DEPARTMENT OF REGIONAL AND URBAN STUDIES AND PLANNING

MASTER'S DEGREE PROGRAMME IN

TERRITORIAL, URBAN, ENVIRONMENTAL AND LANDSCAPE PLANNING

CURRICULUM PLANNING FOR THE GLOBAL URBAN AGENDA

Transit-Oriented Development and Gentrification: The Transit-induced Gentrification in Two TOD Neighborhoods in Hong Kong

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Academic Year 2023/2024

ABSTRACT

Transit-oriented Development (TOD) has gained significant recognition and global adoption since its establishment in the twentieth century, confirming its crucial role in modern urban planning. TOD, according to its principles, promotes the establishment of urban places that are efficient, pedestrian-friendly, environmentally friendly, and sustainable, hence promoting innovative approaches to urban development. Recent study indicates that the implementation of TOD strategies leads to a rapid increase of land value and commercial upgrading in neighborhoods connected to transit, which in turn affects the local demographic composition. These changes exhibit obvious parallels with the mechanism of gentrification, presenting a novel concept titled Transit-induced Gentrification (TIG). Currently, most of the current studies focus the TIG in the Global North, particularly in the U.S and Europe. Nevertheless, considering the rapid growth of TOD projects in Asian cities, several studies have observed the occurrence of the TIG phenomena in the Asia contexts. The study focuses on the research background of Hong Kong, a city famous for its metro transit and Transit-Oriented Development (TOD) plan. Specifically, it studies two TOD areas in Tseung Kwan O New Town that have undergone TOD development between 2011 and 2021. To investigate TIG at the neighborhood level, the thesis adopts methodologies from Dominie (2012), Mostafa et al. (2014), Chen et al. (2023), and National Association of Realtors (NAR) to examine the spatial shifts, demographic changes, and housing affordability indexes. The thesis provides an in-depth evaluation of the impact of TIG on the advancement of urban development in Hong Kong by integrating the findings.

Key words*: Hong Kong, Transit-oriented development, Transit-induced gentrification, Gentrification, Demographic changes, Low-income households*

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LIST OF ABBREVIATIONS

3D	Density, Diversity, Design
5D	Density, Diversity, Design, Destination accessibility, Distance to transit
BART	San Francisco Bay Area Rapid Transit District
CBD	Central Business District
CCTV	Closed-circuit Television
CSD	Census and Statistics Department
CSDI	Common Spatial Data Infrastructure
CTOD	Center for Transit-oriented Development
DID	Different-in-Different
ESRI	Environmental Systems Research Institute
FAR	Floor Area Ratio
GDP	Gross Domestic Product
GIS	Geographic Information System
HAI	Housing Affordability Index
HHs	Households
HK	Hong Kong
HKSAR	Special Administrative Region of Hong Kong
HKU	University of Hong Kong
HUD	Department of Housing and Urban Development
ITDP	Institute for Transportation and Development Policy
LCSR	Land Compulsory Sale for Redevelopment Ordinance
LDC	Land Development Corporation
LVC	Land Value Capture
MPIR	Median Mortgage Payment to Income Ratio
MRIR	Median Rent to Income Ratio
MRT	Mass Rapid Transport
MTODP	Metro's Transit-oriented Development Program
MTR/MTRC	Massive Transit Railway Corporation
NAR	National Association of Realtors
PD	Planning Department
POIs	Points of Interest
PPP	Public Private Partnership
R+P	Rail + Property Model
SAR	Special Administrative Region
SCMP	South China Morning Posts
SDGs	Sustainable Development Goals
SQL	Structured Query Language
TIG	Transit-induced Gentrification
TKO	Tseung Kwan O
TOD	Transit-oriented Development
TPB	Town Planning Board
UNCTAD	United Nations of Conference on Trade and Development
URA	Urban Renewal Authority
URI	Urban Reform Institute

I. INTRODUCTION

1.1 Research Background

Transportation plays an essential part in the development of cities, since it facilitates the movement of products, culture, and population across the cities and the rest of the world. Thanks to the advanced development of trains and railroads in the 19th century, the revolutionary technologies have fundamentally transformed traditional methods of transportation, hence promoted the emergence of new urban planning concepts and restructured the dynamic between urban and rural areas. In 1898, Ebenezer Howard proposed an innovative idea in his book "*To-morrow: a peaceful path to real reform*", also later in 1902 in "*Garden city of Tomorrow*". His idea outlines a system of center public parks, core metropolis, and satellite towns linked by roads and trains. The aim of the system is to control scientific urban growth and establish efficient connections between center areas and production zones. This idea challenged traditional planning methodologies and inspired the birth of the Garden City Movement in the beginning of the 20th century. Following that, several communities in Europe and North America were selectively designed to explore the feasibility. The primary concept is known as Development-oriented Transit, which is regarded as the first phase in the evolution of ***Transit-oriented Development*** (TOD) (Carlton, 2009).

In the 1960s, metropolitans in the United States witnessed a series of massive social changes. Under the rapid economic growth and social reform, the migration of wealthy households from the city center to the suburbs resulted in the depopulation of the city, leading to a significant transition from public transportation reliance to the main usage of private automobiles. The deconcentration process was regarded as a representative of counterurbanization and concluded the impact as disorganized urban sprawls and social conflicts (Berry, 1980). On the basis of this background, the U.S. government started by utilizing the construction of the urban mass transport system as a tool to control urban growth. Between the 1970s and 1990s, scholars and authorities observed the impact of Mass Rapid Transport (MRT) systems on metropolitan areas and the redevelopment of parking lots in surrounding areas of those transit routes. They recognized that this urban planning model had the capacity to greatly impact transport patterns and boost the value of land. In 1989, a committee named "Transit-based Housing" was established in the San Francisco Bay Area Rapid Transit District (BART). The committee included architects, planners, economists, and other real estate professionals, and its purpose was to evaluate the development potential of the surrounding areas (Carlton, 2009). In 1993, Peter Calthorpe, one of the founders of the Congress of New Urbanism and the proposer of "*Pedestrian Pocket*", introduced the concept of Transit-oriented Development in his book "*The Next American Metropolis: Ecology, Community, and the American Dream*." He defined it as "*a mixed-use community that encourages people to live near transit services and to decrease their dependence on driving*" (Calthorpe, 1995).

TOD is currently a widely accepted urban planning model all over the world by its benefits in achieving Sustainable Development Goals (SDGs). Firstly, TOD is well known for promoting the public transport ridership, encouraging pedestrian and cycling, reducing the number of car users, flourishing the local economy, and creating mixed-use zones with high-density residential and commercial space. Focusing on the present issues of the transit area's relationship, the traditional layout of the transit station impacts the city by its single land use and creates the large vacant space. However, by adding retail and developing the upper level of the station, the TOD concept effectively addresses these urban problems. It also obtains the capacity to capture land values by refurbishing the station as a commercial hub (Yen et al., 2023). Secondly, TOD also promotes sustainability and climate actions. The connection of metro transits, bus routes, pedestrian roads, and bicycle lanes is an obvious way of supporting public travel behavior. It's believed that by organizing transportation methods, air pollution can be reduced and traffic congestion will be eased (Gomez et al., 2019). Thirdly, the density of housing units and mixed-use are also crucial for TOD. The layout of compact mixed-use center and low-density residential surroundings is another characteristic of TOD. It fully absorbs the compact city theory for controlling urban sprawl and preventing land over-exploration (Liu et al., 2022; Mohamad Zulkifli et al., 2017).

When looking at the overall benefits of TOD, it influences the city from urban planning and economic perspectives, helping it to fulfill the SDGs and realize the dream future of urban. However, the evaluation of TOD should also take into account its contribution to the micro perspective: the idea of people-oriented. Similar to other urban planning strategies, the TOD can be influenced by external factors such as policies and traditions which can work on the users. The complex procedure of implementing a project always has a cumulative impact on the residents in the local neighborhood. Thus, the study of social inclusion and equity is equally important.

TOD is defined as an urban development strategy in a specific location; therefore, it may cause displacement or evictions to the residents. In recent years, scholars have summarized their findings of negative impacts of TOD practices. During the initial stage of the TOD project, it is probable that the original low-income residents may experience displacement and be forced to relocate. This phenomenon is common in certain developing countries, where it is often regarded as a consequence of economic pursuits (Garmany & Richmond, 2020). In the operative stage, the increased number of passengers in the transit increases the maintenance pressure and leads to the worse travel experience and service quality. In most metropolitan cities, the longer duration of travel and the overcrowded train cabins push commuters to revert to personal automobiles. In the meanwhile, the increasing uses of Closed-Circuit Television (CCTV) and security against the privacy of the passengers (Liang et al., 2020). Social housing is an essential requirement for TOD; however, the advanced amenities may result in an increase in housing price. Changes in the real estate market create barriers to the maintenance of social housing and eventually trigger the crisis of housing policy. Moreover, high housing prices also result in rent gaps, as the higher rental price prohibits existing renters from affording extra living costs (Debrezion et al., 2007).

These findings indicate that the implications of social disparity contradict the supposed objectives of TOD strategies, resulting in significant social tensions such as gentrification and social segregation.

Gentrification is typically defined as the process in which the middle class displaces the low-income class, who are then compelled to relocate to the urban suburbs (Glass, 1964). It's an ongoing phenomenon occurring as urbanization and globalization progress, and driven by various factors. Recently, scholars have identified a pattern of gentrification in TOD communities. This new form not only can be driven by the classic triggers, but also exhibits the relationship between transit and demographic changes. Consequently, a new definition is formulated, which is known as ***Transit-induced Gentrification*** (TIG), to describe this particular type of gentrification based on the findings. As to the definition, it involves three dimensions: the demographic changes, commercial upgrading, and transfer behavior. In the context of demographic changes, it occurs in areas characterized by either new construction (direct displacement) or the redevelopment of existing urban fabrics. Following the development plan, the allocation of investment for urban revitalization and amenities for the middle class resulted in an increase in housing price and consumption standard. As a result, the local lower class was forced to relocate to other places (Chava J, 2016). Commercial upgrading refers to the process in which local, small, and independently-owned stores are replaced by newly-opened major chain stores or supermarkets which are located in busy transit zones (Lin & Yang, 2019). Transit behavior change refers to the displacement of low-income causes the reduction of transit users (Danyluk & Ley, 2007).

TIG is occurring worldwide. In the United States and Europe, scholars have already extensively studied the phenomenon, evaluating internal variables and external effects. While in the Global South countries such as China, India, and Brazil, the situations are different. The demands of urbanization and economic growth pushed a lot of TOD projects, but the study of social influences is less mentioned. Therefore, during the rapid development stage, although these countries have finished a large number of projects, the TIG research is still limited (Kahn, 2007). In recent years, due to the close communication of western world and urbanization has reached its end, Brazil and India have begun to confront the challenges associated with gentrification. Nevertheless, the research in East Asia, especially in Chinese cultural zones, is still undeveloped. The gap emerges from the different understandings of gentrification. Considering the high population density and outdated urban structure, the redevelopment is regarded as one of the best choices for urban regeneration. Thus, the gentrification which follows the redevelopment is considered as a neutral effect. As a result, the studies on gentrification have been long neglected (Ley & Teo, 2014). However, as one of the most important strategies for solving the population and urban growth challenges in Chinese megacities, the research of the social impacts of TOD should be considered as the same weight as to its design methodology under current background.

Regarding all the Chinese nations and territories in East Asia, Hong Kong stands out as the city that relies most on transit and has a long history of implementing TOD. Since the 1980s, Hong Kong has constructed TOD communities as part of its new town development projects. It has been conducted to improve the capacity to accommodate a growing population and address the challenges of urban expansion. During the development of the TOD concept, Hong Kong adopted its unique model known as the *"Rail plus Property (R+P)"* model. The R+P model establishes a distinct system in which railway transit should develop together with the real estate properties. The Mass Transit Railway (MTR) corporation, the major provider of the public transport network in Hong Kong, has the right to operate and supervise the investment of these projects. This model effectively achieves the objectives of TOD and is widely recognized as one of the most successful models globally. However, over the 30 years of implementation, these communities have exhibited signs of social inequity. High housing prices and cost make the city unfriendly to the low-income groups and limits their activity scopes. Song & Zhu (2010) summarizes the three particular gentrification processes in Hong Kong: (1) Downtown areas have not undergone significant decline, but instead are experiencing revitalization through infrastructure upgrades, and certain demographics are being displaced. (2) The development plan and markets are dominated by the local government. (3) Gentrification occurs as a result of urban renewal, where the process involves the replacement of social classes by establishing gated communities.

As mentioned before, Hong Kong has sufficient examples and practices to examine the occurrences and the impacts of TIG. In the meanwhile, the current existing studies of TIG in Hong Kong contexts are less to be found. Therefore, the thesis focuses on Hong Kong as the study background to examine TIG and tries to make an effort to fill the research gap.

1.2 Research Question

The thesis aims to address the main topic:

"***Is Transit-induced gentrification happening in the TOD neighborhoods in Hong Kong***?"

By structuring the topic, 3 related questions will be answered in the following sequence:

i. "*Has the construction of metro-related TOD caused neighborhood change?*"
ii. "*Does this change intensify the occurrence of transit-induced gentrification?*"
iii. "*How does the transit-induced gentrification reform the demographic and built form of the TOD neighborhood?"*

1.3 Outlines of the Thesis

The thesis has six chapters. Chapter I presents an overview of the study's background and the research questions. Chapter II goes into the details of TOD and TIG. Chapter III outlines the urban planning strategies and TOD models in Hong Kong. Chapter IV and V are connected chapters. Chapter IV clarifies the methodologies and introduces

the data which is used for analysis. Chapter V presents the findings and provides a brief summary of all these findings. Chapter VI offers the final conclusions and discusses the future work. The following paragraphs provide more in-depth explanations.:

Chapter I introduces an overview of the research background and clarifies the season of choosing this topic. Subsequently, this chapter points out the research questions for organizing the research.

Chapter II consists of three parts: the presentation of the TOD concept and examples, the explanation of gentrification and TIG. Firstly, this chapter addresses the TOD concept from its history, elevation in recent years, and three examples in Portland, Copenhagen, and Tokyo. Subsequently, it explains the concept of gentrification and how it relates to the topic of this research, Transit-induced Gentrification (TIG). TIG is a specific type of gentrification that is closely associated with transit systems, particularly in the neighborhoods that are designed as TOD.

Chapter III introduces the background of Hong Kong, which is famous for its massive transit system and the implementation of TOD. Lastly, the chapter provides the introduction of Hong Kong's urban planning process and the current research results of related topics.

Chapter IV describes the methodologies which are adopted to study the TIG conditions and its impacts on TOD neighborhoods. The methodologies can be categorized into three aspects: spatial analysis, demographic, housing affordability. The spatial analysis can present the urban growth and building types. The analysis of demographic changes is based on percentage change comparisons and index calculation. The housing affordability calculation can reflect the level of living costs for homebuyers and renters. The analysis can provide a general overview of the TIG impacts.

Chapter V follows closely with the methodologies. It provides a comprehensive overview of all the findings about the impacts of TIG in two TOD neighborhoods.

Chapter VI concludes all the results and highlights the important findings. Additionally, it discusses the limitations of the research and points out the future work of this topic.

1.4 Contributions

Gentrification is on the limits of the study of urbanism and sociology in Asian countries and territories. Also, the existing studies are mainly focusing on classic gentrifications. The thesis chooses transit-induced gentrification as the topic for filling the gap of the gentrification concept under east-Asia context. simultaneously, it's going to complete a small puzzle of the studies on the socio-economic impacts of TOD implementation. Finally, the research hopes to assist urban planners and managers in playing greater attention to societal equality and developing suitable strategies throughout urban TOD projects.

II. LITERATURE REVIEW

2.1 Transit-oriented Development

2.1.1 The History of Transit-oriented Development

Transit-oriented development (TOD) is a valuable model for balancing transportation and development. It has been extensively examined worldwide for decades and is recognized as a key feature of modern urban planning. The TOD concept seems like a brand-new concept to address the needs of urban development. However, it has evolved from the experience accumulated in design practice and the advancements in urban transportation methods. To provide an in-depth overview, this section will explain the historical development of TOD and its practices.

In the late 1980s, the United States experienced significant de-urbanization and urban crisis. Peter Calthorpe, an urbanist and architect, began imagining an urban planning model centered around transit and road networks. Later in 1993, he officially proposed this model as "*Transit-oriented Development*" in his publication "*The New American Metropolis*", which can be regarded as the first formal description of TOD. Although Calthorpe described the TOD as a design for transit-related communities, this concept can be traced back to Ebenezer Howard and his Garden City Movement in the early 20th century.

During the period between the 19th and 20th century, the classical architectural principles gave way to new concepts, one of which was the birth of Utopianism. Ebenezer Howard came up with an urban model known as the Garden City Movement that takes inspiration from Utopian ideas. His model aims to promote the development of towns surrounding the center city and establish a well-connected network of road networks. Garden cities consist of multiple satellite towns, central green spaces, and factories for production. In this model, Howard presented new principles for urban planning, especially focusing on city size, population density, and land use layout to improve the effectiveness of urban formation. The concept of the garden city offers an innovative viewpoint to the urban planners at that time. The constructions of Letchworth in 1903 and Wythenshawe in 1920 by Raymond Unwin and Barry Parker were two successful examples of the practices. These designers adopted Howard's concepts and effectively examined the feasibility of a transport-based city model. During this phase, urban growth typically occurs in the nearby areas of road networks and promotes the establishment of small residential clusters; therefore, this type of development model is categorized as "Development-oriented transit" (Dittmar & Ohland, 2003). This term implies the development is created by the land value capture actions from the landowners, rather than managing the urban development by providing transport infrastructures. Therefore, this approach was quickly replaced by new theories in the 1930s. With the rapid increase in private automobile ownership, the relation between transport and development has been overtaken by a new model known as

"Auto-oriented Transit" (Dittmar & Ohland, 2003).

From the 1940s to the 1980s, there was a great technical evolution in North America which brought the urban life into a new era. The advanced technology had a significant role in driving economic growth and promoting the construction of skyscrapers and transport infrastructures. The cars became a sign of fashion and modern life to present the social status. The car ownership in United States were more than any other countries in the world at that period. However, the widespread use of automobiles led to traffic congestion and environmental issues, also limited the growth of public transportation facilities. To solve the barriers, academics proposed new theories such as 10-minute walk circles, walkable road infrastructure, and environment-friendly actions, which were later incorporated into the TOD principles (Carlton, 2009). However, these approaches hadn't work effectively till F. Nickson became the president. Nickson's government recognized that the disorderly expansion and the environmental issues were dismembering American cities. In order to solve the problem of traffic congestion, the government brought measures to add the load of streetcars. As one of the outcomes, the Mass Rapid Transit (MRT) systems were introduced in the metropolitans in Bay area in the 1970s. This system is considered as the first massive transit project in United States. The projects are strategically situated in busy zones to attract commuters who rely on public transportation and provide spaces for drivers to park their vehicles. The implementation of the MRT system successfully decreased the number of vehicles in the city and encouraged the utilization of public transportation. However, it failed to revitalize the neighborhood as the vast parking area did not provide any revenues for the local government (Dittmar & Ohland, 2003).

From an economic aspect, transit has a significant influence on land prices. The accessibility is always a key factor for homebuyers seeking to invest in real estate. Thus, the appropriate actions that correspond to economic principles involve maximizing the utilization of the area surrounding the transportation system. Nevertheless, early MRT systems only allocated large areas for parking, resulting in a waste of land value. In the 1990s, transit agencies and local governments implemented new strategies to address this problem. They aimed to guarantee the land's value and implement specific land development plans for transit sites. Portland and Los Angeles were the pioneer cities where the government transformed parking lots into residential and offices. The success of this redesign has been proved by its ability to boost local revenue and improve the value of surrounding land, hence leading to better service quality and maintenance of local transportation. This joint development approach has been referred to as "Transit-related development". In the meanwhile, a new type of community design called "Urban Village" appeared, centered by the dense population and self-sustaining districts. Then, as it merged with the design of transit stations, it matured as the concept of "Transit Village". The primary objectives of the new concept are to strengthen the prosperity of the community and decrease reliance on automobiles. Furthermore, it has been proven that it efficiently reduces greenhouse gas emissions and other pollutants (Dittmar & Ohland, 2003). During this period, transit stations became closely

associated with land-use development. Calthorpe and his colleagues started to conceive innovative approaches to clarify this design concept: a high-density community design centered around transit stations, with diverse active commercial enterprises in the surroundings.

While working in the New Urbanism Congress, Calthorpe identified the shortcomings of previous urban models and developed the new design principles in his publication "*The Pedestrian Pocket Book*". The book highlights a mixed-use community located near the transit station. It also emphasizes the importance of pedestrian road network design and environmental actions. Nowadays, the model is considered as the prototype of the TOD in the micro scale (Carlton, 2009). The Pedestrian Pocket principle was famous for its adoptions in Portland and Sacramento in 1989. It was proved to fulfill the requirements of urban growth and wide adaptability in different metropolitans. After accumulating the practices and revisions, Calthorpe improved his concept and later completed the framework through collaboration with Professor Robert Cervero, eventually assigning the formal term of "Transit-oriented Development". And later, the principles are outlined in the book "*The Next American Metropolis*" by Calthorpe (1995):

- *Organize growth on a regional level to be compact and transit-supportive.*
- *Place commercial, housing, jobs, parks, and civic uses within walking distance of transit stops.*
- *Create pedestrian-friendly street networks that directly connect local destinations.*
- *Provide a mix of housing types, densities, and costs.*
- *Preserve sensitive habitats, riparian zones, and high-quality open space.*
- *Make public spaces the focus of building orientation and neighborhood activity.*
- *Encourage infill and redevelopment along transit corridors within existing neighborhoods.*

2.1.2 Definition of Transit-oriented Development

Calthrop defined TOD as "*A mixed-use community within an average 2,000-foot walking distance of a transit stop and core commercial area*" (Calthorpe, 1995). TOD aims to create a walkable, compact, and mixed-use community in the transit surroundings, which provides enough social housing, positive commercial, and environmentally friendly community. In this theoretical model, in order to reduce automobile ownership, it is crucial to ensure the destinations are in reasonable distance to the residents. Mixed land-use is another important factor for TOD, since the zoning plan contributes to sustain the economic growth and satisfy the daily requirements of residents. The TOD initially functions at the local level, but due to its dependence on transportation, the neighborhoods are naturally linked by transport infrastructures. Thus, the concept of TOD at the regional level was introduced. In the book "*The Regional City*" (Calthorpe & Fulton, 2013), Calthorpe proposed the concept of TOD at both the

city and regional scale. He stated a comprehensive TOD system that would connect metropolitan areas and their satellite cities through highway networks.

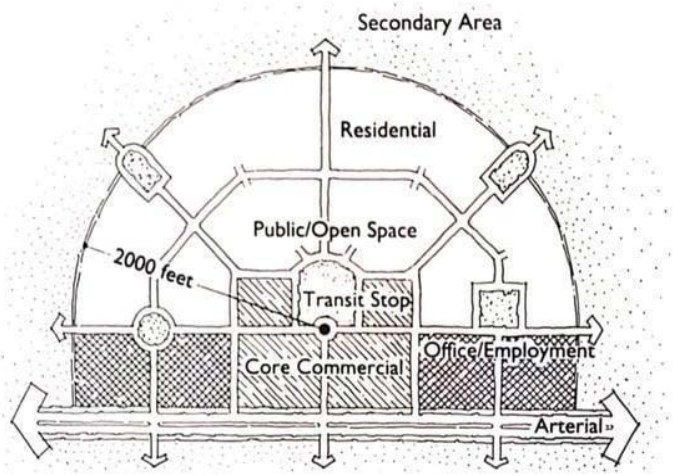


Figure 1 The concept of TOD
(Source: Peter Calthorpe, 1993)

Calthrop's definition leaves space for further interpretation. He outlined the desired outcomes and overall framework of the goal as *"identify the community buildings, and sustainable urban forms, suppurative policies, and public-private partnerships as the means to achieve the goals*" (Jamme et al., 2019). The essential principle inherits the concepts of the Pedestrian Pocket and the Transit Village, however due to the advancements in transport technology and population rapid growth, it became unable to meet the new demands. Therefore, the TOD concept experienced new interpretation in the twenty-first century. The new views can be broadly categorized into two directions: one direction focuses on providing distinct explanations for the outcomes of development (specifically in the real estate sector) and the processes involved in achieving sustainability. The other direction involves a debate on whether TOD should be considered as an urban planning strategy or as an architectural megastructure (Jamme et al., 2019). Current TOD differs from factors such as urban typology, community size, and the functions. Although there are no agreements on the new principles, the core concepts adhere to the classical ones. Typically, the TOD community consists of a central transit hub, public spaces, surrounding high-density mixed-use zones, and lower-density residentials on the edges. The places should be located within a radius of 500-800 meters and should provide pedestrian and cycling access to all destinations. The Institute for Transportation and Development Policy (ITDP) introduces the commonly defined TOD as:

"TOD is an answer to the unsustainable, car-dependent, and transit-poor urban sprawl that has characterized the growth of cities around the world in the last century. It also contrasts with transit-adjacent development that fails to foster the strong walking and cycling environment needed to complement and actively support the use of transit." (ITDP, 2017)

Contemporarily, TOD has surpassed its original purpose as a single urban planning

model, and has evolved into a comprehensive social and economic framework, shaped by governmental policies and financial restrictions. Moreover, The process of urban development has resulted in the widespread adoption of TOD because of the influence of globalization. TOD strategy has significantly contributed to the improvement of residents' traffic behavior and environmental strategies in many metropolitan areas (Thomas & Bertolini, 2020).

2.1.3 5D Principle

TOD offers an ideal framework for urban planners, defining the connection between the transport's accessibility and the quality of life for citizens. Many cities have experienced urban development in recent years, resulting in the presence of industrial or abandoned land. This results in a waste of land resources and a higher risk of neighborhood deterioration. Therefore, the design of TOD typically concentrates on developed fields or the outer boundaries of newly expanding urban areas (Calthorpe, 1995). Simultaneously, the key features of TOD require that such projects take the responsibility of reviving local economic activities and improving transportation quality. In 1997, Cervero and Kockelman (1997) introduced a 3D principle which is regarded as a conclusion of TOD principles. The 3D principle includes three aspects of *Density*, *Diversity*, and *Design*.

Density. The objective of density is to increase the resident population by offering more housing and a higher FAR in the transit station nearby. The larger number of residents can have access easily to transportation and social housing. As a result, the increase in residents can increase the public transport users and strengthen the local labor force. Meanwhile, efficient transit can decrease the possession of private automobiles which can benefit the environment and reduce road accidents.

Diversity. Diversity means the mixed land uses and the variety of destinations in the transit station. It plays an essential part in stimulating the local economy and providing services. Furthermore, the destinations like offices and social services concentrated in the transit area can reinforce the connection between the neighborhood and the whole city. Thus, the diversity in land use can be beneficial to prevent local degradation. Through the examinations, the researchers established a standard configuration for the mixed land-use, which made up four categories: residential occupies 50%-80%, commercial 10%-40%, and services and public space 10%-15%. This arrangement has been shown to create a self-sustaining community, where all destinations are reachable within a fifteen-minute radius (Kristianto et al., 2020).

Design. Design refers to constructing safe pedestrian road networks and improving the building environment. TOD aims to minimize automobile usage and promote public transportation such as transit, pedestrian, and cycling. Therefore, the design of suitable transport infrastructure is one of the major goals. Furthermore, the design of building and land use zoning can help capture the land value and improve the efficiency of transit.

In 2008, Cervero and Murakami introduced the 5D principle as an extension of the 3D principle. They added two more principles, namely ***Destination accessibility*** and ***Distance to transit***. The principle of Destination accessibility implies a system of convenient access to the destinations of residents within the TOD, as well as the accessibility to other TOD communities. It highlights the roles of urban TOD corridors and encourages the design of regional TOD plans. The principle of Distance to transit is considered as a supplement of the principle of Design. It signifies that the transport should be placed at the heart of the TOD, ensuring convenient accessibility for transit users.

There also have other extensive principles such as the five performance-based goals formulated by (Dittmar and Ohland in 2003: *Location efficiency, Rich mix of choice, Value capture, Place making, and Resolution of the tension between node and place*; eight TOD keywords summarized by ITDP (2017): *Walk, Cycle, Connect, Transit, Mix, Densify, Compact, and Shift*; and another additional principle for 5D framework by Ndebele and Ogra (2014): *Demand management through reduced parking near transit*. However, the 5D principle remains the most accepted framework in the current urban planning context. It covers the ongoing improvement of new TOD characteristics and the achievement of social needs.

2.1.4 Transit-oriented Development Typology

TOD serves for the purpose of creating an outstanding urban formation. However, different types of TOD exhibit different results according to the factors like the geographical location, services, and density. Therefore, in order to observe the outcomes and evaluate the effects of TOD implementation, it is important to categorize TOD based on distinct morphological and functional attributes (Su et al., 2021). Currently, the classification of TOD is operated in two approaches: the *Qualitative approach* and the *Quantitative approach*.

The ***Qualitative approach*** categorizes TOD typologies based on the target description. For example, when considering the geographical location of TOD, it can be categorized into *Inner city*, *Peri-urban*, and *Extended areas*. As well, when considering the type of land development, it can be classified as *Infill development*, *Redevelopment*, and *Greenfield development*. Likewise, the scale of the TOD can be divided into *Site level*, *Station level*, *Corridor level*, and *City-region level* (The World Bank & Global Platform for Sustainable Cities, 2018). In general, there is no definitive conclusion on the typology of TOD due to variations in urban contexts, planning frameworks, and development goals. The study of typology is different from institutions and schools based on the local TOD conditions. Calthorpe presented a typological analysis that classified two forms based on their location: *Metropolitan TOD* and *Neighborhood TOD*. The metropolitan TOD is classified as the community located close to major transit lines with high-density land uses, while the neighborhood TOD locates to streetcar stops on the urban edge. Dittmar further refined the classification method by considering the features of the metropolis. The different types of TODs were

categorized as *Urban downtown*, *Urban neighborhood*, *Suburban town center*, S*uburban neighborhood*, *Neighborhood transit zon*e, and *Commuter town*. This kind of TOD classification inspired other methods, Center for Transit-oriented Development (CTOD), a professional organization for promoting TOD strategies in North America, classified TOD in 2009 as eight types of typologies: *Regional center, Urban center, Suburban center, Transit center, urban neighborhood, Transit neighborhood, Special-use/Employment district, and Mixed-use corridor* (CTOD, 2009). This classification is widely recognized in North American and has been further extended to other countries.

The ***Quantitative approach*** relies on a set of indicators to accomplish the segmentation of TOD typology. This approach is mainly based on a *Node-place* model which was established by Bertolini in 1999. The Node-place model utilizes the y-axis to represent transportation, which is referred to as "Node", and the x-axis to represent urban structure, which is referred to as "Place". The conditions of TOD can be described using five indicators: *Unsustained Node*, *Stress, Balance*, *Dependency*, and *Unsustained Place*. In the schema, land use and transport are interrelated and influenced by five indicators. For instance, land use and transport will experience significant development in the Stress category, but will have limited progress in the Dependency category. According to Figure 2, the balanced node will remain in the central Accessibility line, while the clusters located in the upper left and lower right are considered unbalanced nodes. The "node-place" model, which has been suggested for over two decades, has certain limitations. However, researchers have made advancements by developing hierarchical, two-step, and latent class clustering techniques to provide a full description of the model (Phani Kumar et al., 2020). By applying empirical methodologies and scientific research, the images produced by this approach clearly reflect the performance of TODs, allowing for quantitative comparisons across all case studies.

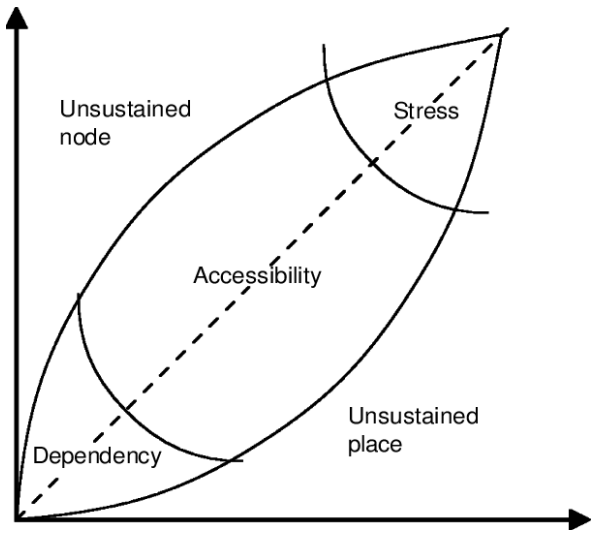


Figure 2 The "Node-Place" Model
(Source: Luca Bertolini, 1999)

An example of a *Quantitative approach* is the case study of TOD in Washington State. The research categorizes local institutions into five distinct types: *Core, Center, Village, Commuter, and Destination*. The typologies are classified by indicators such as employment, housing density, and transit quality. In the Node-Place model, the location of the TODs performance in the schema is influenced by all the metrics. The Core TOD is located downtown with a high zoning capacity; it also has good accessibility to facilities and more than two high-capacity transit nodes. The Center TOD provides job opportunities and allows for different destinations. It has sufficient zoning capacity and is served by at least two modes of long-term transit service. The Village TOD is a compact small community that maintains sufficient transportation infrastructure to support essential services. The Commuter TOD is separated out of the metropolitan area and serves as key nodes along the network corridor. The Destination TOD is a community with special features such as airports, universities, and stadiums (Nikolic et al., 2009).

2.1.5 Outcomes of Transit-oriented Development

As mentioned earlier, the 5D principle can also be used as guidelines for evaluating TOD outcomes, but it is still worth examining their local effects. Gomez (2019) has categorized the evaluation of TOD outcomes in Malaysia into three dimensions: environmental, economic, and social. The research highlights the positive influence of TOD on improving the environment quality, revitalizing the economy, and promoting social equity (Gomez et al., 2019).

Knowles and Ferbrache (2019) provided a comprehensive case study by analyzing the TOD projects in three major cities in the United States: *Salesforce Transit Center* in San Francisco, *Washington Union Station* in Washington, and *Miami Central Project* in Miami. From the building environment perspective, the TOD achieves 3 results: (1) increasing public green spaces and reshaping community quality, (2) improving the accessibility and safety of public transportation, and (3) implementing environmental adaptation measures in the central urban area. From the economic perspective, TOD brings 3 changes: (1) enhancing the capacity of urban centers, (2) establishing multi-center development corridors, and (3) thriving economic growth to generate employment opportunities and attract additional residents. From the society perspective, the TOD management and investment system promotes collaboration across various government departments as well as between the public and private sectors. This leads to the establishment of a stable power structure and decision-making mechanism (R. Knowles & Ferbrache, 2019).

Overall, TOD offers significant benefits to the entire city, as it combines convenient mobility with a reliable economic development strategy, resulting in an important contribution to urban regeneration.

2.1.6 Transit-oriented Development in Global North

In the context of globalization, the flow of technology and capital has accelerated, leading to concentration of population in cities that are rich in resources, resulting in the formation of megacities. Due to the rapid population growth, the existing urban infrastructure is insufficient to accommodate the increasing needs. As a result, TOD has come up as a solution, leading to the development of multiple TOD planning models based on local policies, culture, economy, and geography (Cervero, 2009). Based on statistical research, the United Nations Conference on Trade and Development (UNCTAD) categorizes countries into the Global North and Global South. These classifications are based on varying levels of economic development, income inequality, and democracy[1]. The TOD strategies show different formations in countries due to the different economic development stages. Global South countries like India, China, and Brazil are still seeking to appreciate TOD models to solve local challenges. These countries consistently confront barriers such as low income and high population, which consequently constrain urban development. Therefore, these countries are still at the beginning stage of TOD. However, countries in the Global North countries have already proven the great success in TOD strategies in their long implementation history. In this section, the United States, Denmark, and Japan are selected as examples to demonstrate the framework of TOD.

The United States is the region with the highest reliance on private vehicles in the world, but successful TOD implementation can still be found in metropolitans. Since 1993, TOD strategies have been widely used in the urban planning of American cities. These projects have effectively contributed to the regulation of private car usage, reduction of environmental pollution, and alleviation of traffic congestion. According to an official survey in 2007 (Poticha S, 2008), there are over two hundred TOD projects in North America, including both the United States and Canada. Additionally, four hundred cities have intentions to implement TOD plans. Therefore, as a city with a long TOD implementation history, Portland can be regarded as a good example. In 1997, a government agency called Metro's Transit-oriented Development Program (MTODP) was founded to response to the design and management of TOD. As a regional heavy industrial center, Portland always faces the problems of increasing transport requirements, large number of private vehicles and green gas emission. Therefore, the solution of TOD projects in Portland is centering with the light and heavy railroad transits to form the mixed-use neighborhoods. The rail-related TOD projects not only connect the city, but also create a regional TOD corridor to link other cities. In 2020, MTODP with the support from Dill and McNeil, conducted research to provide a comprehensive overview of the transformative effect of TOD on the whole Portland throughout the preceding twenty years. The research emphasizes the general decline in private car ownership in Portland and a notable rise in the usages of public transportation (Dill & McNeil, 2020).

[1] *Source:* https://unctadstat.unctad.org/EN/Classifications.html

Europe also has a matured TOD planning framework, the La Defense TOD project in Paris and King's Cross Station project in London are well known for their success in the improvement at station scale. Whereas, Scandinavian countries are considered as the pioneers in the urban scale TOD. The famous Copenhagen Finger Plan (*Egnsplan*) was proposed in 1947 and continues to serve as a regional long-term plan today. Five corridors are designed to link all the communities in the metropolitan area. Copenhagen, as an important port city with a large resident population, has a close connection between its urban growth and transportation.

In 1990, the implementation of a suburban rail system led to the launch of four projects to improve the urban functional zoning and the construct of the residential communities: (1) *Redevelopment of Copenhagen Harbourfront;* (2) *Orestad new town, Metro and Development Corporation;* (3) *Oresund fixed road and rail link to Malmo and southern Sweden;* (4) *Cultural capital of Europe 1996.* In 2020, the use of safe street designs and cycling lanes during urban renewal projects significantly enhanced the sustainability of transportation for urban residents, while also bringing about a transformation in the original urban landscape. The case of Copenhagen shows TOD strategies typically involves a broad regional planning approach and a long term of design phase. Furthermore, its emphasis on promoting transportation connection and focusing on the sustainability and safety of transportation (Knowles R., 2012).

Japan establishes its TOD systems under the influence of its special transport model. Tokyo is a large metropolitan area, characterized by an extensive railway network and a significant quantity of transit stations. During the 1960s to 1970s, Japan experienced a period of significant economic growth. Due to the significant accumulation of wealth and population, Tokyo experienced rapid growth and transformed into a megacity. In response to the immense traffic congestion, the local government authorized the development of the Shinkansen and Tokyo Metropolitan Loop (Yamanote Line) train network to lighten the transportation burden. However, the massive railway network caused challenges in maintenance. To solve the problems, the government implemented a system where private railway businesses would assist in managing the public railways. This led to the birth of a distinctive railway operating model: state-owned railways responsible for urban development and private railway enterprises responsible for suburban development. Private railway firms, operating under a for-profit basis, started developing the areas surrounding transit stations to maximize their earnings. In Japan, this approach is referred to as the Japanese business model. It is characterized by a collaborative operational framework involving both the public and private sectors. Public institutions are responsible for managing and devising growth strategies, while private corporations oversee regional development and the maintenance of transportation routes (Yajima et al., 2019).

2.1.7 Challenges of Transit-oriented Development

Land development projects always relate to the changes in land ownership, restoration of the existing urban structure, and influence on the original residents. TOD, being a development strategy, also links with the destruction and reconstruction of the building environment and relationships. The fast expansion of megacities has resulted in various aspects that need to be considered during the redevelopment of transit station areas. These aspects include geographical location, involvement of different stakeholders, inadequate or overwhelmed use of infrastructure, and government political support. From a macroscopic aspect, TOD is considered as an urban redevelopment strategy with a large number of policy-relevant frameworks and economic compensation mechanisms. From a microscopic aspect, TOD offers an environmentally-friendly and economically beneficial development approach. However, despite its advantages, it is important to note that TOD is not without shortcomings as it is influenced by the strong agglomeration effect of megacities on population and resources. This leads to higher pressures on public transport and maintenance, as well as the displacement or eviction of original residents (Yajima et al., 2019). Therefore, the focus of TOD research is increasingly shifting from improving TOD facilities to investigating the social impacts. The book "*Transforming Cities with Transit*" (Suzuki et al., 2013) provides a comprehensive summary of seven challenges at the current stage:

(1) ***The urgency of short-term demands overriding long-term visions.*** The process of TOD planning, from initial environmental impact assessment to final construction completion, typically lasts several years or even decades. However, the change of local government occurs within a maximum of five years. Therefore, for policymakers, the implementation of short-term goals such as urban greenery and travel subsidies can please voters better than road construction or land redevelopment. Meanwhile, the government's fiscal condition also influences the implementation process. This is because the construction of transportation infrastructure and land development require long-term investments to achieve the desired objectives. However, the funds of local governments are typically already allocated to various civic projects, leaving little available for TOD initiatives. Thus, on the local level, short-term projects are always more appreciated than long-term projects. This factor represents an important influence on TOD at the top of the local power structure because the approval and construction of TOD highly rely on government support and investments.

(2) ***Fragmented institutional frameworks.*** In urban and regional planning, regional governments and local governments are the main executors. Regional governments are responsible for comprehensive strategic plans and setting objectives, as well as providing financial support. On the contrary, local governments are charged with executing specific planning methods. However, the functions of government are related to local traditions and political structures. Since the promotion of governmental transparency and flattening political structure, the TOD planning process is under public supervision and has to involve variable entities. It results in the division of power

and decision-making. Implementing a comprehensive development plan like TOD requires collaboration between transportation planning agencies and urban planning departments. However, the process is obstructed by the power struggle and conflicting interests among these departments. This situation increases the duration and financial burdens of TOD implementation, making achieving the desired goals more challenging.

(3) ***Regulatory constraints.*** Regional development and scientific planning can promote the utilization of urban land and improve the living standards of urban residents. Therefore, good management and regulation may reduce informal urban development. However, in the case of many emerging nations, the rapid expansion of urban areas has made traditional management techniques inadequate. Certain local policies have led to conflicts on both undersupply and overstock in specific land-use zoning areas. The local governors prefer to build new facilities in service-intensive city centers rather than develop the suburban areas. This action causes the decrease in public space and the concentration of urban population, which results in greater inequality in resources and social services. Furthermore, the rough urban planning methods worsen the unequal development.

(4) ***Financial constraints.*** As mentioned earlier, the construction of stations and infrastructures is a long term and low return work for the local governments. It requires a large amount of investment to operate and maintain, but the transit agencies normally impossible to cover all the cost. Thus, the development of the surroundings near the transit stations can be a solution to compensate.

(5) ***Neglected urban design at the neighborhood and street level.*** Commuters in megacities often spend long travel time in public transport and stations. Therefore, providing better traffic conditions and more comfortable rest areas can take care of commuters' well-being. However, in most of the megacities, authorities always focus more on design TOD but neglect the neighborhood and transit corridors.

(6) ***Retrofitting problem.*** The retrofitting in TODs has social and economic impacts. One major challenge is the fragmented ownership of land, which makes it difficult to establish a united committee to facilitate the transfer of land ownership and the modification of land use. The complicated ownership arrangement severely limits the government's authority in overseeing land use management and retrofitting. Yet, the retrofit projects may cause inconvenience to the users and displeasure vested interest groups. The negative impact is varied, the users have to move to other places to use public transportation, while retailers who run businesses in the transit station have to leave.

(7) ***The power of vested interests.*** The implementation of TOD has a significant impact on the local business and housing value. Thus, the stakeholders who are going to lose their advantages may reject the TOD proposal. On the contrary, those who may gain benefits are likely to support the implementation. Primarily, TOD can accelerate the increase of housing value. High housing prices may lead to high financial pressure

for the tenants and homebuyers, but the landowners are willing to accept the results. Furthermore, TOD projects include large indoor commercials, which can impact the original business activities. Lastly, the low-income in the area may lose their position in the neighborhood due to the housing prices. As the low-income moves out, the rich class moves in, later forming the gentrification in the transit community (Suzuki et al., 2013).

The seven challenges indicate the obstacles of TOD. Currently, the study has reached an advanced level in design methodology, but it is still insufficient in researching social equity. Thus, the thesis focuses on a special type of gentrification in TOD communities.

2.2 Transit-induced Gentrification

2.2.1 Definition of Gentrification

Gentrification refers to a process of neighborhood change that involves both neighborhood renewal and displacement of residents (Marcuse, 1985). It's a complicated phenomenon that includes economic, cultural, political, social, and institutional aspects. It also manifests the income, education, and professional skills of the local population, as well as in the dynamics of the real estate market. Although there are different views among scholars, the current agreement is that gentrification has negative impacts, such as the displacement of residents, a decline of social housing, and an increase in costs of social amenities. These effects may lead to social segregation and neighborhood deterioration (Jones & Ley, 2016). Gentrification, as a result of capital investment and urban regeneration, has been extensively studied by urban planners and sociologists over the past years. This phenomenon has significant impacts for social equity during the process of urbanization.

In 1964, Ruth Glass defined the term "Gentrification" to describe the process of the wealthy replacing the working classes in the downtown of London. It is characterized by the displacement process of the working class or minority group, who are forced to relocate to suburban areas or other declining communities:

"*One by one, many of the working-class quarters of London have been invaded by the middle classes – upper and lower… once this process of 'gentrification' starts in a district it goes on rapidly until all or most of the original working-class occupies are displaced and the whole social character of the district is changed*." (Glass, 1964)

The classic theory of gentrification was studies during the redevelopment of historical blocks in London in the mid-20th century. The massive urban redevelopment resulted in the reconstruction process of the new skyscrapers and housing clusters in the history center. This redevelopment approach was criticized by architects and sociologists. Therefore, Glass's theory was based on summarizing these critiques of the changing in Anglo-Saxon cities. It points to the unfair process to the low-income population and the reshape of the sense of the neighborhood. However, current gentrification theory has

gone beyond local redevelopment. It also includes the driven of economic growth, which aims to lead the local policies towards financialization.

In the market-driven economy, capital always seeks to maximize the profits. This trend can be observed in the urban development process. A development plan always involves the construction or renovation of the buildings and transports, which may create huge profits for the whole interest chain. But its potential can be influenced by its geographical location, innovative approaches, and consumers. Therefore, considering the return-on-investment rate, the investors always first choose the place which has excellent transport and facilities. This preference promotes the birth of the Central Business District (CBD) concept, a well-developed commercial zone in the center urban area. In the meanwhile, the macroeconomic behavior also reflects in individual behavior. Among all the factors which can attract the people to settle down, the centrality and accessibility typically are the first consideration (Smith, 1987). Thus, the economic impacts and individual behavior result in the uneven development and centralization in the urban fabric, which boost the emergence of gentrification. Neil Smith developed a new definition of gentrification which links the classic theory to the economic behavior:

"*Gentrification, the reinvestment of capital at the urban center, which is designed to produce space for a more affluent class of people than currently occupies that space. The term, coined by Ruth Class in 1964, has mostly been used to describe the residential aspects of this process but this is changing, as gentrification itself evolves.*" (Hackworth & Smith, 2000)

Urban redevelopment has the potential to significantly increase land value as well as improve the quality of nearby amenities, thereby increasing the expectations of individual landowners on the price of their land. This expectation reflects on the sell price or rentals on the future land users. The rapid increase in land prices creates a rent gap between the actual property value and the expected value perceived by property owners. Through the process of redevelopment, the surrounding buildings and environment contribute to the increase of land value. Consequently, the housing costs in the real estate market might become excessively high, finally forcing the original tenants to relocate to affordable areas (Smith, 1987).

Based on the new factors to influence the emergence of gentrification, the research has focused on the Global North in the past decades. Davidson and Lees (2005) illustrate four key factors of current gentrification by using the case study of London riverside. These include: (1) *reinvestment of capital*, (2) *landscape change*, (3) *the social upgrading by an influx of high-income groups*, and (4) *direct or indirect displacement of low-income groups*. It reveals the impact of gentrification on redevelopment projects in developed countries. However, the impacts in Global South countries are more complex. The process of international communication has facilitated the concentration of income and people in megacities such as Bangalore and Bangkok, leading to the emergence of new urban middle class. In order to meet the demands of the wealthy

class, urban managers have accelerated the urban renewal process, hence fostering the rise of mega-gentrification (Lees et al., 2016). At the same time, during the process of capital scaling up, international groups have the opportunity to engage in the decision-making process of local government. These informal behaviors have led to the formation of interest groups that are united by governments and commercial entities, resulting in the economic-oriented city development strategy (Shin & Lopez-Morales, 2019).

As mentioned before, gentrification has become a more complex phenomenon over time. The current stage differs significantly from the mid-twentieth century. Hackworth and Smith (2000) have drawn up a timeline that categorizes gentrification into three phases. The first wave began from the 1950s to 1973, characterized by the reinvestment in urban centers in the United States and European countries. This redevelopment was facilitated by government policies and expected to mitigate the impact of the pressure of the global recession. The second wave occurred during the 1970s to 1980s, as high-paying occupations started to concentrate in global metropolitans and gentrification became increasingly connected to the real estate and financial institutions of the global system. The third wave, which emerged in the mid-1990s, is characterized by its complete dominance by financial circumstances. The extensive partnership between major capital and local governments has fundamentally altered the functioning of real estate markets, leading to the expansion of gentrification beyond city centers to encompass suburban and rural areas.

Lees et al (2008) provides an addition for the fourth wave, in which the main focus of neighborhood transformation has shifted from the middle class to global capital. However, as globalization continues to impact the real estate markets, the fifth wave of gentrification has arrived. The term “fifth wave”, as introduced by (Aalbers, 2019), refers to the period from 2010 to 2020 in the United States. It describes the strong correlation between gentrification and the financialization of housing. Currently, the investment of a house has beyond its actual value for living, leading to a significant number of properties being utilized as a means of preserving asset value, resulting in the rise to a property bubble (Hyra et al., 2020).

In the current context, Glass's traditional theory of gentrification is inadequate to explain the current worldwide phenomenon of gentrification, which has surpassed the simple patterns of residents moving in and out. Lees and Phillips (2018) categorize gentrifications into seven types: (1) *Slum gentrification*, (2) *New-build gentrification*, (3) *Social housing gentrification*, (4) *Tourism gentrification*, (5) *Retail (commercial) gentrification*, (6) *Urban environmental gentrification*, (7) *Wildness (rural) gentrification*. These branches demonstrate different forms of gentrification within distinct economic, geographic, political, and cultural conditions. They indicate that gentrification's impact on social equity is comprehensive, involving features such as the residential living environment and the availability of public facilities.

2.2.2 Gentrification and Public Transport

Convenient transportation is one of the significant factors that affects urban development. An efficient road network can create favorable conditions for economic movement, encouraging the export of urban productions and the import of essential commodities. Therefore, within the context of globalization, the first cities that gain advantages are the ones situated on the coastline. The advancements in transportation technology have led to the efficient development of inland connections. As the implementation of transportation-related planning strategies, a special phenomenon has been noticed by the scholars: the rapid increase in housing prices in transit station surroundings. LeRoy and Sonstelie (1983) first proposed the correlation between transit stations and gentrification, asserting the phenomenon may challenge the future urban development.

In the twentieth century, researches have shown that changes in land values are strongly correlated with the construction of transportation infrastructure. McDougall et al. (2023) discussed the fact that within the political framework and neoclassical approaches, transit has been used as a tool to stimulate economic growth and generate different impacts on housing prices along the transit. However, the high housing price drives the low-income groups to relocate far away from the transport infrastructures, leading to the unbalanced distribution of public resources.

The objective of public transportation is to build a link between urban facilities and their users, ensuring fast and efficient transit. However, recent research has indicated that the construction of public transportation infrastructure may lead to the occurrence of gentrification in neighborhoods. The purpose of new transit systems is to provide public services, but these projects have influences on the land values. Despite the expansion of the urban transportation infrastructure can increase the mobility of the entire city, the improvements will not benefit low-income people. Instead, these groups may be forced to relocate to more remote areas, resulting in gentrification driven by transportation. Ostrensky et al. (2022) studied the tendency of newly constructed metro stations in São Paulo to induce gentrification in surrounding areas. The findings reveal that the new stations associated with an upward trend between the average income of residents and the ratio of apartments to households. Also, Jackson and Buckman (2020) examined the impact of LRT stations on the Evans station neighborhood in Denver. They discovered that the presence of new stations leads to an increase in young professionals moving into the area and changes in housing features. These changes eventually result in visible stages of gentrification. Superficially, this phenomenon of transit-related gentrification presents a threat to equal access to public services. Essentially, it reflects the features from both residential and commercial gentrification: the unaffordability and decay of social housing, and the replacement of small retails.

2.2.3 Transit-induced Gentrification Concept

The past two decades have witnessed the growth of TOD in the cities around the world and its contribution to reducing automobile reliance. As an urban planning model and policy framework, TOD aims to encourage the use of public transportation and pedestrian-friendly street design, while focusing on neighborhood redevelopment. It makes neighborhoods more attractive and accessible through renovating old buildings, restoring urban landscapes, and providing social housing (CTOD, 2009). In the meanwhile, TOD impacts the land value significantly.

Haas et al. (2016) refer to the location-efficient neighborhoods as the areas with least transportation consumption and highest accessibility. Typically, these communities are occupied by low-income households and minorities who could not afford living in urban centers. However, during the urban redevelopment process, the location-efficient neighborhoods are often chosen as areas for TOD implementation. Later, as the immigration of the middle class, the low-income groups are forced to move to other places. The essence of this phenomenon is that the construction of TOD attracts the middle class to move in, resulting in the original poor people to be displaced.

Although the topic of gentrification has been a topic of discussion for many years, the relationship between TOD and gentrification started to gain attention from scholars in the year 2000. Kahn (2007) studied gentrification in TOD in fourteen United States cities. Jackson and Buckman (2020) researched how TOD shapes neighborhoods in Denver. Chen et al. (2023) learned the relationship between public transit and gentrification in New York. However, there was no formal term for the phenomenon. The researchers titled as *Transit-induced Gentrification* (Dawkins & Moeckel, 2016), *Transit-related Gentrification* (Deka, 2017), *TOD-induced Gentrification* (Sandoval, 2021), or *Transited-oriented Gentrification* (Chatman et al., 2019), etc.

Currently, with the deeper research on the new topic, *Transit-induced Gentrification* (TIG) has been widely recognized by urban planners and adopt the definition from Dawkins as:

"*The phenomenon that occurs when transit proximity is capitalized into TOD housing prices, resulting in higher income households outbidding lower income households for housing in transit-proximate locations.*"(Dawkins & Moeckel, 2016)

TIG affects TOD neighborhoods in two perspectives: S*ocial impacts* and *Travel Behavioral impacts*. The social impact reflects in replacing the original demographic structure and creates public transit inequalities. The fundamental forms of traditional gentrification are the influx of wealthy people and the eviction of low-income populations. This impact also results in the improvement of local business and the rise of life expanse. TOD is founded on the idea of promoting increased use of public transportation. Research has demonstrated that TOD can indeed lead to reduced travel times and improved access to destinations (Hidalgo & Yepes, 2005). However,

households with low incomes face financial constraints that limit their ability to spend on transportation. Consequently, even if they stay in a TOD area, their limited resources restrict the number of trips they can make, resulting in a lack of accessibility. Also, high housing prices in TOD takes away from poor households' expenditures, creating struggles between housing and transportation.

TOD aims to reduce the usage of private cars and promote public transport, however, TIG may restrain the results. As the demographic structure changes in TOD neighborhoods, the transit users may decrease due to the low-income population moving out. (Su et al., 2021) and Dong (2017) both predict an extreme scenario in the gentrified TOD community: middle class households still use private automobiles, while low-income households cannot afford trips with public transport as much as they want.

Moreover, the results of researching whether low-income people move out of the TOD neighborhood are mixed (Dong, 2017). In certain situations, the limited choice of social housing units prevents the mobility of low-income populations. When TIG occurs, these households will have two choices: (1) to move away because the high housing prices are unaffordable; and (2) to accept the high housing prices but reduce other budgets. However, even if they stay in the TOD areas, they cannot enjoy the benefits due to the high cost of living (Kim, 2021).

The discussion of TIG is centered around the practices of TOD, which is an emerging issue. The current findings in TIG typically give different findings, mostly due to variations in the measures and indicators used. The next section will present various approaches employed in research studies.

2.2.4 Measurements of Transit-induced Gentrification

Gentrification is a dynamic process characterized by changes in the demographic and socioeconomic status of a neighborhood, where wealthy people move in and low-income people move out.

Atkinson (2000) outlined the relationship between redevelopment and demographic change in London. This relation is mainly affected by differences in the economic conditions of households. Atkinson selected seven variables, namely *working class, unskilled labor, households privately renting, ethnicity, unemployed, elderly*, and *lone parent*, to assess the presence of gentrification in a specific location. In later studies, scholars have devised their own sets of metrics to measure gentrification, drawing from Atkinson's seven variables. Landis (2016) categorizes the variables into 4 categories for measuring the changes: (1) *aggregate sociodemographic and economic characteristic of neighborhood residents*; (2) *physical, occupancy, and financial characteristics of the building stock*; (3) *specific number and characteristics of the move-in population*; and (4*) investment into and out of neighborhoods*.

However, in contrast with traditional gentrification, TIG is a complex phenomenon that isn't just driven by physical and economic factors, but also shaped by political, social, and individual considerations. Therefore, recent study emphasizes the examination of TIG should propose including of multiple dimensions, such as transportation and accessibility, to fully evaluate the situation. The physical aspect of TIG can be measured in multiple ways under different conditions. On one side, different spatial locations create distinct TIG outcomes. For example, TIG impacts urban TOD communities stronger than on suburban communities. On the other side, the construction period of TOD can influence the findings. Since TIG occurs in a certain time interval, it's not appropriate to use either a new constructing TOD or a long-standing constructed TOD as samples.

In light of the varying methodology and indicators employed in TIG studies, this thesis has selected thirteen current articles to sum up the key elements of case studies, data collection, primary approaches, and study findings (Table 1). Within this collection of papers, ten out of the thirteen cases specifically examine countries in the Global North. This indicates that research on the current TIG is predominantly focused on developed countries. However, it is important to note that this selection bias may be attributed to the fact that TIG is more readily observed within a timeframe of eight to ten years following the implementation of TOD. In addition, developed countries typically have an immense amount of open data that can be utilized for research purposes. Still, some studies have demonstrated that TOD in the developing countries has already generated TIG characteristics (Ostrensky et al., 2022).

Different methodologies determine the frameworks and results of a study, there are two methodologies most commonly used in the papers: Different-in-Different (DID) Approach and Regression Model. The Different-in-Different approach is a specific sort of Quasi-experiment analysis that involves comparing changes in a set of variables between a "Treatment" group and a "Control" group. The viability of the approach is dependent on the definition of the control group and the selection of variables (Padeiro et al., 2019). The Regression Model offers a mathematical model that explains the relation between one or more independent variables and one or more dependent variables.

The findings of the papers are mixed, Dong (2017) and Kim (2021) discover no noticeable demographic changes and housing affordability decline, but the rest of the studies clearly indicate the presence of TIG features. Most of the findings result in the reduction of the low-income population and the improvement of resident quality. Furthermore, in the case study of the cities in the United States reveal the most social inequity in different ethnicities.

Table 1 The summary of 13 related papers

Author (year)	Study area	Topic	Type of TOD	Data/sample	Key Method	Result
V.P. Ostrensky et al. (2022)	San Paolo, Brazil	Public transport and gentrification	MRT (new station)	National census 1991, 2000, 2010	DID	Results show income and apartment numbers increase but no evidence for population immigration
Y. Chen et al. (2023)	New York-Northern New-Jersey-Long island (U.S.)	Public transport and gentrification	All Transit stations	American Community Survey (ACS); General Transit Feed Specification (GTFS); open street map; 2014 U.S. Geological Survey	Statistical description, regression	Results prove the significance of transit in gentrification progress
D. Will (2012)	Los Angeles (U.S.)	Transit station area residents travel behavior	MRT	1990,2000,2010 censuses; 2006-2010 ACS	Regression model	Results show many transit stations have gentrified in 2 decades, and did lose transit riders and gain drivers
J. Lin et al. (2021)	Tokyo (Japan)	Transit-induced gentrification	MRT	Census 1970, 1980, 1990 2000, 2010	Regression model and DID	TIG occurs in long-term experience, and increases in MRT station density over time
H. Dong (2017)	Portland (U.S.)	Transit-induced gentrification with affordability	Suburban rail transit	Census 1990,2000; ACS 2005-2009; ACS 20110-2014	Longitudinal quasi-experimental design and DID	Results did not show TIG in suburban, neither show transit reduce home affordability
S. Kim (2020)	Phoenix (U.S.)	TOD and affordability	LRTOD	Location affordability index (LAI) data, census 2000	DID	TOD increased residential costs but balance with increased income and reduction of transportation costs, and make neighborhoods more affordable
S. He et al. (2021)	Hong Kong (China)	TIG and sense of community	MRT	Census 2016; telephone-based survey (424 samples)	DID	Results show existing MRT did not determine residential mobility
D.M. Baker and B. Lee (2017)	14 Urbanized areas (U.S.)	TIG	LRT	2010 census from LTDB and NUCA; public transportation data from NHGIS	Spatial regression model	Mixed results show the impacts of LRT depend on local and regional contexts and planning efforts
Y. Qi (2023)	14 metropolitan areas (U.S.)	TIG and neighborhood upgrading	Rail and BRT	Census short term (2000-2010); long term (2000-2016)	DID	Rail is more likely to induce gentrification than BRT
L. Cao et al. (2022)	Hong Kong (China)	Rail TIG	MTR	Census 2001 and 2006	DID	MTR development led to increase and influx of high levels of education and decline and outflux of low-income population
J. Roberts et al (2020)	Prince George's County (U.S.)	TIG	LRT	Questionnaire	Statistical analysis	TIG upscales nearby neighborhood and displacement and impacts health outcomes
S. Jackson and J. Buckman (2020)	Evans station, Denver (U.S.)	Light rail development and gentrification	LRT	Questionnaire and ACS 2000-2015	Statistical analysis	Evans station may not be the catalyst of gentrification but still brings feelings of gentrification to settlers
W. Dominie (2012)	Los Angeles (U.S.)	Transit station, travel behavior, and gentrification	Rail stations	ACS 2006-2010; 1990, 2000, and 2010 decennial censuses; 2010 census tract relationship files; census transportation planning package	Regression model and indexes calculation	Many of the stations gentrified and lost transit users

III. BACKGROUND OF HONG KONG

3.1 Introduction of Hong Kong

3.1.1 Overview of the City

As a special administrative region (SAR) of China, Hong Kong is one of the famous international financial centers and commercial ports in the world. With a nominal GDP of around 353 billion U.S. dollars, it ranks as the 35th largest economy. Since 1841, Hong Kong has been under British colonization, resulting in the adoption of British ideas for urban development by the colony government. In 1997, the governance of Hong Kong was passed to the People's Republic of China, a process known as the 1997 Hong Kong handover. However, Hong Kong retained its autonomy under the "*One country, Two systems*" policy. Consequently, the administration of the Hong Kong Special Administrative Region (HKSAR) maintains a parliamentary system and upholds a free-market economy, which sets it apart from mainland China. As a result, although the government has absorbed many Chinese political characters in recent years, the British political tradition is still influencing the administration mechanism.

Hong Kong is situated on the Pearl River Delta in Southern China. It is surrounded by the South China Sea and consists of Kowloon Peninsula, Hong Kong Island, and several small islands. The overall land area measures 1,114 square kilometers, with 280 square kilometers designated as developed land. The entire territory has a population density of almost 26,700 individuals per square kilometer, making it one of the most densely populated cities globally. Hong Kong is regarded as a highly developed autonomy due to its status as a metropolis with the highest per capita earnings and the largest number of skyscrapers in the world. The city is renowned for being the most public transport-friendly city, holding the largest transit ridership of 4.7 million daily trips. Additionally, it has the lowest car ownership rate, with only 105.6 private vehicles per 1000 people[2].

[2] *Source: Census and Statistics Department: https://www.censtatd.gov.hk/en/*

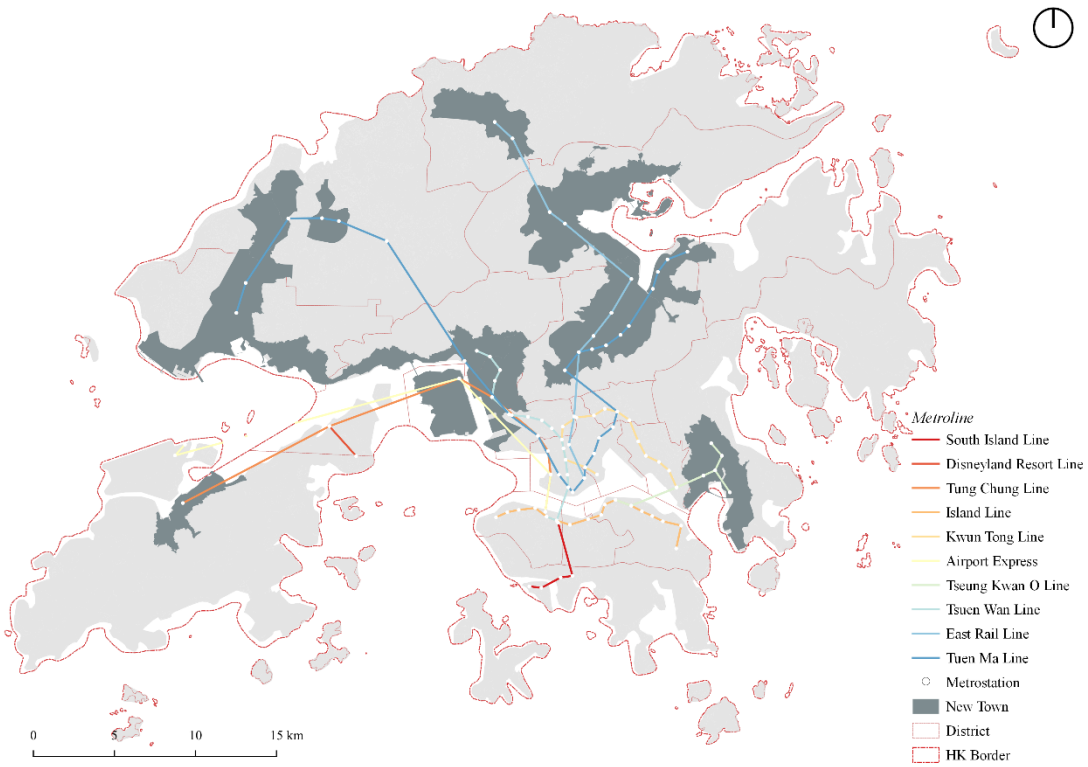


Figure 3 Hong Kong Territory and new towns
(Source: Made by author by ArcGis, data from Common Spatial Data Infrastructure Portal)

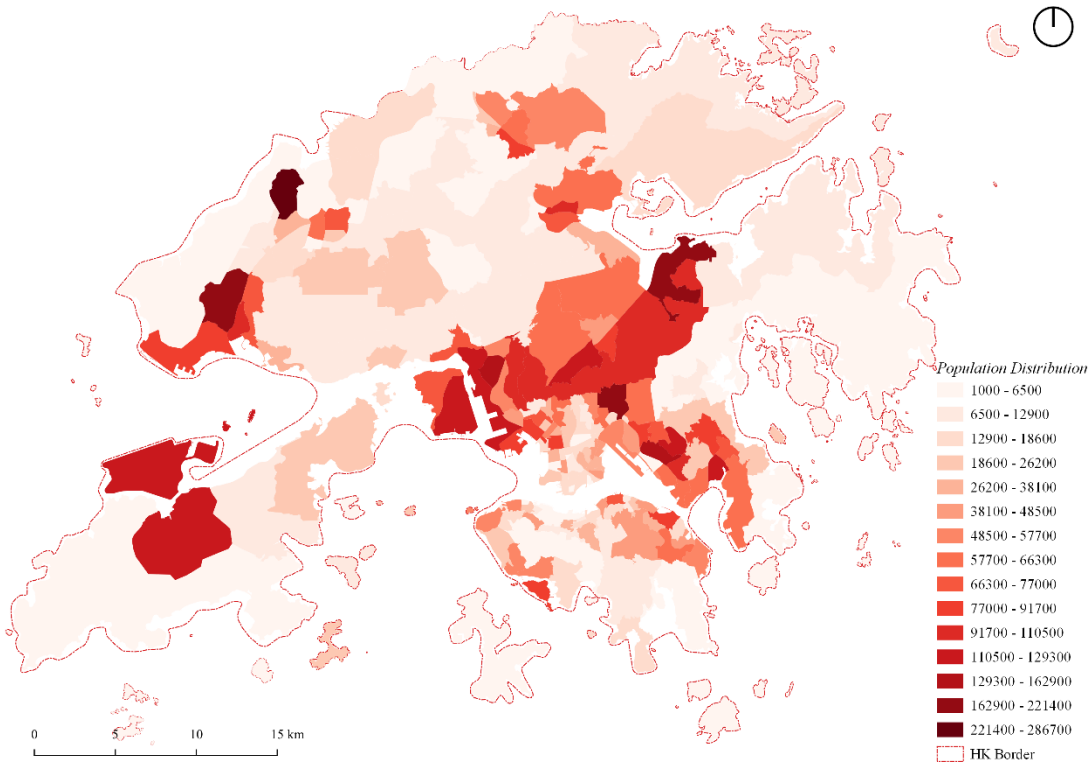


Figure 4 Population density 2023 in Hong Kong
(Source: Made by author by ArcGis, data from Common Spatial Data Infrastructure Portal)

3.1.2 Urban Planning Framework

Urban planning in Hong Kong began with the British Hong Kong Government during the colonial era in 1842. Under the British planning framework, the first urban plan known as "Planning Schema" was made in 1922 to present the blueprint of Victoria Harber (Hong Kong's bay area). Responding to the urban growth in the 1950s, the Hong Kong government made the decision to reclaim land and expand the new towns to deal with the increasing urban population. By the time of Hong Kong's Handover in 1997, the planning framework had been reorganized, the level of public participation increased, and the system of land planning and management had been strengthened. The framework supports the formation of a rational and effective urban planning process, which contributes to the urbanization of Hong Kong. In the framework, the Planning Department conducts planning summaries and outlooks every ten years. Currently, the most recent territorial development strategy and visions are published in the book *"Hong Kong 2030+"* (Development Bureau & Planning Department, 2016).

Figure 5 Territorial development strategies
(Source: Hong Kong 2030+)

Hong Kong has two major urban planning authorities. One is the Town Planning Board (TPB), which was established in 1991 according to the Town *Planning Ordinance Section II*. TPB aims to ensure the health, safety, convenience and general welfare of the community through the process of guiding and controlling the development and use of land, and to bring about a better organized, efficient and desirable place to live and work. It consists of two planning committees: the Metro Planning Committee and the Rural and New Town Planning Committee. These committees are responsible for reviewing planning applications and proposing statutory plans and territorial strategy. Besides, there also has a committee called Representation Hearing Committee which is responsible for presenting the urban planning proposals and results to the public (TPB, 2023).

The Planning Department (PD) is another authority founded in 1990 with the purpose of regulating the land administration. The key task of PD is to formulate two detailed

land use plans (Suzuki et al., 2015): the *Outline Zoning Plans* and *Development Permission Area Plans*. PD includes two branches: the Territorial Planning Branch and District Planning Branch. These branches have the right to regulate and design the urban plans at all scales. In short, from the perspective of power structure and functions, TPD plays a role in the decision maker, while PD is the proposer and executor of urban planning.

Besides the public authorities, Massive Transit Railway Corporation (MTR) is another important participant in Hong Kong's urban development. As a privately owned transportation company, MTR has collaborated deeply with the PD to develop the land surrounding the railways and transit stations. The conflict between the people and land in Hong Kong has led to the adoption of the TOD theory as a major development tool. This has resulted in the emergence of the "Rail + Property (R+P)" model and the Public Private Partnership (PPP) framework. It allows the city to maximize the use of land and increase the efficiency of public transport. In Hong Kong, all land is public-owned and the government has the right to collect or assign land to other entities. Therefore, the mechanism of the R+P model is the government transfers the land near transit stations to MTR for developing and managing, and the MTR returns the revenue after selling the properties and running the business.

In general, Hong Kong's land policy limits urban development in two aspects: the inner-city renovation and the new town construction. Urban renovation is achieved through the construction of high-rise buildings and remodeling the neighborhoods. This strategy provides diversified services and commercial activities to the existing urban layouts. It leads to the upgrading of neighborhoods which makes the renewed area more prosperous and livable. The new town construction involves two methods: the land reclamation and satellite town construction. Reclamation projects commonly take place near the harbor areas, with the purpose of adding more functions including office, commercial complexes, or green spaces. While, the satellite towns are built to relocate the overcrowded urban populations. It aims to offer better services and living environments to the residents.

3.2 Transit-oriented Development and Hong Kong

3.2.1 MTR and PPP Framework

Massive Transit Railway Corporation (MTRC or MTR) is the major rail transportation provider in Hong Kong. It was founded by the Hong Kong government in 1975 and privatized in 2000 with the 23% of its shares sold to the private sector. Since MTR merged with the Kowloon-Canton Railway in 2007, it acquired the operating rights for most of Hong Kong's major railways. Currently, it manages the railway network of a total distance of 266.3 kilometers including all ten rapid metro lines and twelve light rail lines. Differ from other transit companies in other cities, MTR plays a key role in the urban development process. It works as the third party between the government and private developers. Since MTR obtained the right of land development, instead of

selling the land, it works as a partner with the developers in construction of the TOD neighborhoods. Therefore, MTR serves as a bridge in the power structure, facilitating communication and negotiations among different stakeholders at the different stages of TOD development. Tang et al. (2004) identified four key components of the system: (1) ***Policy***, supports from the government; (2) ***Process***, forward-looking planning, management, and control procedures that ensure an efficient approach from project inception to completion; (3) ***Project***, High-quality real estate projects that appeal to tenants, shoppers, and transit users; (4) ***Organization***, an entrepreneurial entity that balances the financial interests of investors with larger societal goals.

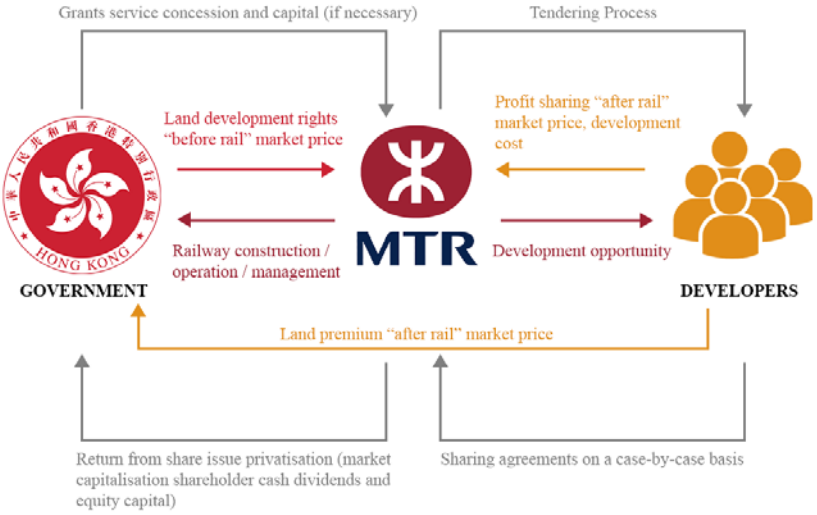


Figure 6 Framework of the R+P planning model
(Source: Jauregui-Fung, 2022*)*

It is widely accepted that the return on investment in transportation infrastructure takes long time. Additionally, the maintenance of these facilities requires an enormous funds input, leading to economic pressure for local governments. Hong Kong's R+P model is not only an urban development strategy which is based on TOD theory, but also is a Land Value Capture (LVC) model. It can gain profits by exploring the land development around stations. Furthermore, through the rental of commercial spaces and selling tickets, MTR also can collect the interests to maintain the growth of itself and repay the revenue to the government. The diversified profit structure guarantees a favorable economic circle of MTR, thus maintaining the quality of public transport services. This mutual system allows MTR to become one of the most successful public transportation companies globally (Jauregui-Fung, 2022; MTR, 2022).

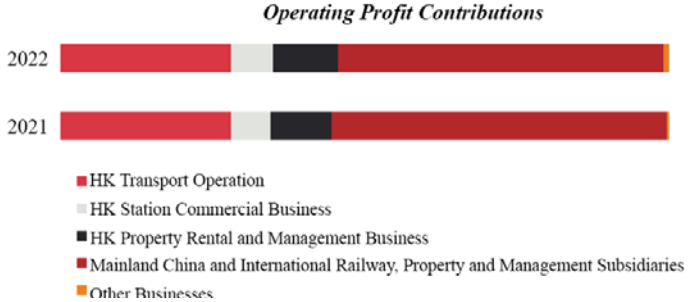


Figure 7 Operating Profit Contributions
(source: MTR Annual 2022)

3.2.2 "Rail + Property" Model

"Rail + Property (R+P)" model is Hong Kong's special urban planning theory. It fully merges the local condition and TOD concept to solve the challenges among transport, population, and land (Tang et al., 2005). The model shows a wide inclusion of all the stakeholders and builds a structure for balancing the interests. In most of the cases, the R+P model stands in the same line with the development requirements of the Hong Kong government. It provides high-quality transport and housing units for the public, and return taxes contribute to the governmental fiscal revenues. Baek et al. (2015) summarizes the workflow of this model. (1) The government transfers land to MTR for developing stations and surrounding neighborhoods. (2) MTR carries out plans to maximize the synergies of station development. (3) MTR cooperates with other developers to jointly develop the TOD communities, and share the profits after the implementation.

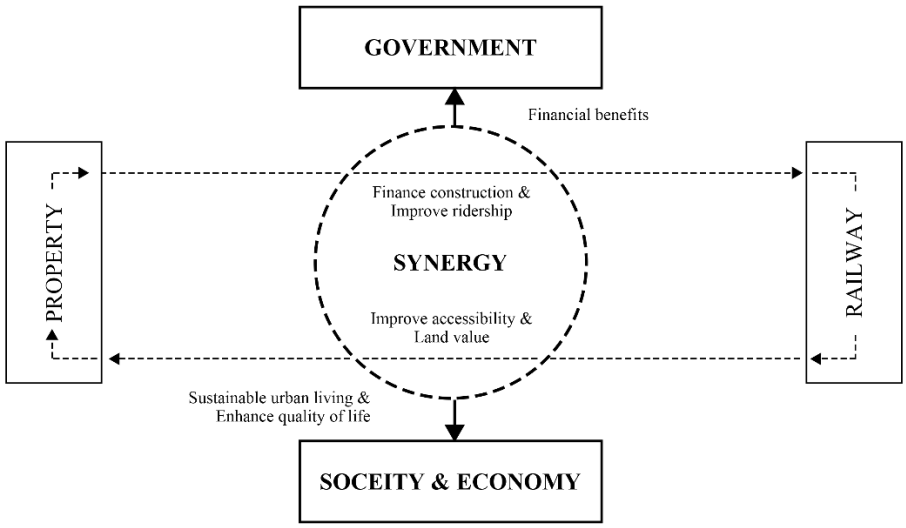


Figure 8 Synergy of integrated R+P model
(source: Tang et al., 2005)

Since its emergence in the 1980s, the R+P model has experienced three evolution phases (shown in Figure 9). The initial phase focused on single land use development around the stations, with the aim of gaining revenue to compensate for the investment in the railways. The second phase was influenced by the changing status of Hong Kong in the global economy and the influx of massive foreign investment. It focused on the mixed use and pedestrian road networks. The building blocks during this period were characterized by a variety of high-rise residential towers and commercial complexes. The third phase has transformed into the Greenfield TOD in urban brownfields and rural undeveloped areas. This new type integrates the concept of sustainable development and better environment by paying attention to the future urban growth (The World Bank, 2018). The change in design philosophy also led to the changes in building cluster formation: the architecture design generated from skyscrapers clusters to megastructures of mixed-use complexes (Suzuki et al., 2015).

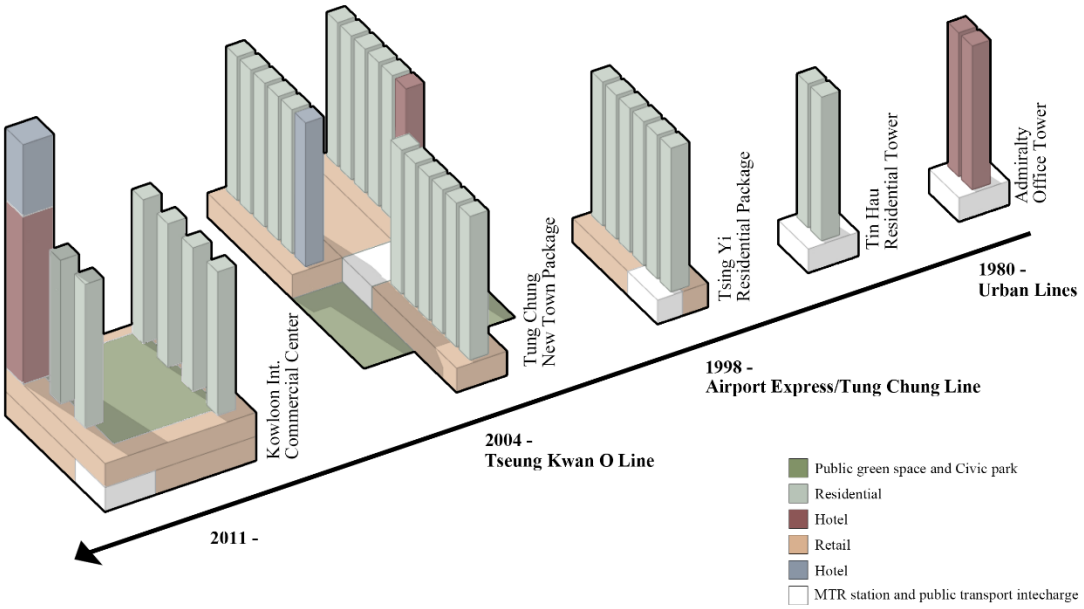


Figure 9 Physical typology and evolution of R+P practices since 1980s
(Source: Suzuki et al., 2015)

The benefits of the R+P model can be observed in many aspects. Suzuki et al. (2015) summarized four aspects: *Financial impact*, *Ridership increase*, *urban environment*, and *Carbon emissions*. Furthermore, it's a successful implementation of the TOD theory, which basically meets the 5D principles and performs better in environmental protection and sustainability. Hong Kong applies this model for efficient land value capture due to the multifactor such as high population density, public land ownership, and low automobile reliance (The World Bank, 2018). By the end of 2022， MTR managed more than 118,000 residential units and 820,000 m^2 of commercial and office space in Hong Kong (MTR, 2022).

3.2.3 Typology of Hong Kong's TOD

Hong Kong's topography provides the city with sufficient natural urban parks and ecological reserves. The government has a strict land development policy to protect its valuable ecology resources, thus there exists a clear boundary between urban and rural areas. However, the high density of population in the city has created problems such as housing shortages and traffic congestion. Therefore, the TOD concept or locally titled R + P model has been used as one of the most important strategies for urban development since the 1980s.

As a city with a long TOD implementation history, Hong Kong has a variety of TOD communities in the whole territory. The layout of TOD in Hong Kong usually has two cover ranges: MTR station as center, a 250m radius of office, open space, interchange systems, services and commercial complexes, and a 500m radius of high-density mixed residential areas (Das & Roy, 2023). This layout creates a highly efficient circle for the commuters and residents by reducing the distance of traffic length, improving the utilization of pedestrian and public transports.

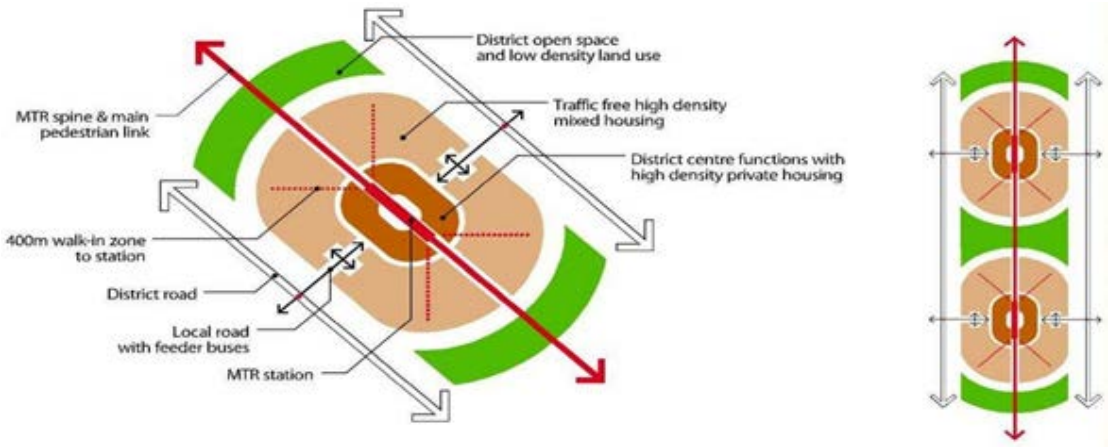


Figure 10 Overview of R+P Development
(Source: (Das & Roy, 2023)

According to the features of TOD communities, Al-Kodmany et al. (2022) identified four types of TOD communities in Hong Kong:

(1) *"Plug-in" TOD in the old city*. The purpose of such TOD is for the renovation and redevelopment of existing urban areas. In the case of Mong Kok station on the Kowloon Peninsula, a large number of mixed-use blocks and skyscrapers were constructed in the 1970s.

(2) *City-edge TOD in city expansion*. Hong Kong's geography dictates the use of reclamation activities, and new TOD development plans are centered around the new reclaimed land for city expansion, of which the development of the Olympic station belongs to this type of development.

(3) *"One-building TOD"*. This type of TOD is classified as a megastructure or large-scale mixed-use complex, of which the development model of Kowloon station is the most famous, with the combination of commercial, office, and residential complexes above ground and an underground transport system.

(4) *Suburban TOD in new towns*. In order to cope with the growing urban population, Hong Kong has formulated plans for new towns, closely integrating new town development with rail transit, thus achieving a reduction in residential and traffic pressure in the central city and completing polycentric development.

The beginning of the "New Towns" projects can be dated back to the 1970s. It aims to build new satellite towns in order to relocate the urban population and to improve the transportation and sanitation. During this period, Hong Kong put more attention to the connection between inner city and new towns, resulting in the construction of the metro lines. Along with the metro lines, most of the neighborhoods near the transit stations were built using the R+P model. The model creates a combination of densely populated residential and mixed-use commercial zones.

The New Town projects can be categorized into three generations. The first generation

which started in the 1970s includes three areas: Tuen Men, Sha Tin, and Tsuen Wan. The second generation lasted from the 1970s to the 1980s, including Yuen Long, Tai Po, and Sheung Shui. During this period, urban development plans followed the principle of "the rail follows the people", which means that the metro lines should be planned in dense population areas. However, the new towns in third-generation follow different strategies. These towns were founded on the principle of guiding urban growth by the metro lines, with the purpose of relocating and accommodating more population in new communities. The representation of the third-generation new towns are Tseung Kwan O, Tin Shui Wai, and Tung Chung. Thus, the third generation of new towns represents the maturation of the TOD theory and R+P model in Hong Kong (X. Chen, 2013).

3.3 The Study of Gentrification

3.3.1 Gentrification is Happening

Lee Tung Street (known as Wedding Card Street) is a very famous walking street in Wan Chai. It preserves a large number of Tong Lau (a type of historical tenement buildings in Hong Kong) and many traditional printing shops. In the 1980s, the unique street scenery and wedding card production attracted lots of visitors. However, the government decided to reform this area into a mixed-use development in 2003, by the construction of four 40-story residential towers and a modern shopping street. Despite widespread opposition to the redevelopment plan, the street was eventually rebuilt in 2010. After construction, the printing shops were allowed to re-enter the street. However, as a result of the neighborhood change and high rental costs, all of those stores were replaced by upgrading commercial (Douay, 2010). The redevelopment of Wedding Card Street is a widely recognized example of state-led gentrification in Hong Kong.

Figure 11 Lee Tung Street Before and After
(Source: https://hongkongfreetours.com/lee-tung-street/)

Before 2001, the interpretation of gentrification was often confused with the concept of "urban regeneration" or "urban redevelopment" in Hong Kong (Qian & Yin, 2018). Due to the 50-year land use rights of the buildings, the demolition of outdated ones was a normal issue to the public. At that period, the debate between the authorities and the

public was mostly focused on the unjustifiable compensation and the prevention of the changes in local neighborhoods. In the interview of local residents and officials, Ley and Teo (2014) stated:

"Demolition and eviction seem to be naturalized as an inevitable part of urban life in an environment where residential property deteriorates to a point that it requires replacement after 50 years or less."

However, things changed after the redevelopment of Lee Tung Street, the occurrence of gentrification was criticized by the public and scholars. Although the phenomenon is similar to the common gentrification narratives, the local journals still refuse to use "gentrification" when characterizing this kind of neighborhood change.

Ley and Teo (2014) conducted a search in the English version of the newspaper South China Morning Posts (SCMP) to find the articles which are related to the keywords of *Gentrification*, *Redevelopment*, *Displacement*, or *Evictions* between 1984 to 2010. The results show that out of 161 recorded events in five downtown districts, 88 articles were identified that involved keywords *Redevelopment* and *Eviction*. However, it's worth noticing that none of these articles mentioned the keyword *Gentrification*. However, Tang (2017) takes a contrary view of matching the gentrification in Hong Kong with the Western experience. He argued that the process of gentrification in East Asia cannot be defined in the Anglo-American model. The geographic and socio-political contexts shape the district features of Hong Kong's urban development. Rather than simply defining gentrification by the displacement of the working class, the key should lie in the relationship between land and property in Hong Kong.

The land recovery policy is a special approach for the government to maximize the usage of land in Hong Kong. Since the disbanding of Land Development Corporation (LDC) in 2001, its work has been assigned to Urban Renewal Authority (URA). The purpose of URA is to promote urban redevelopment by using reasonable approaches in the form of Public-Private Partnership. Its functions include offering reasonable compensation to landlords, providing rehousing for tenants, and encouraging the public to express their opinions. Cooperating with the private developers, URA facilitates the land reclamation and gains economic interests through the process of transforming old blocks into upscale ones. This is the process by which gentrification is one of the major outcomes of the large-scale redevelopment projects[3].

La Grange & Pretorius (2016) summarized the connection among Hong Kong's economy, land development, and gentrification in 3 factors: *the nature of government*, *the land management actions*, and *urban morphology*. Nature of government points out that only the government has the right to lease and hold land, while the urban renewal plan is controlled by URA. Thus, the government are the main drivers in gentrification

[3] *Source: Land Department of Hong Kong, https://www.landsd.gov.hk/en/resources/publicity-materials/ex-rate.html*

(so called *State-led gentrification*). Land management action explains that Hong Kong's fiscal strength significantly relies on managing land as a resource. The objective of most land actions is to gain benefits from the redevelopment projects. Urban morphology represents the conflict between land and population. The limited flat land evokes the requirement of compact and dense urban formation. It triggers the demolition of the existing old buildings and replaces them with taller and denser residential towers as the default option.

Gentrification is often regarded as a result of government-led redevelopment, but the private sector also plays an important role in Hong Kong. With the increase in foreign investment, the private sector has been invited to participate in the redevelopment process. Since the 1980s, due to the prosperity of the economy, the international companies have participated in governmental projects. In order to speed up the redevelopment in the inner city, the government approved the publication of the *Land Compulsory Sale for Redevelopment Ordinance* (LCSR). LCSR stipulates that if the private sectors made agreements with 90% owners in a single old building, the government can engage in the negotiations with the remaining protests in order to promote the property auction. In 2011, for promoting more urban renewal projects, the percentage of owners who agree to the agreement in LCSR was adjusted downward from 90% to 80%. The modification has led to a reduction in the minimum requirement for acquiring auction rights, resulting in unfairness among landowners and the low-income households (La Grange & Pretorius, 2016). Another notable phenomenon is that urban redevelopment does not always take place on a large scale. The redevelopment may occur in single blocks or single buildings. As a consequence, the high-end residences and outdated buildings coexist in the city center communities. Thus, although the gentrification occurs in the downtown, the segregation level is low (Monkkonen & Zhang, 2011).

Furthermore, the implementation of a public housing policy since the 1960s has become a solution for accommodating the low income. The policy includes the construction of social housing units in new towns. The original portion of public housing and private housing in Hong Kong was regulated as half to half, but since the 2010s, the ratio has kept shrinking (in Table 2). Although the government requires the developers to provide a certain percentage of public housing in new built communities, the large number of applicants and the increasing population still result in an undersupply of social housing units.

Table 2 Domestic households by type of housing

Type of Housing	2003	2008	2013	2018	2023
Public Permanent Housing	47.5%	46.9%	46.2%	46.2%	45.9%
Public rental housing	(30.6)	(30.2)	(30.5)	(30.9)	(30.4)
Subsidized Permanent housing	(16.9)	(16.4)	(15.7)	(15.3)	(15.5)
Private permanent housing	51.6%	53.3%	53.1%	53.1%	53.3%
Temporary housing	0.9	0.7	0.7	0.7	0.9

(Source: Census and statistics department; https://www.censtatd.gov.hk/)

In addition, the eligibility of public housing in 2023 is challenging for the applicants.

Taking a two-person household as an example, the total monthly income should not exceed 19,550 HK$ and the asset value should not exceed 376,000 HK$. Compared with the average monthly rent of an 11m^2 room is HK$6,500, the public housing is minimum HK$3,000 (Housing Bureau, 2023). On the contrary, only if the household income exceeds 100 times more than the eligibility of the social housing, the resident should move out. Consequently, a large number of public housing units are converted into long-term housing.

The difficulty in applying for affordable housing has exacerbated the choice of low-income people to live in central districts. Under the influence of high prices, they have to move elsewhere. However, low-income people living in affordable housing also suffer from difficulties. The surrounding upscale communities make the social housing buildings become isolated islands.

According to the points mentioned above, the government becomes the main driver of gentrification during the urban redevelopment process. On the one hand, Hong Kong's gentrification is accompanied with the redevelopment and is a result of the pursuit of economic growth. On the other hand, the public-owned land has created the opportunities for capital accumulation. Under the top-down politics, the formation of gentrification is shown in Figure 12. During the process, the role of the middle class is magnified. They are considered as the main consumers of the infrastructures, services, and housing units. By the influence of the consumerist atmosphere, developers build “Elite Enclaves” that attract the middle class to buy properties that can demonstrate their social status by elite lifestyles and high-end amenities (Wang & Lau, 2009).

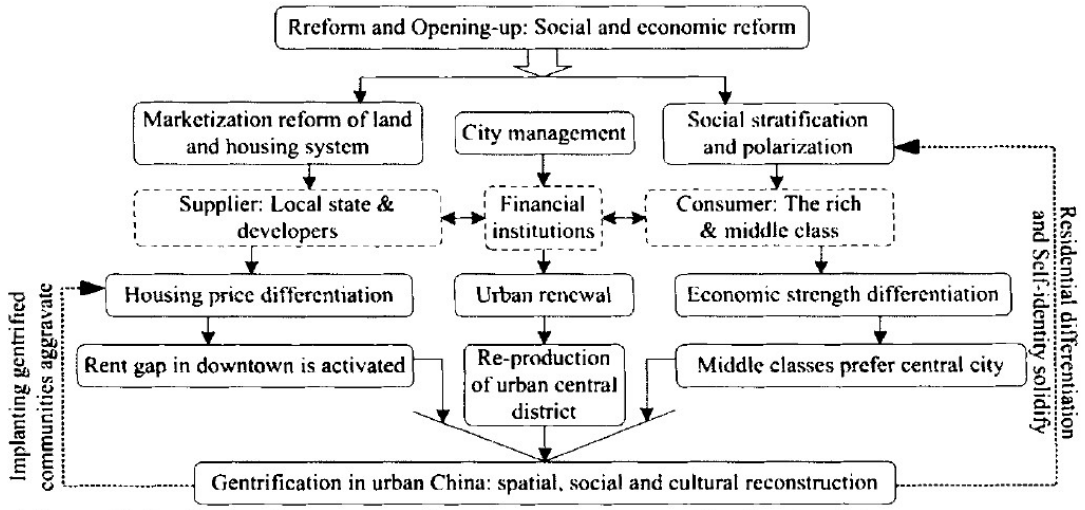


Figure 12 Social background and evolvement of gentrification in China (Source: Song & Zhu, 2010)

The impact of gentrification is tremendous, it reshapes the social structure in the city through socioeconomic transactions and urban redevelopment, excluding the poor from the society, resulting in social polarization and social inequity (Song & Zhu, 2010).

3.3.2 The Research of TIG in Hong Kong

As a new topic, the TIG studies in Hong Kong are limited in numbers. Most of the existing materials are related to the other gentrification types, such as new-built gentrification (Ley & Teo, 2014), state-led gentrification (Tsang & Hsu, 2022), and tourism gentrification (Lo & McKercher, 2023). However, with the implementation of the R+P model for more than 30 years, the gentrified phenomenon in station neighborhoods has begun to gain the public's attention. In 2014, Enid Tsui[4], a reporter for the *South China Morning Post*, published a journal describing the extension of West Island Line has already led to gentrification in three newly constructed TOD neighborhoods. Recently, the research on Kwun Tong Town Center Project (KTTP) also indicates that the rocketing property prices have driven low-income move-out and the neighborhood is gentrified by the middle-class (Qian & Yin, 2018; Tsang & Hsu, 2022).

According to the previous sections, the TOD neighborhoods in Hong Kong have exhibited the potential of TIG features. These features include the migration of different income groups, changes in demographics, and upgrading of commercial activities. However, the research is still in an inadequate status. Currently, Wadu Mesthrige and Maqsood (2022) studied the property values increased with the improvement of railway accessibility; He et al. (2021) found transit stations weakened the sense of community and captured the trend of TIG; He (2020) studied the railway accessibility have a significant capitalization on property prices during the year 2001 to 2011; Liang et al. (2022) through measured 2001 and 2006 demographic data in new metro lines found the occurrence of TIG in TOD neighborhoods. These studies mainly use the mathematical methodologies to simulate the correlation between TOD implementation and demographic changes at a regional scale. But the study of TIG impacts at the neighborhood level has not been explored, which illustrate the research gap under Hong Kong's context.

[4] *Tsui E., 2014, West Island MTR line has led to the rapid gentrification of Kennedy Town. Journal, South China Morning Post, https://www.scmp.com/lifestyle/food-drink/article/1396779/west-island-mtr-line-has-led-rapid-gentrification-kennedy-town*

IV. METHODOLOGY

4.1 Approaches to Questions

Current research has pointed out the initial state of transit-induced gentrification (TIG) in Hong Kong. He et al. (2021) and Liang et al. (2022) have applied mathematical models to simulate the occurrence of TIG in new towns at the regional scale. Nevertheless, there are limits in the availability of relevant cases for exploring the occurrence and consequences of TIG along the metro lines at the neighborhood scale. Therefore, basing on the findings of previous studies, the thesis focuses on the research of the TIG in the metro-related TOD neighborhoods in Hong Kong. The research is conducted by analyzing secondary data provided by the official authorities, with the aim of filling the research gap.

For the purpose of defining the border of the case study, two TOD communities located in suburban regions were selected, based on their typology and the time period in which they were constructed. Through analyzing the demographic and urban fabric changes between 2011 and 2021, the study seeks to investigate the impact of TIG at neighborhood level. Furthermore, it's worth noticing that the findings only represent the situation in Hong Kong because of its distinctive TOD model, economic structure, and land use policy.

Following the three research questions which are formulated in Chapter I, this section introduces the methodology which are adopted to address these questions:

1. *Has the construction of metro-related TOD caused neighborhood change?*

The characteristics of the community transformation manifest in two dimensions. Firstly, the construction of new buildings and the renovation of existing structures serve as indicators of tangible shifts in economic capacity and social status of local residents. This phenomenon also results in changes in the local business activities, marked by an increase in the number of businesses such as cafes, boutiques, or chain supermarkets, while witnessing a reduction in the number of small private retailers. Secondly, there has been an obvious change in the composition of the local population, particularly in the demographic statistics that demonstrates an increase in middle-class households identified by their advanced education, professional occupations, and high incomes. Therefore, the proposed methodology for answering the question consists of three parts: (1) establishing the pre- and post- conditions of the two case studies; (2) implementing spatial analysis methods to study the urban fabric and commercial POI; and (3) conducting demographic change analysis through percentage change calculation and comparisons.

2. *Does this change intensify the occurrence of transit-induced gentrification?*

Gentrification has a self-reinforcing mechanism, as the costs related to living and housing prices keep rising as the process advances in the gentrification, finally resulting

in the exclusion of all low-income households in the neighborhood. Therefore, the upgrading of commercial and decline of housing affordability can indicate the mechanism of gentrification. The methodology to examine this question involves two parts: analyzing the changes of housing affordability indexes and estimating the cost of living in the case study areas by POI.

3. *How does the transit-induced gentrification reform the demographic and built form of the TOD neighborhood?*

The answer of this question is presented in the last section (Section 5.5) of Chapter V, through summarizing the findings from previous two questions. A narrative description is conducted by integrating the data and graphical results from previous research methods.

4.2 Research Method

4.2.1 The Outline of the Research

The research of TIG is complicated, as the different measurement approaches can reach different results, which are influenced by multiple factors. To clarify the impact of TIG to the neighborhood, the study adopts the methodological framework proposed by Chen et al. (2023). In the study of the impacts of TIG in New York's public transportation system, Chen created a linear approach which consists of spatial analysis and demographic analysis. Therefore, the thesis adopts Chen's framework but modifies methodologies according to the research purpose and data accessibility.

Based on the study framework presented in Section 4.1, the outline of methodologies can be divided into four parts. The first part is defining the pre- and post-conditions of the case study. It involves collecting and structuring the foundational data, as well as defining the temporal intervals and geographic boundaries. The data is sorted by pre-condition and post-condition into excel tables. Each variable in the table is clearly defined and comes with an explanation.

The second part includes spatial analysis. For urbanism research, the fundamental stage typically involves analyzing the changes in the building environment. In order to demonstrate the changes taking place in TOD neighborhoods, the study analyzes the typologies of buildings, the land uses, and the expansion of urban areas.

The third part is the demographic analysis. The analysis of demographic changes plays the most important role in researching the occurrence of gentrification within the neighborhood. To provide a more comprehensive explanation of the changes and trends, the third part consists of two approaches. The first approach includes three steps. Firstly, formulating a new table which extracts the TIG-related variables from the general table. Secondly, comparing the percentage changes based on the data of pre- and post-conditions of the two TOD communities. Thirdly, making another comparison between the changes at the district level and neighborhood level. The second approach uses two indexes from the research of Dominie (2012): the *Socioeconomic change index* and the

Gentrification index. These two indexes combine TIG-related variables into one formula, which can illustrate the degree of social change or gentrification in a simple way. In the study, the indexes are implemented at census tracts in the whole district. Thus, the difference of change degree in normal census tracts and TOD-related census tracts can be easily read from the results.

The fourth part focuses on housing affordability, which works as a quantitative measure of the living standards. Hong Kong is known for its high housing value and low per capita living space. Therefore, conducting an analysis of affordability can provide a clear understanding of the local situation. This part includes two approaches. The first approach is analyzing the changes of Median rent to income ratio (MRIR) and Median mortgage payment to income ratio (MPIR). These two ratios are employed in Hong Kong's census investigation Mostafa et al. (2005). The second approach is using the calculation of Housing Affordability Index (HAI) which is defined by the National Association of Realtors (NAR). The HAI is a common and simple method for analyzing the affordability.

In this methodology, the analysis tools vary slightly from one another, differing from the research objectives and data characteristics. In the first part, QGIS is used for collecting and processing raw data, while Excel works as the SQL tools for data classification. The second part uses Google Earth Pro and QGIS to make the spatial analysis and visualize the data. The third part uses Excel to calculate the percentage changes and QGIS to produce the graphics of two indexes. The fourth part uses Excel to calculate the HAI and make comparisons between present and past records. The specific research process is detailed in the flow chart (Figure 13).

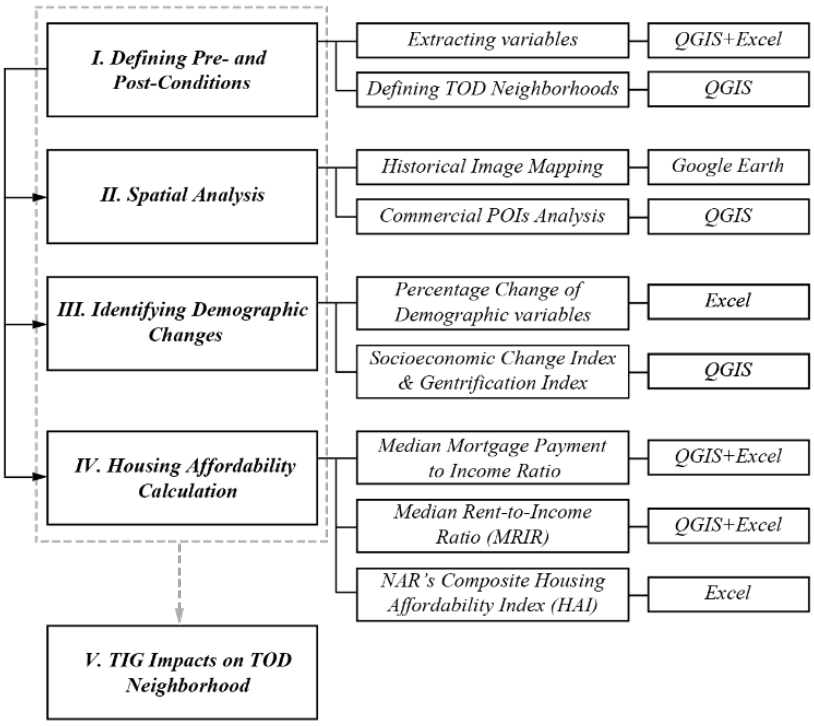


Figure 13 The flow chart of methodology
(Source: made by author)

4.2.2 Defining the Pre- and Post-Condition

The defining the pre- and post-conditions works to define the parameters of the study and the range of data collection. Since the study takes the city as the research object, the definition of the research parameter includes two perspectives: the time interval and the physical boundary. According to the literature review, most of the research indicates that a ten-year time interval is suitable for the studying of TIG. The demographic changes are typically significant during the first ten years. Therefore, the study also employs a ten-year timeframe for examining the changes in the communities. Hong Kong has had the tradition of making the census every ten years since 1961, hence the most recent census is in the year 2021. Considering the ten-year interval, the pre-condition should be the census in 2011. Therefore, the construction period of the TOD communities which are selected as case studies should match the start around 2011 and completed around 2021. Since TOD is a station-centered planning model. Therefore, the physical boundary is defined as the buffer zone with a radius of 700 meters centered around the station. All census tracts that are fully or partially covered by the buffer zone are considered as one TOD neighborhood.

Hong Kong's census tracts are categorized into four levels according to its scale: *District council district*, *Tertiary planning unit groups*, *District council constituency area*, and *Subunit groups*. The District council district includes 18 administrative districts. The large Tertiary planning unit groups are further split into 154 pieces. The District council constituency area is a classification based on voting areas which contains 412 census tracts in 2021. The large Subunit group (in 2011 called street block group) is census tracts at block scale. It contains 1620 census tracts in 2011 and 1746 census tracts in 2021. After examining the data in these tracts, the study uses the District council districts to collect demographic data in district level, and large subunit groups to collect demographic data in block scale. There are two points that need to be mentioned. Firstly, due to the absence of the tracts in neighborhood scale, the demographic data of TOD neighborhood is calculated from the census tracts which are covered in TOD buffer zone. Secondly, a large subunit group in 2011 is different from 2021, a joint process is necessary for data collecting.

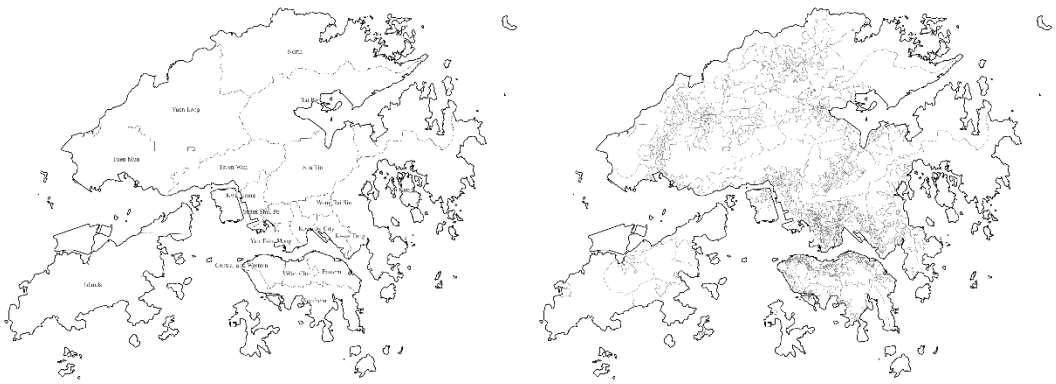


Figure 14 District council district and Subunit group census tract in 2021 (Source: CSDI)

As mentioned in Section 2.2.4, Landis (2016) classified four commonly used indicators to study the phenomenon of gentrification, which have been accepted by other researchers. Therefore, the study adopts two out of the four indicators to summarize the variables which are collected: (1) *the sociodemographic and economic characteristics of the neighborhood* and (2) *the physical and financial characteristics of the building stock*. The variables listed in Table 3 mostly refer to the research of Dominie (2012), Dong (2017), He et al. (2021), Liang et al. (2022), and provide more explanation under the context of Hong Kong.

Variable Box I: Socioeconomic characteristics includes a set of demographic factors of the community.

Total population: directly reflects the local population changes.

Age: lists the number of age groups to describe the population structure.

Ethnicity: lists Chinese, White, and Southeast Asian. The white and Southeast Asian are the minority in the society. The white work with a high salary. The Southeast Asian includes Filipino and Malaysian work as domestic workers with low salaries. Research in the United States shows that ethnic minorities are usually driven to the margins of communities, but Hong Kong is on the opposite side. The domestic workers are required to live with their employers, so the changes of the Southeast Asian population can indirectly reflect the middle-class household changes.

Education and Occupation: higher education and professional occupations are key variables for measuring gentrification.

Income: According to the definition of poverty line from Hong Kong Poverty Annual Report (Census and Statistics Department, 2021), households with a monthly income below 9,999HK$ are defined as poverty; between 10,000HK$-19,999HK$ are defined as low income; between 20,000HK$-39,999HK$ are defined as medium income; exceeds 40,000 HK$ are defined as high-income. In the study, the household income less than 19,999HK$ is categorized as low-income, more than 20,000 HK$ is categorized as middle income and above.

Variable Box II: Physical and Financial Characteristics of Housing Stock includes housing characteristics.

Small-sized units: The definition of the small-sized units is the available rooms from zero (single studio) to two (parents with one child). These units are more likely for the young and professional middle-class families.

Occupied units: reflects the number of households in the neighborhood. It can demonstrate the migration of the local population.

Units of housing types: includes the number of public housings and private housing. The proportion of housing type can serve as an indicator of changes in the real estate market and the living conditions of residents.

Table 3 Defining variables of the pre- and post-conditions

Variables	***Definition***
Box I: Socioeconomic Characteristics	
Total Population	
Age	
Person 25y to 44y	The adult population
Person 65y and over	The old population
Median Age	The median age of total population
Ethnicity	
Chinese	Majority ethnicity
Southeast Asian	Minority ethnicity includes Indonesian and Filipino, usually work as domestic worker with low salary but live with rich households
White	Minority ethnicity usually work as professional occupations with higher salary
Education	
Low Education Level	Adults with lower education degree
Medium Education Level	Adults with high school degree
High Education Level	Adults with bachelor degree or above
Occupation	
Professional Occupations	Occupations in managers, administrators, and professionals
Income	
Median HHs Income	The median income of a household which has two working population
The Number of Low-income HHs	Hong Kong CSD defines Household income less than 19,999HK$ as low-income
The Number of Middle-income and above HHs	Household income over than 20,000 HK$ is defined as middle-income and above
Household characteristic	
Tenant	The number of households which rent for living
Home Size 1 to 2 Persons	The number of small-sized family
Median Household Size	The median household size
Box II: Physical and financial characteristics of housing stock	
Housing characteristic	
Small-sized Units	The number of studios and houses have 1 to 2 rooms
Occupied Units	The number of occupied units
Units of Public Housing	The number of public housings
Units of Other Housing	The number of housing rents are subsidized by government or are paid by employers
Units of Private Housing	The number of private permanent housing
Median Household Rent	The median rent of households
Rent to Income Ratio	Median monthly rent to domestic household income ratio
Number of Low Monthly Rent Units	Number of the units with monthly rent less than 5,999 HK$
Number of High Monthly Rent Units	Number of the units with monthly rent over 6,000 HK$

Median household rent: reflects the median rent of households in the tracts.

Rent to income ratio: The ratio is the proportion of monthly rent to the total income of residents, and it can be used as a measurement for evaluating affordability of renters. The ratio is obtained from Hong Kong's census tracts.

Number of low monthly rent units: By using Hong Kong's average monthly rent of 6,000 HK$ as a threshold, the study defines the rental housing units with a monthly rent less than 5,999 HK$ as low monthly rent units.

Number of high monthly rent units: By using Hong Kong's average monthly rent of 6,000 HK$ as a threshold, the study defines the rental housing units with a monthly rent more than 6,000 HK$ as high monthly rent units.

4.2.3 Spatial Analysis

The spatial analysis is divided into two parts. The first part is the studies of the urban expansion behavior by mapping historical images. The second part is analyzing the commercial POI in the TOD neighborhood and analyzing the commercial upgrade phenomenon.

Historical image analysis. Four satellite images from the years 2000, 2011, 2016, and 2021 are used to map the historical change. The local urban fabric is presented through 3D models and the shapefile of building blocks.

Commercial POIs analysis. Due to the absence of POIs of 2011, the analysis of the commercial POIs relies on the data of 2021. The study categorizes POIs into six types based on the business types including *Companies and groups*, *Social services*, *Education services*, *Restaurants*, *Stores and shopping*, and *Medical services*. Through the fishnet analysis in QGIS to find the density of each category in the TOD neighborhoods. Afterwards, according to the features, several types are defined as upgrading commercial (Table 4).

The definition of commercial upgrading business refers to the research on commercial gentrification of Lim et al. (2013), Lin and Yang (2019), Thrash (2001), and Zukin et al. (2009). The phenomenon involves that the local stores are displaced by chain stores, the changes of prices, and emergence of high-end boutique and fancy commercial services. Besides, due to the limited data available from POIs, empirical identification methods are also used to define commercial upgrade business categories. For example: in Hong Kong, the international schools and private training institutions are classified as upgraded educational services, as they require higher tuition fees. Also, foreign cuisine restaurants such as Japanese and Western food typically charge higher prices compared to Chinese restaurants and fast foods.

Table 4 Commercial categorizes and upgrading sign

Categorize	***Upgrading***	***Categorize***	***Upgrading***
Restaurants		Clinic	
Foreign food (Japanese, western, etc.)	x	Public hospital	
Chinese food		Health care services	x
Chain fast food	x	***Education services***	
Chain restaurant	x	International school	x
Food related services		Private institution training	x
Large food mall		Private school	x
Café	x	Public school	
Dessert shop	x	Culture center	
Stores and shopping		others	
Chain 24h store	x	***Social services***	
Exclusive store (jewelry, fashion, etc.)	x	Laundry	
Supermarket	x	Property agency	
Shopping mall (duty-free, etc.)	x	Post office	
Chain fashion store	x	Beauty saloon	x
Furniture store		Social services	
Cloth stores		Others	
Others		***Companies and groups***	
Medical services		Small company	
Pet hospital	x	Large company group	x
Dental		Factory	
Farmacy			

4.2.4 Identifying the Demographic Changes

Studying the TIG can be achieved by analyzing demographic change. The basic approach involves identifying key TIG-related variables such as the number of residents with high education, the number of professional occupations, and the number of middle-incomes households (Bardaka et al., 2018; Chava & Renne, 2022; Dominie, 2012; Dong, 2017; C. Liang et al., 2022; Qi, 2020). Then using percentage change comparison can conclude the change of these variables during the timeframe. Lastly, the study focuses on census tracts in block scale by adopting two indexes from Dominie (2012). Therefore, the approach of identifying demographic changes is divided into two steps.

The first part is the calculation of the percentage change of TIG-related variables at neighborhood and make a comparison with the percentage change at district scale. Table 3 provides the overview of the demographic of the TOD neighborhoods. Then, eleven TIG-related variables (which are listed in Table 5) are extracted for calculating the percentage change (Dominie, 2012; Dong, 2017; C. Liang et al., 2022). The formulation of percentage change is shown as follow:

Census variables change: $Percent\ Change = (Census_{2021y} - Census_{2011y}) / Census_{2011y}$

After calculating the percentage change of each variable in Table 5, a comparative analysis is done between the district level and the neighborhood level. The results reveal the correlation between TOD neighborhoods and the district.

Table 5 Indicators of transit-induced gentrification

Categories	***Variables***
Socioeconomic and economic characteristics	Total population
	Middle-income and above HHs
	High education level
	Professional occupations
	Southeast Asian population
	Low-income HHs
	Median income
	Tenant
Housing characteristic	Occupied units
	Median rent price
	Median property value

The second part is related to the calculation of the Socioeconomic Change Index and Gentrification Index. This part focuses on the changes on all the census tracts in the Sai Kung district (Figure 15). In the calculation, the variables are limited in four: *the middle-income and above households*, *the number of high education levels*, *the number of professional occupations*, and *the low-income households*.

It's highlighted that Dominie's formulation employs the z-score as the input values. However, the quantity of Hong Kong's data cannot support the z-score, so the input value is replaced by difference value.

The formulation is shown as follow:

Socioeconomic Change Index[5]*= Value (change in high-income households) + Value (change in high-educated adults) + Value (change in professional occupations) - Value (change in low-income households)*

Gentrification Index[6]*= (% of low-income households in 2011) * (Value (change in high-income households) + Value (change in high-educated adults) + Value (change in professional occupations) - Value (change in low-income households))*

The indexes are calculated in QGIS and exported as graphics. The results are classified into six levels, from six to zero represent the changes from high to low. By analyzing the distributions of the entire Sai Kung district, the differences between TOD-related census tracts and normal census tracts can be observed.

Figure 15 The census tracts in Sai Kung District in 2021 (Source: CSDI)

[5] *The original index definition is from W. Dominie: Socioeconomic Change Index = z-score (change in high-income households) + z-score (change in high-educated adults) + z-score (change in professional occupations) - z-score (change in low-income households)*

[6] *The original index definition is from W. Dominie: Gentrification = (% of low-income households in 2011) * (z-score (change in high-income households) + z-score (change in high-educated adults) + z-score (change in professional occupations) - z-score (change in low-income households))*

4.2.5 Housing Affordability

The objective of researching housing affordability is to study the relation between property value and the income levels of residents. Since the TOD has the ability to raise the property value, the price-to-income ratio is likely to be changed, which later impacts the housing affordability. Therefore, researching housing affordability can benefit the improvement of housing policy. Currently, the CSD provides two data which relate to affordability in the census tracts: *Median rent-to-income ratio* (MRIR) and *Median mortgage payment to income ratio* (MPIR). Therefore, extracting these data and presenting them on the diagrams can help finding changes. Mostafa et al. (2005) and (Lewis et al., 2022) explain the methods of how CSD calculates two ratios:

*Median rent-to-income ratio (%) = Median rent (monthly) / Median households' income (monthly) * 100%*

*Median mortgage payment to income ratio (%) = Median mortgage payment (monthly) / Median households' income (monthly) * 100%*

The two ratios both show uncorrelation with the affordability. The lower value implies the high affordability. According to the Department of Housing and Urban Development (HUD) in the United States, the 30% of the ratio is the redline in this method. If the ratio is above 30%. It means the homebuyers and renters have to pay more for housing which can reduce their daily costs. Therefore, the analysis of MRIR and MPIR is regarded as a simple way to learn the local housing pressure.

Hong Kong is always recognized as one of the cities which has the most challenging housing affordability conditions globally. Despite Hong Kong's social housing policy having a favorable effect on controlling property rents, the housing prices are still more than affordable to the normal working-class. Consequently, the study introduces another approach to go deeper to the affordability: the Housing Affordability Index (HAI) from National Association of Realtors (NAR)[7]. Different from Hong Kong's approach, HAI shows correlation with its affordability. The higher value indicating the house is more affordable, lower value indicating the house is less affordable. When the HAI value is 100, it indicates that the income of a household precisely meets the requirements for a mortgage loan. The formulation is shown as follow:

*Composite Housing affordability index (%) = (Median annual household income / Qualifying income) * 100%*

The median annual household income is the multiple of the monthly median income (in Table 5) by 12 months. The formulation is shown as follow:

*Median annual household income = monthly median income * 12*

[7] *Source: https://www.nar.realtor/research-and-statistics/housing-statistics/housing-affordability-index*

The qualifying income means the requisite household income that can meet the requirement of repaying the home mortgage and allows for adequate coverage of other essential life expenses. It is the minimum income for balancing both mortgage and the standard of living. The formulation is shown as follow:

*Qualifying income = monthly payment * 4 * 12*

Monthly payment is defined as the total monthly loan payment (including principal and interest) that buyers need to pay.

4 means reverse 25% ratio on monthly housing expense to gross monthly income.

12 means 12 months in a year.

The monthly payment is calculated through Midland Reality's mortgage calculator. In order to use the calculator, 3 values should be defined: total property price, down payment ratio, and repayment period. According to the common rules of mortgage, the study assumes the buyers make a 20% down payment and 30 years as repayment period. The total property price is derived by multiplying the average price per area of properties in 2021 by the house area. In Hong Kong, the per capita living area is 16 m^2 in 2021 (Housing Bureau, 2023). Therefore, assuming a three-person family stays in a house with 48 m^2 (516 ft^2). The average price per area is collected from the historical records of Centaline Property and Midland Reality.

4.3 Study Area

4.3.1 Study Area Selection

Hong Kong's metro lines were mainly constructed between the 1980s and 1990s, covering a time period of more than three decades till now. Most of the TOD-related neighborhoods have already developed for a long time. Thus, the urbanized city centers would not be good options for observing TIG. In order to reduce the external factors, the selection of study areas has to seek the TOD neighborhoods in suburban districts which were constructed in recent years.

Suburban areas in Hong Kong are always associated with the New Town developments. The objective of these new towns is to relocate urban populations. Therefore, through the case studies, it's possible to gain an overview of the socioeconomic changes. Based on the background research of Hong Kong, it finds that the three third-generation new towns completely followed the TOD principles (R+P model). Thus, considering the time interval and location, two metro-related TOD neighborhoods in Tseung Kwan O (TKO) New Town are selected as case studies: Tseung Kwan O Town Center TOD and LOHAS Park TOD.

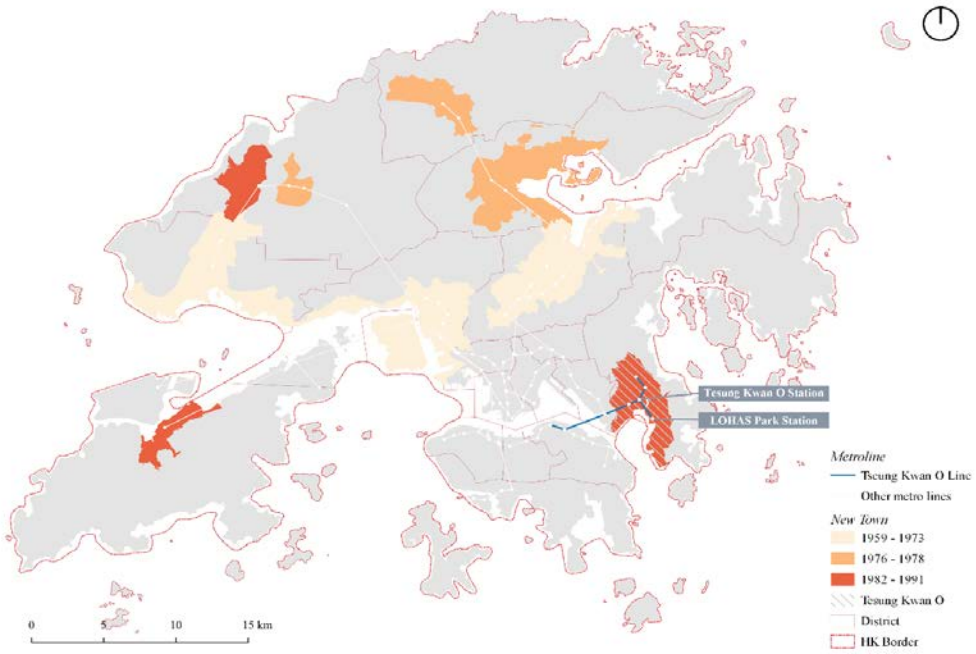


Figure 16 The location of Tseung Kwan O Newtown and TKO Metro Line
(Source: made by author)

4.3.2 Tseung Kwan O New Town

TKO New Town is situated in the southwestern area of the Sai Kung District within the New Territories East Region. It is located in close proximity to the central area of Kowloon East and Kwun Tong. The total municipal area is 17.18 square kilometers. The new town is surrounded by the hills of the Clear Water Bay Peninsula and is near to Junk Bay in the south. The special terrain has greatly supported the flourish of shipping and shipbuilding enterprises. However, the limited flat land also constrains urban development. Therefore, to attain more available land, the Hong Kong government operated the reclamation in the 1960s. Currently, the new town consists of eight distinct neighborhoods: Po Lam, Tsui Lam, Hang Hau, Tseung Kwan O Town Center, Tiu Keng Leng, Tai Chik Sha, Siu Chik Sha (LOHAS Park), and Pak Shing Kok.

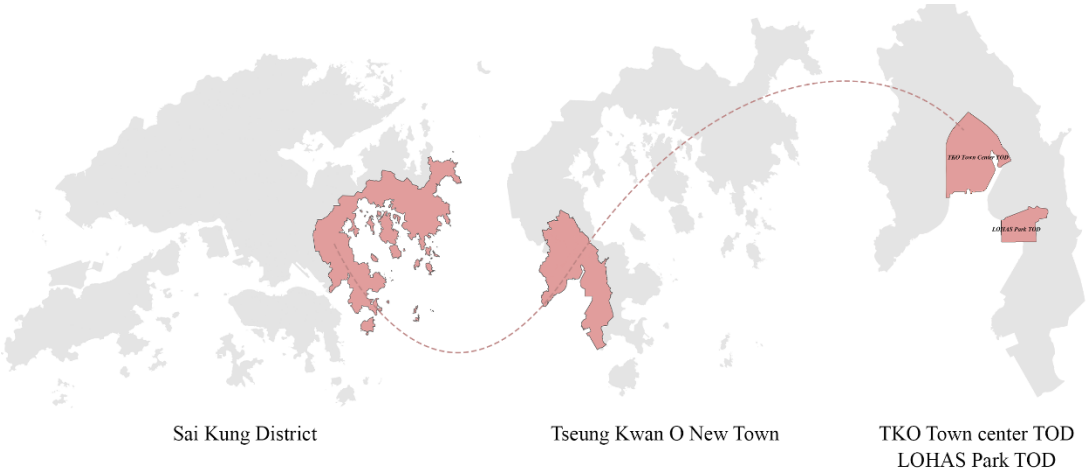


Figure 17 The location of TOD communities
(Source: made by author)

The history of TKO can be traced back to the 13th century, when the excellent natural harbor topography was occupied by the fishermen. During the 16th century, the area had transformed into residential areas especially for the fishing community. Later in the 19th century, the British colonized the area and took over the governance from the Chinese government. Under the control of the British, Tseung Kwan O (former name Junk Bay), was developed as the central hub for shipbuilding industries, which included shipyards and companies for maritime manufacture.

Following the approval of the New Town projects by the Hong Kong British government in 1982, the TKO industrial zones were moved to the southern border (Planning Department of Hong Kong, 2022). These zones now only accept high-tech companies. After three development phases in 1983, 1986, and 1988, the New Town became the major satellite city of Hong Kong. Based on the census survey, the population in the eight communities of TKO New Town has grown from 175,000 in 1983 to 417,639 in 2021, representing 85% of the entire population in the Sai Kung District[8].

Figure 18 The photo of Tseung Kwan O New Town
(Source: Planning Department, 2022, Planning for livable New Towns: Tseung Kwan O)

The transport connecting TKO New Town and central Hong Kong includes the TKO Tunnel and the MTR Tseung Kwan O Line. The construction of the TKO highway tunnel in 1990 aimed to build a direct link between the city center and the industrial park. In the meanwhile, to improve the connectivity between the new town and the Kowloon center, MTR opened four new stations in 2002: Tiu Keng Ling, Tseung Kwan O, Hang Hao, and Po Lam. Furthermore, the fifth new station, LOHAS Park, began operating in 2009. By now, the distinctive urban landscape of TKO new town is characterized by dense high-rise residential buildings facing the seaside.

[8] *Source: CSD 2021, https://www.census2021.gov.hk/*

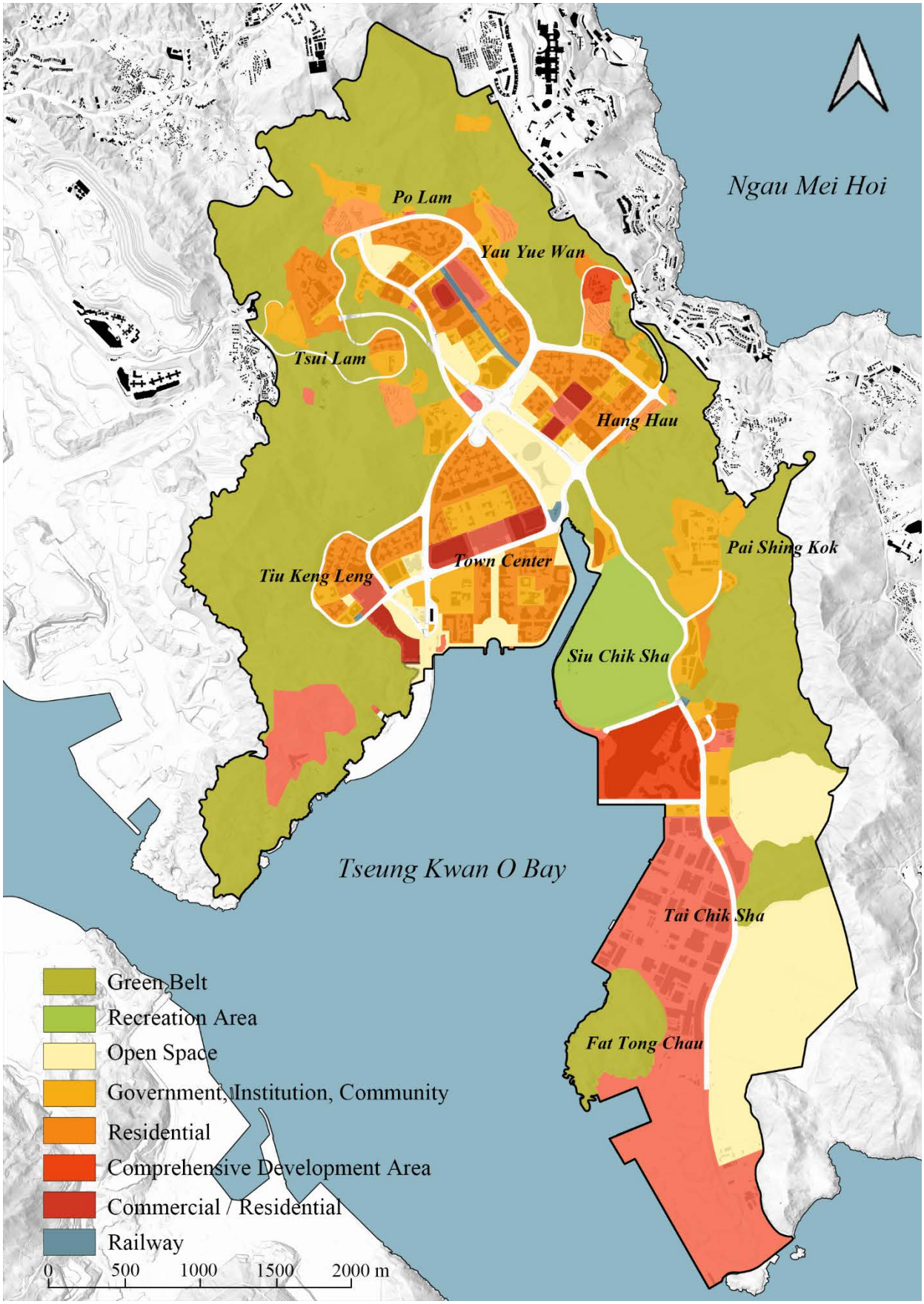


Figure 19 Tseung Kwan O Outline Zoning Plan
(Source: Planning Department. 2021; remake by author)

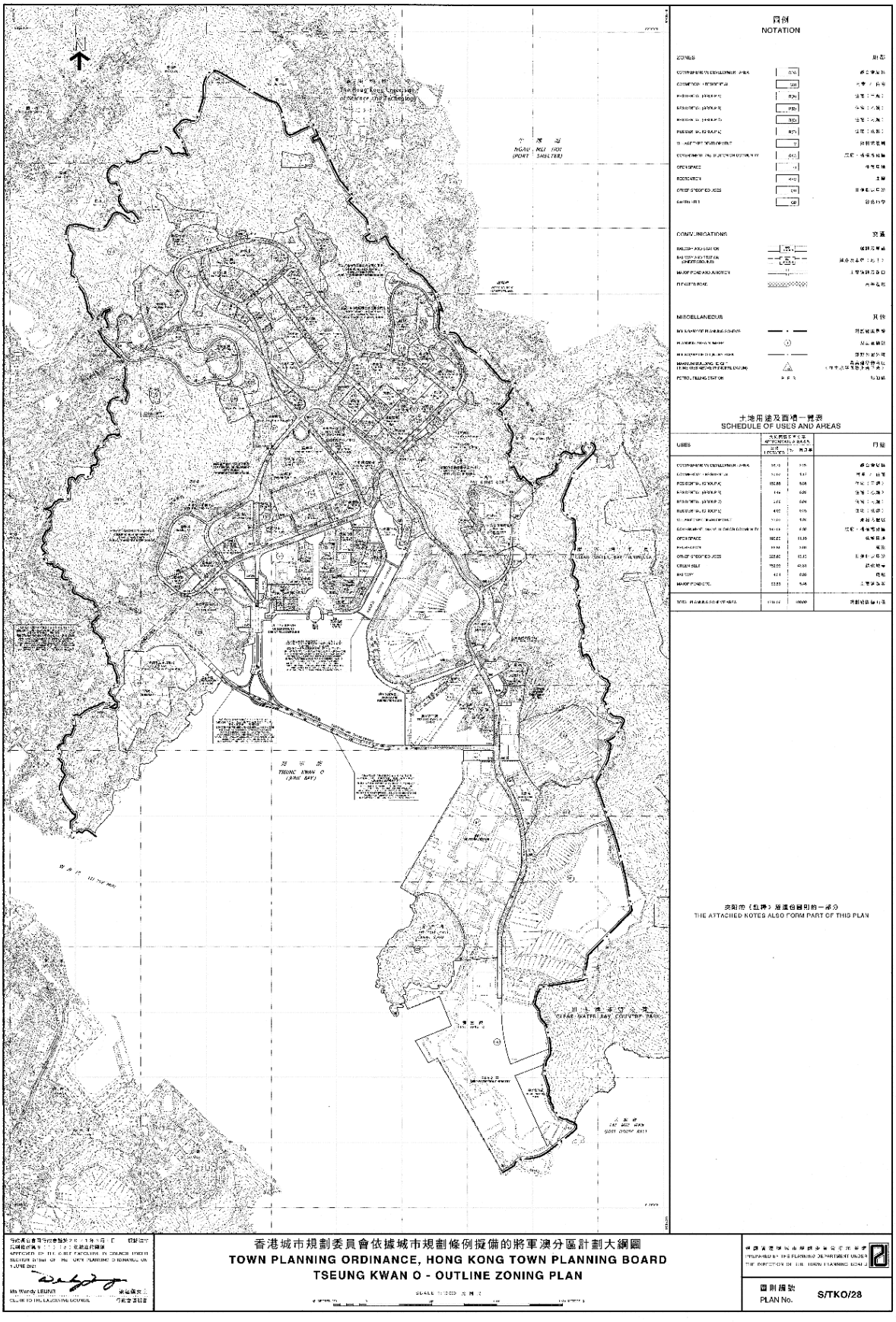


Figure 20 Tseung Kwan O Outline Zoning Plan
(Source: Planning Department. 2021)

4.3.3 Tseung Kwan O Town Center TOD

The TKO Town Center TOD neighborhood is located on the southern coastline of the new town. The neighborhood consists of three parts: center north area, town center, and center south area. The center north area was developed before the TOD strategy was implemented. With the purpose of relocating the population in downtown, the area was developed for social housing projects around 2000. Two years later, the metro station of TKO town center was brought into use, the town center area started to develop. Until 2011, and the area was covered by super high residential towers and mixed-use zones. Currently, the town center works as the activity center of the TKO new town. It provides offices, large commercial complexes, hospitals, and government services. The development of the center south area is the last phase of TOD implementation. During the year 2011 to 2019, the area was constructed as waterfront residential zones with large green outdoor space and high-end residential buildings.

The TKO Town Center TOD places an important role in the new town. It works as the transport hub to link the new town with the downtown area and provides multiple functions and services for the residents. Therefore, the TOD neighborhood is classified as city center TOD by the (Planning Department of Hong Kong, 2022).

Figure 21 Town Centre of Tseung Kwan O South
(Source: Planning department, 2022)

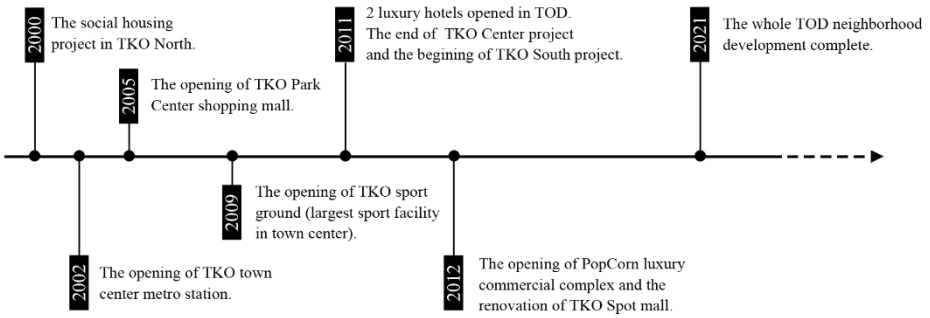


Figure 22 Timeline of TKO Town Center TOD
(Source: made by author)

4.3.4 LOHAS Park TOD

LOHAS Park TOD is located on the southeast of TKO New Town. The northward of the neighborhood is the TKO Town Center TOD neighborhood, which is links by the TKO metro line and highways. The south of the neighborhood is a large high-tech industrial zone, TKO Innopark. The whole TOD neighborhood includes a total area of 33.6 hectares and is recognized as the largest private residential area in Hong Kong. The development of LOHAS Park TOD was led by MTR and other private developers since 2009 (MTR, 2022). Till now, the neighborhood consists of 50 residential towers with an average of 50 stories in height and a floor area ratio of 5. The whole neighborhood theoretically has the capacity of accommodating 75,000 residents (Lu et al., 2014).

As the newest neighborhood in Hong Kong, LOHAS Park TOD is famous for its housing qualities and transport connections. It also creates a balance between the green outdoor space and the buildings. The waterfront scenery and the natural parks also make an excellent urban landscape. Therefore, the housing prices in the neighborhood are higher than other neighborhoods in TKO new town. However, due to the better services and building environment, it continues attracting the middle class to move in.

Figure 23 LOHAS Park TOD overview in 2020
(Source: Wikimedia Commons)

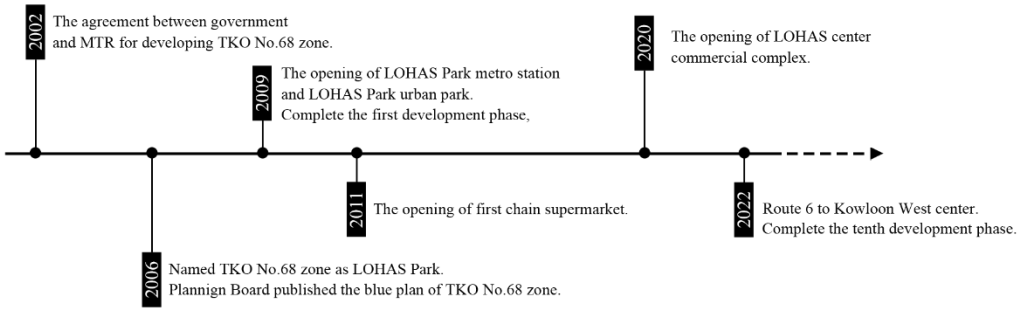


Figure 24 Timeline of LOHAS Park TOD
(Source: made by author)

4.4 Data Collection

4.4.1 Data Sources

The study relies on a multifaceted dataset consisting of historical images, census data, spatial data, and other relevant information. The historical images are collected from Google Earth pro. The census data is sourced from the census surveys in both 2011 and 2021 from the Census and Statistic Department of Hong Kong (CSD). The spatial data includes shapefiles and POIs obtained from Hong Kong's official digital data platform, Common Spatial Data Infrastructure (CSDI), as well as ESRI Open GIS-spatial data. Other information includes the Outline zoning plan of TKO New Town from the Planning Department (PD). The housing value records are collected from two private enterprises: Midland Reality and Centaline Property.

Table 6 Data and data sources

Data	***Data Source***
Historical satellite imagines	
Year 2000 Year 2011 Year 2016 Year 2021	Google Earth
Census	
2011 census data (Big subunit groups, District council district) 2021 census data (Big subunit groups, District council district)	Census and Statistics Department (CSD)
Spatial data	
Shape files (POIs, metro lines and stations, building blocks, land use, etc.)	Common Spatial Data Infrastructure (CSDI) Open Geo-spatial data (ESRI) Open Street Map
3D urban model	CAD mapper
Others	
Outline zoning plan	Planning Department (DP) Town Planning Board (TPB)
Historical housing price	Midland Reality (midland.com.hk) Centaline Property (hk.centaline.com)

4.4.2 Spatial Data

Spatial data includes a wide range of shapefiles, such as geographical location of metro stations, road networks, building blocks, and commercial POIs. The geographical information serves as an important asset for analyzing land use changes, urban development dynamics, and commercial information.

Utilizing the spatial analysis approaches to illustrate the changes of urban fabric in TOD neighborhoods and present them through data visualization. However, there are some obstacles during the data collection. There are still certain historical data that have not been published in Common Spatial Data Infrastructure (CSDI). The missing data includes commercial POIs records and land use conditions in 2011.

4.4.3 Census

The Hong Kong Census and Statistics Department (CSD) undertakes a census survey every ten years and a mid-term survey every five years. The results are released on the department's website in shapefiles and statistical data tables.

There are two issues that should be noticed. Firstly, the census tracts in 2021 are different from 2011 due to the administration shifts or other political purposes. Thus, it's necessary to execute a joint progress in QGIS. Secondly, due to the consideration of privacy and security, Hong Kong only provides the processed data in census shapefiles. Although it simplifies the data processing work of data users, the possibility for deeper analysis is limited. Therefore, the common mathematical model cannot be implemented.

4.4.4 Historical Housing Price

The acquisition of housing prices is important to calculating the housing affordability. However, Hong Kong's official statistical data does not include information on median house prices and historical records. Therefore, it is necessary to gather data from private companies. The data of historical transaction price and per square foot value price are collected from Midland Reality and Centaline Property, which are two large real estate companies in Hong Kong.

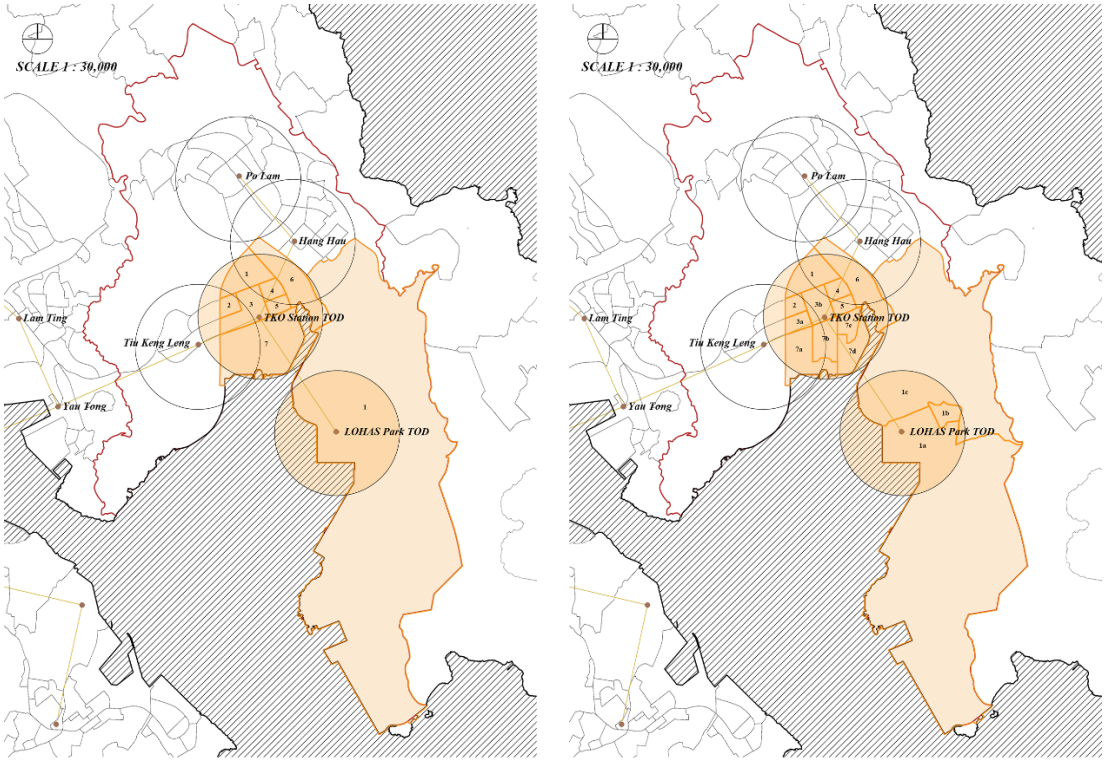
V. FINDINGS

5.1 The Pre- and Post-Conditions

According to the rules of defining the precondition and postcondition in Chapter IV, the time interval is the ten years between the years 2011 to 2021. The physical boundaries of the two TOD neighborhoods are defined in QGIS by creating buffer zones centered around the location of metro stations, with a 700-meter radius.

There are seven census tracts that can be observed in the TKO Town Center TOD neighborhood in 2011. The census tracts are numbered from 1 to 7 by following the sequence from North to South. And there is only one census tract in LOHAS Park TOD neighborhood which is numbered as 1 (Figure 25, on the left).

In 2021, some of the census tracts were further divided into smaller tracts by the government. There are eleven tracts in the TKO Town Center TOD neighborhood and three tracts in LOHAS Park TOD neighborhood. In order to facilitate a clear comparison, these tracts are numbered following the rules as before. Therefore, the census tracts in the TKO Town Center TOD neighborhood are numbered as 1, 2, 3a, 3b, 4, 5, 6, 7a, 7b, 7c, 7d. The census tracts in LOHAS Park TOD neighborhood are numbered as 1a, 1b, 1c (Figure 25, on the right).



Census tracts in 2011 *Census tracts in 2021*

Figure 25 Census tracts in TKO New Town
(Source: made by author)

Furthermore, there are several unique land use features that can be noticed inside the TOD neighborhood while using the Google Map of the year 2021 as the cartographic reference (Figure 26).

In the TKO Town Center TOD neighborhood, some distinctive land use characteristics are involved in the census tracts. The tract TKO 3b concentrates most of the education resources and high-end commercials. TKO 1, 2, 4 and 7c are designated as the areas for social housing. TKO 6 is dedicated to public parks and sports facilities. TKO 7a has a half of the area occupied by government institutions.

In LOHAS Park TOD neighborhood, the three census tracts cover a large area. The tract LOHAS 1a is the largest tract which contains the TOD neighborhood, TKO Innopark, and nature parks. However, within the 1a zone, only the neighborhood has residential units. Therefore, the demographic of LOHAS 1a can represent the TOD neighborhood's demographic. LOHAS 1b is also a part of the TOD neighborhood. LOHAS 1c is specifically authorized for the Fire and Ambulance Services Academy. Therefore, 1c is ignored in the later analysis.

In conclusion, the precondition is the two TOD neighborhoods in the year 2011, the post-condition is the two neighborhoods in the year 2022. After the identification of the TOD-related census tracts, the related data is exported by QGIS and formed a table in Excel (Table 7). Moreover, another table (Table 8) contains the same types of data of Sai Kung District for the comparison.

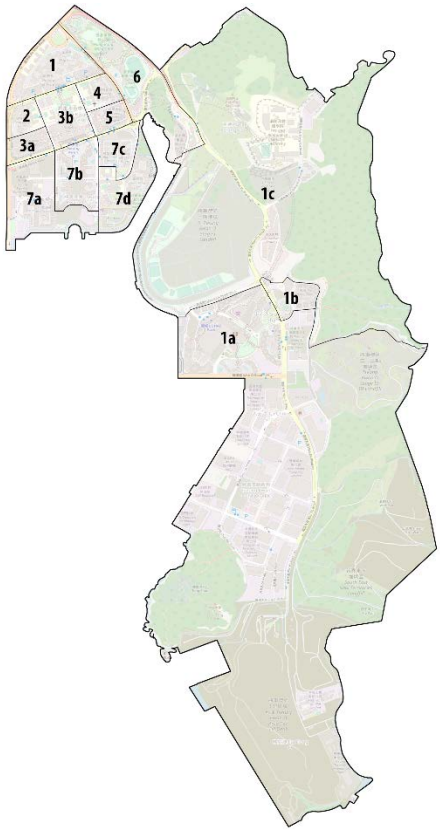


Figure 26 Census tracts with numbers and base map in 2021
(Source: made by author)

Table 7 Census demographics of TKO and LOHAS Park

	TKO TOD		LOHAS PARK TOD	
Variables	2011	2021	2011	2021
Population	96,063	122,150	11,501	47,991
Age				
Person 25y to 44y (%)	35,501	38,661	4,500	17,345
Person 65y and over (%)	8,297	19,110	406	4,343
Median Age	-	-	-	-
Ethnicity				
Chinese	91,811	113,214	10,471	41,140
Southeast Asian	3,312	6,367	841	3,732
White	198	467	9	567
Education				
Adults with a lower education degree	14,320	13,747	695	2,193
Adults with a high school degree	43,723	47,520	10,471	13,469
Adults with a bachelor degree or above	24,369	46,003	4,607	25,052
Occupation				
Managers and administrators, professionals	8,824 (5.7%)	17,940 (8.9%)	2,126 (10.8%)	10,680 (12.9%)
Income				
Median household income (HK$)	33,000	51,600	52,000	54,800
Low-income HHs (<19,999HK$/month)	9,592	10,480	270	2,143
High-income HHs (>=20,000HK$/month)	20,416	31,277	2,518	13,956
Household characteristic				
Tenant	7,115 (23.7%)	12,540 (30%)	1,957 (56.4%)	5,487 (34.1%)
Home size 1 to 2 persons	10,366 (34.5%)	17,983 (43.1%)	1,209 (34.8%)	6,985 (43.4%)
Median Household size	-	-	-	-
Housing characteristic				
Small-sized (0 to 2 rooms) units	3,298 (11%)	5,347 (13%)	14 (0.4%)	1,200 (7%)
Occupied units	30,154	41,890	3,487	16,095
Units of Public housing	5,393 (18%)	7,451 (17.8%)	N/A	N/A
Units of Other housing	13,780 (36.1%)	15,036 (46.2%)	N/A	N/A
Units of Private housing	10,835 (45.9%)	19,270 (36%)	3,472 (100%)	16,099 (100%)
Median HH rent (HK$)	9,875	17,800	11,500	16,900
Median monthly rent to income ratio	21.4%	28.5%	23.7%	28.2%
Units of Rent price < 5,999 HK$	5,504	7,575	4	5,045
Units of Rent price >= 6,000 HK$	1,655	448	1,963	5,460

Table 8 Census demographics of Sai Kung District

	Sai Kung District		
Variables	2011	2021	Percentage Change
Population	436,627	489,037	12%
Age			
Person 25y to 44y	151,229	150,700	- 0.4%
Person 65y and over	39,342	77,273	96%
Median Age	39	45	-
Ethnicity			
Chinese	407,213	442,447	9%
Southeast Asian	18,891	26,631	41%
White and other foreigners	5,034	7,348	46%
Education			
Adults with lower education degree	70,350	62,673	- 10.9%
Adults with high school degree	190,615	189,559	- 0.6%
Adults with bachelor degree or above	119,381	180,476	51%
Occupation			
Managers and administrators, professionals	43,254 (6.1%)	68,675 (8.7%)	58.8%
Income			
Median household income (HK$)	26,870	37,840	40.8%
Low-income HHs (< 19,999HK$/month)	49,445 (35.7%)	46,652 (27.8%)	- 5.6%
High-income HHs (> =20,000HK$/month)	88,764	121,195	36.5%
Household characteristic			
Tenant	44,209 (32%)	54,208 (32.3%)	22.6%
Household size 1 to 2 persons	50,709 (36.7%)	73,628 (43.9%)	45.2%
Median Household size	3.1	2.9	-
Housing characteristic			
Small-sized (0 to 2 rooms) units	17,842 (13%)	21,812 (13%)	22.2%
Occupied units	139,506	168,975	21.1%
Units of Public housing	29,031 (20.8%)	29,373 (17.4%)	1.2%
Units of Subsidized housing	44,416 (31.8%)	46,927 (23.8%)	5.7%
Units of Private housing	64,999 (46.6%)	91,119 (53.9%)	40.2%
Median HH rent (HK$)	1,800	3,540	96.7%
Median monthly rent to income ratio	14.3%	17.7%	3.4%
Units of Rent price < 5,999 HK$	32,493	32,174	- 1%
Units of Rent price > = 6,000 HK$	13,356	24,370	82.5%

5.2 Spatial Analysis

5.2.1 Urban changes of TKO Town Center TOD

The development of the TKO Town Center TOD neighborhood started in 2000 and finished in 2021. The process of expansion starts from the north social housing zones to the southern waterfront residential blocks. In accordance with the future development goals, the neighborhood contains a large number of mixed-use zones and social services.

According to Google Earth and ESRI, the analysis found the ground floors in the building blocks were designed as commercial zones. The residents in the community can enjoy corridors and pathways to reach the destination easily. In the TKO metro station surrounding area, the transit area is designed as a megastructure complex called Park Center Project which involves stores, hotels and offices. Furthermore, the education resources including primary schools and high schools are centralized around the metro station. In general, the urban layout creates an efficient and livable zone for the residents.

The residential towers in the neighborhood can be categorized by building features and housing types. The First type is the social housing units in the center north area, which are designed as high-rise, small room size, and high FAR towers. These projects were built adjacent to other early developed communities in the 1990s. The second type is the skyscrapers with high FAR in the town center area. These buildings are mostly served for the private homebuyers. The third type is the high-end waterfront resident blocks in the center south area. In this area, the buildings are built with lower height compared with other areas. Due to the better seashore landscape and large scale of public green spaces, the area is shaped as luxury residential zones by the developers. By 2021, the unit area price in center south has already reached 220,000 HK/ft^2, which surpassed most of the prices in the TKO Town Center TOD neighborhood.

Tong Ming Court Social Housing *Park Central Residential Tower* *The Wings High-end Community*

Figure 27 Photos of different housing buildings
(Source: Wikipedia)

The 3D model indicates a downward trend in building height and residential density in the town center area and the center south area, while the ratio of the green space is increased. The trigger of the changes may be because the urban planners want to preserve the urban landscape and the developers are eager to attract wealthy households by improving the building environment. The impact of the transition of the development strategy reflects on the increase of the housing price on the waterfront blocks.

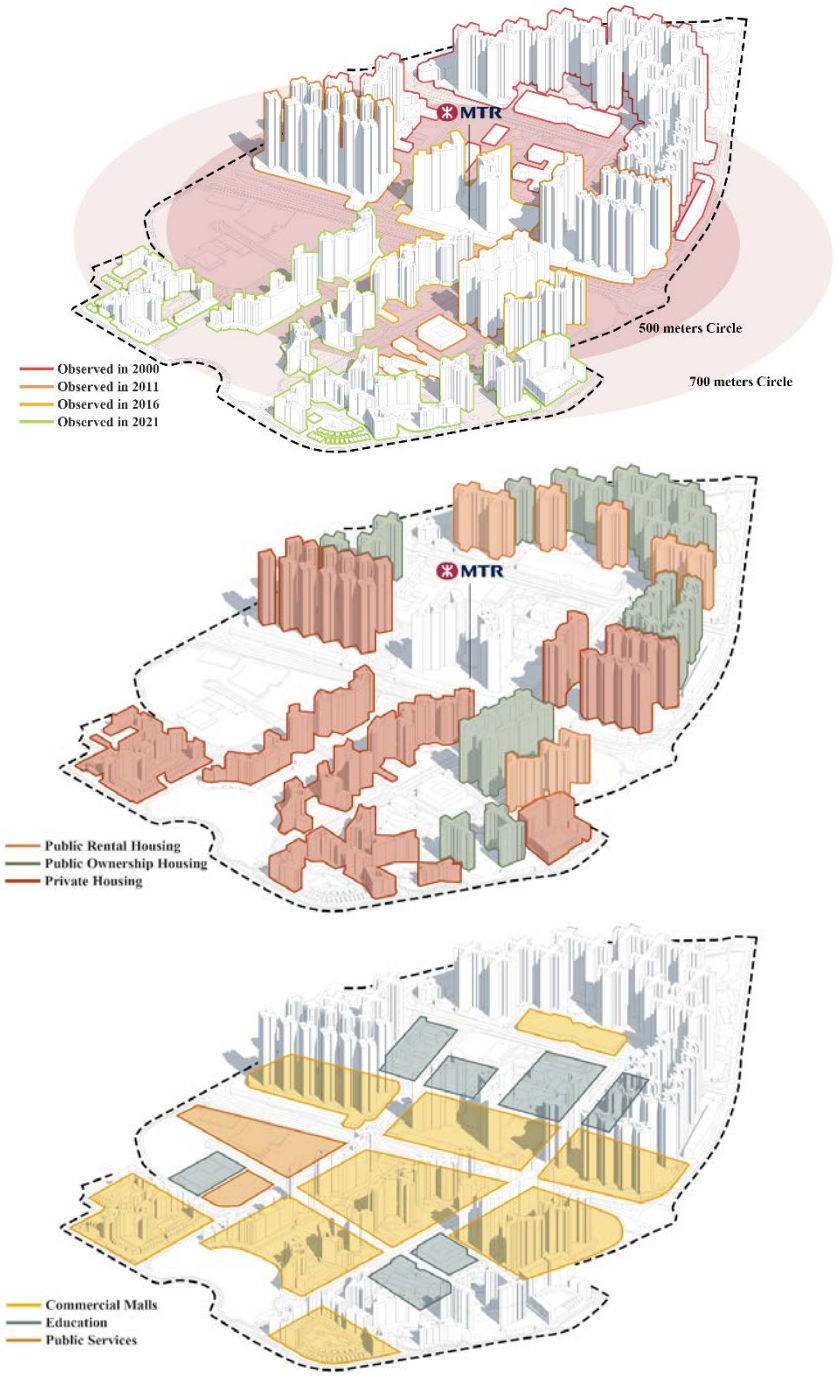


Figure 28 TKO town center TOD development phase, housing type, land use (Source: made by author)

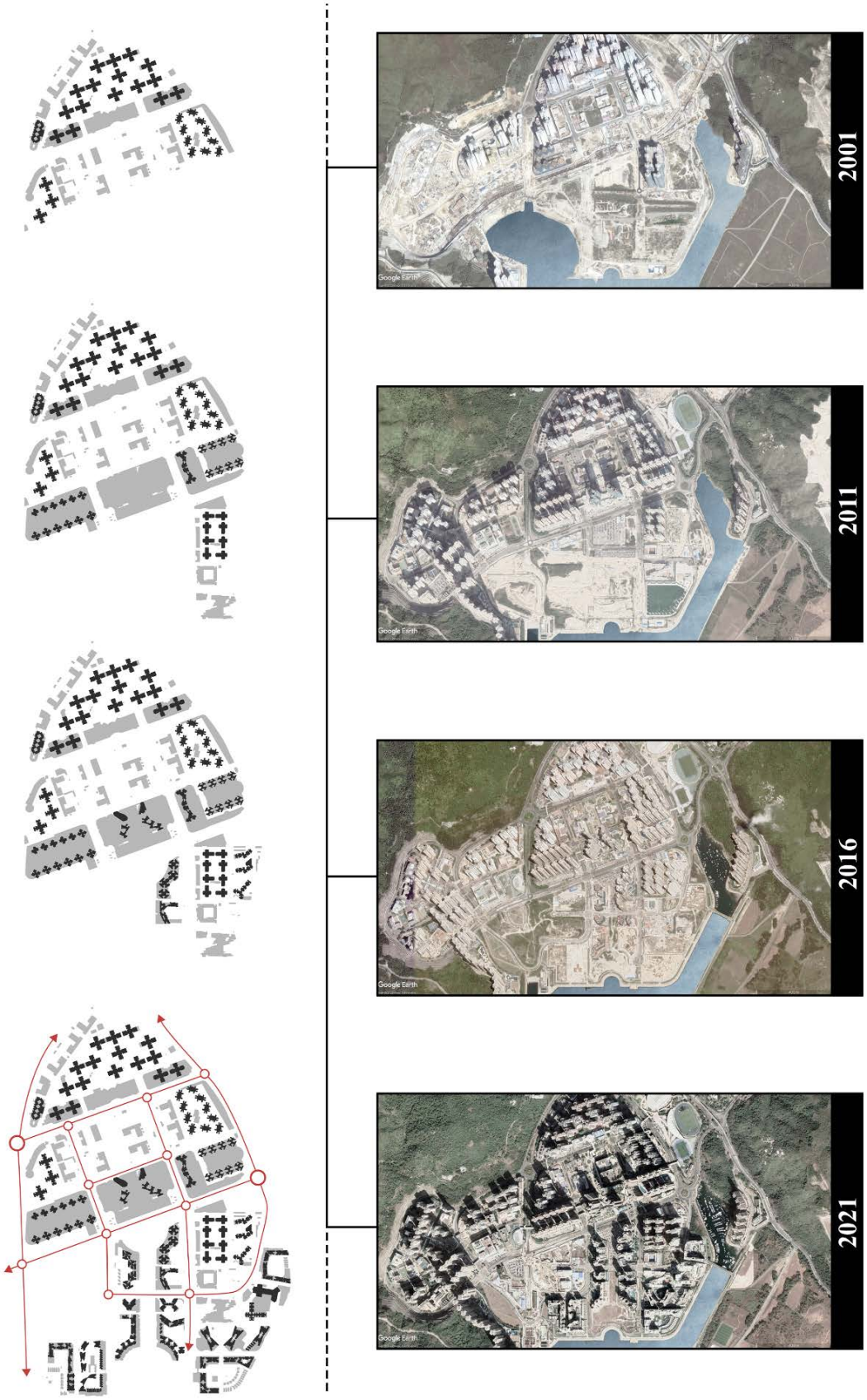


Figure 29 Urban expansion of TKO Town Center TOD
(Source: made by author)

5.2.2 Urban changes of LOHAS Park TOD

The LOHAS Park TOD is the newest TOD neighborhood in the new town. Located on the reclaimed land and near to the nature parks, which enhance the aesthetic appeal for the residents. The community centers around the metro station and creates a highly efficient walkable environment through the use of open corridors and tunnels. In the meanwhile, the residential towers in LOHAS Park TOD neighborhood are shaped as skyscrapers, and the cluster of tall buildings shapes a special urban landscape in Hong Kong.

As a residential TOD, the facilitates purposes for meeting the needs of local residents. The neighborhood has the largest private housing zones, the price of residential units is higher than most of the areas in the new town. However, the high price doesn't prevent the population from moving in. The good quality of residential buildings and the excellent garden city design achieve a relative balance between urban and nature. From the perspective of the consumer, the neighborhood has a strong attraction to the wealthy.

Malibu the 3rd Phase
Residential tower

Marini the 9th Phase
Residential towner

Sunrise Boulevard

Figure 30 Photos of residential buildings
(Source: Wikipedia)

From the 3D models, the LOHAS Park TOD neighborhood uses a different design strategy from TKO Town Center TOD. All the towers are built in a high height, but the greenery coverage is larger. Even though the neighborhood still implements the concept of compact city, the land value still keeps higher than other places. This finding provides new aspects for rethinking the urban development strategy. The development progress of the neighborhood is characterized by a sequential expansion from inland to the coast. The beginning of the construction can be chased into the year 2011. Since the opening of the LOHAS Park metro station, the surrounding residential towers were brought into use.

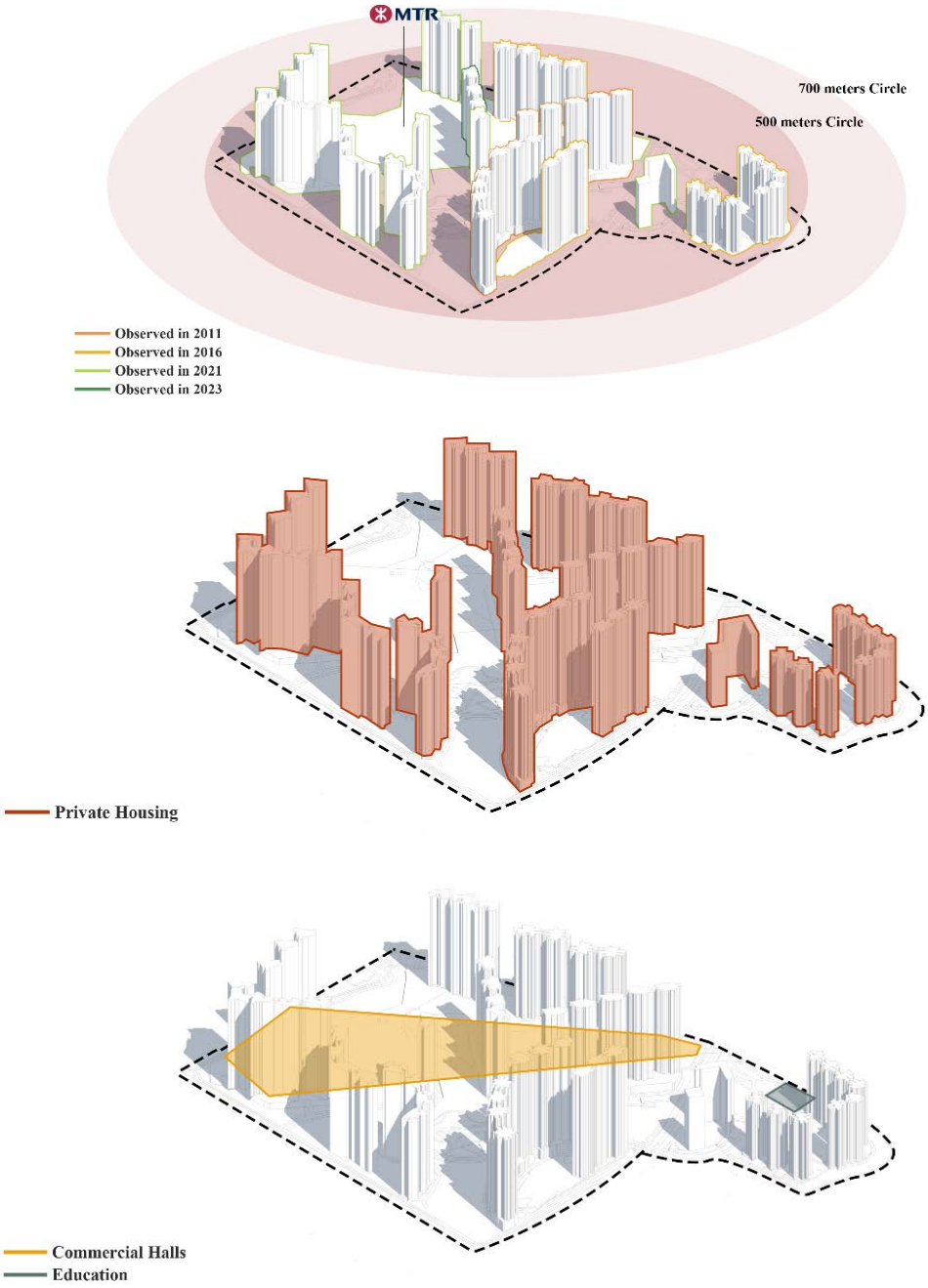


Figure 31 LOHAS park TOD development phase, housing type, land use (Source: made by author)

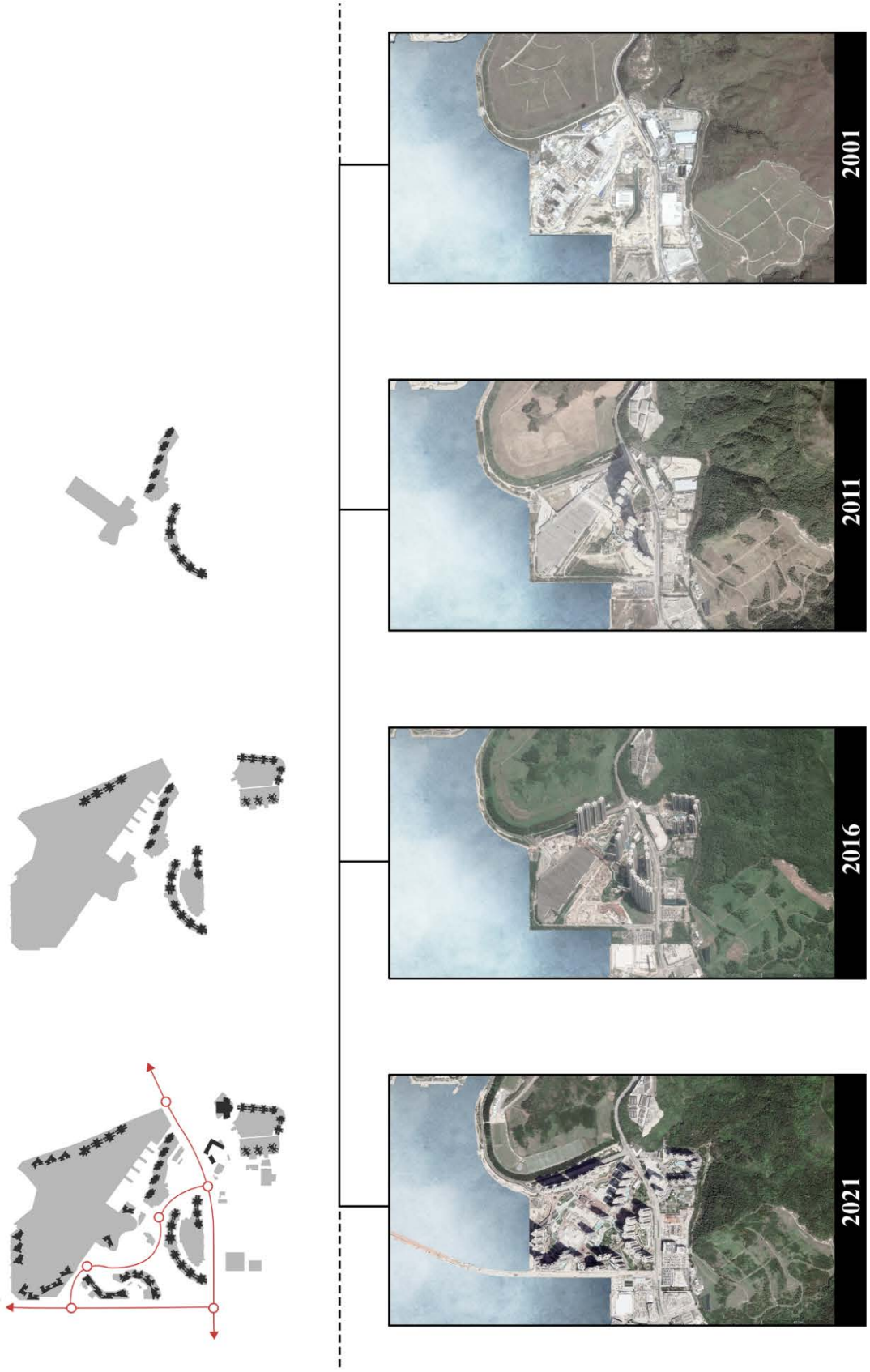


Figure 32 Urban expansion of LOHAS Park TOD
(Source: made by author)

5.2.3 Commercial POIs Analysis

The analysis of the POIs shows that in 2021, there were 214 restaurants, 158 companies, and groups, 67 social services, 85 educational resources, 128 medical services, and 207 retails in the two TOD neighborhoods (Figure 33).

The findings of the fishnet analysis (Figure 34) shows that the TKO Town Center TOD neighborhood has the highest concentration of all types of business. In the eleven census tracts, TKO 3a, 4, and 5 have the highest density of *Medical services*, *Restaurants*, and *Stores*. On the contrary, the LOHAS Park TOD shows a large number of companies, however, other businesses are less than TKO Town Center TOD.

The findings align with the goal of the new town development. TKO Town Center TOD works as an urban center providing all kinds of services to satisfy the needs of inhabitants. LOHAS Park TOD focuses on accommodating more population and offering job opportunities.

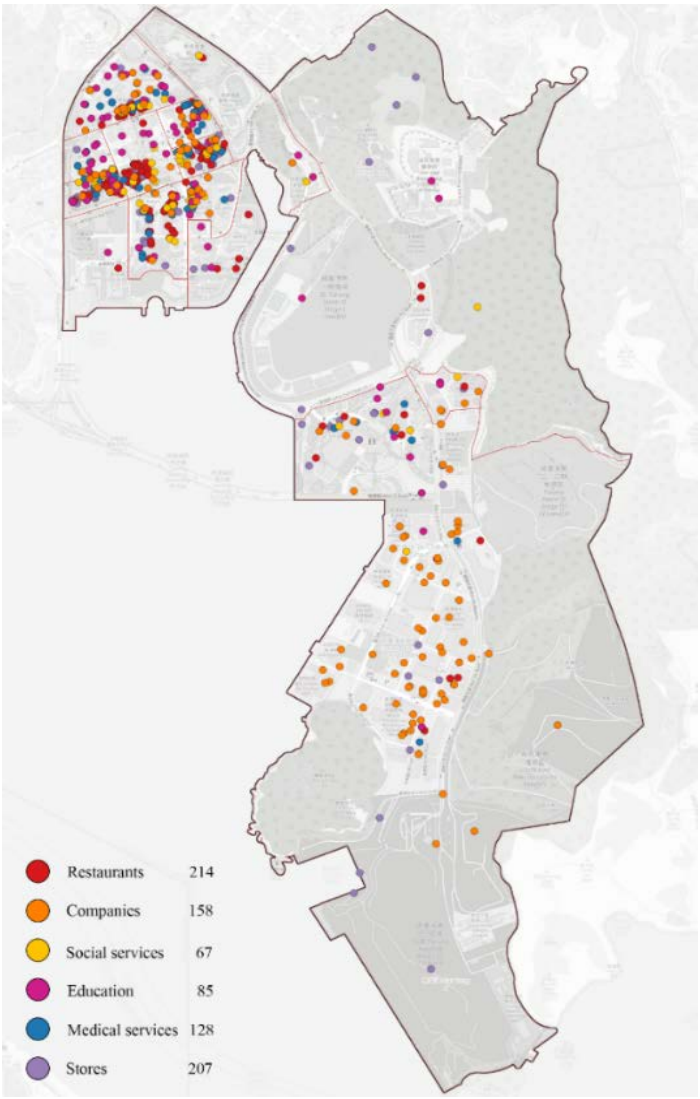


Figure 33 Number and distribution of commercial POI
(Source: made by author)

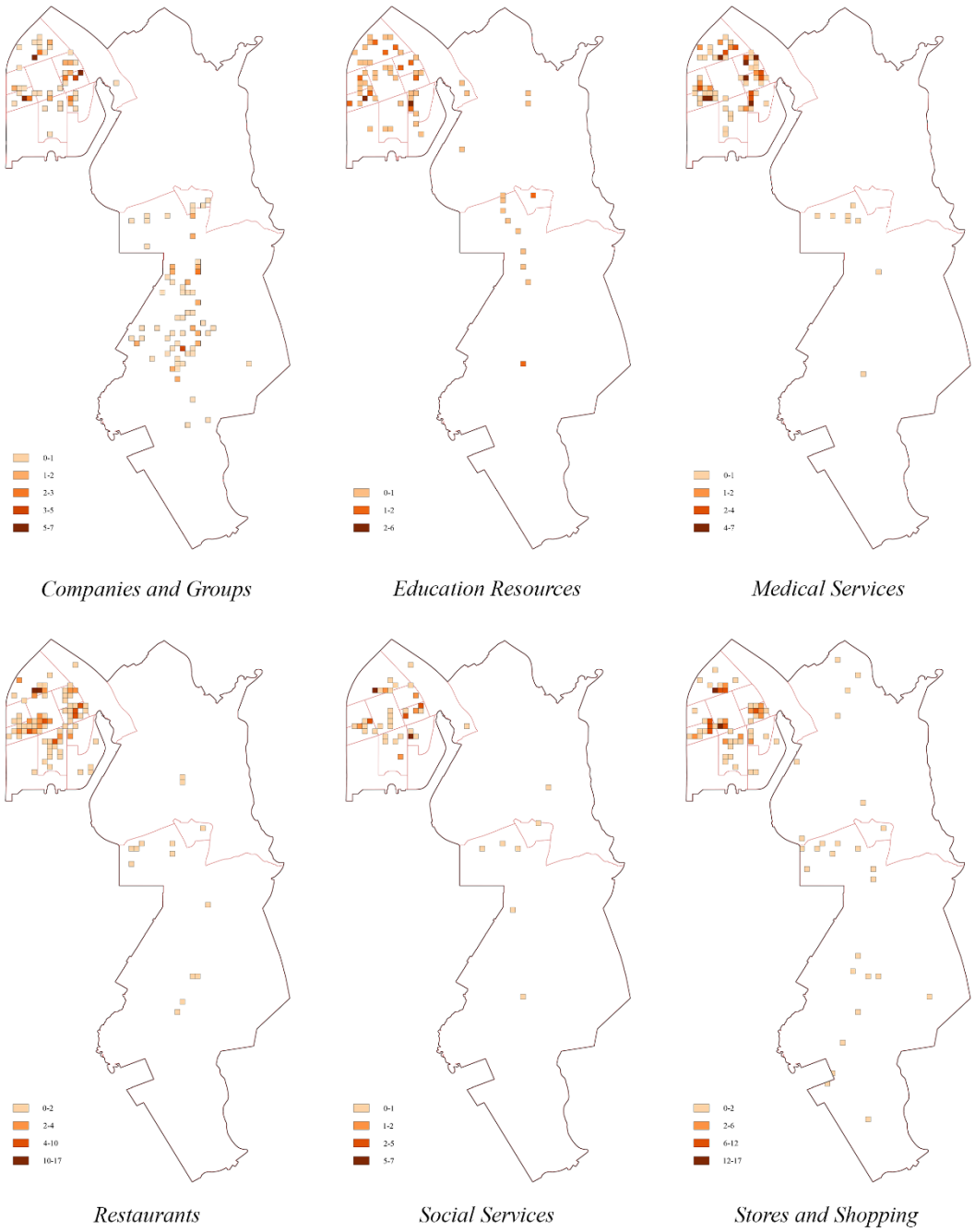


Figure 34 The results of fishnet analysis
(Source: made by author)

After listing all the business categories, it shows the notable commercial upscaling phenomenon in three categories *Restaurant*, *Store and Shopping*, and *Education Resources,* whereas the other three categories don't. These three categories all have a strong relation with the daily expenses of the residents.

In the *Restaurant* category, the upscaling entities occupy 60% of the total. Most of the restaurants are chain restaurants and foreign cuisines, furthermore, café and dessert stores also appear in the neighborhood.

In the *Store and Shopping* category, high-end stores occupy 66% of the total, among which are brand stores, duty-free shops, chain supermarkets, etc.

In the *Education resources* category, 61% of the entities are private education institutions for art and music training or cram schools. Also, the international schools and private schools also appear in the neighborhood.

Figure 35 The ratio of commercial categorizes (Source: made by author)

5.3 Demographic Change

5.3.1 The Changes of Variables

As the expansion from the original urban fabric, the TKO Town Center TOD shows a notable positive growth in the variables of gentrification. The variables of high educational attainment, professional occupations, median household income, and median rental price all experienced significant growth despite only 27.2% increase in the total population. Meanwhile, the population also leads to an increase in the number of lower-income families, but their share of the total population decreases from 32% to 25%. In addition, although the increase in median monthly rent and property value showed a fast increase, the percentage change in occupied units also increased to 38.9%. This condition shows that the high housing prices haven't stopped the buying and moving-in behavior in TOD neighborhoods. It indicates the ongoing trend of out-migration of low-income households and in-migration of the middle class.

Compared to the TKO Town Center TOD, the percentage change of all variables in the LOHAS Park TOD is significant. From 2011 to 2021, the large influx of people has increased the number of households, but the ratio of middle-income households to low-income households has remained stable at 9 to 1. The proportion of the highly educated population in the LOHAS Park TOD has increased dramatically from 29.2% in 2011 to 61.5% in 2021. However, the percentage of the professional occupation population only increased from 12.9% to 13.6%. Additionally, the percentage change in median income over the ten years was only 5.4%. The reason for this result may be due to the monthly median income in 2011 was 52,000 HK$, which is already higher than the general average household income level. Therefore, the change of household income is not significant. Moreover, the number of rental households has decreased from 56.4% to 34.1%. It indicates that the majority of households prefer to purchase property, despite the median housing price being as high as 139,000 HK$/ft^2.

Compared to the overall changes in Sai Kung District, the two TOD neighborhoods both experienced significant growth in all variables. TKO Town Center TOD showed a similar trend to the Sai Kung District, but the percentage changes are always one or two times greater than the district. The percentage change in the LOHAS Park TOD is outstandingly greater than in the district. Although the percentage changes of median income and median rent are lower in LOHAS Park, these two values are already higher than average value in the year 2011 (listed in Table 9). The only variable that shows an opposite change is the percentage of low-income households, which increased in TOD neighborhoods but decreased in Sai Kung District. The reasons for this result are diverse, including the growth of the working population in Southeast Asian households and the migration of workers to ongoing construction projects.

Table 9 Census variable change comparison

	LOHAS Park TOD			Sai Kung District
Variables	2011	2021	% Change	% Change
Total Population	11,501	47,991	317.3%	12%
Middle-income and above HHs	2,518 (90%)	13,956 (87%)	454.2%	36.5%
High education level	4,607 (29.2%)	25,052 (61.5%)	443.8%	51%
Professional occupations	2,126 (10.8%)	10,680 (12.9%)	402.4%	58.8%
Southeast Asian population	841 (7.3%)	3,732 (7.8%)	343.8%	41%
Low-income HHs	270 (10%)	2,143 (13%)	693.7%	- 5.6%
Median HHs income (HK$)	52,000	54,800	5.4%	40.8%
Occupied units	3,487	16,095	361.6%	21.1%
Tenant	1,957 (56.4%)	5,487 (34.1%)	180.4%	22.6%
Median rent price (HK$)	11,500	16,900	47%	96.7%
Median property value (HK$/ft^2)	10,041	13,900	38.4%	-

	TKO Town Center TOD			Sai Kung District
Variables	2011	2021	% Change	% Change
Total Population	96,063	122,150	27.2%	12%
Middle-income and above HHs	20,416 (68%)	31,277 (75%)	53.2%	36.5%
High education level	24,369 (29.6%)	46,003 (42.9%)	88.8%	51%
Professional occupations	8,824 (5.7%)	17,940 (8.9%)	103.3%	58.8%
Southeast Asian population	3,312 (3.4%)	6,367 (5.2%)	92.2%	41%
Low-income HHs	9,592 (32%)	10,480 (25%)	9.3%	- 5.6%
Median HHs income (HK$)	33,000	51,600	56.4%	40.8%
Occupied units	30,154	41,890	38.9%	21.1%
Tenant	7,115 (23.7%)	12,540 (30%)	76.2%	22.6%
Median rent price (HK$)	9,875	17,800	101.4%	96.7%
Median property value (HK$/ft^2)	9,025	12,596	39.6%	-

5.3.2 Socioeconomic Change Index and Gentrification Index

The census tracts which are related to TOD neighborhoods have the most significant demographic changes in Sai Kung District. The results are shown by the two indexes in the following graphics (Figure 36 and Figure 37). From the graphics of two indexes, it can be observed that most of the census tracts with a change level above 4 are concentrated in the TKO New Town area. The major census tracts in these two TOD neighborhoods experienced greater changes than most of the tracts in the district. In short, the results of *Socio-economic change index* and *Gentrification index* indicate that in the suburban district, TOD communities undergo significant demographic changes and a more markable trend of gentrification than non-TOD communities.

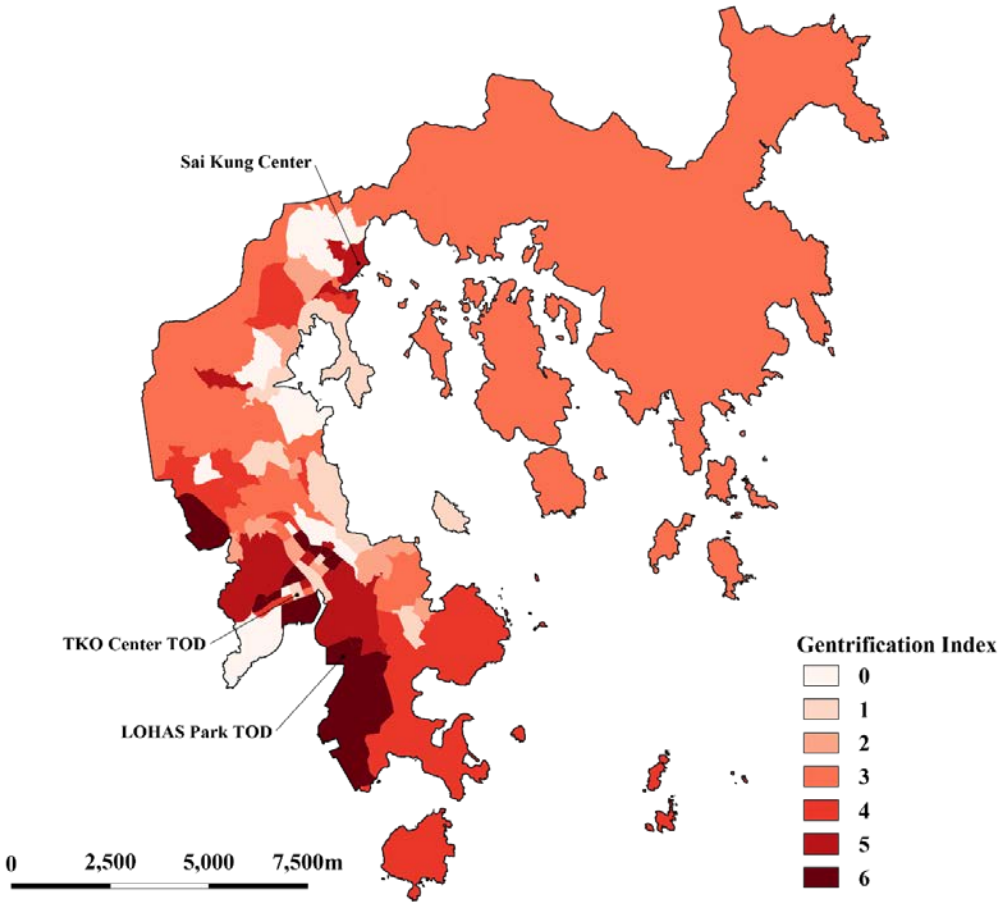


Figure 36 Gentrification index
(Source: made by author)

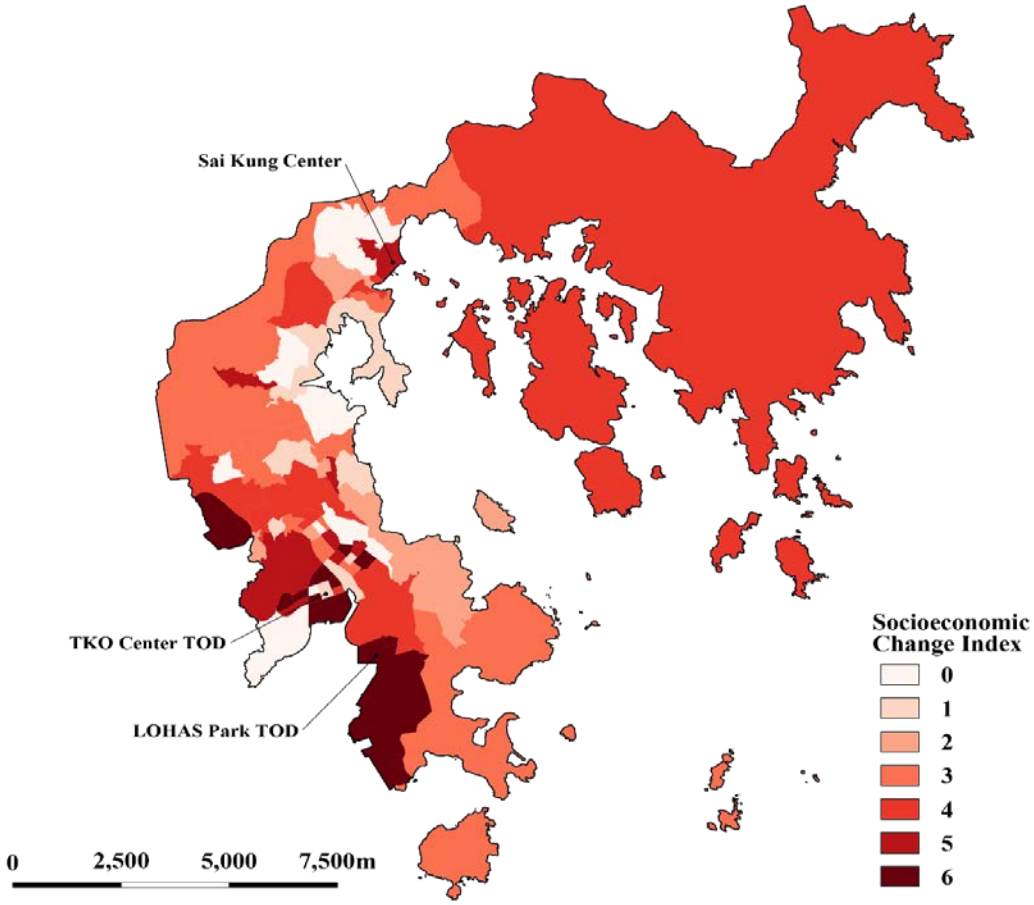


Figure 37 Socioeconomic change index
(Source: made by author)

5.4 Housing Affordability Analysis

5.4.1 MPIR and MRIR

For homebuyers, the change of Median mortgage payment to income ratio (MPIR) in both two TOD neighborhoods is still in an affordable condition. However, the results of changes in each census tract are mixed. Half of the tracts show increased trends in MPIR, while others show decreased trends.

Four census tracts including TKO 1, 2, 7b, and 7d experienced a significant increase in the percentage change. TKO 1 (change from 19.2 to 24.2, percentage change +26%) and 2 (change from 14.9 to 23.1, percentage change +55%) are social housing tracts, indicating that the government's housing policies also began to occupy a large portion of residents' incomes. TKO 7b (change from 18 to 24.7, percentage change +37%) and 7d (change from 18 to 26, +44%) are high-quality residential blocks with a percentage change of more than 30%.

In addition, six tracts (TKO 4, 5, 6, 7c, LOHAS 1a, and 1b) show a decreasing trend, which means the affordability is increasing in these tracts. Although the decrease is not significant, the conditions of the homebuyers are getting better. The reason for the finding might be the middle class move-in, their household incomes are higher than the local housing price.

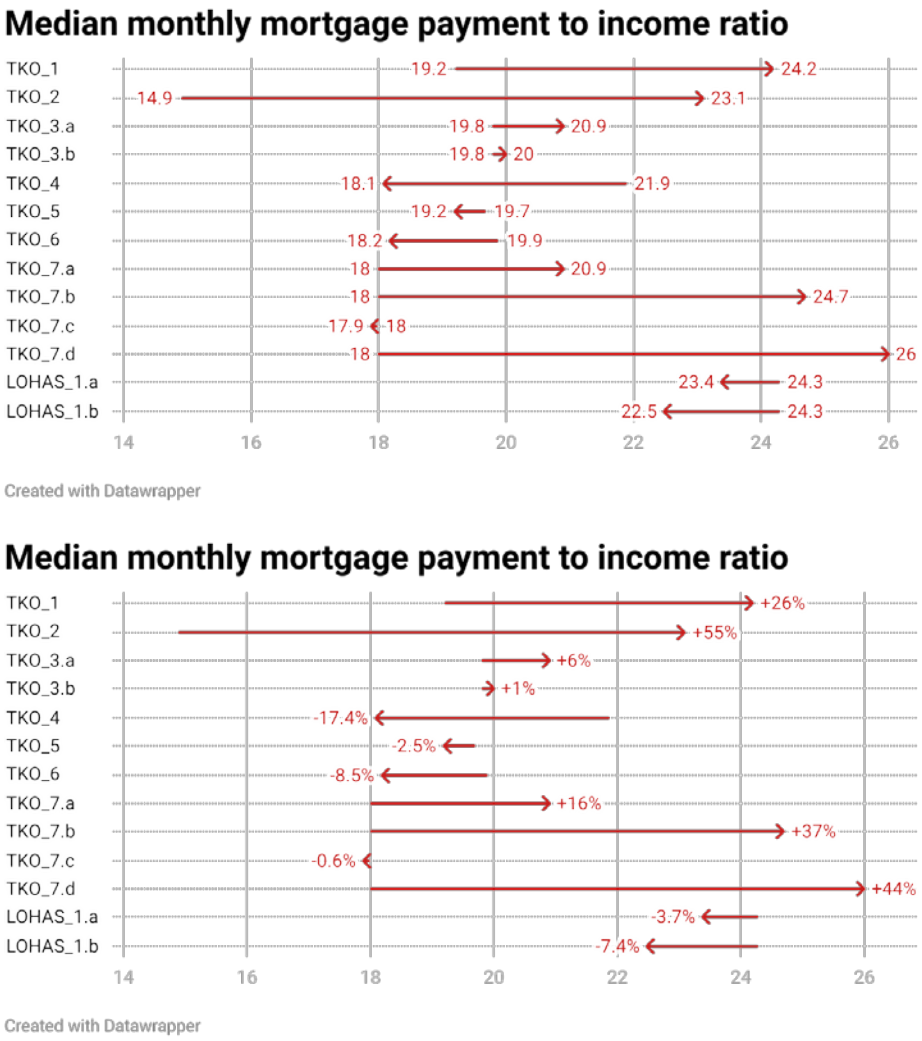
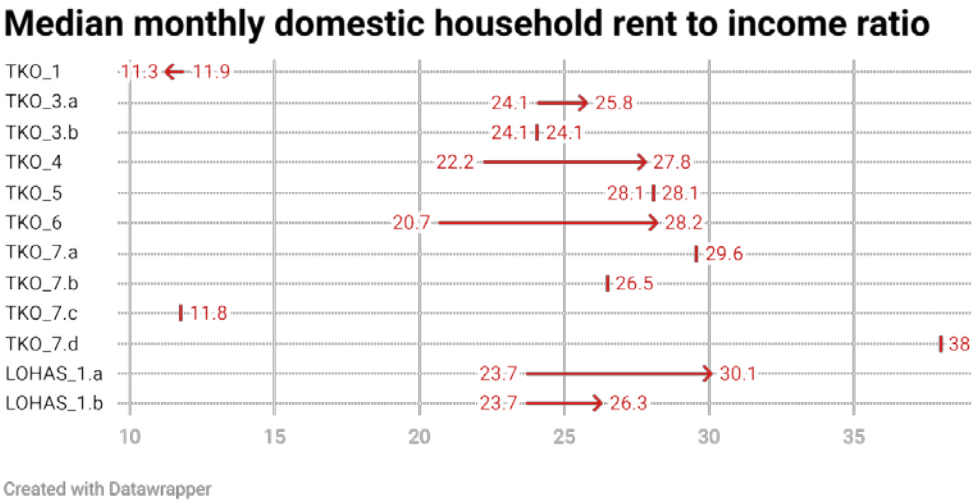


Figure 38 MPIR and change percentage
(Source: made by author)

For renters, the affordability is reflected by the Median rent-to-income ratio (MRIR). The changes in two TOD neighborhoods show an overall upward trend. TKO 4, 5, 6, 7a, as well as LOHAS 1a, have reached or exceeded 28, which indicates that renters are balancing their daily expenses and rents. However, the MRIR of TKO 7d has reached 38, which shows the renters are spending a higher proportion for rent of their income.

The increase of the rental costs may be due to an overall decrease in the number of rental units and renters. It can be explained from the percentage change of occupied units and tenants in Table 9, the number of occupied units shows a significant increase while the number of tenants shows decline.



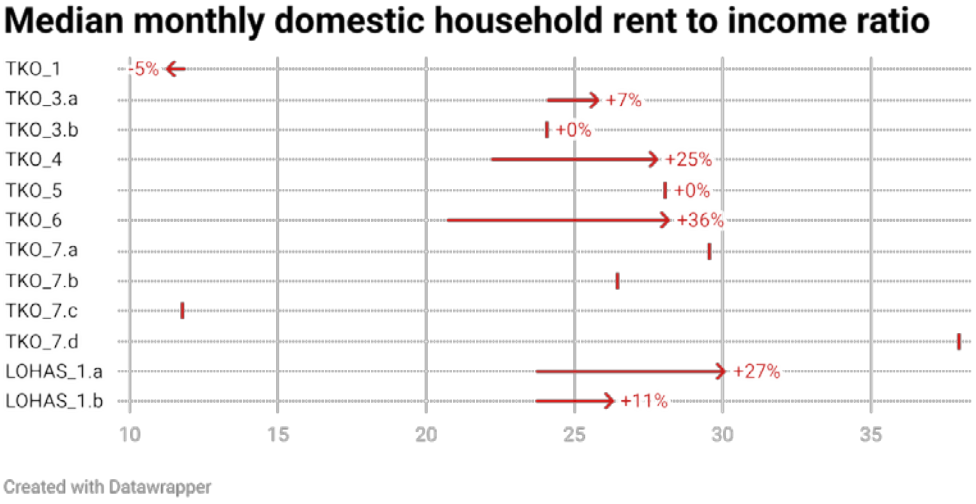


Figure 39 MRIR and change percentage
(Source: made by author)

In two TOD neighborhoods, the MRIR and MPIR show different trends. The results indicate that renters are under more pressure to pay rents than homebuyers to pay their mortgages. In other words, no matter living in public housing or in private housing blocks, all the renters are facing more financial pressure. The results reflect the previous findings that residents in TOD neighborhoods prefer to buy their property rather than rent.

There are three reasons to explain this situation. Firstly, according to Hong Kong's policy, the homebuyers don't have much pressure to pay their monthly mortgage. Secondly, in a market-driven economy, the investment potential of real estate is promising. If the owners buy housing for rent, they can gain more interest from rental and selling. Thirdly, the buying behavior may relate to the local tradition that owning real estate is a sign of independence from the family.

5.4.2 NAR's Housing Affordability Index

After calculating the HAI of thirteen census tracts in two TOD neighborhoods, the results indicate that the majority of HAI values range from 33% to 40%, the highest HAI is found in TKO 3b (55%), while the lowest was found in TKO 7c (27%). However, all the HAI values are far lower than the standard value (HAI 100%). Thus, TKO 7c is the least affordable block, while TKO 3b (HAI 55%) and LOHAS 1a (HAI 54%) are the most affordable blocks. However, even in these two blocks, homebuyers still face large pressure to pay their mortgages.

Combining with the social housing distribution in TOD neighborhoods, the low affordability blocks like TKO 1 (37%), 2 (36%), and 7c (27%) are characterized by public rental or public ownership units. In contrast, blocks with high affordability are dominated by private properties. This phenomenon reflects the blocks are segregated by household income. The households living in public housing units have lower median income, but housing prices for buying remain high, contributing to the low value of HAI in these blocks.

Table 10 HAI calculation of all census tracts in two TOD neighborhoods

Number of Census Tracts in TOD Neighborhoods	Average housing price (HK$/ft^2)	Housing price (HK$/516 ft^2)	Monthly payment of HHs (HK$)	Qualifying income (HK$)	Median HHs monthly income (HK$)	Yearly HHs income (HK$)	HAI
TKO 1	10,183	5,254,428	20,560	986,880	30,620	367,440	37%
TKO 2	10,101	5,212,116	20,394	978,912	29,380	352,560	36%
TKO 3a	18,595	9,595,020	37,607	1,805,136	54,190	650,280	36%
TKO 3b	19,596	10,111,536	39,632	1,902,336	87,680	1,052,160	55%
TKO 4	11,884	6,132,144	24,035	1,153,680	38,070	456,840	40%
TKO 5	18,272	9,428,352	36,954	1,773,792	49,970	599,640	34%
TKO 6	14,009	7,228,644	28,332	1,359,936	52,250	627,000	46%
TKO 7a	20,516	10,586,256	41,492	1,991,616	75,100	901,200	45%
TKO 7b	19,596	10,111,536	39,632	1,902,336	74,320	891,840	47%
TKO 7c	12,059	6,222,444	24,389	1,170,672	25,910	310,920	27%
TKO 7d	18,634	9,615,144	37,686	1,808,928	50,210	602,520	33%
LOHAS 1a	13,977	7,212,132	28,268	1,356,864	61,240	734,880	54%
LOHAS 1b	13,824	7,133,184	27,958	1,341,984	53,470	641,640	48%

5.5 The Summary of TIG Impacts

Previous findings show the presence of TIG signs in two TOD neighborhoods. Therefore, it's necessary to give a comprehensive summary in order to provide an overview of the research. Based on the literature review and research findings, the general summary (Table 11) can be concluded from three aspects to depict the transformation in TOD.

The first summary can be concluded by the methodology of spatial analysis, which involves the urban development strategies and the upgrading of commercial categories. Referring to the implementation of TKO Town Center TOD, it can be regarded as an example of the modifications in urban planning strategy during the development process. Over the ten years, there has been a decline in the proportion of social housing in new residential projects, while more high-end private housing blocks were constructed. Moreover, the commercial categories also experienced a process of upgrading and upscaling. Large shopping malls and chain stores have replaced small-scale retailers, meanwhile the local traditional restaurants have been replaced by foreign cuisines and fast foods.

Different from TKO Town Center TOD, LOHAS Park TOD was planned as a private residential neighborhood. All the projects in the neighborhood are built in compact high-end residential towers for accommodating more population. Also, due to its location near the high-tech industrial zone, the TOD neighborhood has a larger number of households with high educated level and professional occupations. As a result, the whole neighborhood has the capacity to consume higher quality services. To fulfill the demands of residents, most of the facilities are organized in large commercial complexes placed close to metro stations. The business environment naturally excludes the small retails from the communities. In short, Hong Kong's R+P model and land policies are aiming to build an equal society by maximizing the land use and promoting the quality of life. However, the research of the two case studies finds the negative effects due to the TIG.

The second summary is related to the demographic changes. During the year 2011 to 2021, both TOD neighborhoods had a significant change in population composition. The findings are reflected in the percentage change and total proportion of the eleven TIG-related variables, in particular four key variables: *the number of high-education level*, *the professional occupations*, *the middle-income households*, and *the low-income households*. Typically, a newly built community especially located near to the transit station has a strong attraction for the population. However, compared to the normal community, the two case studies both show the unusual changes in demographic features in new residents, with a higher proportion of middle-class households moving in and a significant decline in the percentage of low-income individuals.

The results can be proved by the comparison with the percentage change of Sai Kung District as well. The percentage change of TKO Town Center TOD closely aligns to the trend of the district, but the value of the variables increased dramatically. Moreover,

LOHAS Park TOD also exhibits an increasing trend, but the values are ten times more than Sai Kung District. The outcome indicates that the change of TIG-related variables in TOD neighborhoods are more significant than the average changes in the larger scale. Furthermore, the socioeconomic change index and gentrification index also support that the TOD-related census tracts (in the block scale) experienced more dramatic changes than these tracts which are not related to TOD.

The Third summary can be referred to the housing affordability in TOD neighborhoods. The analysis of the housing affordability indicates whether the housing price matches the income of households. It simplifies the observation on the behavior of homebuyers with different income levels. However, the two approaches which are used in the analysis show mixed outcomes.

Hong Kong's approach focuses on calculating the *Median mortgage payment to income ratio* (MPIR) and *Median rent to income ratio* (MRIR). The results of the two ratios demonstrates that both the renters and the homebuyers can achieve a generally balanced lifestyle in the two neighborhoods, although renters have to experience slightly higher levels of financial pressures than the buyers.

NAR's approach is calculating the general housing affordability index (HAI) which is based on repayment factors such as total price and loan term. It reveals that homebuyers in all the blocks have to face huge financial pressure to pay the repayment. The two TOD communities are less affordable for the buyers.

The different outcomes may explain by factors which are calculated in the approaches are different. The calculation of MRIR and MPIR is simple considering the monthly payment and income, while the NAR's HAI is considered as more accurate due to it includes more details in the calculation. Furthermore, based on the data published by the Urban Reform Institute (URI) in 2023 (Urban Reform Institute, 2023), Hong Kong's housing affordability is ranked 94th globally, with a score of 18.8. It places Hong Kong as one of the most unaffordable cities. Thus, the analysis assumes that the outcomes of HAI are more reliable. In general, the finding indicates that even middle-class households have to face economic pressure when living in the two TOD neighborhoods.

Table 11 The summary of findings

Spatial Analysis ◆ ***The urban changes and commercial POI analysis reflect the TIG signs in building environment and business upgrading.***
Urban changes ◆ TKO town center TOD has more private housing than public housing, the new projects are built as high-end residentials with large outdoor spaces. The housing price in most of the blocks increased to a high level. ◆ LOHAS park TOD was built as a private housing neighborhood with a very high level of housing prices.
Commercial POIs ◆ TKO town center TOD concentrates most of the all categories of commercial types. ◆ In two TOD neighborhoods, 3 categories: *Restaurant, Store and Shopping*, and *Education Resources* show the significant signs of commercial upgrading. The percentages of upgrading business to total are 60%, 66%, and 61%. ◆ In two TOD neighborhoods, 3 categories: *Companies and Groups, Medical Services*, and *Social Services* have no obvious signs of commercial upgrading.
Demographic Analysis ◆ ***The demographic changes significantly in TIG-related variables.*** ◆ ***TOD neighborhoods experienced dramatic socioeconomic change and gentrification than other neighborhoods.***
Percentage change of selected variables ◆ All of the selected variables exhibit more significant percentage change in TOD neighborhoods than in Sai Kung District's percentage change. ◆ In two TOD neighborhoods, the variables: *Middle-income and above HHs, High education level, Professional occupations* show significant changes. ◆ The variable of *Low-income HHs* shown an increase trend in percentage change but shows decline trend in total portion.
Socioeconomic change index and Gentrification index ◆ Compared with all census tracts in Sai Kung District, most of the tracts (except the tracts which are categorized as social housing) in TOD neighborhoods show a very high level of socioeconomic change and gentrification.
Housing Affordability Analysis ◆ ***Hong Kong's MPIR and MRIR don't show obvious TIG signs, while NAR's HAI shows very obvious signs.***
Median mortgage payment to income ratio (MPIR) ◆ The MPIR results are mixed, 7 census tracts show increase, others show decline. ◆ In 7 census tracts which MPIR increased, 4 of these tracts show significant percentage change: 2 tracts are public housing tracts, another 2 tracts belong to newly built high-end blocks.
Median rent to income ratio (MRIR) ◆ The overall MRIR shows an increase trend. The value of 2 census tracts with public housing remains in low 6 census tracts have reached the redline of balancing monthly rents and income. ◆ The increase of MRIR indicates that the rents increase into a high value during the years.
NAR's Housing affordability index (HAI) ◆ All the census tracts are in very low HAI values which means less affordability for homebuyers. ◆ The social housing blocks suffer most unaffordability.

VI. CONCLUSION AND DISCUSSION

6.1 Conclusion

The thesis investigates the phenomenon of Transit-induced Gentrification (TIG) in Hong Kong's TOD neighborhoods at the local level by using multiple methodologies. The study focuses on two TOD neighborhoods located in Tseung Kwan O New Town. It analyzes the TIG by examining the neighborhood changes that occur during the TOD implementation process. The changes can be described from three perspectives: urban spatial, demographic, and housing affordability. The thesis aims to address the existing research gap about the TIG in Hong Kong. It attempts to provide a new viewpoint on improving TOD outcomes by investigating the negative impacts on social equity and inclusion.

Since it was proposed by Calthorpe in 1993, TOD has been recognized as one of the most efficient tools for addressing the challenges related to current urban mobility and housing. TOD promotes urban development by establishing a compact and mixed land use community within a walkable distance from both a transit station and a central business district. In the meanwhile, it also creates a good living environment for the residents. At present, the TOD strategy has been adapted to the local development plans in various metropolitans worldwide and kept offering the benefits to the local lifestyle. In addition, due to the concept of sustainable development being placed at the center of the urban development achievements, the classic principles have been widely expanded. The 5D principles (*Density, Diversity, Design, Destination accessibility, Distance to transit*) are made as the basic TOD principles for achieving the objectives. However, despite the TOD has proven its success, it still faces various problems, such as the fragmented governance frameworks, financial constraints, and social repercussions (Calthorpe, 1995; Carlton, 2009; ITDP, 2017; Jamme et al., 2019; R. Knowles & Ferbrache, 2019; Su et al., 2021; Suzuki et al., 2013; Thomas & Bertolini, 2020).

Under the wave of globalization, house has been given the meaning of investment products in addition to its basic role as shelter. This shift has significant implications for urban development strategies and urban life. In a market economy, the value of houses is determined by multiple factors such as the location, building quality, and surrounding facilities. During urban renewal, the determinants are reinforced by redevelopment projects. As a consequence, the properties located in the development areas experience a continuous increase in their value, resulting in an influx of the middle-class and the displacement of the low-income residents. Ruth Glass defined this phenomenon as the process of gentrification. However, measuring gentrification in a standardized approach is challenging due to the multitude of reasons and results. The gentrification has been categorized into many forms according to their distinct features, such as new-built gentrification, commercial gentrification, and tourism gentrification. Currently, since urban growth has a strong reliance on transport, public transit has been identified as a crucial factor influencing real estate markets. Thus, a new term named

Transit-induced gentrification (TIG) is defined by scholars to describe the gentrification which is influenced by the presence of transit stations. Moreover, according to the definition of TIG, it is often associated with TOD (CTOD, 2009; Davidson & Lees, 2005; Dawkins & Moeckel, 2016; Dong, 2017; Glass, 1964; Jones & Ley, 2016; Kahn, 2007; Lees et al., 2008, 2016; Smith, 1987).

At Present, the majority of TIG research is concentrated in the United States and European countries. Given that Asian countries have adopted TOD as the major framework of future urban development, it is valuable to examine TIG within the context of these countries. After an in-depth study of the current scenario of TOD across East Asian countries and regions, Hong Kong has been chosen as the research case study. Hong Kong, as a special administrative region of China, has the highest population density within its limited land. As a result, the theory of TOD plays a crucial role in urban planning. During the TOD implementation, Hong Kong adopted its "Rail plus Property (R+P)" model and "Public Private Partnership (PPP)" collaboration. Under this framework, government institutions take the lead while MTR works with private enterprises to develop metro stations and real estate projects. This framework addresses the transportation and housing demands of residents, while boosting the city's revenue and reducing the investment for transportation infrastructure. In the past, urban studies in the Chinese context have paid little attention to gentrification. Nevertheless, as urbanization comes to an end, a gap between social structure and economic growth brings the issues of social justice. So, the gentrification gradually obtains the public's attention. Regarding Hong Kong, although its mature and developed society, the current research on gentrification remains limited. Furthermore, some studies have previously identified signs of TIG by analyzing demographic changes in TOD areas. Thus, Hong Kong can be regarded as an ideal site for studying TIG (Baek et al., 2015; X. Chen, 2013; He et al., 2021; C. Liang et al., 2022; MTR, 2022; B. S. Tang et al., 2004).

Based on the literature review, the study aims to investigate the TIG phenomenon in Hong Kong's metro-related TOD neighborhoods. To exclude the impacts of external factors, specific parameters are set: the study area is confined to TOD neighborhoods in the suburbs, and the time frame is defined as from 2011 to 2021. Following a review to the development stages of all TOD neighborhoods in Hong Kong, the Tseung Kwan O Town Center TOD and LOHAS Park TOD are selected as the case studies. After establishing the pre- and post-conditions, the study employs the methodology which is introduced by Chen et al. (2023) to analyze the spatial transformations, including development phases, housing types, and commercial POIs. Secondly, the analysis and visualization of demographic changes are achieved by utilizing the percentage changes of variables, as well as socioeconomic change index and gentrification index from (Dominie (2012). Thirdly, two methodologies are employed to examine the housing affordability in TOD neighborhoods. One approach is outlined by Mostafa et al. (2014) that involves calculation of Median monthly mortgage payment to income ratio (MPIR) and Median monthly rent to income ratio (MRIR). Another approach is the Housing Affordability Index (HAI) calculation developed by the National Association of Realtors (NAR). Lastly, all the findings are summarized.

The answers to the research questions are as follow:

Has the construction of metro-related TOD caused neighborhood change?

In both case studies, the construction of the TOD exhibits significant changes in both urban layouts and demographics. The TOD neighborhoods have a higher rate of population growth compared to their original condition. The neighborhood development provides a huge number of housing units to ensure the accommodation of more households. Therefore, a large population has brought an improvement in the quality of the residents in terms of education background and household income. Furthermore, the commercials in TOD exhibit an upgrading and upscaling trend during the construction process, with high-end establishments gradually replacing original retails. Meanwhile, the results of the Socioeconomic change index and Gentrification index reveals that TOD neighborhoods have undergone greater social changes than others between 2011 and 2021.

Does this change intensify the occurrence of transit-induced gentrification?

In both case studies, the implementation of the TOD is closely linked to the occurrence of TIG and intensifies its impact. The commercial upgrades in TOD imply more expenditure by inhabitants to maintain an adequate standard of life. At the same time, the calculation of housing affordability reveals that most of the homebuyers, even the middle class, have to experience difficulties in paying their mortgage repayment. The circumstance indicates that the neighborhoods are unsuitable for low-income households to stay unless they stay in social housing units. However, there has been a decrease in the quantity of public housing units from 2011 to 2021, leading to a fall in the low-income population. In conclusion, the emigration of the low incomes and the immigration of the middle class changed the demographic composition and made the life in neighborhoods unaffordable, resulting in intensifying the TIG impacts.

How does the transit-induced gentrification reform the demographic and built form of the TOD neighborhood?

The process of TIG reforming the TOD neighborhood can be characterized from three perspectives. Initially, the buildings underwent a transformation from compact residential clusters and small unit sizes to high-end residential blocks and large outdoor green spaces. This transformation can be observed during the development of the south waterfront blocks in the TKO Town Center TOD. Secondly, there has a significant change in demographic, with the increase of the middle-class population replacing the low-income. It resulted in an overall improvement in the quality of the population. Thirdly, the new demographic structure changes consumer behavior, causing shifts of business tactics such as the establishment of big commercial complexes. It also led to the emergence of upscaling businesses like duty-free shops and chain stores.

In summary, the findings indicate that the TOD neighborhoods experience TIG during the ten years from 2011 to 2021. Also, it's likely to continue the process of TIG until the neighborhoods undergo complete gentrification. The transformation process has led

to considerable changes, including the relocation of low-income residents and the adjustment of development strategies to appeal to the middle class.

6.2 Limitations and Future Work

TIG is a topic that is hard to measure and the existing research based on Hong Kong is limited. Therefore, the study process is inevitability accompanied by several restrictions. These restrictions include the data accessibility, methodology selection, etc.

One of the issues is the complexity of TIG research methodologies. It listed some methodologies used in previous studies in the literature review, but there are currently no standardized approaches for TIG studying. The study is challenging due to the various factors that drive demographic changes and the different situations in case studies. Resulting in difficulties in selecting proper variables. For example, the quantitative methods are unable to explain the influence of local policy and personal choices on the residents. Furthermore, the census in Hong Kong only provides processed data rather than raw data. The quantity of available data at the neighborhood level is inadequate for utilizing the Difference-in-difference (DID) or regression methods for mathematical analysis and obtaining meaningful results. Plus, the POI data in 2011 is unavailable which restricts the analysis of changes in business types and quantities.

Another issue is about the lack of in-person interviews and on-site investigations. The qualitative approach is an important methodology for investigating sociological topics, which involves the design of questionnaires to collect data from individuals. The investigation also can let researchers engage in the community. Moreover, in situations where secondary data lacks sufficient information, primary data might compensate for this limitation by offering a comprehensive dataset and presenting more representative samples.

Considering the comprehensive findings and the limitations, the future works may concentrate on two main aspects: conducting further research on TIG, and exploring its corresponding impacts.

Conducting further TIG research. In order to precisely assess the future demographic changes and urban development, it’s necessary to carry out long-term observations of TOD neighborhoods. Policy and local culture also have huge influences on the development projects and individual behaviors. Development projects in Hong Kong are regulated by the government. Therefore, it’s important to consider the policies and regulations as references. Furthermore, the individual behaviors are shaped by the local tradition and common senses. Thus, exploring the correlation between TIG and Hong Kong's unique culture can provide a new aspect for the research.

Exploring the corresponding impacts. This study only focuses on the basic TIG phenomenon; however, displacement and segregation are also important relevant topics in the study of gentrification. Hence, the investigation of displacement and social segregation in Hong Kong may present as another future research. While Hong Kong's

housing policy has effectively dealt with the problem of displacement, the strategy of integrating social housing blocks into private residential communities may result in segregation. Referring to the layout of the TKO Town Center TOD neighborhood, the barriers formed by high housing prices restrict the mobility of low incomes, and force them to endure a high stress life in a worse living environment. This condition significantly hampers urban development and undermines social equity.

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