planning that consists of a principle mixed land-use orientation, improvement of urban facilities, vehicle access restriction zoning. It should be used as a foundation for participative governance in formulating policy options and creating understanding among urban stakeholders (Gavanas, 2019). Otherwise, the introduction of new mobility can be hastened or delayed by policy, regulatory, and planning practices (Grush & Niles, 2018b).

Currently, the discourse on the impact of automation mobility technology toward city dynamics and urban development has been wildly discussed (Soteropoulos et al., 2019; Stead & Vaddadi,

2019). In parallel, the dependence how current urban geography, spatial setting, will influence the governance of CASE deployment have received minimal attention from previous scholars in autonomous mobility. The understanding of specific urban practices trajectories is important in decision-making for the early adoption stage. The reconsideration of the geography of urbanization and urban mobility system aim to shed light on how each city is likely to uptake CASE deployment that best fits their needs and values (Grush & Niles, 2018a). The idea relies on explaining the long-term feedback effect of the political process to what extent the institution helps generate a political coalition that works towards the continuation of the policy (Sorensen, 2006).

3. Methodology

This research adopted an exploratory scenario approach to explore plausible scenarios on new urban mobility. The exploratory approach illustrates a set of hypothetical future situations by focusing on a range of uncertainty factors and their complex interaction effects with each other. The critical uncertainties are identified through an inductive process by which the driving force has a high degree of impact and uncertainty level (Derbyshire & Wright, 2017).

Regarding uncertainty futures, the scenario building in this study area inevitably requires extensive fuzziness data. Combining trends reviewing technique and reconsideration of urban geography are essential to funnel critical uncertainties. The scanning driving forces stage comprises of two level of a generic level and place-specific level. Then, the plausible scenarios were developed that best fits the area-based context.

3.1 Bibliometric analysis

The scientific communities are always play actively role in searching for solutions to emerging problems and extend frontiers of knowledge in the advancement of society (Mazov et al., 2020). The first study stage adopted the bibliometric analysis to scan research trends based on publications' metadata. The author's keyword is important component in research publication that can express its main idea. This study focused on author's keywords as the input variable. Keyword co-occurrence under bibliometric analysis is a useful technique for assessing research trends and exploring the cognitive structure of study areas (Tripathi et al., 2018).

The data is derived from the Scopus database using keywords and synonyms related to AVs, then filtered contents relevant to urban and policy dimensions. The search was done in June 2021 and returned 2,721 academic publications in AVs and urban studies out of the total academic publications in AVs of 50,142 publications. This study focuses on the network analysis of the co-occurrence of author-keywords. The co-occurrence network of author-keywords performed the network clustering technique in VOSviewer software. Then, the filtering process is necessary to merge-common keywords of synonyms, singular and plural nouns, numeric characters, and acronyms to induce redundancy into a dataset. A threshold of 5 was applied to define the minimum number of co-occurred times the keyword appears in the documents. The processed output files obtained from the analysis in VOSViewer contain attribute values as shown in the following:

- The occurrence values of keywords occurrence frequency
- The link values

- The total link strength values.
- The average publication year attribute values
- The average number of citations values received by the publication in which a keyword or a term occurs
- The average normalized number of citation values received by the publication in which a keyword or a term occurs.

The qualified co-occurrences keywords represent research hotspots, which are considered a driving force for implementing the new urban mobility with autonomous vehicles' features. The analysis follows the quasi-deterministic classifications approach provided in VOSviewer software that involves recursive decomposition output as an input to further decomposition at a next-lower level (Leydesdorff et al., 2017). The number of clusters has been initially determined into two and four clusters. The first processing round considers a main-cluster lever, which aims to discover two critical uncertainties. The second time follows the hierarchical classification from the first round's decomposition to explore their sorts of paradoxes of critical uncertainties at a sub-cluster level.

3.2 Spatial Analysis

Spatial analyses of BKK and HCM were performed to driving forces and critical uncertainties from path dependence of urbanization at the place-specific level. Spatial analyses consist of transit node accessibility analysis and street network capacity analysis of BKK and HCM, employing a GIS software of ArcGIS and RStudio. The spatial data were derived from open sources of OpenStreetMap and PlugShare Portal.

First, structural analysis of the streets' network is instrumental to understanding transportation infrastructure usage (Hamaina et al., 2011; Kirkley et al., 2018). A streets' network is represented as a spatial graph comprised of nodes and edges. Structural analysis of the streets' network assesses street network flow capacity using centrality indices in graph theory algorithms. In this study, we focus on the betweenness centrality value, representing the likelihood of dynamic path movement, and the prediction of congestion level on the given street segment (Freeman, 1977; Kirkley et al., 2018; Newman, 2010). The street network's connectedness was analyzed in RStudio software, an integrated development environment for R with SF and Tidygraph library.

Second, the transit node accessibility analysis assesses the ability to reach different transport nodes. This section consists of geospatial network analysis and spatial autocorrelation analysis. The network distance from the centroid of a synthetic hexagon with a 1-kilometer radius to the closest transit node was calculated using the closest facilities method in Network Analysis toolset in ArcGIS Pro software. Points of interest for collective transit nodes cover bus stops, metro stations, and regional train stations. The accessibility to individual transit nodes considers toll-way booths and charging EVs stations as points of interest. Next, this study adopted spatial autocorrelation tests to prove the dispersion of transportation accessibility between collective versus individual transit nodes. This study follows queen contiguity weights since the study focuses on a location pattern of polygon feature classes. To begin, the global Moran's I index test was performed to examine the spatial autocorrelation of the entire study area. The results show a positive spatial autocorrelation of each transport mode, confirming the spatial clustering presence. Then, the local Indicators of Spatial Association (LISA) was performed to find where such clustering occurs. To discuss the synergy of results, the author combined all the

mapping results following the mapping overlay analysis methods, which allows the comparison of attribute and location information with multiple map layers. The methodology details for accessibility cluster analysis are provided in Appendix 1.

3.3 Scenario building in the cross-impact analysis

Two critical uncertainties from the previous stage are used as input for scenario building. The cross-impact analysis illustrates plausible futures by plotting the four-scenario matrix. Critical uncertainties are resulted from the synergy between the scientific research trends and path dependence of urban dynamics. Opposite pairs of critical uncertainties frame the scenario matrix as the polarity of the axis. The four-quadrant results show the collection of distinctly plausible scenarios, each based on a different combination of critical uncertainties factors. Each scenario contains a set of narratives, which explain a story for each scenario.

4. Scanning Driving Forces

4.1 The co-occurrence network of author-keywords

Spatial analyses of BKK and HCM were performed to driving forces and critical uncertainties from path dependence of urbanization at the place-specific level. Spatial analyses consist of transit node accessibility analysis and street network capacity analysis of BKK and HCM, employing a GIS software of ArcGIS and RStudio. The spatial data were derived from open sources of OpenStreetMap and PlugShare Portal.

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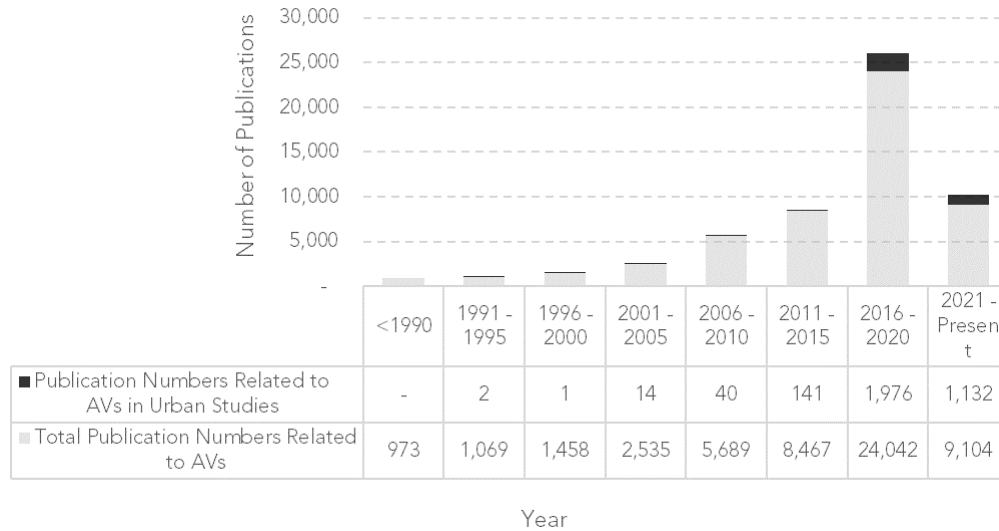


Figure 1 Filtering of publication numbers related to AVs in urban studies from the total numbers related to AVs

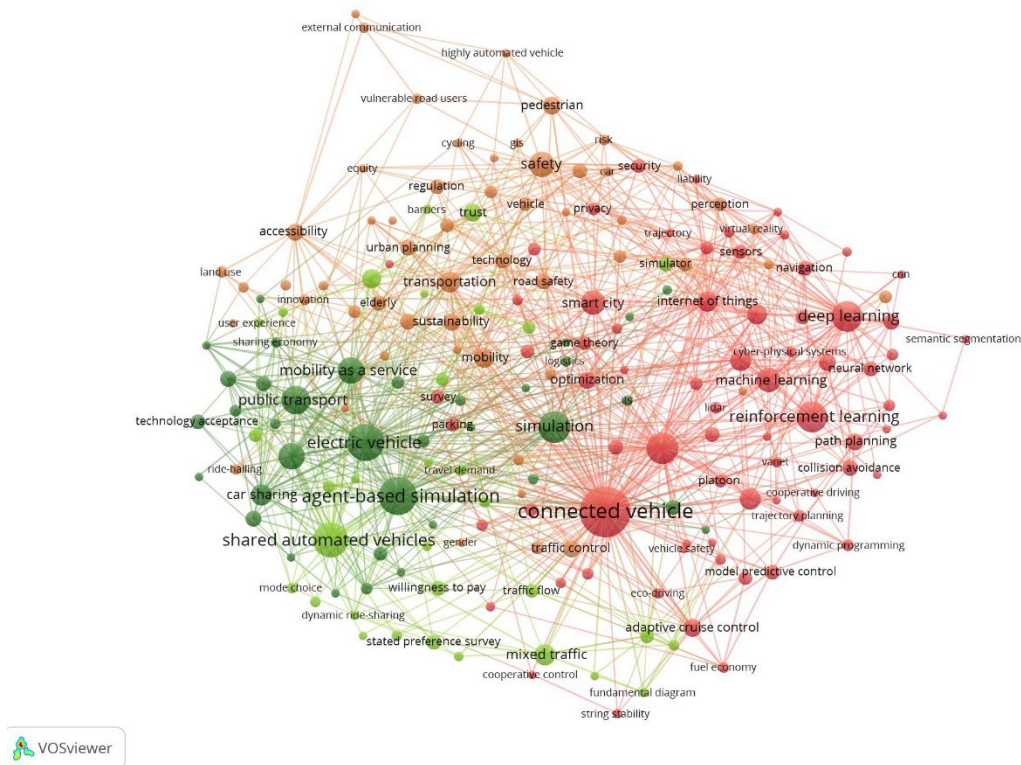


Figure 2 The cluster mapping of author's keyword in co-occurrence analysis

The first main-level cluster in green color tone consists of 68 co-occurrences keyword. The discussion on shared mobility has caught the research interest as expected, as seen in one of the central nodes of the cluster. A mobility solution-related issue is represented by the prominent

node group. The dark green cluster contains 36 co-occurrence keywords, with "agent-based simulation," "electric vehicle," "simulation," "public transportation," and "mobility as a service" ranking first through fifth, respectively. This cluster's keywords are mostly involved with autonomous mobility's transportation supply and its consequences issues. With 32 co-occurrence terms, the light green cluster has a modest cluster size. "Shared autonomous cars," "mixed traffic," "acceptance," "trust," "expressed preference survey," and "willingness to pay" are over-represented as a significant node in the co-occurrences. The character of the cluster member indicates the debate over transportation demand and societal acceptance. The agglomeration pattern of this main cluster indicates two different patterns. The large AVs and transport supply cluster (dark green) is encompassed by a scattered pattern of small keywords from the transport demand cluster (light green). This pattern captured research trends in the impact of different deployment models and social acceptance.

The second main-level cluster in red tone color consists of 127 co-occurrences keywords. Keywords are aggregated in clumped dispersion pattern of research interests in governance-related keywords and technology-related keywords. The "connected vehicle" keyword appears as the largest node, which is encompassed in the middle triangle between a group of governance topics and a group of technology topics. The dark red cluster consists of 72 co-occurrences keywords. This cluster contains keywords with a clear meaning that are associated with technology development and intelligent algorithms topics. The second sub-cluster is represented by orange color and has 55 terms that discusses on policy tools and governance topics. Despite intelligent AV algorithms, this main cluster and its sub-cluster pattern accurately portray the significance of connection concerns across a board range of academic disciplines. The keyword "smart cities" is, unsurprisingly, the most commonly used, with its location in the heart of the clusters. Indeed, this notion unites technical and innovative governance disciplines to help cities deal with urbanization challenges. Some of the terms linked with spatial governmental instruments include "transport policy," "urban planning," "urban form," and "built environment".

Table 1 The occurrences weight and total link strength information of the top 15 co-occurrences keywords

Keywords	Occur- Rences	Total Link Strength	Avg. Norm. Citations	Keywords	Occur- Rences	Total Link Strength	Avg. Norm. Citations
Mobility Solutions				Governance Approaches			
Transport supply and their consequences				Technology development and intelligent algorithms			
Agent-Based Simulation	103	123	1.07	Connected Vehicle	178	248	1.39
Electric Vehicle	97	149	1.18	Intelligent Transport Systems	70	109	1.45
Simulation	72	100	0.95	Deep Learning	66	75	1.25
Public Transport	56	61	1.20	Reinforcement Learning	66	69	0.73
Mobility As A Service	51	92	0.94	Machine Learning	43	64	1.66
Shared Mobility	50	86	1.25	Smart City	41	66	1.50
Car Sharing	32	48	1.18	Decision Making	32	44	1.35
Ride-Sharing	18	27	1.25	Intersection Management	32	42	0.62
Sustainable Mobility	18	40	1.07	Artificial Intelligence	28	48	1.19
Multi-Agent Systems	17	26	0.58	Internet Of Things	28	64	2.49

Keywords	Occur- Rences	Total Link Strength	Avg. Norm. Citations	Keywords	Occur- Rences	Total Link Strength	Avg. Norm. Citations
Urban Mobility	17	29	0.79	Adaptive Cruise Control	23	28	0.64
Technology Acceptance	15	13	1.02	Optimization	22	39	1.10
Matsim	13	26	1.81	Path Planning	22	19	1.31
Pricing	11	14	0.25	Motion Planning	21	30	1.10
User Acceptance	11	14	1.35	Collision Avoidance	18	15	2.56
Transport demand and social acceptance				Policy Tools and Governance			
Shared Automated Vehicles	88	109	1.65	Safety	46	77	1.53
Mixed Traffic	33	40	1.55	Transportation	33	65	0.86
Acceptance	26	24	0.91	Mobility	28	57	0.57
Trust	23	19	1.17	Pedestrian	23	23	2.00
Stated Preference Survey	17	16	1.64	Sustainability	22	42	0.95
Willingness To Pay	15	20	1.07	Traffic Control	22	26	1.30
Simulator	15	13	2.30	Accessibility	20	26	1.85
Traffic Flow	14	29	1.34	Transportation Policy	19	33	1.31
Car-Following	13	26	0.80	Urban Planning	18	28	0.97
Attitudes	12	19	1.79	Road Safety	18	26	1.65
Air Quality	11	18	1.22	Regulation	15	25	1.13
Travel Behavior	11	19	1.37	Ethics	15	23	0.83
Vehicle Automation	11	13	3.25	Elderly	15	19	0.83
Travel Demand	10	17	1.69	Perception	14	30	0.81
Congestion	9	18	2.76	Governance	14	20	1.24

4.2 Spatial Analysis:

Generally, driving forces from the previous stage capture trends at a general level, regardless of a place-specific context. A review of driving forces from current urbanization and urban mobility systems could help in illustrating what will likely happen from the path dependence of urbanization to different scenarios, based on the synergize between spatial analyses' results and the assumption of character in different AVs deployment models.

Bangkok

Bangkok has a lack of street network hierarchy and geographically skewed movement flow as showed in Figure 3. The synergic result on the transit node accessibility and streets' network structural analysis in Bangkok addresses inherent problems of weak transportation networks. Regarding the streets' network structural analysis, the path with high betweenness centrality value represents a likelihood of busy path movement. Although, the result shows the geographically skew as an urban superblock pattern of the street network. Highways and arterial roads frame a gigantic grid. The urban core areas have more accessibility to various transit nodes with different transit modes. However, many railway tracks run parallel to a road in which the rails are embedded in the existing roadway. Thus, different transport modes on parallel routes become competitors to attract passengers as a preferable route choice (Pujinda & Yupho, 2017). This is critical to promote mass transit railway as the backbone structure of an integrated mobility system.

The rapid growth of Bangkok urban development is facing urban sprawl problems. After decades of rapid urbanization, the growth of middle classes is more likely to move to suburbs, as a result, the number of gated communities is rising strongly. The expansion of gated communities hinders the city and society by limiting public access. The spatial pattern of gated communities can be seen on dead-end or tortuous local streets. People who live inside an urban superblock struggle to connect with the main street, so they are forced to use a private car or paratransit as a feeder to mass transit node. The quality and the safety level of paratransit services remain substandard. Meanwhile, the cost of commuting is higher than a formal bus cost (Ratanawaraha & Chalermpong, 2016). The idea of privatization fuels difficulties finding optimization of spatial structure and promoting collective autonomous transportation approaches. This would be highly likely to fuel the exclusiveness of future mobility.

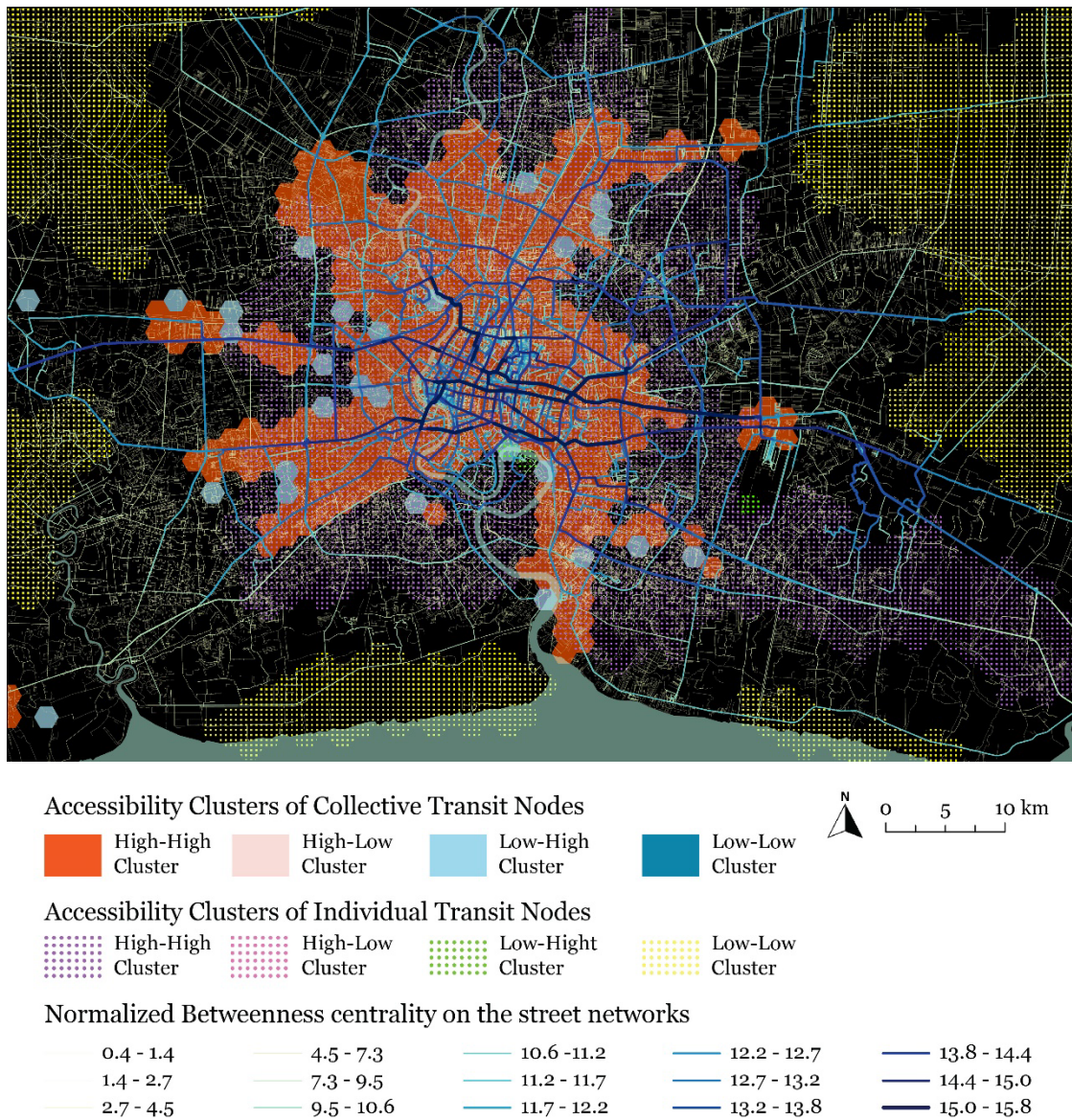


Figure 3 The Summarize of Spatial Analyses of Accessibility Cluster and Street Networks in Bangkok

Ho Chi Minh

Ho Chi Minh has a well-connected street network, good density in urban areas with a smaller metropolitan size (Figure 4). A pattern of high-density street networks and fine-grained urban fabric in urban cores may be associated with the European-style block planning from the colonial periods (Yue et al., 2021). The accessibility analysis to transit nodes shows the outstanding bus service accessibility. There are over a hundred bus routes with highly frequent schedules. However, the destined routes are not the most direct route. The regional train station represents the regional connection. By far, personal motorbikes are the current primary transportation mode in Ho Chi Minh because they are more affordable and have lower operating costs than personal cars. Ho Chi Minh has the largest share of motorcycles nationwide and continuously increasing (Huu & Ngoc, 2021). Their small size has a maneuverable and flexible feature, allowing motorists to move between lanes and move along space between cars during traffic congestion.

Ho Chi Minh has been transitioning from monocentric to polycentric in the last decade (Nguyen, 2015; Ton, 2020). The growth of peri-urban areas is rapidly expanding due to large-scale development projects towards areas previously characterized as former agricultural areas. The large-scale development projects result from the new development of industrial zones, which aims to draw foreign investment (Kontgis et al., 2014). The new industrial zones will attract the migration of blue-collar workers. This factor will significantly impact travel behaviors shaped by land use transformation, economic activities, transportation, and housing.

The existing spatial characteristic could be efficient with multi-modal mobility. The benefits cover the trip generation, more affordable with short duration ride, potential to have fewer trips with an empty car. But the currently available public transit mode (only bus) is a challenge to increase transport demand in shared mobility and compete with massive penetration of private motorcycles. Lastly, the challenges remain in expanding and connecting to the upcoming development zones surrounding urban core areas to avoid repetitiveness to the ribbon orientation like Bangkok.

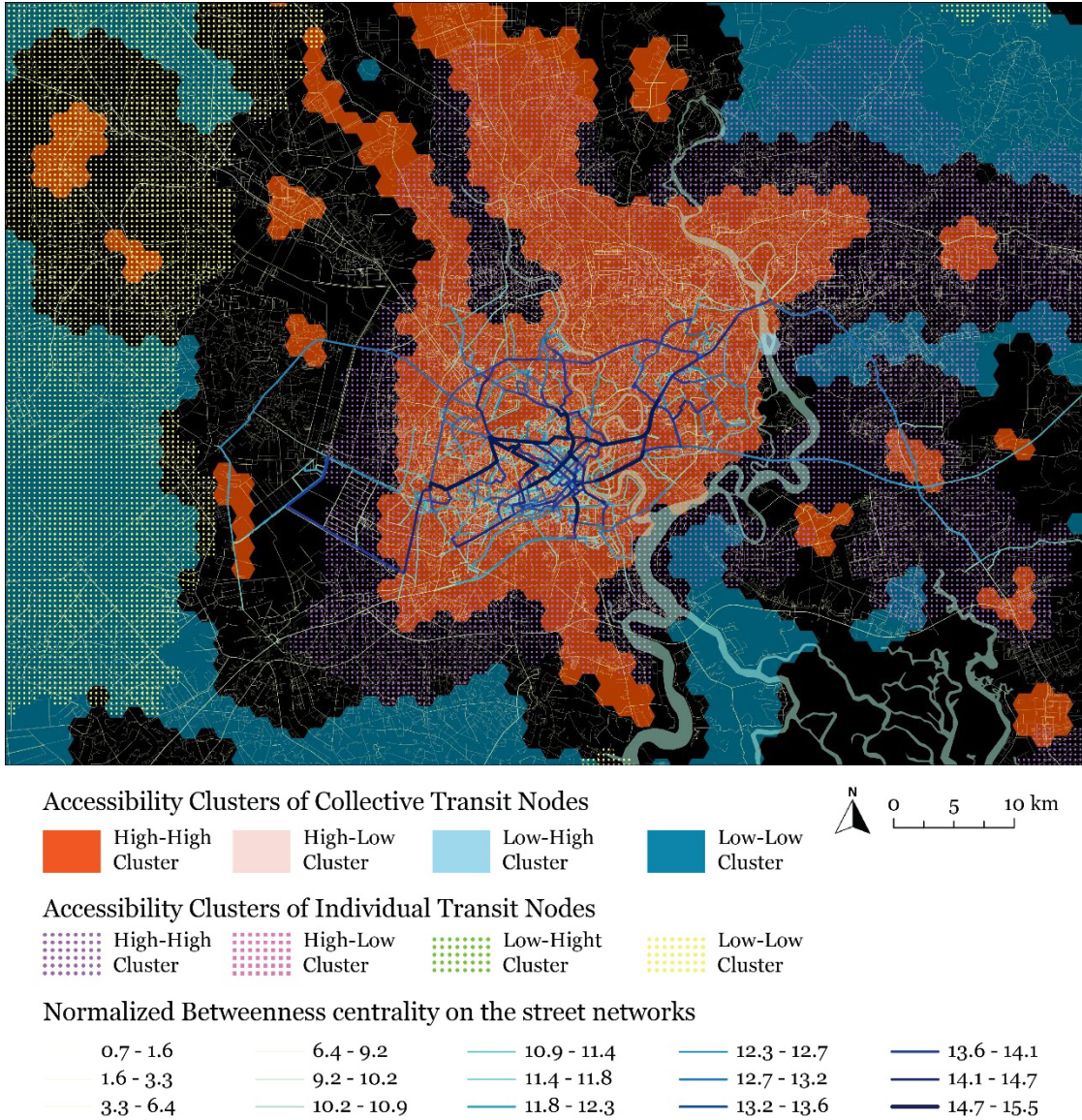


Figure 4 The Summarize of Spatial Analyses of Accessibility Cluster and Street Networks in Ho Chi Minh City

4.3 Critical Uncertainties

At the generic level, the booming research interest in the battle between private motorized transport versus collective transport and its societal impact reflects a tremendous uncertainty in urban mobility. The impact of different AVs deployment models on urban change will remain unknowable until years after commercialization. Meanwhile, the reconsideration of the current urban mobility system in spatial analyses highlights a long path dependence on the weak transportation networks and lack of accessibility to public transportation. These existing problems could fuel ignorance of CASE adoption and continue the high penetration rate of private transport, both privately-owned autonomous car and mobility-on-demand AVs taxi. Therefore, the categories of mobility solutions have been selected as the first critical uncertainty.

Technological breakthroughs fuel the four main characteristics under the CASE concept to enable the emergence of new mobility systems. Connected vehicles require a whole new supporting technology infrastructure as part of a transport network in high-speed mobilizing vast amounts of data received and processed. Whereas, connected car development poses a threat to data-security risks issues, which is why pressure on government actions in a timely manner is increasing to create new infrastructures and establish appropriate standards for communication. This points to the question that how emerging technology should be governed (Cohen & Cavoli, 2019). Moreover, AVs notably require a wide range of technologies in urban infrastructure transformation, such as roadside sensors, machine-readable signs, lane markings, and connected telecommunications network infrastructure to ensure AVs' compatibility in street spaces. This concern is in line with the advent of the co-occurrence keywords such as "transport policy", "urban planning", "accessibility", and "land-use". The list of keywords reflects the importance of spatial planning policies. The challenges are how responsible governments at all levels acknowledge their extent, which is complex and widely impacts social issues. How each city uptake the AVs and its consequence will be up to the government to sort out policy pathways and at what timing. Therefore, the polarization of governance approach is selected as the second critical uncertainty to explore different policy pathways, covering government intervention versus non-government intervention.

To conclude, two critical uncertainties draw attention to how the path dependence of urbanization and government capacity could widen or narrow the divergence between technological advancements and sustainable urban mobility. The spatial planning strategies need multidisciplinary competence, particularly in engineering and social sciences.

5. Developing Quadrants of Plausible Scenarios

In the third stage, the characteristics of two critical uncertainties are used to determine the quadrant axis. The first axis is the categories of mobility solutions. This axis covers integrated versus fragmented mobility solutions. The integrated model represents an integration of mobility solutions among providers as a multi-modal journey. The fragmented model represents an individualized mobility solution. The second axis contrasts the implication of the government intervention versus the non-government intervention. The commitment of public authorities to maximize the social advantages of AVs is referred to as government involvement in this context. The term "non-intervention government" refers to governments that refrain from interfering with the functioning of the free market economy. The private sector is driving or leading the development of autonomous vehicles. Four-scenarios matrix was plotted from the axes of the categories of mobility solutions and the polarization of governance approaches (Figure 5).

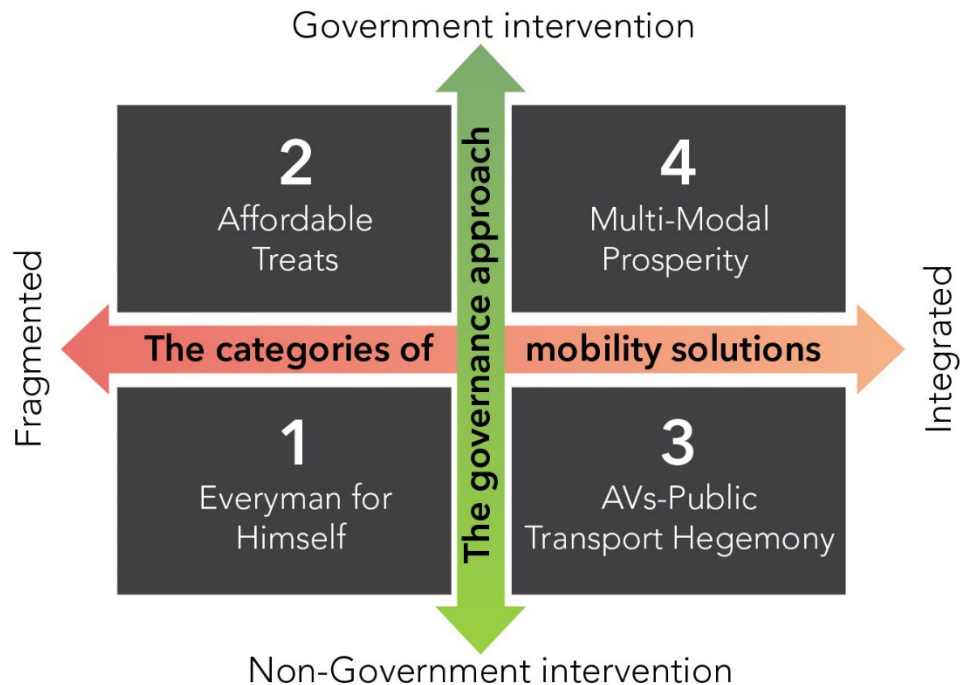


Figure 5 Quadrants of plausible scenarios for the development of AVs

The first scenario assumes that the current trends of car dependency will remain largely unchanged. Every man for himself attitude leads to tautologies of the car dependency cycle, which prioritizes private cars and some AVs and EVs adoption. This scenario assumes that governments stay idle or ignore growing technological trends. The great infrastructure requirement does not take place to catch up with new mobility technologies. The mobility capacity will be failed to meet the inhabitants' travel demand, such as highway congestion and inadequate taxi service. . The exclusive deployment scenario could lead to a greater urban sprawl pattern and fuel the social-economic gap in different zoning.

In the second scenario, shared mobility service becomes the predominant transportation solution, which will be operated as private property. Shared vehicles in fleet mobility services are expected to be more affordable, convenient, and attractive to a mass of users. MaaS service itself is only a platform with commercially viable, which plays a role as an aggregator of multiple offers from transport service providers rather than its role in interconnecting multi-modal journeys. Without planning policy, the shared mobility-on-demand service could only flourish within dense urban areas with sufficient travel demand. This scenario tends to fail on mitigating urban sprawling problems. In a city with inadequate public transit systems, a demand on private ownership may be reduced, but little life luxuries and convenience like on-demand mobility services will be remained to make life worth living regardless of suffering from poor public transport services.

The advent of automation vehicles disrupts how states govern urban transportation. The predominant mobility service will be operated and owned by public authorities in the third scenario. Governments play functions as a single leading player in promoting CASE covering supportive policies implementation, advanced infrastructure development, and service provider. The transformation of public transportation from massive fleets of transit vehicles with fixed

schedules to micro transit fleet using automation vehicle, wandering along limited routes with flexible schedules time table as an autonomous shuttle bus (Grush & Niles, 2018b). The AVs shuttle bus is demand-driven shuttles designed to close the first and last-mile gaps between home and the following public transport stop. However, most local and regional governments do not have enough authority capacity and budget to operate significant investments. The challenges remain as a gap widening by the different institutional structures. Nonetheless, this approach is inconsistent with the fundamental of an open market and democratic society.

Lastly, the fourth scenario represents a combination of a public-led governance approach with integrated mobility systems. Governments play an active role in promoting AVs' uptake through supportive policies, advance infrastructure development, and initial in setting up public-private partnerships. The government interventions are used to to promote social equity and able to maintain profit-orientation management. Mobility services by private providers will be assimilated to integrated mobility systems, which can alleviate government risks and burdens in delivering mobility services. Private actors play a role in delivering innovative mobility solutions for public services. This approach allows the competitive on fleet operations with a transparent public performance goal (Grush & Niles, 2018b). The shared automation mobility supports first or last-mile transportation, which could enhance mass uptake of public transit in areas outside accessible areas to public transit nodes. Moreover, the integration with micro-mobility modes may positively promote more localized and healthy lifestyles from walking, cycling, and using a scooter (Marsden & Reardon, 2021). The personalized mobility configuration can carry out through the MaaS platform with seamless coordination among different public and private mobility service providers.

6. Proposed Robust Strategies to Ensure a Performance of CASE

The discussion on urbanization problems of mega-urban regions in SEA context captures additional challenges from an extra layer of paratransit mode and gated communities compared to the Global North context, in which the number of research is limited as well as a lack of richness of data that are important in decision making for the early adoption stage. The synergic between quadrant scenarios and path dependency of urbanization sheds light on long-term strategies planning requirements in response to different autonomous mobility deployments. Indeed, the disruption by AVs will be on various dimensions of social, economic, and environmental. Therefore, the reaction of anticipatory governance will be unavoidable due to the need for public democratic discussion. The intensity level of government intervention remains a matter in balancing the degree of freedom in markets and ensuring public interests.

These inherent problems would be highly following the exclusiveness scenarios that could fuel ignorance of CASE adoption. Indeed, the reaction of anticipatory governance will be unavoidable due to the need for public democratic discussion. The intensity level of government intervention remains a matter in balancing the degree of freedom in markets and ensuring public interests. This research recommends participatory planning to develop comprehensive urban-regional planning considering multi-level governments of local and regional levels in the metropolis and neighboring cities, private sectors, and communities. The proposed robust strategies involve building seamlessness user experience, encouraging the attractiveness of public transportation,

and enhancing social acceptance of autonomous ride-sharing and multi-modal transportation, underlying the idea of minimizing the maximum regret covering public rights-of-way, incentive zoning, and taxation strategies.

7. Conclusion

The main purpose of this research is to explore different policy pathways in CASE adoption and promote collective transportation systems in the SEA mega-urban region. The discussion on interchangeable forms of shared autonomous mobility pointed out that the form of deployment becomes matter than the ownership type. The quadrant scenarios demonstrate significant interdependencies between the advent of emerging autonomous mobilities and the improvement of urban structure. The insufficient transportation networks and mobility services in SEA mega-urban regions are a compound of mobility inequalities, which could fuel the ignorance of collective urban mobility usage. It's critical to respond to the local transportation needs, commuter characteristics, and mobility culture in the autonomous deployment.

The reaction of anticipatory governance toward the deployment of AVs will be unavoidable due to the need for public democratic discussion and explicit spatial consequences. Indeed, the introduction of CASE requires the synergy between technological breakthroughs and innovative governance in making collective urban mobility more attractive and gaining public confidence in the multi-modal transport system. This research recommends participatory planning to develop comprehensive urban-regional planning considering multi-level governments at the local and regional levels in the metropolis and neighboring cities, private sectors, and communities.

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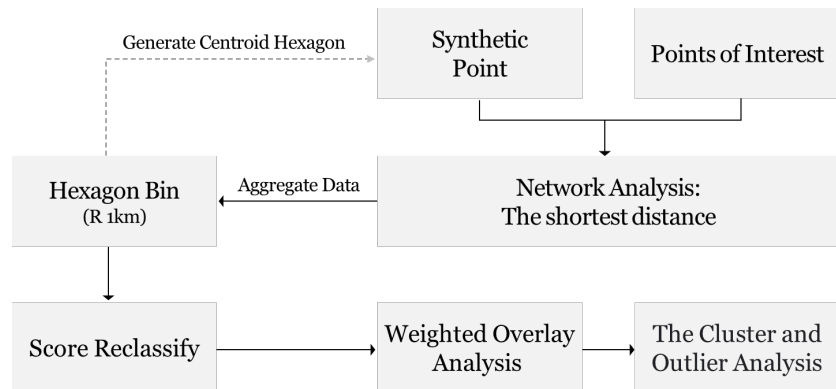
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Appendix



Appendix 1. Methodology for Accessibility Cluster Analysis