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The Disruptive Mobility and The Potential for Land Reclamation: the case of Auckland's CBD and other Metropolitan Centres

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Abstract

This working paper investigates the potential for land reclamation based on the deployment of disruptive mobility in Auckland's CBD and in ten other metropolitan areas. This investigation is developed based on the following primary assumptions: the shared electric autonomous vehicles (SEAVs) will be the dominant transport system in the near future; the transition from the existing pervasive car ownership transport system to SEAVs (disruptive mobility) will potentially reduce the demands for car parking, and the existing open and covered car parking can be reclaimed. The land reclamation will provide a great opportunity for planners, urban designers, and other decision makers to reuse the reclaimed lands for their required urban needs, such as public space, commercial, and also residential buildings.

The Central Business Districts of cities and metropolitan centres attract a large number of people for different purposes, including, but not limited to, working, education, entertainment and shopping. Based on the current car-oriented land-use planning practice, the provision of car parking is perceived as one of the most important principles in allocating land for different land use activities. A large amount of land in the CBDs and metropolitan centres has been allocated for open air and covered parking. As the business hubs, the land in the CBDs and metropolitan is a scarce resource, and its value is relatively higher than in the surrounding residential neighbourhoods. Disruptive mobility will potentially assist in reclaiming these valuable lands by providing an alternative mobility option for the residents. By using ArcGIS, this working paper investigates the potential for land reclamation in Auckland's CBD and its ten metropolitan centres. The GIS maps are used to illustrate the existing capacities in the eleven areas. Based on secondary resources such as Auckland Council's data set, the report shows the financial benefits that can be achieved through the land reclamation. The reclaimed land can be used to address existing urban issues, such as public space, business activities and high dense housing. This working paper argues that land reclamation can be used to reinforce Transit-Oriented Development (TOD) to attain sustainable transportation.

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1. Introduction

There is an emerging expectation that smart technologies will significantly disrupt our cities and their functions. In this context, the new technologies challenge and eventually will replace the pre-existing technologies because of their efficiencies and effectiveness. The replacement of these technologies will provide new opportunities, and may cause a new set of issues and problems for the cities. It is important to investigate these opportunities and issues to achieve the highest benefits and mitigate the adverse side effects through the replacement of technologies.

Disruptive mobility, including automation, electrification, and sharing mobility, is one of the most important innovative technologies that is shaping the built environment and our everyday lives. If the autonomous electric shared vehicle was erstwhile an imaginary technology in science-fiction movies and books, it now is a reality on roads around the world, including New Zealand.

While the potential impacts of disruptive mobility on cities, including urban form, design, planning, and development, seem significant, the capacity of disruptive mobility in changing cities has not been well investigated and understood (Hörl, *et al*, 2016). Lennert & Schönduwe,2017, p. 229) argued that

> The performance of emerging and integrated new transport and mobility systems will be fundamental in identifying successful and sustainable transformation paths and to inform long-range policy design. This is a complex and challenging task requiring analytical insights and empirical evidence from across disparate disciplines and domains, relating to complex interactions between technology development, service innovation, user behaviour and preferences, infrastructure and urban design, spatial and economic efficiency and environmental performance.

This working paper investigates how disruptive mobility potentially may provide new opportunities for Auckland through the transformation of car parking to other desired land use activities in Auckland's CBD and metropolitan areas.

Disruptive mobility modes will be pervasively accepted when they are shown to work efficiently and affordably (Skinner & Bidwell, 2016). This paper argues that disruptive mobility should be considered as a component of a wider social, economic, and technological transformation that is essentially changing our everyday lives (Barnes & Turkel, 2017). This working paper is developed based on the assumption that the new smart technology is fundamentally changing the pervasive ownership-based economy into a new form of the sharing economy as demonstrated by the studies of Simoudis (2017) and Sperling (2018). This paper explains why the capacity of Electric Autonomous Vehicles (EAVs) in combination with the smart economy will transform our travel behaviour based on a new form of smart shared mobility.

This working paper suggests that Shared Electric Autonomous Vehicles (SEAVs) will reshape the built environment, particularly by decreasing the demand for parking. It shows how the new social, economic and technological changes provide new opportunities to reshape and reuse urban space for people instead of cars. SEAVs can assist in reclaiming invaluable land that is currently allocated for public parking. The reclaimed land can be used to provide urban services and amenities in places where a shortage of land is perceived as one of the main obstacles in generating high-quality urban spaces.

2. Car-oriented Transportation and Land-use Planning

> "What's transportation for? This is a question that highway engineers apparently never ask themselves: probably because they take for granted the belief that transportation exists for the purpose of providing suitable outlets for the motorcar industry. To increase the number of cars, to enable motorists to go longer distances, to more places, at higher speeds has become an end in itself."
>
> (Lewis Mumford, 1968)

"In all metropolitan regions in the world today, the problem of the automobile and its impact on urban societies is a major issue" (Kenworthy & Laube, 1999, p. 691). Martin Heidegger argued that machinery 'unfolds a specific character of domination . . . a specific kind of discipline and a unique kind of consciousness of conquest' over human beings' (quoted in Zimmerman, 1990, p. 214). Since the late 19th century, the automobile has significantly changed our cities; the private car has become the centre of the transportation system (Zimbron-Alva, 2016). Christopher W. Wells (2012) named the twentieth century as the 'automobile century'. "One billion cars have been manufactured in the twentieth century" (Sheller & Urry, 2000, p. 737). Sperling and Gordon (2008) argued that one billion motorised vehicles were used globally in 2008, and the number of vehicles is expected to be doubled by 2020.

The invention of the automobile has dramatically altered the pre-developed collective transportation system such as the train by facilitating individual commuting within and beyond cities (Newman & Kenworthy, 2015). The establishment of Ford's assembly line has made private car ownership affordable for a large number of middle class residents. "The development of automobile dependence in cities is a complex process, enacted over decades of land-use and infrastructure development linked to the dominant economic waves of innovation" (Newman & Kenworthy, 2015, p. 2). The pervasive usage of private cars as the dominant mode of travel significantly transformed cities' built environments and their

residents' everyday lives (Gehl, 2013). Highways, roads, squares, and open/covered car parking have become inevitable components of our cities (Newman & Kenworthy, 2015).

The pervasive car ownership has expanded the cities' boundaries. Fox (2016, p. 2) argues that "when we talk about urban sprawl, we talk about cars". However, suburbanisation initially emerged around railways. Cars have provided easy, fast, and affordable access to different parts of cities that mostly lack direct rail service. Using cars has generated a "new scale of local distance" within cities. They shorten the time of the residents' commuting by putting residential neighbourhoods, amenities, and businesses far from the city's Central Business Districts (CBD) (Wells, 2013). This new scale of local distance has justified further green development and land release beyond urban boundaries. "Cars made sprawl in its current form possible, and suburban development has ensured the continued dominance of the automobile through design centred nearly entirely around its needs. That design has taken a toll on both humans and the environment" (Fox, 2016, p. 2). The hegemony of cars in our cities has resulted in low-density urban development, a low quality built environment, and a highly consumptive development, particularly of fertile land (Newman, Kenworthy, & Vintila, 1995). This car-oriented urban development also has increased the demand for parking spaces. To respond to this demand, urban planners have allocated significant urban lands for covered and open parking spaces.

Cars have dominated our streets and public spaces (Gehl, 2013). Newman and Kenworthy (2015, p. 201) argued that "the contemporary cities have been reshaped around the car, with major shifts in every conceivable aspect of city life as residents became more and more dependent on private motorized mobility". Following the hegemony of cars across the world, cities have not only adapted cars to the varied uses of urban spaces including streets but by prioritising the movement of cars. Car-oriented planning and codes have removed all perceived obstacles to facilitate the movement of cars. The prioritisation of cars in cities has eliminated public life from our urban spaces, including city centres and streets (National Association of City Transportation Officials, 2017).

The new technological achievements in the second decade of the 21st century, particularly the signs of progress in Shared Autonomous Electric Vehicles (SEAVs), creates a historic opportunity to reclaim our public spaces and urban life by correcting the mistakes of urban planning and urban design (National Association of City Transportation Officials, 2017). "A major goal of urban design, especially in centers, is to reduce automobile dependence in order to address issues of viability and sustainability" (Newman & Kenworthy, 2006, p. 35).

3. Disruptive Mobility and Future Cities

> Cars "exert an awesome spatial and temporal dominance over surrounding environments, transforming what can be seen, heard, smelt and even tasted."
>
> (Sheller & Urry, 2000, p. 746)

Over the last century, around one billion cars have been produced. It is estimated that 1.2 billion cars are currently used around the world, and it is expected that the number of cars will increase to 2 billion by 2035 (Noyman, Stibe, & Larson, 2017). After a century of urban sprawl and suburbanisation, "it is evident that the surrender to the car, its industry and marketing efforts is pivotal in the impetus behind the design of cites" (Noyman et al., 2017, p. 5). Sheller and Urry (2000, p. 738) address the misconception of the car in urban studies, arguing that,

> [C]ars have been conceived of either as a neutral technology, permitting social patterns of life that would happen anyway, or as a fiendish interloper that destroyed earlier patterns of urban life. Urban studies have omitted to consider how the car reconfigures urban life, involving … distinct ways of dwelling, travelling and socializing in, and through, an auto-mobilized time-space.

Over the last century, this neutralisation and subsequent prioritisation of cars in plans and urban design projects have resulted in a pervasively car dependent urban form, including suburbanisation, low density, and urban sprawl.

Urban scholars have extensively considered the relationships between modern types of mobility and their impacts on cities. They have developed several concepts and terms such as 'car-culture', 'car-dependent urban planning', and 'car-architecture' to describe the role of cars in the transformation of urban form, the design of cities and neighbourhoods, and even the architecture of buildings. Noyman et al. (2017a, p. 3) argue that "the car gutted buildings and streets, shuffled land-use and redefined the design of landscapes".

The prioritisation of cars in urban planning and design has adversely reshaped residents' travel behaviours as well as the physical environment. Cars are often the only adequate and feasible transport mode for most people living in the suburbs due to a lack of safe, convenient, and affordable transport alternative modes (Newman & Kenworthy, 2015). Skinner and Bidwell, (2016) maintain that the prevalence of car dependency has transformed the built environment; for example, front gardens are increasingly paved over to park multiple cars. Drivers seeking to avoid congested main collecting roads have increasingly used local suburban connector roads and streets, particularly during peak hours. As a result of widespread car dependency, pedestrian and child safety, noise, air quality, and traffic speeds are a growing cause for concern in cities and particularly in neighbourhoods.

Lewis Mumford, a famous urban scholar, argued that "forget the damned motor car and build cities for lovers and friends" (Jackson, 1985, p. 75). As previously explained, although the implementation of disruptive mobility seems promising in addressing some of our urban issues such as traffic congestion, noise, air pollution, and safety, these potential benefits of automation are not guaranteed. Urban planning and design must proactively lead disruptive mobility to prioritise people-centric design in order to maximise the benefits and mitigate the adverse impacts of the usage of this technology (National Association of City Transportation Officials, 2017).

The widespread usage of disruptive mobility may assist in improving the quality of living in neighbourhoods. First, SEAVs would result in more efficient usage of road networks due to the system-wide control over route choice. Second, SEAVs would direct traffic out of

residential areas, except where they form an essential element of the trip (Skinner & Bidwell, 2016). Third, the provision of SEAVs as a mobility service to a neighbourhood would offer appropriately sized vehicles within minutes with significantly lower costs than running a car and thus would decrease car ownership dramatically (Sperling, 2018). SEAVs "could provide better mobility experiences at radically [up to ten times] lower cost" (Bösch, *et al.*, 2018, p. 76).

The increasing interest in mobility services does not totally exclude private car ownership and its usage in neighbourhoods in favour of SEAVs in the near-term future; the replacement of private cars with SEAVs will be a transition process. For example, households will initially use SEAVs instead of owning a second car. By building trust and familiarity with mobility services, a shift is expected towards greater use of SEAVs for everyday trips to and from home in the neighbourhood. However, it may be that some residents purchase and use their own EAVs in the future. Declining car ownership in neighbourhoods will gradually transform the built environment and urban form (National Association of City Transportation Officials, 2017).

The widespread shift to SEAVs is part of the unprecedented attempt to achieve sustainable transportation. City leaders, transport planners, and urban designers have increasingly promoted, experimented with, and implemented different sustainable modes of transportation, such as biking, walking, and public transport, to improve the quality of life in their cities. The implementation of the SEAVs should complete this progress (National Association of City Transportation Officials, 2017). Accordingly, SEAVs should be used and developed as a component of a sustainable transport system in the future. However, some have perceived SEAVs as a potential threat to attaining sustainable transportation goals that include safety, equity, public health, and environment protection. There is general concern over a large number of unknowns in the future. As explained previously, most of these concerns will be addressed through technological developments as well as the implementation of the required regulations (National Association of City Transportation

Officials, 2017). The deployment of SEAVs will potentially provide some benefits for our neighbourhoods:

A- Safety:

- Setting speed limits for the SEAVs will increase walking, cycling, and other activities. Based on the zoning mechanism, the sensors will automatically reduce the SEAVs' speeds between the predefined speed limits, such as 15 to 30 (K/H), in neighbourhoods and residential areas.
- Setting speed limits for SEAVs will increase safety for children, elderly, and disabled residents
- SEAVs will be programmed to prioritise people and their movements
- Real time data collection from SEAVs will assist in identifying hazardous locations and redesigning them to improve safety

B- New transport planning:

- Updating existing traffic and transport models to cater to SEAVs as well as reducing the need for roadways
- Reallocating existing roads to SEAVs and residents' active and transit movements
- Redesigning the streets and pavements to be shared by SEAVs and the residents

C- Design for a lower number of vehicles:

- Reducing parking minimums in zoning codes to reflect lower parking needs in the neighbourhood
- Supporting the SEAVs by allocating space for charging stations and employing an occupancy-based congestion price
- Supporting and developing infrastructure for public transit and active modes in the neighbourhood

This working paper attempts to provide a base for policies and an aspirational framework for the deployment of SEAVs. The policies and plans will lead future cities into the autonomous era. However, with the lack of such plans and policies, transportation network companies and technology companies will play the main role in reshaping urban transportation in the future. Their technical and financial rationale and knowledge may neglect residents and their needs in the cities. Therefore, the large usage of SEAVs could generate new urban issues in the future. SEAVs "can support cities as they work toward streets that prioritise pedestrians, dedicate more space to better bicycle infrastructure, and allow for reliable transit service – but only with smart, thoughtful, intentional policies" (National Association of City Transportation Officials, 2017, p. 16).

4. CBD, Land-use Planning and Parking Spaces Supply

Parking is entirely a product of the car ownership culture. "The space that parking requires can be problematic in any part of a city, but it poses particular problems in central business districts" (Manville & Shoup, 2005, p. 231). Parking supply is constantly increasing in cities because the zoning ordinances force its supply as a requirement with any new development project. Brierley (1972, p. 22) argued that,

> we must plan for the motor vehicle to be used in our cities, our towns, our villages and in the countryside. It is fundamental to our planning that we accept the motor vehicle as a beneficial invention with an assured future.

Urban planning and "zoning regulations play a significant role in the development of parking" (Marshall & Garrick, 2006). After the Second World War, the parking provision had become one of the main priorities in urban planning and land-use planning for several decades. For example, Parking in the City Centre was published in 1965, suggested planners should increase parking supply in city centres to meet growing parking demand (Smith, 1965).

Since the late 1960s, it has become evident that parking supply is increasing car usage because "the mandated provision of parking tacitly subsidizes automobile ownership" (Manville & Shoup, 2005, p. 233). In his book *The City in History*, Lewis Mumford (1986, p. 510, first

published in 1960) named Los Angeles the “reductio ad absurdum” of the cult of the car. He argued that the city is hijacked by the false promises of the motor age. Mumford said two-thirds of Los Angeles’s CBD was devoted to streets, freeways, parking facilities, and garages. He argued that this is “space-eating with a vengeance” (1986, p. 621).

Form the early 1970s, it becomes evident that parking supply adversely affects urban spaces and everyday life. The 1972 edition of the Eno Foundation for Transportation’s Zoning, Parking, and Traffic reported a survey result that was collected from more than 200 planning officials around the USA (Jakle & Sculle, 2004). However, most respondents indicated that insufficient parking supply leads to traffic congestion. Some comments showed their concern that the more parking you supply, the more cars you attract and you’re back where you started. Automobiles are a detriment to the business district; that is why we do not require parking with new buildings in the business district (Marshall & Garrick, 2006, p. 165).

Recently, researchers have studied the socio-economic effect of parking and how it influences the quality of urban space in general and city centres in particular. Manville and Shoup (2005) investigated parking regulations in four major American cities, including Los Angeles, San Francisco, and New York. They argued that the implementation of a similar parking requirement across an entire city adversely impacts the CBD and metropolitan centres, because of the cost associated with complying with this requirement and the cost of lost opportunities. Los Angeles, for example, has suffered from trying to accommodate too much parking in its downtown area (Manville & Shoup, 2005). Yet, a uniform parking regulation is deployed in most cities (Marshall & Garrick, 2006).

Planning regulation mostly mandates minimum parking provision by specifying the fewest number of parking spaces that must accompany a building. Most business buildings, including office and retail activities, should offer the required parking spaces based on their square footage of leasable space, and residential buildings often should provide the required parking space based on the number of units (Marshall & Garrick, 2006). Shoup (1995) argued that the provision of the minimum parking requirement encourage car usage because it guarantees

parking space availability. This increases a higher demand which subsequently generates a vicious cycle of requiring even higher future minimum parking requirements.

The pervasive adverse side effects of minimum parking supply persuade planning professionals, including transportation planners, to change the way they think about parking problems and evaluate solutions (Litman, 2018). They endeavour to reduce the number of parking spaces required through parking management. The reduction of parking supply provides various benefits. Litman (2018) indicated some of the benefits as follows:

• Facility cost savings: reducing parking supply often decreases costs to governments, businesses, developers, and consumers.

• Improved service quality: it reduces congestion and improves the efficiency of facilities.

• More flexible facility location and design: it offers urban designers and planners more ways to address the residents' needs and requirements.

• Revenue generation: it generates revenues through land reclamation.

• Mobility management support: it is an important component of travel demand management to attain sustainable travel behaviour such as active modes and public transport usage, which helps reduce traffic problems in cities.

• Smart growth support: it assists in creating more accessible and efficient land use patterns and supports other strategic land use planning objectives.

• Support for alternative modes: it encourages walking, cycling, and transit use.

• Reduced storm-water management costs, water pollution, and heat island effects: it reduces storm-water flow, water pollution, and solar heat gain because it provides more land for the vegetation and green spaces.

• Support for equity objectives: it improves travel options for non-drivers.

• More liveable communities: it improves the quality of spaces based on the land reclamation.

The Central Business Districts and metropolitan centres have mostly flourished on high density development because their prime advantage over other residential areas is the immediate accessibility to a wide variety of socio-economic activities such as cinemas, shopping centres, museums, theatres, restaurants, and offices (Voith, 1998). The pervasive car usage has imperilled the CBD's advantage. First, parking increase an unnecessary distance between

various land uses that adversely influences the quality and liveability of space. Second, the density made the CBD unsuitable for driving (Jakle & Sculle, 2004). Parking requirements are not a strategy that comes without costs. Voith (1998, pp. 4-5) argued that "Abundant, inexpensive parking … would make the CBD more attractive if it had no other consequences; however, plentiful, low-cost parking may be at odds with the very aspect that makes a downtown area unique— high density." Parking supply may diminish a CBD's prosperity because land allocated for parking lots often has a very high and very visible opportunity cost. "Instead of a building teeming with people, there is an expanse of asphalt with a single employee manning a booth; where there could be something, there is instead not much" (Manville & Shoup, 2005, p. 231). Manville and Shoup (2005) recommend that cities should implement parking maximums policy instead of the minimum parking requirement that allows the market to cover the cost to park. Parking maximums are increasingly utilised in some major American cities such as San Francisco, Seattle, and Portland. Some cities such as Portland have utilised regional parking policies.

There are some benefits and costs associated with the utilisation of either minimum or maximum parking provision. In *The Economic Impacts of Parking Requirements in Auckland*, MRCagney (2013) reported these benefits and costs in the Auckland context as follows:

Regulation	Benefits	Costs
Minimums	Reduces parking spill-over *[adjacent residents]* Improves ease of finding car-park *[drivers]* Avoids need for parking management *[AT]*	Reduces value of development *[developers]* Increases traffic congestion *[drivers]* Creates compliance costs *[developers / AC]*
Maximums	Reduces traffic congestion *[drivers]* Improves amenity *[pedestrians]*	Reduces value of development *[developers]* Increases parking management costs *[AT]* Creates compliance costs *[developers/ AC]*

The report indicates that "the economic cost of minimum parking requirements is mainly an *opportunity cost*, in that they reduce the land and/or floor space available for other potential uses, rather than a *financial cost* associated with the construction of parking itself" (MRCagney, 2013, p. 5).

5. The SEAVs will Potentially Transform the Metropolitan and Town Centres

The widespread uptake of SEAVs will create an opportunity to reinvigorate city and town centres. By using the capacity of SEAVs, urban designers and planners will be able to make the metropolitan/town centres greener, cleaner, and more liveable places (Skinner & Bidwell, 2016).

The land allocated to public parking in the metropolitan/town centres is significant (Litman, 2014). SEAVs will not need parking in the same way as conventional private vehicles do, and the level of car ownership will reduce significantly. The allocated land for public parking can be reclaimed for other activities in the cities, particularly in metropolitan/town centres. Skinner and Bidwell (2016) investigated the capacity of SEAVs to claim parking land in the cities. They argue that there are 6.5 hectares (16 acres) of parking for every 40.5 hectares (100 acres) of land in the urbanised area of Los Angeles which is more than double the 2.8 hectares (7 acres) of parking coverage in 1950. The central area of London has approximately 16% parking coverage that includes around 6.8 million parking spaces. Based on an average parking lot size, this means that around 8,000 hectares (19,700 acres) of central London is used for parking. Skinner and Bidwell (2016) generalised the figures of 15% to 30% parking coverage as typical of New York, Paris, Vienna, Boston, and Hong Kong.

Skinner and Bidwell (2016) argue that the implementation of SEAVs could provide between 15% and 20% additional developable land compared with a typical central urban layout due to the removal of parking spaces as well as the amendment of roads and streets. The development of SEAV zones within the existing metropolitan centres would create at least 15% additional land area for more valuable uses (Skinner & Bidwell, 2016). Depending on size and location, this reclaimed land could be potentially used for residential and mixed land uses, as well as extra land for quality green, urban amenities, and quality public spaces.

Reclaiming land in the metropolitan/town centres may persuade private developers to invest in the establishment of SEAVs as it would provide more efficient use of land for business

activities instead of car parking in ground level space, and perhaps above or below, depending on the parking situation (Skinner & Bidwell, 2016). For example, an estimation shows that the establishment of a SEAV zone with a 100 hectare development in the heart of London would gain more than £1.25 billion directly in additional land value increase. The introduction of SEAV zones could, therefore, become a significant factor in future development viability appraisals (Skinner & Bidwell, 2016). The deployment of SEAVs in Auckland would assist in reclaiming land currently allocated for parking in the CBD and other metropolitan areas. This reclaimed land could be used as a tool to boost the economy in the future.

Developers and landowners may make significant gains through the replacement of car-oriented development with SEAVs-based development. Landowners and developers may perceive the reclamation of 15-20% additional land for further development in the centres as a new source of revenue and/or construction cost savings (Skinner & Bidwell, 2016). This is especially relevant to those who wish to achieve a long-term interest in their sites, for example through a Private Rented Sector (PRS) model. It seems feasible that access to SEAVs will become part of the package available to future residents. The economic drivers may persuade the private sector to invest and collaborate with the public sector to maximise the benefits of the deployment of SEAVs in the metropolitan/town centres (Skinner & Bidwell, 2016).

Developers and landowners may be attracted to invest in centres that are not currently viable due to poor transport access but which may become far more accessible with the introduction of SEAVs. Some newer metropolitan/town centre developments are designed, planned, and delivered based on Transit Oriented Development (TOD) that has no or lower car parking spaces. These new developments are close to a station offering fast, frequent, public transport services (Newman, 2015). The establishment of SEAV zones should be a component of this larger integrated transport strategy to be delivered equitably across far larger areas including several neighbourhoods, giving everyone a high-quality transport solution at their front door (Skinner & Bidwell, 2016).

The expansion of SEAVS zones would increase the amount of residential land in the centres by removing parking spaces, thus making future developments considerably more viable and

affordable (Skinner & Bidwell, 2016). DCLG's data (2015) identifies that post-development residential land value uplifts of £1-4 million per hectare are typical of much of the UK. In New Zealand, Auckland's metropolitan/town centres are mostly planned for high densification and mixed land use development. Land reclamation through SEAVs in these centres would reinforce the process of high densification and mixed land use in the future. The introduction of SEAVs, therefore, opens up the potential for hundreds of thousands of new homes in our existing city centres.

The utilisation of SEAVs will improve safety, efficiency, and air quality in the city centres. Drivers who search for parking spaces generate around 30-45% of city centre traffic (Skinner & Bidwell, 2016). SEAVs will offer additional place-making benefits and congestion relief. Unnecessary parking can be eliminated from city centres, and the reclaimed land can be reused, re-planned, and redesigned for other required land uses. Some of this land can be used for pedestrian and cycle enhancements, small-scale retail and commercial improvements, and better open spaces. SEAVs will result in a lower number of AVs and cars in circulation than today's car-based patterns. Several research projects have revealed that private cars are stationary 96% of the time (James, 2017) and SEAVs would be in use for a far greater proportion of time (Skinner & Bidwell, 2016).

6. Land-use Planning and Parking Spaces Supply in Auckland

Current transportation policies in Auckland, including parking policy, became embedded in the late 1940s (Gunder, 2002; MRCagney, 2013). In 1947 a Department of Internal Affairs publication declared that "the exciting novelty of the motor car has worn off, and we are becoming aware of its problems" (Harris, 2007, p. 11). Auckland City Council started implementing parking policies to manage parking demand. For example, parking meters in Auckland were the first ones to be installed in any Commonwealth country. Auckland City Council achieved £284,000 from the installed parking meters during the first seven consecutive years (MRCagney, 2013).

The first minimum parking requirement in Auckland was implemented in the District Scheme of 1961. The requirement of providing at least one off-street car parking space per dwelling persisted through to the end of the 1980s (Donovan & Nunns, 2015). "While minimums may have been required earlier than this, it is relatively difficult to tell because a succession of more informal guidelines, draft schemes, and by-laws predated the 1961 scheme" (MRCagney, 2013, p. 2). The minimum parking requirement has changed over time. Auckland City Council updated the regulation to require more off-street parking spaces, including a minimum of one car park for a house in addition to 0.4 car parks per each inhabitable room.

Under the influence of global trends, a parking maximums policy was deployed in Auckland in the early 1980s. The focus of the maximum parking policy was on inner suburbs that exempted minimum parking requirements for retail activities. Minimum parking requirements were removed from Auckland's CBD in 1996. From the middle of the 1990s, the minimum parking requirement has been omitted, or at least reduced, in various Auckland metropolitan centres such as Newmarket and New Lynn (MRCagney, 2013). MacArthur (2010) argued that Auckland CBD's parking maximums are too moderate to address its urban issues such as traffic congestion. He suggested a total parking ban policy for the area of Auckland's CBD that is walkable in approximately 20 minutes. The implementation of a total parking ban policy in Auckland's CBD may challenge people who have a legitimate need for access to cars, such as those with impaired mobility.

The Auckland Regional Parking Strategy (2009) indicated that parking should assist in the creation of an integrated transport network for the Auckland region through parking supply, management, pricing, and control policies that:

- support plans for land use intensification around selected mixed use high density centres and corridors,
- encourage travel behaviour changes for a more sustainable, less car-use-intensive future,
- support the economy of the region's activity and commercial centres,

- integrate parking supply and management and implementation actions with planned improvements to the public transport system,
- support increased travel by public transport and active modes,
- make better (more efficient, environmentally and socially friendly) use of existing parking resources,
- achieve consistency in district plan rules and standards for parking provision and operation among equivalent developments and centres throughout the region, and contribute to more efficient land uses,
- improve urban design, public amenity, and high quality open space, particularly in high density centres and corridors.

Auckland Regional Council (2009) sets out a new direction for the Auckland Regional Parking Strategy. The new direction opposes the past parking policies which have contributed to excessive reliance on travel by car through encouraging the provision of an ample supply of free parking, the true costs of which are not perceived by the user. The parking strategy replaces minimum parking standards with maximum parking standards for the region's high density mixed use town centres to avoid the continuation of policies which have generally led to an oversupply of parking. The parking strategy includes policies for encouraging the use of more sustainable forms of transport such as carpooling, car sharing, cycling, and the use of motorcycles or scooters.

The Auckland Unitary Plan (PAUP) proposed a number of changes to the rules governing parking provisions, including the introduction of maximum parking limits in larger centres and tighter controls on the provision of new off-street parking buildings (Auckland Council, 2012). The PAUP as the planning rulebook tightened on-site parking provisions relating to new development as well as for stand-alone car parking facilities. Aiming to limit the parking supply, the PAUP suggested the following:

- Continue the use of maximum parking regulations with no minimum requirement in the CBD and expand the use of maximum parking regulation to other metropolitan centres. There is an expectation that the implementation of this parking regulation mitigates the oversupply of parking associated with new developments, and that it subsequently results

in using valuable land in the centres better, reducing development costs, and supporting public transport.

- Any new additional parking buildings should be subject to Council approval and assessed on the individual merits of the proposal against the provisions of the Unitary Plan.
- Developing Park and Ride facilities requires resource consent (unless the site is designated) and assessed based on a limited set of considerations.

Auckland Transport (AT) released a Parking Discussion Document for public consultation. The document identifies the major parking issues in Auckland and suggests various potential solutions to address the issues. The outcomes of community consultations assist AT to develop its Auckland Transport Parking Strategy. The consultation process includes 22 workshops with different stakeholders such as local boards, industry groups, business associations, and the Auckland Council, as well as over 5,500 submissions. The *Auckland Transport Parking Strategy* (Auckland Transport, 2015) provides the strategic direction for the management and supply of parking in the Auckland region. The direction mainly suggests maximum parking requirement, at least for the Auckland's CBD and the metropolitan centres.

The Auckland Plan 2050 (Auckland Council, 2018a) indicated "paved and sealed surfaces that form part of the transport system, including roads, streets and parking lots, also have negative environmental impacts". The plan offers a set of solutions to mitigate the existing congestion as well as the allocation of valuable land to be used as parking space. The solutions include:

- "greater use of public transport, walking and cycling,
- an increase in the number of people travelling in each vehicle,
- taking non-essential trips outside peak times" (Auckland Council, 2018a).

The Auckland Plan 2050 (Auckland Council, 2018a) suggests that the main investment in transportation should focus on busy locations like the CBD, metropolitan centres, and other major employment areas, such as Auckland Airport. These locations mostly attract large numbers of car users which results in widespread congestions and requires a lot of valuable lands to be used for parking instead of more productive uses like homes and businesses.

These planning documents have largely emphasised the necessity of saving valuable land, particularly in the Auckland CBD and its metropolitan areas. The role of technological progress in mobility, particularly SEAVs, is overlooked. This working paper investigates these new emerging capacities to claim the land in Auckland's CBD and its metropolitan centres.

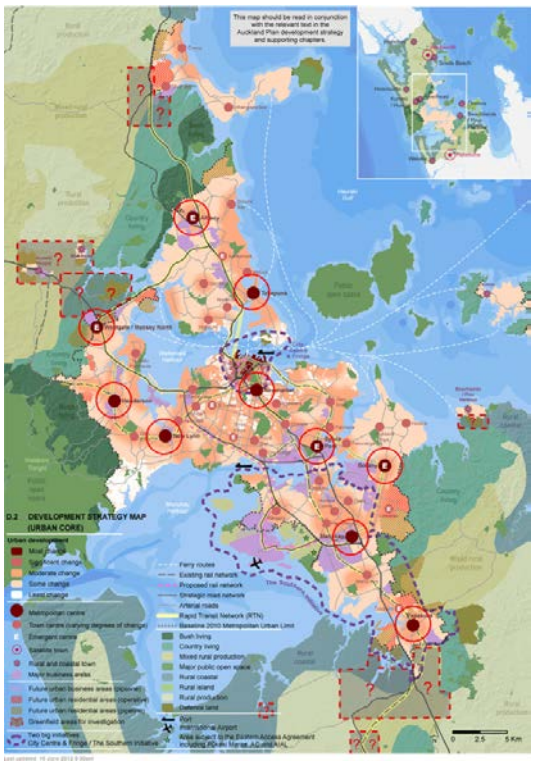
7. Methodology of Research

The author uses a mixed methodology of research that includes 1) the literature review, 2) ArcGIS map analysis, and 3) land value estimation. The literature review assists in clarifying the issue and why it is important to be studied. According to Gaber and Gaber (2018), the literature review is a qualitative method to analyse both academic and non-academic resources. The literature review has informed this working paper's aims and objectives and shaped the research assumptions. This working paper used a GIS-based methodology for evaluating the potential land reclamation in the Auckland CBD and its metropolitan centres. Finally, the working paper estimated the land value that can be reclaimed through the pervasive utilisation of SEAVs. The value of the potential reclaimed land will be estimated based on the Auckland Council's land valuation. Decision makers, planners, and developers may use this land value estimation as evidence to empower their arguments for transforming the existing parking to other land use activities. It also assists in justifying the utilisation of SEAVs on a large scale in Auckland through revealing its financial benefits for public and private sectors.

8. Land Reclamation in the CBD and the Metropolitan Centres of Auckland

The Auckland Plan expected that much of Auckland's growth would occur in the Auckland city centre and its metropolitan centres (Auckland Council, 2012). According to the Auckland Plan (2012), the ten metropolitan centres are:

- Albany,
- Botany,
- Henderson,
- Manukau,
- New Lynn,
- Papakura,
- Newmarket,
- Sylvia Park,
- Takapuna,
- Westgate/Massey.



The Auckland city centre (CBD) is perceived as the main place for intensification and business activities. The metropolitan centres are located in various sub-regional catchments of the Auckland region. The centres are "focal points for community interaction and commercial growth and development and contain hubs serving high frequency transport" (Auckland Council, 2016). The metropolitan centres offer a vast variety of social, cultural, and economic activities and opportunities such as business, entertainment, high-density residential, tourist, cultural, community, and civic services. The Auckland Plan (Auckland Council, 2012) has identified these centres for further growth and intensification. Expansion of these centres may be appropriate depending on strategic and local environmental considerations. The Auckland Unitary Plan allows high-rise buildings in these centres.

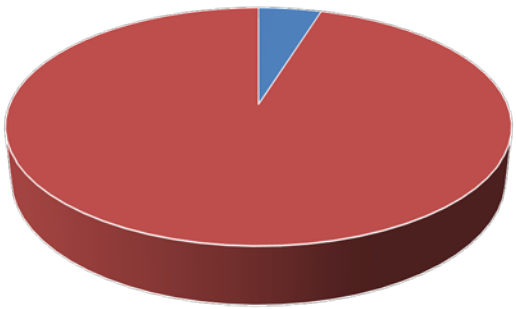
The Auckland population is projected to increase to 2,376,707 residents over the 30 years to 2048; that means an increase of 720,000 residents from 2018 (Auckland Council, 2018b). The Auckland Unitary Plan aims to accommodate this growth using the "compact city" approach. The CBD and other ten metropolitan centres will settle this population through intensification. These metropolitan centres are along transit corridors and railway that provide transit services to support better accessibility and reduce automobile dependence in Auckland (McArthur, 2017). The deployment of SEAVs will potentially facilitate the attainment of these aims. The existing parking can be converted to high-rise mixed used buildings.

Auckland Parking Spaces:

The GIS investigation reveals that around 223 hectares of land is allocated for parking in Auckland's CBD and its other metropolitan centres. Only 10.7 hectares of land is publicly owned. Therefore, the private sector, with 212.3 hectares, is the primary parking provider in Auckland.

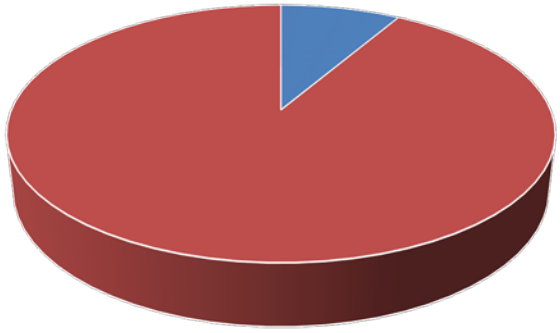
Public parking is owned by Auckland Council (AC) or Auckland Transport (AT). Private parking is owned by private organisations such as Wilsons, Secure etc. The public sector only offers parking spaces in six centres: Auckland CBD, Manukau, Papakura, Henderson, Takapuna, and New Lynn. There is significantly less public parking than privately owned parking.

Fig 1 - Publicly owned parking vs privately owned parking



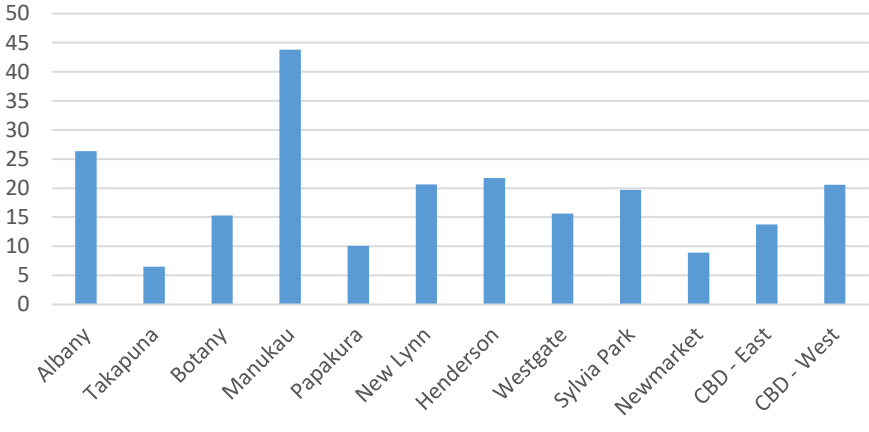
The land reclamation through the utilisation of SEAVs will provide a great opportunity to transfer the existing land use (parking) to a more beneficial and productive land use activities such as business, retail, and accommodation. Public mixed parking refers to publicly-owned parking buildings with other uses at ground level and private (mixed) refers to covered privately-owned parking buildings with other uses at ground level. Currently, only 8% of parking spaces in the Auckland CBD and other metropolitan centres are employing mixed used activities, meaning 92 % of the land is utilised as parking space only (see figure 2). There is not a significant difference between privately or publicly owned parking regarding mixed land use and single land use for parking only.

Fig 2 - Parking space land use in Auckland CBD and its metropolitan centres



The GIS map analysis reveals that the major business and trade hub centres, such as Manukau (20%), Auckland's CBD (17%), and Albany (12%), offer the highest land allocations for parking space compared to other centres. On the other hand, Takapuna (3%), New Market (4%) and Papakura (5%) offer lower land allocations for parking.

Fig 3 - Total land allocated for parking spaces (hectares) in Auckland CBD and other metropolitan centres



9. Land Price

The land is generally perceived as a scarce resource that should be used in a productive way. Land price is an important factor in land allocation for different urban activities and land use planning. Based on Auckland Council's Land Value (LV) estimation in 2017 (Auckland Council, 2019), the value of parking land is calculated as follows:

Centres	Average land value 2017 ($ per square metre)	Allocated Land for Car Parking (square metres)	Total land value (million dollars)
CBD	16,000	343,648	5498.4
Takapuna	6,000	64,732	388.4
Albany	1,100	263,443	289.8
Botany	2,000	152,769	305.5
Manukau	1,000	438,178	438.2
Papakura	900	100,613	90.6
New Lynn	1,000	206,422	206.4
Henderson	800	217,130	173.7
Westgate	1,600	156,125	249.8
Sylvia Park	1,000	197,153	197.2
Newmarket	12,000	88,971	1067.7

The total value of allocated land for parking in Auckland's CBD and other metropolitan centres is NZ$8,905 million. The reclamation and reusing of parking space in Auckland's CBD and other metropolitan centres as a consequence of the pervasive utilisation of SEAVs will significantly contribute to economic growth through the transformation of parking space as an unproductive land use activity into productive activities.

10. Conclusion

Disruptive mobility is significantly transforming the built environment, transportation, and everyday life. This report briefly reveals that the utilisation of disruptive mobility in the future will generate new opportunities for decision-makers, urban planners, and urban designers to transform our cities. This mainly focuses on the off-road parking spaces in Auckland's CBD and the ten metropolitan centres.

However, the implementation of maximum parking limits in larger centres and tighter controls on the provision of new off-street parking spaces is aimed to reduce the number of parking space, particularly in the CBD. The GIS map analysis reveals that parking is yet one of the major land use activities. 223 hectares of land are currently allocated for both covered and open off-street parking in the centres, which can be reclaimed and reused to address the residents' needs and improve the quality of space.

According to Jan Gehl's book *Cities for People* (2013), urban planners and designers often endeavour to transfer the existing urban spaces, particularly metropolitan centres, to more people friendly spaces. However, the prioritisation of people's movements and activities against car movements and parking has mostly been perceived as a crucial factor in planning and designing a high quality urban space because of its positive social, environmental, and economic impacts on the people and the city. Planners and urban designers generally are confronted with various limitations to implement this transformation in car-dependent cities such as Auckland.

During the last decades, the existing transport system was developed on the premise of pervasive car ownership and usage, and this has shaped the built environment of our cities. As this research reveals, the private sector has significantly invested in providing the required infrastructure, including parking space, in our cities such as Auckland. In this context, private and public sectors perceive the provision of parking in the CBDs and other metropolitan centres as a lucrative business activity. Thus, urban planners and designers hardly can change

parking spaces as a profitmaking activity to other alternative land use activities that may not generate the same or higher profit for the public and private landowners.

This report is developed on the assumption that the disruptive mobility, including Shared Autonomous Electric Vehicles (SEAVs), will significantly change the existing car-dependent transport system. The pervasive usage of SEAVs will decrease the existing needs for parking space in our future cities. Declining the needs for parking will challenge the existing economic and financial justification of parking as profitable land use. The utilisation of SEAVs will generate a historic opportunity for planners and urban designers to reallocate parking space for alternative land uses and through this to transform the built environment and improve the quality of urban space.

However, the pervasive usage of SEAVs seems promising and beneficial for the cities (Meyer & Shaheen, 2017). The adaptation of these new emerging technologies by people requires further investigations. The author has conducted a research project on the Aucklanders' perception of SEAVs. The result of the project will be published as a working paper and a journal article.

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