

TRANSIT-ORIENTED DEVELOPMENT IN CHINA:

DESIGNING A NEW TRANSIT-ORIENTED NEIGHBOURHOOD IN HEXI NEW TOWN, NANJING,
BASED ON HONG KONG CASE STUDIES

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ABSTRACT

China is urbanizing rapidly and questions regarding urban sustainability has arisen. Researchers point out that China is going through a sub-urbanization with increasing automobile-dependence. Researchers underline that, with the concurrent rapid growth taking place on the urban periphery of Chinese cities, now is the critical time to achieve a sustainable urban form through implementation of Transit-Oriented Development (TOD). Researchers argue that while Chinese cities are currently investing heavily in infrastructure for mass transportation, they fail in integrating land use with transit. Furthermore, regarding urban design, the accessibility for non-motorized travellers is not well catered for.

Although the concept of Transit-Oriented Development (TOD) can be traced to originate in Europe and the US, it has gained significant attention in China. Hong Kong is pointed out as the benchmark for how the TOD concept can be implemented in Asian cities and specifically in mainland China. Therefore a case study of several neighbourhoods in Hong Kong was made, using the TOD aspects Density, Diversity, Design, Destination accessibility and Distance to transit.

To implement these principles, a case in Nanjing was chosen. Hexi New Town is a large scale commercial and residential area planned in the last ten years, and currently under construction. Several metro lines are constructed simultaneously with the development, yet the opportunity of fully integrating the new development with transit was missed. In this thesis, functional zoning, lack of density concentration around transit, and a focus on auto-oriented urban design were identified as the main problems. Plans are underway for extending the metro lines further out to the surrounding countryside. The aim of this thesis is to propose a design for a new neighbourhood around one of the future metro stations, using a transit-oriented concept. The long term goal is reduced car dependence.

After taking into account local restraints in Nanjing, the key findings were synthesized into a set of design principles. While many aspects of previous developments in Hexi are kept, the proposal greatly contrasts with existing developments in the way land use is integrated with transit and how the public space is designed. The built environment is proposed to focus on providing ease of access for pedestrians, instead of the current car dominance. The level of mixed-use is greater and the distribution of density is more integrated with transit. Far more public places are also proposed. However, the use of Hong Kong design principles meant that local planning regulations could not be followed. The study shows that in order to fully implement the TOD strategies of Hong Kong, changes need to be made to the current Nanjing planning regulations. Central government policies promoting car sales as a way to grow the GDP is another problematic obstacle for obtaining the desired benefits of a transit-oriented design.

Key Words: Urban design, transit oriented development, TOD, automobile-dependence, sustainable urban form, neighbourhood, public space, Nanjing, China

摘要

在中国城市化进程异常迅速的同时，有关城市可持续发展的问题也正不断显现。研究者指出中国正在经历一个对汽车非常依赖的郊区化过程。研究人员强调，随着中国城市边缘城市化的迅速发展，现在是通过实施公共交通换乘为导向，从而实现城市可持续发展的关键时刻。研究人员认为，中国城市目前大量在大众运输基础设施上进行投资，但他们在结合土地利用上失败了。此外，关于城市设计，非机动车的旅客没有得到很好的无障碍照顾。

虽然换乘导向型发展（TOD）的理念可以追溯到它是起源于欧洲和美国的，但它已在中国取得了显著的关注。香港已经被选择作为在亚洲城市特别是中国大陆如何实施TOD的概念的基准。因此，通过使用的TOD的密度、多样性、设计、目的地无障碍和过境距离等方面在香港进行了个别居民区的案例研究。

南京作为一个实施案例被选中。河西新城在过去的十年中被设计建成一个大型的商业和居住中心，目前还正在建设中。几条地铁线同步建设与发展，尽管充分整合的新的机会已经被错过。在这篇论文中，功能区划不足，围绕地铁站的居住密度不足，以及私家车导向型的城市设计被确定为现今南京城存在的主要问题。现正计划向周围的乡村进一步扩大地铁线路。本文的目的是使用公共交通换乘为导向的概念，提出在未来的一个地铁站的附近设计一个新的居民区。文章的长期目标是减少城市对私家车的依赖。

综合考虑南京的本地制约因素之后，所有的发现可以归结为一系列的设计原则。在河西，原有建筑的许多方面都被保留了，这个建议与现存建筑的严重矛盾主要在于，土地利用已与交通运输相结合，以及如何设计公共场所。这样的建成环境的主要目的在于为行人进出提供便利，而不是现在的以汽车为主导。混合利用的程度越高，分布密度就越和交通运输相关。有许多公共场所也被提及。然而，使用香港设计原则就意味着不会再遵循当地规划条例。研究表明，要想贯彻实施香港TOD策略，必须对现行的南京规划条例进行调整。中央政府为了促进GDP增长而颁布的促进汽车销量的政策，对于公交导向的设计来说，是取得期望利益的另一大阻碍。

ACKNOWLEDGEMENTS

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This thesis is a culmination of four months of work, undertaken while living in Shanghai. Living here while writing the thesis provided much inspiration and sparked many discussions regarding urban planning issues between me and my fellow thesis writers here in China.

I would like to extend special thanks to my tutors, Gunnar Nyström at Blekinge Institute of Technology and Liu Wei at Nanjing Forestry Universty, for providing guidance and advice during these four months.

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PART 1

INTRODUCTION, LITERATURE REVIEW & METHODOLOGY



CHAPTER 1: INTRODUCTION

RESEARCH BACKGROUND

The concept of Transit-Oriented Development (TOD) has been a hot topic for research ever since its conception in the early 1990's by Peter Calthorpe in his book *The Next American Metropolis: Ecology, Community and the American Dream* (1993). TOD is a strategy for achieving sustainable urban form through concentrating mixed-use and pedestrian friendly developments around transit stations. It is a tool for integrating land use with transit. Much effort has been put into researching its desired outcomes. While TOD encompasses many different fields, such as regional planning and economic factors such as financing or value capture, this thesis focus on urban design aspects of TOD. Recently the TOD concept has gained significant attention in China. China is urbanizing rapidly and questions regarding sustainability has arisen. Since the opening and reform of China after 1978, urbanization has increased exponentially. With the vast number of rural immigrants streaming into the cities, the urban population has risen from 80 million in 1978 to more than 560 million in 2007 (Zhang M. , 2007). Today fifty percent of China's population lives in urban areas (Zhang & Lin, 2011, pp. 1). The issue of automobile dependence is considered serious. The total number of private automobiles in China rose from 3 million in 1997 to more than 30 million in 2007 (Zhang, Tian, & Zheng, 2010). Researchers point out that China is going through an automobile-oriented sub-urbanization, with increasing automobile-dependence. This may lead to congestion problems, pollution, and loss of agricultural land (Cervero & Day, 2008) (Campanella, 2008). The Chinese state and local governments have realized the problem and are investing heavily in mass transit. There are currently rail based mass transit systems in 12 Chinese cities on the mainland, and plans for constructing them can be found in 15 more cities. Researchers underline that, with the concurrent rapid growth that are taking place on the urban periphery of Chinese cities, and heavy investments in mass transit, now is the critical time to achieve a sustainable urban form through implementation of the TOD concept (Cervero & Day, 2008) (Cervero & Murakami, 2009) (Zhang & Lin, 2011) (Zhang M. , 2007). Although TOD is pointed out as having much promise in China, it is not possible to directly transfer American or European principles of TOD, they have to be adapted to the Chinese context. Since there is limited research on this topic in a Chinese context, many researchers look to Hong Kong as a benchmark for a successful TOD strategy, given for example the similar culture and problems with population growth (Cervero & Day, 2008) (Zhang & Lin, 2011) (Zhang M. , 2007) (Cervero & Murakami, 2009) (Curtis, Renne, & Bertolini, 2009).

THEORETICAL FRAMEWORK

This thesis is based on the aspects of the five 'Ds' commonly used in research about Transit-Oriented Development. Three of them were originally introduced by Cervero and Kockelman (1997), and was later complemented with two additional ones (Ewing & Cervero, 2010). Each these 'Ds' is used to analyse certain aspects of the built environment. They are as follows:

DENSITY. Density not only refers to the chosen location's population density, but also dwelling unit density and floor to area ratio.

DIVERSITY. Diversity refers to the degree of land use mix. Land uses are divided into several different categories. When making an analysis, various levels of land uses between different areas are compared in relation to other aspects, such as the proportion of transit use. The elasticity between certain chosen categories and values can then be calculated.

DESIGN. This refers to the design of the street network. A street network can be highly connected with straight streets, typical of a downtown area, to curved streets and cul-de-sacs usually found in suburban areas. It also refers to block sizes, number of four way intersections and number of intersections per area unit. Other urban design aspects are sidewalk coverage, building setbacks, street width, number of pedestrian crossings, presence of street trees, and more. It also includes the grid spacing of the pedestrian and bicycle network.

DISTANCE TO TRANSIT. This refers to the distance to transit. It measures the shortest routes from the home or workplace to the nearest transit stop, usually a rail station or bus stop. On a more regional scale it can measure number of stations per unit area or the distance between stops.

DESTINATION ACCESSIBILITY. This refers to how accessible destinations are. More specifically it means the chosen locations distance, or ease of access, to the most common destinations. This can be both regional and local destinations. Regional accessibility can be the distance to downtown, or the number of jobs reachable within a certain specified travel time. Usually, being located near downtown means good destination accessibility. Local accessibility measures the amount of stores and services within a certain distance from the home.

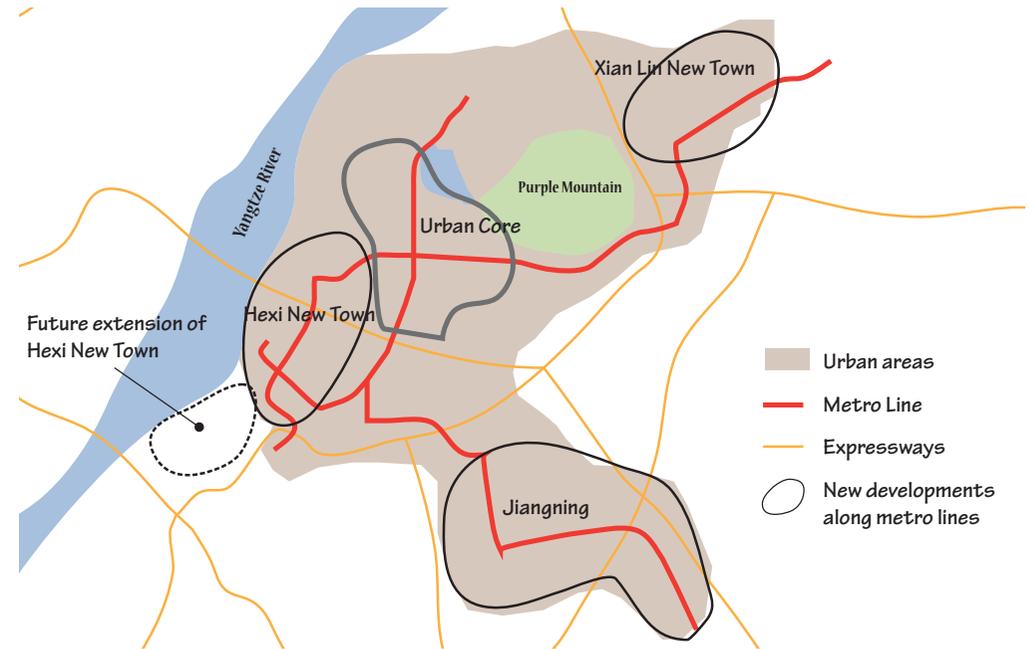
INTRODUCTION TO THE PROBLEM

Chinese cities are currently implementing TOD strategies. However, they fail in integrating land use with transit, in the form of providing mixed-use and a pedestrian- and bicycle-friendly environment, or by concentrating densities around transit stations (Zhang & Lin, 2011). It is clear that investments in transit does not automatically give transit-oriented benefits. Instead, the planning of new neighbourhoods usually take the same form, regardless if they are located near a transit station or not. They are simply transit-adjacent, failing to capitalize on their location close to a transit stop (Zhang M, 2007) (Zhang & Lin, 2011) (Renne, 2009).

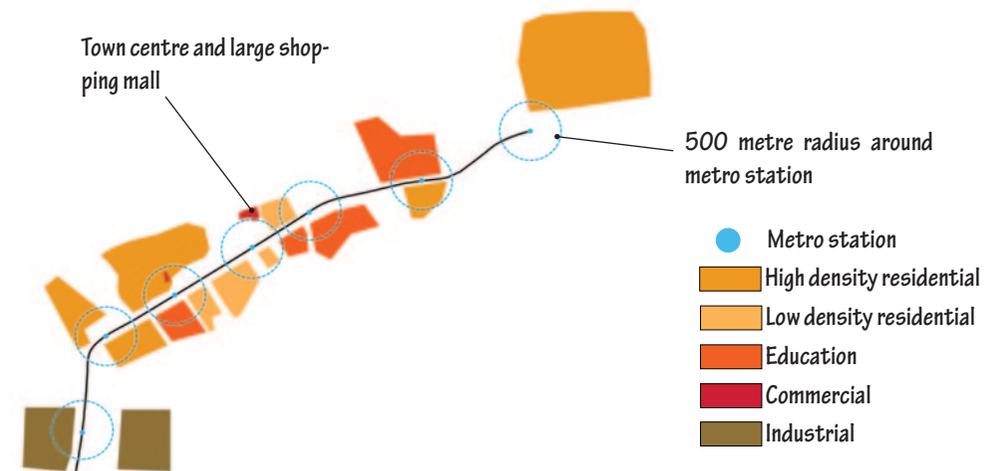
CASE BACKGROUND: NANJING

This problem can also be observed in Nanjing, China. Nanjing is located 300 km north-west of Shanghai, on the southern bank of the Yangtze river. It is the provincial capital of the Jiangsu province and an important regional centre. Population has grown quickly in the last decade, resulting in a rapid expansion of the urban area. The population growth is expected to continue. Nanjing currently has a population of 8 million, and that is expected to grow to 10 million by 2018 (Nanjing Population Development Report, 2012). This puts heavy pressure on the city's infrastructure and housing demand. Like other Chinese cities, Nanjing is investing heavily in mass transit. By 2030, the city is planned to be served by 17 metro lines (Nanjing City Masterplan 2007-2030, 2011). Before the year 2000, the urban area was mainly concentrated to the urban core shown in the map. The city is now growing rapidly, with most new developments being constructed at the urban periphery along the newly constructed metro lines. While Nanjing is seemingly adopting transit-oriented development principles on a regional scale, opportunities for integrating land use with transit on the local scale around the stations was missed.

In a case study of one of the new towns in Nanjing, Chen (2010) underlines some problems with Nanjing's Transit-Oriented Development implementations. Xian Lin New Town in the eastern part in Nanjing was planned in the 1990's as an ecological new town to be served by the planned metro line two. It is planned to have 800,000 residents when fully developed. Chen notes that: "The planning of the light-rail route in the area has taken no consideration of the distribution of urban functions and population". Chen further explains that the blocks are too large in terms of creating a pedestrian friendly environment, and that functions are distributed over a too large area. Chen concludes that although it was the goal, TOD principles were not implemented when the plan was realized. The result is the opposite, the built environment promotes the use of cars instead of mass transit.



Map of Nanjing. The brown area shows the current extension of Nanjing's urban area. The urban area has grown along the two metro lines with several new towns planned in conjunction with construction of the metro lines. Map based on satellite photos from different years: www.baidu.cn



Xian Lin New Town. Developments are placed away from the metro stations. The station lie next to very wide roads with a large open space around them. The large high density residential development next to the terminal station in the east is placed far away from the metro station. One station is in the middle of a very low density industrial area consisting of a few large warehouses. The centre of the town, in the form of a large shopping complex, is placed more than 500 metres away from the nearest stop.

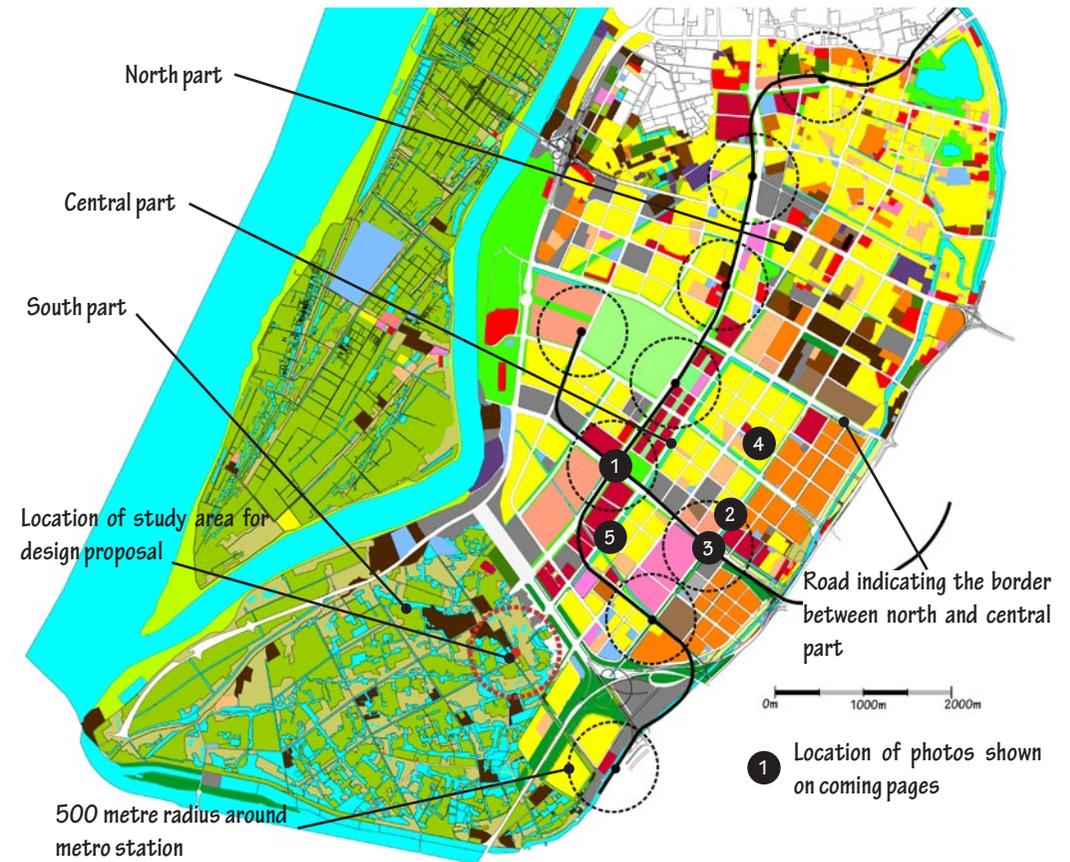
HEXI NEW TOWN

The Xian Lin New Town case shows that investments in transit does not automatically generate transit-oriented benefits. In this thesis, another case study in a more recent new town development in Nanjing was chosen for study.

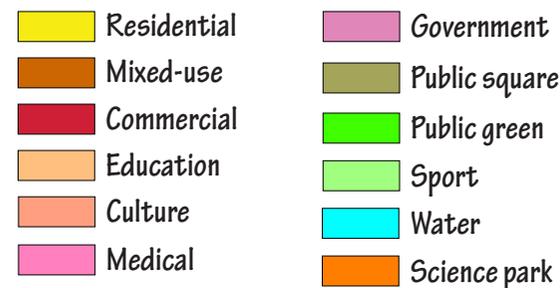
Hexi New Town is a large scale residential and commercial area that started construction in 2002. The New Town is divided into three parts. The north part was built first. The central part is nearing completion. The southern part is still under planning. It was planned and constructed simultaneously with two new metro lines. (Nanjing Hexi New Town, 2012). Here was a perfect opportunity to integrate land use with transit, yet the opportunity was missed. No lessons were learned from the mistakes made in Xian Lin New Town as similar problems can be found in Hexi. While Nanjing is clearly adopting TOD, it is merely doing so on a regional level. Developments take the same form regardless of their proximity to a transit stop. The opportunity of integrating the new developments with the transit stations on the local neighbourhood scale was missed.

On the Hexi New Town official website, the description reads: “*Nanjing Hexi, an emerging modern, people-oriented new Town...*” (Nanjing Hexi New Town, 2012). Few people-oriented aspects can be found in Hexi New Town. The area has the unmistakable character of an auto-oriented suburb. Instead of encouraging transit use, the built environment in Hexi New Town does the opposite; it encourages car use. The organization of land use can be seen in the land use map of Hexi New Town to the right. As in Xian Lin New Town, functions are separated over a very large area and the blocks are often more than 400 metres in length. Previous research states that both of these aspects greatly discourages walking and bicycling.

The map shows a clear difference between the north and central parts of Hexi New Town. The newer central part is more functionally separated and automobile-oriented. Despite the opening of the first metro line in 2005, when the central area was still in its initial stages of construction, the newer developments are actually becoming increasingly automobile-oriented compared to the developments of ten years ago in the northern part, which did not have any metro stations at the time of completion (Nanjing Planning Bureau, 2012). Since most developments in the central area of Hexi New Town was built at the same time or after the first metro line was completed, this thesis formulates the problem statement based on the built environment in the newer central area.



Land use map of Hexi New Town. The paradigm of functional zoning is clearly visible in the newer central part of Hexi New Town. Commercial functions are concentrated in a long axis. A science park runs along another axis. In between them is a large scale residential area. Land use map from Nanjing Planning Bureau.



ORIGINAL PLANS FOR HEXI NEW TOWN

The images to the right show the main concept sketches for Hexi New Town in 2004. It is obvious that the focus was on planning for the car. The master plan on the far right are from the same 2004 plan as the concept sketches. The metro stations are not in the plan, even though they were nearing completion.

FUTURE PLANS FOR HEXI NEW TOWN

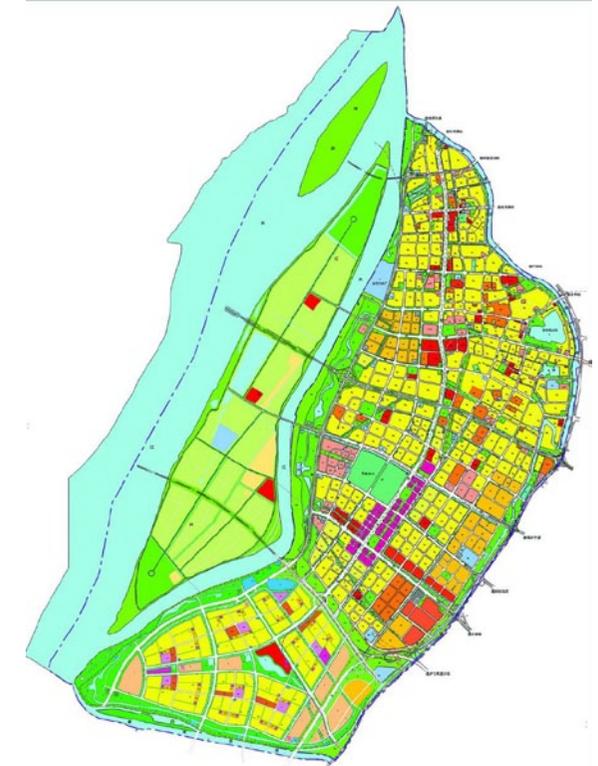
Hexi New Town is planned to expand further southwest. Two new metro lines will be built through the area. In the master plan from early 2012, no metro stations are marked out, gas stations and parking garages are however clearly marked out in their own separate map. The metro stations were not added until the latest version of the plan, which was just approved. The basic structure of the plan was set before consideration was taken regarding the position of the metro stations. The metro stations were added in at the last stages of the planning process. Clearly, the metro lines are not the driving force behind the planning. Although there are more mixed-use areas in the new plans compared to central Hexi, the general structure and character of the south area will most likely be similar to previous developments. There is no indication that the current auto-oriented development of Hexi will change. Actually, construction of the road network started several years ago already, despite the fact that the plan was still a long way from receiving final approval.

Future plan from early 2012. In the almost finished version of the plan, metro stations were still not part of it.

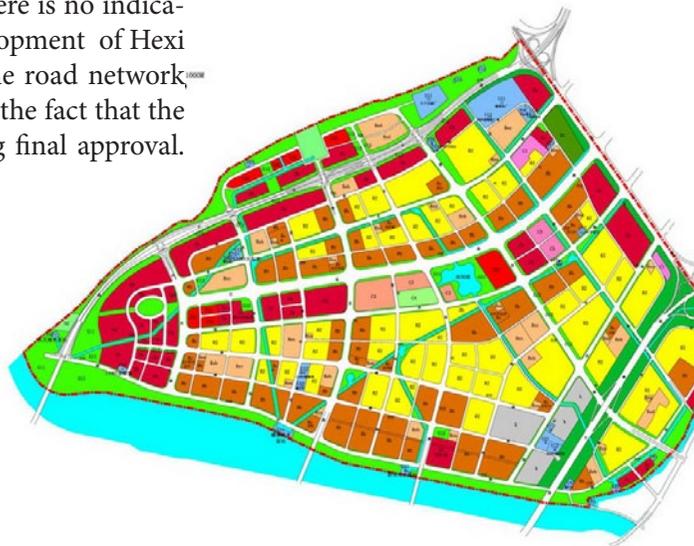
All maps and images are from the Nanjing Planning Bureau.



Main concept sketches. From the revised Hexi New Town master plan of 2004



Original plan. Revised master plan of Hexi New Town from 2004.



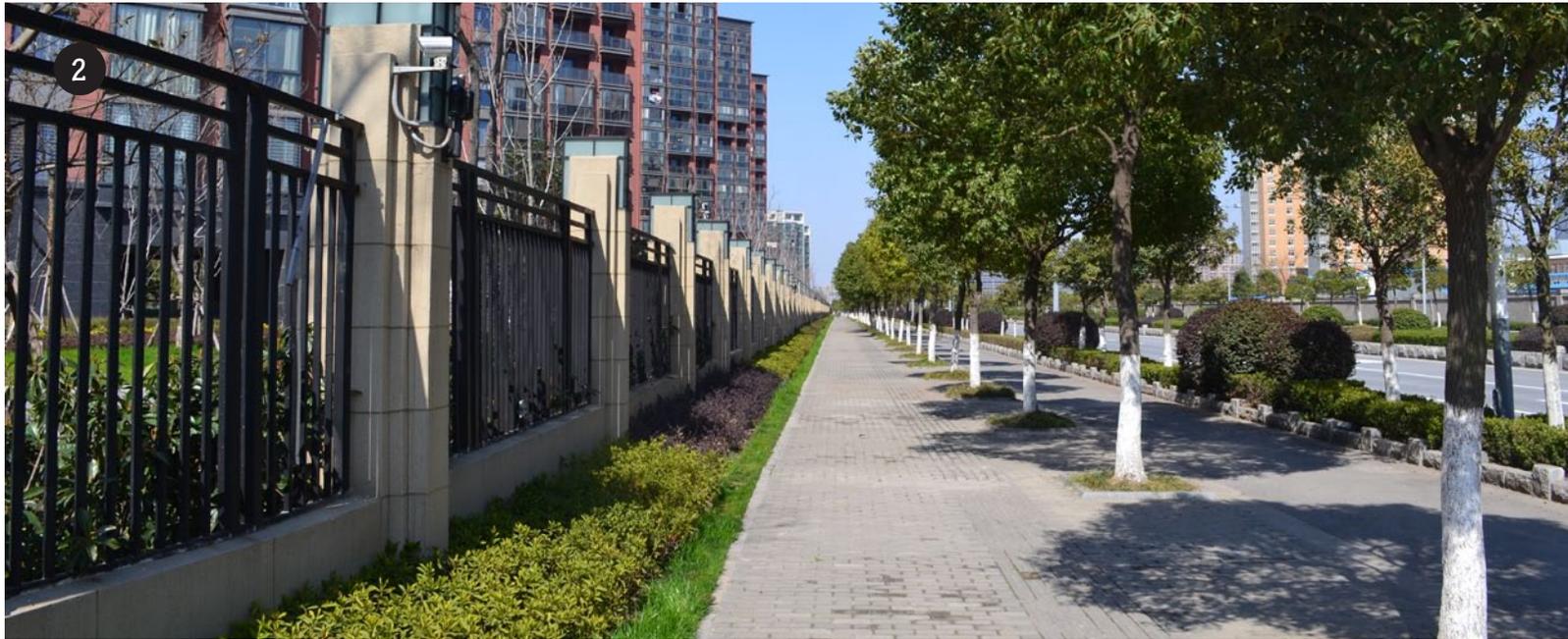
Final plan. In the final plan metro stations have been added. It is an indication that metro stations are not added until the final stage of the planning process.

1



Metro station

Focus on automobile infrastructure. Typical situation at one of the metros stations in the central part of Hexi New Town. The density around the station is also very low.



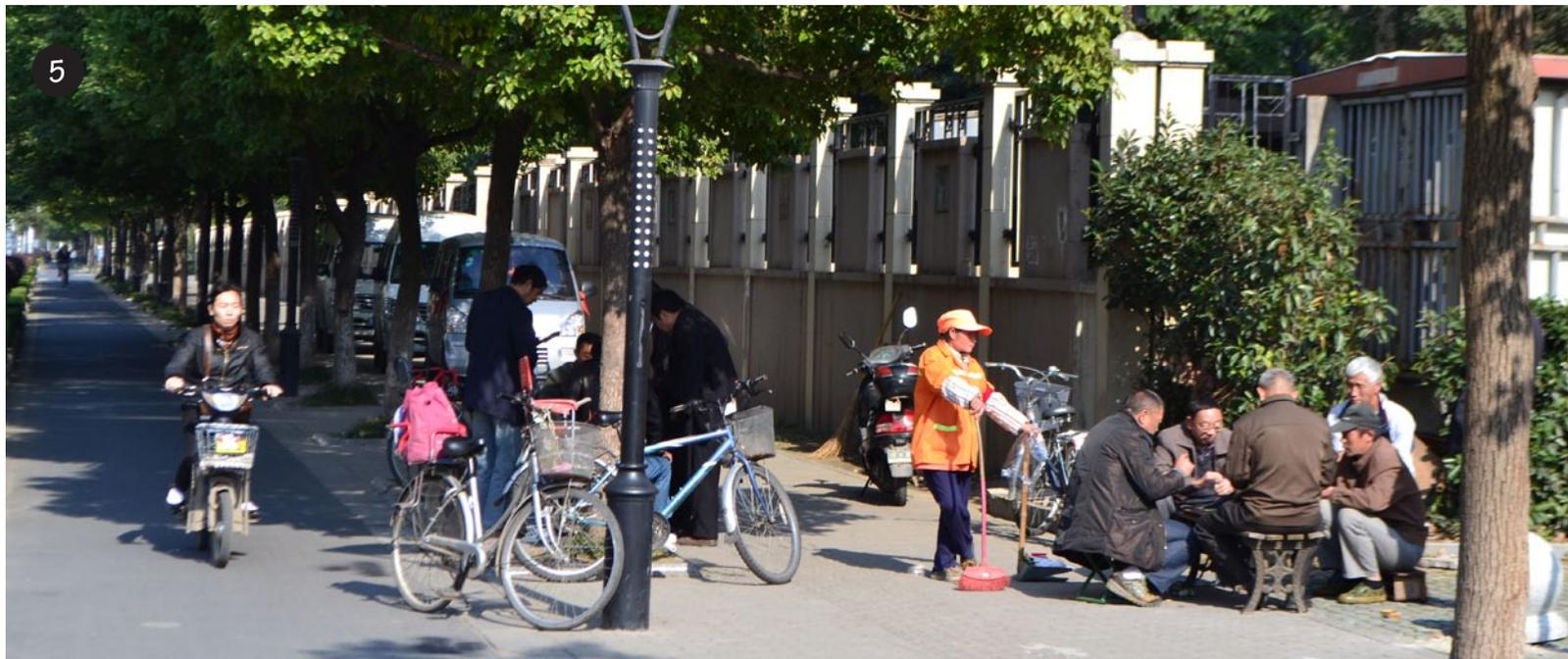
Very large blocks, enclosed by walls. The blocks are very large, discouraging walking. The blocks are enclosed by walls, with only one or two entrances per block, limiting accessibility for pedestrians.



Focus on automobile infrastructure. Excessively wide roads with little traffic. A common sight in Hexi New Town. This picture also shows the relatively low density around the metro stations. The metro station is just behind where the photo is taken, and the view is similar in all directions.



Focus on automobile infrastructure. The few commercial uses that exists within the vast residential areas are directed at car owners. At every area with commercial use, parking lots are located between the street and the shop front.



Lack of public places. Inside the residential areas, very few, if any, public places can be found. Here is a temporary sitting area arranged on a sidewalk. The lack of public places discourages walking.

PROBLEM STATEMENT

ACCORDING TO THE FIVE DS

MAIN PROBLEM

New developments in Hexi New Town has not taken advantage of their proximity to a metro station by integrating land use with transit. Developments look the same regardless if they are located near a metro station or not. They simply happen to be next to transit. They are transit-adjacent, not transit-oriented. The form of the built environment encourages private car use over transit use. The current auto-oriented sub-urbanization is negative from a sustainability point of view. The auto-oriented structure is expected to dominate also in future expansions of Hexi New Town.

The problems are outlined below, sorted according to the five Ds. The problems are based on findings of the literature review, found in chapter three. Many of the problems stated here for Hexi New Town are the same as the ones found in the Xian Lin New Town case study by Chen (2010), as explained on page nine in this thesis. The problems are also based on an own case study of Hexi New Town, found in part two of this thesis.

DESIGN

- No attention has been given to the distribution of density in relation to transit
- Low density around metro stations.
- Densities are the same, regardless of distance to transit.
- Low population density

DIVERSITY

- The paradigm of functional zoning has been taken to its fullest extent in Hexi New Town. The area has a clear single-use character. The result is very low diversity.
- There is no possibility to do for example shopping while walking home from the metro station. Commercial uses are not distributed along movement paths between metro stations and residential areas. Instead, accessibility to commercial uses prioritizes cars.
- Different functions are placed far apart, often separated by wide roads and green buffers.

DESTINATION ACCESSIBILITY

- Regional destination accessibility is good, since it is only a few stations to downtown. The destination accessibility on the local scale is however very low, since there are very few local shops within the residential areas, and different functions are placed far apart.

DESIGN

- A general focus on automobile infrastructure. Excessively wide roads. Pedestrian accessibility is neglected in favour of accessibility for cars.
- Very few public places and opportunities for sitting down. In some residential areas there are no public places at all except the streets.
- Superblocks often more than 300 metres in length surrounded by two meter high walls with only one or two openings, hindering walkability. It creates a monotone walking environment, with no activity in the ground floor of the blocks.
- The large private blocks result in a very wide grid spacing in the pedestrian network.
- The urban design of the pedestrian environment is the same regardless of the presence of a metro station. Pedestrian accessibility to the metro stations has not been given special attention.
- Buildings are set back far from the street. Pedestrians walking on the sidewalks need to cross over parking lots to reach the few commercial functions that do exist along the streets.

DISTANCE TO TRANSIT

- Since densities are relatively low, and does not concentrate around transit stations, distance to transit are negatively affected. The metro stations are placed away from the highest concentrations of population.

AIM

OPPORTUNITIES & POSSIBILITIES

The problems that this thesis focuses on, as outlined on the previous pages and in the literature review in a later chapter, is the issue of the current auto-oriented sub-urbanization trend in China. As researchers point out, the fact that rapid urban growth on the periphery is taking place at the same time as heavy investments in mass-transit, provides an excellent opportunity for implementing the TOD concept. Hexi New Town has these conditions, therefore it is chosen as the study area for this thesis. Hexi New Town is planned to expand further southwest. Plans are also underway for several new metro lines that will pass through this area, extending outwards to the surrounding countryside. Here lies an opportunity for a change of direction from the current auto-oriented development to a much more transit-oriented one.

As Asian metropolises differ to a great extent from their European and American counterparts, the TOD concept has to be adapted to the local context of Nanjing. Hong Kong is pointed out by researchers as a benchmark for how TOD can be implemented in mainland China. However, this should not be seen as a finished model for how TOD could be implemented in Nanjing. Although many similarities exist between Hong Kong and Nanjing, they are for example the same size in terms of population and have similar culture, there are also many differences. This thesis aims to suggest a model based on Hong Kong, but is adapted to the local context of Nanjing. The aim is as follows:

MAIN AIM

- The aim of this thesis is to propose a design for a new neighbourhood around one of the future metro stations in Hexi New Town, based on transit-oriented concepts found in Hong Kong.

The aim is to synthesize a TOD model suitable for Nanjing and specifically Hexi New Town. The problems were outlined according to the five Ds on the previous page. The aim is to address each of these issues according to the TOD concept, from lessons learned from Hong Kong case studies as well as from previous research outlined in the literature review. Taking into account local restraints and conditions, strategies for developing each of the five Ds should be implemented to the furthest extent possible.

The ultimate goal is to design a built environment which reduces car dependency. To encourage mass-transit use as opposed to the current focus on private car use. Ease of access for pedestrians should be promoted.

CONTRIBUTION TO THE FIELD

This thesis aims to fill the gap between theory and design in the current available research regarding Hong Kong's transit-oriented development principles and the possibility of implementing them in mainland China. While previous research have stopped at recommending Hong Kong TOD strategies for mainland China, they have not looked at the possibility of implementing the principles on a specific site, this thesis makes a practical application of the research in the form of a design proposal. The wish is to provide a different point of view. It is made from the point of view of an urban designer, to visualize TOD. This thesis can be seen as an experiment in how Hong Kong design principles could be used and adapted to a large Chinese city like Nanjing. On an academic level, it is the hope that this thesis can contribute to the discussion of TOD and its viability in mainland China.

It is noted that the proposal suggested in this thesis is only one of many possible solutions. It is in no way seen as the "perfect" or "ultimate" solution to the problems outlined here. The hope is more that it could be used to form a base for discussion. Sustainable urban form is a heavily debated subject, and it is important to point out that there exists no "one size fits all" solution.

The result of the design proposal cannot be measured until it is actually built. Originally, it was the ambition that the design proposal could be used as a base for discussion with Nanjing planning authorities. Interesting conclusions could probably have been drawn from such a discussion. However, this was not possible due to the lack of transparency in both local and state governments in China.

RESEARCH QUESTIONS

Following the aim of the thesis, the main research question is addressing the task of the design proposal.

MAIN RESEARCH QUESTION: DESIGN PROPOSAL

- How can the concept of transit-oriented development and its related urban design principles of the five Ds: Density, Diversity, Design, Distance, and Destination accessibility, be used in the urban design of a new development around a future metro station in Hexi New Town, Nanjing?

This question is answered by practical application of the theory of transit-oriented development and the five Ds in the form of a design proposal.

SUB-QUESTION 1: HONG KONG CASE STUDY

- What are the aspects of a, according to research, successful transit-oriented development in Hong Kong, analysed according to the principles of the five Ds?

This question is answered by making own on-site case studies of several transit-oriented developments in Hong Kong, that has been studied in research and concluded to be successful examples of the transit-oriented development concept. The case study will look specifically at urban design aspects of the built environment that relates to the five Ds. The purpose of the case study is to synthesize a set of general design principles for the design of the Nanjing case.

SUB-QUESTION 2: HEXI NEW TOWN CASE STUDY

- How can the design principles found in the Hong Kong case study be adapted to the local context of Nanjing and Hexi New Town?

Before directly implementing Hong Kong TOD design principles in Nanjing, certain local aspects must be considered. This question will address aspects of Hexi New Town, such as building orientation and gated communities, that must be considered when making a design proposal. Some of the existing characters of Hexi New Town may need to be preserved in future developments.

STUDY AREA & DELIMITATIONS

The design component of the thesis is limited to a physical area of Nanjing. An area with a radius of 500 metres around a future metro station, in the planned south expansion of Hexi New Town, is chosen as study area. Two new metro lines will intersect at this station. The area is currently vacant, it used to consist of villages and agricultural land, any buildings have been demolished due to the planned expansion of the city.

This thesis is limited to studying urban design principles of Transit-oriented development on the local neighbourhood scale. Specifically the emphasis lies on the five Ds, as introduced by Cervero and Kockelman (1997), and Ewing and Cervero (2010). The design is based on the findings of the Hong Kong case study, according to the five Ds.

The emphasis on the design is therefore:

- Distribution of density (population density, dwelling unit density and floor to area ratios).
- Distribution of different land uses (residential, commercial, services),
- Design aspects: Street network (block sizes, etc.), street design (street trees, street width, street types etc.), and accessibility in the form of connections for pedestrians, bicycles and other environment design. While there are bicycle related problems, the problems regarding pedestrian accessibility are deemed to be much greater. Also, most of the available research is focused on walkability. The bicycle network will still be handled in this thesis, but in terms of the Design aspect of the five Ds, focus will lie on pedestrian accessibility.

Issues regarding previous land uses such as existing villages and agricultural land are not handled. These are questions outside the scope of this thesis. The study area is treated as a greenfield site.



Location of study area. The chosen site for the design proposal is located around a planned metro station. On the edge of the urban area, roughly 10 kilometres from downtown Xin Jie Kou. Source: baidu.cn



The study area today. The study area is currently being vacated and demolished. The photo shows the remaining rubble of a group of buildings.

OUTLINE OF THE THESIS

The thesis is made up of four different parts. The first part of the thesis contains three chapters: introduction, literature review and methodology.

Next in this thesis comes chapter two, where the current research to date on the topic of transit-oriented development will be reviewed. The literature review will further establish the significance of the thesis, and provide a more detailed description of the underlying theory. First, a general overview of transit-oriented development is made, discussing the origins of the concept and its application in a western context. Research regarding the effects of transit-oriented developments from western cases is studied. This is followed by a review of the application and validity of the transit-oriented development concept in an Asian and Chinese context. Research regarding the transit-oriented development concept in Asian metropolises such as Hong Kong, Singapore, Taipei and Seoul will be reviewed. Finally, certain aspects of Chinese town planning are reviewed in order to get an understanding of how to adapt design principles to the local Hexi New Town case.

In chapter three the methodology is discussed. Here it is outlined what methods were used when undertaking this thesis project, and why those methods were selected.

The second part contains the Hong Kong and Hexi New Town case studies. This part culminates in the synthesizing of design principles to be used for the design proposal.

The third part is where the design proposal is presented. A location analysis is made of the area where the proposal will be made. The surroundings of the study area were analysed in the previous part, in the case study of Hexi New Town.

The fourth and final part concludes this thesis with discussion and evaluation of the design proposal. In order to discuss the results and draw conclusions, the proposal is compared with the case studies in Hong Kong and Hexi New Town.

CHAPTER 2: LITERATURE REVIEW

TRANSIT-ORIENTED DEVELOPMENT

INTRODUCTION

The term Transit-Oriented development has been a subject of much research since its introduction in the early 1990's. Recently the concept has gained much attention in China as a way to curb urban sprawl, automobile-dependence and achieve a sustainable urban form. The concept of TOD and the literature reviewed encompasses many different components, such as regional planning, strategies for public private partnerships and other policies, as well as economic factors such as financing and value capture. This review will however focus on urban design aspects of transit-oriented development. Specifically it will focus on the principles of the five Ds that regularly appear in the literature: Density, Diversity, Design, Distance and Destination Accessibility. Since the principles were introduced by American researchers, they will first be examined in the US context, followed by a review of their application and validity in the Asian and Chinese contexts.

ORIGINS OF THE TERM TRANSIT ORIENTED DEVELOPMENT

The term Transit Oriented Development (TOD) was first put forward by the American architect Peter Calthorpe in his book *The Next American Metropolis: Ecology, Community and the American Dream* (1993). The book outlined a set of urban design principles related to TOD. The general idea of the concept is to create relatively dense, mixed-use and pedestrian- and bicycle-friendly developments concentrated around transit stations. Two different types of TOD are suggested: The local TOD which focuses on the neighborhood around a transit station and the regional TOD which connects these local neighborhoods together. The aim is to reduce automobile dependence and work against urban sprawl. Calthorpe is one of the leading architects behind the New Urbanist movement, which embraces the concept of TOD. Yet New Urbanism does not hold sole claim over this concept. TOD is also found as a component of the Smart Growth concept. It is used in many different contexts under several different names such as transit-sensitive land use, transit-oriented design, transit-focused development and transit-villages (Zhang M. , 2007).

Whatever the term used may be the general concept is still the same: to utilize tools of land-use planning together with transit planning in order to center new developments around transit stations. The arguments for TOD are many. Researchers argue that TOD creates a land-use pattern which increases accessibility, in the form of providing alternatives to the automobile. The main argument put forward is that of sustainability. Especially in the developed world, but also increasingly in the developing world, planners and policy makers are supporting transit based and non-motorized transport instead of the previous automobile-oriented planning. TOD is also claimed to improve the quality of urban life by providing more opportunities for meetings in the public domain, creating a more urban environment, as opposed to the socially segregated urban environment of the more automobile-oriented developments (Curtis, Renne, & Bertolini, 2009). Similarities to TOD concepts can be found in many part of the world, of which many were introduced long before Calthorpe coined the term in the early 90's. Examples include the bus-oriented development in Curitiba, Brazil (Lindau, Hidalgo, & Facchini, 2010), the many developments around railway stations in Europe (Bertolini & Spit, 1998), or the railway-oriented development model, called Rosario's concept, introduced in Korea 30 years ago (Kang, 1980). Europe, and especially Scandinavia, are claimed to be the most fully developed when it comes to the TOD concept. Copenhagen's 'Finger-Plan' and Stockholm's 'Planetary Cluster plan' are held up as good examples of TOD like strategies, where rail infrastructure were often constructed before demand rose in order to control the growth along desired axes. The TOD concept can also be linked to the early streetcar and tram systems in Europe, which was implemented as a way to expand the urban area while still keeping accessibility the city centre. (Curtis, Renne, & Bertolini, 2009). Since TOD is an American term, it is first explored in the context of the United States.

TOD IN THE UNITED STATES

One of the main reasons for implementing TOD in the US is to fight urban sprawl. Urban areas in the US are characterized by low density automobile-oriented developments, with low support of public transport. The solution for a sustainable future, with less automobile dependence, is said to lie in the TOD concept (Belzer & Autler, 2002) (Curtis, Renne, & Bertolini, 2009) (Dittmar & Ohland, 2003). According to Dittmar & Ohland (2003) the idea of orientating new developments along a transit line is not a new one in the US. Before the 1900s the development of streetcar suburbs started in the United States. Streetcar lines and the residential neighborhoods around them were both constructed by a single private owner and provided transport links between the suburbs and the jobs in the city center. They also provided small retail shops and other services around the streetcar stops. By doing so the owner gained profits from

the raising property values of the developments around the streetcar stations. It was an early form of transit-oriented development. This type of development was soon interrupted by the arrival of the automobile. In the post war years, urban planning was heavily geared towards car use and railways were abandoned in favor of highways. In the 1970's rising congestion problems lead to the construction of new public rail transit systems in San Francisco, Atlanta and Washington. However, these transit systems did not consider future development patterns or took any advantage of the potential of creating new developments around them. The stations were designed for suburban car travellers, and were surrounded by large parking lots, instead of providing opportunities for walking, bicycling or taking the bus to them. The idea of linking development with transit was not present in the planning of these public transit systems. Since then however, the TOD concept has gained significant popularity and is the subject of much research. Portland is one of many examples in America that utilizes the idea. Today there are more than 100 TOD developments in the United States alone, though researchers argue that the many of them fail in fully applying TOD principles (Dittmar & Ohland, 2003) (Cervero, o.a., 2004).

URBAN DESIGN PRINCIPLES OF TOD: THE FIVE DS

The TOD concept encompasses many fields. While a lot of focus is put on physical characteristics of a TOD development, economic factors and regional planning are also important components. Public private partnerships are also important when planning a TOD (Cervero, o.a., 2004) (Cervero & Murakami, 2009) (Chatman, 2006) (Curtis, Renne, & Bertolini, 2009). This thesis is however limited to studying the urban design aspects of the built environment. Curtis, Renne & Bertolini (2009) defines the meaning of urban design and TOD as: '*Transit oriented urban design emphasizes the shaping of a pedestrian friendly mixed-use environment to create the convenience of using public transit*' (pp. 100).

There has been extensive research on which urban design principles are the most important for a successful TOD. After much empirical studies, the TOD principles that researchers and planners have generally agreed on are called the 3Ds: Density, Diversity, and Design, introduced by Cervero and Kockelman (1997). Later, they were complemented with two more: Destination accessibility and Distance to transit (Ewing & Cervero, 2001). The five Ds were described in the introduction of this thesis.

THE FIVE DS: EMPIRICAL STUDIES INTO THE CONNECTION BETWEEN URBAN FORM AND TRAVEL BEHAVIOR IN THE WESTERN WORLD

Since the introduction of TOD in the US there has been a vast range of empirical studies undertaken in TOD developments in real life. A study in San Francisco into the connection between the built environment and travel behavior, showed that areas built according to TOD principles of land-use diversity, pedestrian friendly environment and transit near developments, reduce trip rates and encourages non-motorized travel (Cervero & Kockelman, Travel Demand and the 3 D's: Density, Diversity and Design, 1997). Cervero (1996) also conducted a study comparing a mixed-use and transit-oriented neighborhood with an automobile-oriented neighborhood and found that the former showed higher levels of non-motorized- and transit travel. Other researchers are more cautious, claiming that while empirical studies generally lend support to TOD, such a development does not always get the intended effect on travel behavior (Chatman, 2006). This may however, as Chatman notes, have more to do with the fact that some TOD developments accommodates the automobile in the form of wide streets and ample parking places. However, most research does not specifically investigate the TOD concept. The focus is rather on the five 'Ds', which are part of the TOD concept, meaning that the research still has a clear connection to TOD. The main topic for investigation for several decades has been the connection between urban form and travel behavior. Or to put it in a different way, how land-use patterns affect travel behavior.

The lineage of this research field goes as far back as the 1950's, when Mitchell and Rapkin (1954) published their book *Urban Traffic: A Function of Land Use*. Since then, it has been a popular topic among planners and research. The popularity has surged since the early 90's, with hundreds of research reports in the field having been published. The connection between urban form and travel behavior is still a hot topic in the research community.

In a report by Cervero and Ewing (2001) more than 50 empirical studies regarding the connection between urban form and travel behavior are analyzed and summarized. They conclude that the form of the built environment is the most important indicator of automobile-use, rather than socio-economic indicators. This study did however not study walking and transit use, but focused on automobile use. In a recent study, Cervero and Ewing (2010) have updated their 2001 work mentioned before, and this time they included walking and transit use as well as TOD. Using the five Ds as reference, they performed a meta-analysis of more than 200 empirical studies of the connection between urban form and travel behavior, undertaken in the ten years since their previous 2001 study. Factors such as socio-economic status were controlled for. The study reached several interesting conclusions. The main finding was that destination accessibility was the most important factor when it comes to vehicle miles travelled (VMT).

This means that the more central the location, the less automobile use is observed, or as the authors point out: *'Almost any development in a central location is likely to generate less automobile travel than the best-designed, compact, mixed-use development in a remote location'* (pp. 276). This would mean that increasing densities and redeveloping in the inner city could be a viable strategy, although this could be a questionable strategy in high density Asian cities. However, they also note that: *'The primacy of destination accessibility may be due to lower levels of auto ownership and auto dependence at central locations'* (pp. 276). The next important finding is related to street design: *'Equally strongly, though negatively, related to VMT is the distance to downtown. This variable is a proxy for many Ds, as living in the city core typically means higher densities in mixed-use settings with good regional accessibility. Next most strongly associated with VMT are the design metrics intersection density and street connectivity. This is surprising, given the emphasis in the qualitative literature on density and diversity, and the relatively limited attention paid to design. The weighted average elasticities of these two street network variables are identical. Both short blocks and many interconnections apparently shorten travel distances to about the same extent'* (pp. 275). Previously a lot of focus has been on the value of density and street connectivity. However, this conclusion shows the value of a well-designed street network. Street design methods to shorten blocks and provide many intersections are revealed to be very important when it comes to reducing automobile use. Ewing and Cervero further conclude that street network design not only influence VMT, but also walkability: *'Likelihood of walk trips are most strongly associated with the design and diversity dimensions of built environments. Intersection density, jobs-housing balance, and distance to stores have the greatest elasticities. Interestingly, intersection density is a more significant variable than street connectivity. Intuitively this seems right, as walkability may be limited even if connectivity is excellent when blocks are long'* (pp. 275). This provides further argument to shortening block lengths and creating mixed-use developments. It was also found that transit use was strongly connected with transit access. The most important factor of transit use was being located near a transit stop. The second most influencing factor was street design. Good street connectivity and high intersection density lead to higher transit use. This was followed by land use mix: *'Land use mix makes it possible to efficiently link transit trips with errands on the way to and from transit stops'* (pp. 276). A surprising find according to the authors was that transit use was not related to density. Though the authors point out that this may be due to the fact that the value of density is lessened by the other 'Ds', meaning that dense neighborhoods commonly have central locations, land use mix, and shorter blocks. Another issue that is dealt with by Ewing and Cervero is the theory of self-selection. It refers to the theory that walking and transit friendly neighborhoods attract people that are already inclined to using these forms of travel. They play down the importance of this aspect, citing research that shows that even when accounting for self-selection, strong relationships between the built environment and travel behavior are still found.

TRANSIT-ADJACENT DEVELOPMENT VERSUS TRANSIT-ORIENTED DEVELOPMENT

In research about TOD the term Transit-adjacent development (TAD) is also found. A Transit-adjacent development means a neighborhood that is located near a transit station, but that has failed to capitalize on its location. It has not taken advantage of the transit station by providing accessibility and mixed land use, or designing a street network for walkability. Rather, it seems like the neighborhood has been designed without acknowledging the presence of a transit stop. A TAD development, at least in the US context, is characterized by functional zoning, low walkability, low densities, and automobile land uses such as gas stations and drive-troughs (Renne, 2009). The main point is that transit investments will not automatically create transit related benefits. Transit and development need to be integrated.

TRANSIT-ORIENTED DEVELOPMENT IN CHINA

The vast majority of research on the subject of TOD and the connection between urban form and travel behavior has been undertaken in the US. An important question is if the findings regarding the five Ds made by Ewing and Cervero (2010) in the meta-analysis described earlier also can be used in the Chinese context? Given the fact there exist relatively few studies regarding this topic in China, compared to developed countries, this may be difficult to say. The studies that have been made have however confirmed several aspects of the findings by Ewing and Cervero. Several recent studies investigate the potential of TOD in China (Zhang M. , 2007) (Cervero & Day, Suburbanization and transit-oriented development in China, 2008) (Zhang & Lin, 2011) (Xueming, 2010). The potential for implementing TOD in China is regarded as very high among researchers. The researcher appearing the most in this field, Robert Cervero, has also made studies in China. China is urbanizing extremely rapidly. Since the opening and reform of China after 1978, urbanization has increased exponentially. With the vast number of rural immigrants streaming into the cities, the urban population has risen from 80 million in 1978 to more than 560 million in 2007 (Zhang M. , 2007). Today fifty percent of China's population lives in urban areas (Zhang & Lin, 2011, pp. 1). The issue of automobile dependence is also considered serious. The total number of private automobiles in China rose from 3 million in 1997 to more than 30 million in 2007 (Zhang, Tian, Zheng, & Zhang, 2010). Although compared to developed countries, it is still a relatively low share. Yet given the rapid pace of urbanization this still creates automobile related problems (Zhang M. , 2007). Researchers point out that China is going through an automobile-oriented suburbanization: *'More and more, Chinese cities are mimicking the suburbanization trends and patterns of the post-World-War-II United States, the world's most car-dependent nation'* (Cervero & Day, 2008, pp. 315). However, as Campanella (2008) points out, the urban sprawl of China has quite different characteristics compared with sprawl in the US. While urban sprawl

in the US tends to take the form of low-density single family homes, Chinese urban sprawl is characterized by dense high-rise apartment buildings. They often go out to the very edge of the city, creating a sudden boundary between the urban area and the countryside. Still, other characteristics are the same. Chinese urban sprawl is like its US counterpart characterized by functional zoning and car dependence. The sprawling cities of China have also taken up considerable agricultural land. From 1980 to 2004 close to 120,000 square kilometers of agricultural land has been lost to rapidly expanding cities. According to Campanella the loss of agricultural land is a critical problem in China today, for the first time in history China is no longer self-sufficient in agricultural production.

The problems of sustainability and car-dependence are highlighted in most research. TOD is seen as a very promising concept for China: Most developments in Chinese cities today are on the urban fringe. They take the form of gated residential communities, placed in superblocks, and connected by a grid network of very wide roads. Since all land is owned by the government, the developments are initiated, master planned, and zoned by the government. The densities in these areas are usually lower than in inner city areas. The government has however realized the problems of automobile dependence and has in the last decade invested massively in mass transit (Zhang & Lin, 2011). Metro systems can today be found in 12 cities in the mainland, including Nanjing, and plans for constructing mass transit systems can be found in 15 other cities (Cervero & Day, *Suburbanization and transit-oriented development in China*, 2008). The fact that extensive urban growth on the periphery is taking place at the same time as large metro investments, presents a very promising moment for implementing TOD: *Opportunities for creating sustainable city forms through bundling land development and railway investments in large Chinese cities are quite substantial and largely untapped. Today, increasing numbers of large, rail-served Chinese cities are looking to transit-oriented development (TOD) as an alternative form of urbanism that reduces over-reliance on the private automobile* (Cervero & Day, *Suburbanization and transit-oriented development in China*, 2008, s. 315). Or as Zhang and Lin (2011) puts it: *'Many Chinese cities are building or planning to build mass rapid transit systems, which provide a golden opportunity to realize truly sustainable urban transportation. This is the critical timing when we need to fight a battle against upcoming and highly potential auto-dependency in urban China. It is now or never'* (pp. 6). Zhang (2007) also sees the potential for TOD, although he proposes it more cautiously: *'There are strong indications (and concerns) that China is about to become highly motorized with private vehicles. At this critical point, developing mass rapid transit is believed to be a sensible strategy to shape the mobility preference of China's commuters. Physically or spatially, Chinese cities are transforming and expanding on a very large scale. Timing is critical for promoting urban development toward a transit-based corridor-nodal urban pattern that is believed to be more desirable than car-oriented sprawl. TOD in principle provides an*

ideal model to serve those dual intentions' (pp.126). Something that works against TOD in China, according to Cervero and Murakami (2009) is the common Chinese practice to in suburban areas build single use superblocks with monotonous architecture, as well as the practice of building large expressways and thoroughfares through the city (pp. 2041). This aspect will be examined further at the end of the literature review.

A study by Pan et al. (2009) of Shanghai showed that automobile-use was lower and that non-motorized transport use was positively affected by a pedestrian- and bicycle-friendly environment. High density, small blocks and a dense street network were found to be affecting the amount of both modes of travel. They also concluded that when automobiles or taxi are used, they travel much shorter distances. However, there are some problems with the study, at least regarding the conclusion about automobile use. The conclusion is drawn from the fact that one of the neighborhoods showed lower levels of automobile-use. This neighborhood is characterized by small blocks and high density, hence the conclusion. The neighborhood in question is located in the inner city of Shanghai, just around two kilometers from the city center. The other three neighborhoods are located outside Shanghai's inner ring road, more than ten kilometers from the city center. It would have been more interesting if the neighborhood in question had also been located as far away from the city center as the others. Judging from the importance of destination accessibility in Ewing's and Cervero's study, with regards to automobile-use, the location in the city center would automatically give lower levels of automobile use, regardless of the form of the built environment. However, this could also be interpreted as proof of the validity of Ewing's and Cervero's study in China. Though without further study, this cannot be proved.

In a recent study, two developments on the urban periphery of Shanghai following some basic TOD principles were investigated (Haixiao, Shen, & Chang, 2011). The study concluded that the usual benefits of a TOD, found in most previous research, were not obtained in these cases. Relatively few residents of the two neighborhoods used the transit station on a regular basis. Also, the developments have failed to attract enough residents, with many apartments being vacant. They points out that the generic TOD model was developed more for locations closer to the urban center, and is not suitable for areas on the urban periphery. It is concluded that attention has to be given to unique place-specific characteristics, such as the areas location in relation to the urban center. The studied neighborhoods are located more than 30 kilometers from the urban center of Shanghai, more than one and a half hours metro ride away. The selected study area in Nanjing is much closer to the urban centre, only about 20 minutes away with the metro, and should have a much better opportunity

An important question that Zhang (2007) points out is that China already meets a lot of the goals set out by the TOD concept, such as high transit ridership and high density levels. Does TOD really have anything more to offer Chinese cities? Zhang answers

this question by discussing the phenomenon of Transit-adjacent development (TAD) mentioned earlier. As shown by earlier research, simply being adjacent to a transit stop is not enough to encourage transit use and walking. As Zhang (2007) states: *'Will the transit investments automatically generate transit-oriented urban environment and transit-related benefits? It is not the case in the United States nor will it be in China. Lack of proactive efforts to integrate transit and land development may even have negative effects on both transit operation and the local living environment'* (pp. 121). Zhang uses several case studies in Beijing to prove this point. The conclusion Zhang makes is that despite the initial doubts, TOD is an ideal concept for rapidly expanding Chinese cities. Haixiao, Shen, & Chang (2011) state that urban planners in China typically adopt the TOD concept in the planning of new neighborhoods, at least in their own interpretation. And that aspects of high density, mixed-use and careful design are emphasized. This view is not shared by either Zhang (2007) as described above, or by Zhang and Lin (2011). Zhang and Lin claims that developments around transit are merely transit-adjacent and not transit-oriented: *'However, the battle cannot be won if transit fights alone. Most of land use developments surrounding transit stations are merely Chinese edition of TADs, characterized by many undesired travel outcomes'* (pp. 6). Zhang and Lin further explain the problem of TAD in China. It is shown that even though an area has several rail transit stop in the close vicinity, high levels of automobile use and low levels of walking are still found. The authors conclude that this is because lack of accessibility and also because there are abundant parking spaces in the area. They also find low levels of walking and cycling due to a pedestrian- and bicycle-unfriendly environment. It is found that the majority of developments near transit focus very little on providing access to the station in the form of a well-designed pedestrian and bicycle environment. Zhang and Lin (2011) states that: *'Many urban fringe developments in Chinese cities are similar to the aforementioned TAD examples: basically transit systems just happen to be adjacent to land development projects'* (pp. 3). Hence it can be concluded that even though it may look like many Chinese cities are adopting TOD principles, most developments are lacking the functional integration between land use and transit, they are simply transit-adjacent developments. Zhang (2007) has also mentioned some key principles to be regarded when planning for TOD in China. One aspect is that of differentiated density, it refers to the principle of creating very high density in close proximity to the station, and lowering it as the distance from the station increases. Zhang claims that this is even more important in the Chinese context and claims that many TOD implementations in China fail to utilize this concept, and instead create a density that does not vary in relation to the distance to the transit station.

The state and local governments are in charge of all master-planning and planning regulations in China. All land is also state owned. The form of the current built environment is greatly influenced by this top-down planning. Researchers underline that this puts the state and local government in a unique position to change the course of

development. This could be to adapt planning codes that promote pedestrian friendly environments with small blocks and mixed-use (Haixiao, Qing, & Ming, 2009). More emphasis should also be put on integrating land use with transit, currently there is an apparent disconnect between the two (Zhang & Lin, 2011).

THE FIVE DS IN ASIA: TOD STUDIES IN FOUR ASIAN METROPOLISES

Then how should TOD be implemented in China? According to planners and researchers, a lot can be learned from successful TOD implementations in other Asian megacities. Hong Kong, Taipei and Singapore are often cited as examples where TOD has been successfully implemented. Especially Hong Kong is often cited as a model for how TOD can be implemented in China (Cervero & Day, 2008) (Cervero & Murakami, 2009). There has also been much more research regarding TOD in these cities than in Chinese cities, since TOD strategies has been used for a considerably longer time, there has been more opportunities to study the effects .

Several empirical studies have been made in Taipei. Lin and Yang (2009) examine how urban form affects travel behavior in Taipei. They conclude that the basic three 3Ds principles have proved positive effects on choosing non-motorized transport. They emphasize the effect of a pedestrian friendly environment on non-motorized travel choices.

In a South Korean study, Hyungun and Ju-Taek (2011) investigates whether TOD planning principles found in western case studies can be applied to the city of Seoul. As mentioned earlier, TOD like principles were proposed in Seoul more than 30 years ago (Kang, 1980). In order to plan for the rapidly growing population, Kang introduced a rail development plan where new developments would be centered around rail transit stations. New developments were planned to be located in an area within a 1km radius of rail transit stops. The plans were however never realized as the government decided to instead focus development on constructing new towns around Seoul's outlying suburbs. Hyungun and Ju-Taek (2011) concludes that TOD principles have a great impact on forming a transit-oriented city: *TOD planning factors could be successfully applied to the development of rail station areas in Korea just as foreign case studies have shown'* (pp. 81). They also find that some aspects differ and need to be considered when planning for TODs in a high density city like Seoul: *'...rather than focusing mainly on increasing development density, it is necessary to concentrate more on such strategies as strengthening the transit service network, increasing the land-use mix index, and restructuring the street networks and urban design to be more pedestrian friendly around rail stations,* (pp. 81). Since Seoul is already a very dense city, it is more important to focus on the other Ds: diversity and design.

Singapore is also a extensively researched city in terms of TOD. Before the opening of

the Singapore's MRT system in 1987, the city was characterized by auto-oriented development. Since then, TOD urban design principles have transformed Singapore into a transit-oriented city. Research finds that the basic 3 Ds principles remain effective. Most new developments in Singapore have taken the form of high density, transit-near, mixed-use and pedestrian friendly environments. The challenges in implementing TOD in Asia area quite different from those in for example the US, with its low density urban sprawl. With the low amount of available land, Singapore must build very dense. Great attention has therefore been given to accessibility to the stations from the surrounding densely built high-rise developments. According to researchers, this has been a successful strategy for decreasing auto-dependence and limiting loss of available land (Curtis, Renne, & Bertolini, 2009).

Hong Kong is however regarded as the most useful example for cities in mainland China (Cervero & Day, 2008) (Cervero & Murakami, 2009) (Tang et al, 2004). The studies of TOD in Hong Kong will be described in the case study of Hong Kong, in the next part of the thesis.

CONCLUDING REMARKS

The literature review shows that the TOD concept has a high potential in China. The review shows several problems with, or lack of implementation of TOD in China. Although the state and local governments in China are aware of the TOD concept, and aims to implement it, most developments are just simply transit-adjacent, and not transit-oriented (Haixiao, Shen, & Chang, 2011). They fail to integrate land use with transit. More attention should be given to mixed-use and the design of the pedestrian environment and accessibility to the station. The principle of differentiated density seems to be mostly neglected as well, as most transit-near developments do not vary their density in relation to the distance to the transit station. The findings about the applicability of the five Ds in Asia were varying. Although all factors are found to be essential components of a TOD development in Asia, it seems to depend on specific local characteristics which aspects of the five Ds are the most important. For example, in the case of the outlying TOD developments in Shanghai, distance to downtown was the most important factor. Since the chosen study area in Nanjing is located close to the urban center, this issue is less important. What the research did agree on was the importance of the design and diversity aspects, as well as the distance to transit. There is a clear consensus among the case studies from Asian cities regarding the importance of providing a pedestrian- and bicycle-friendly environment. Judging from the available research on the topic in China, density is an important aspect as well, specifically differentiated density, as increased density around a station puts more residents within walking distance. This was also shown in the studies of Hong Kong. Generally, the research lends support to implementing the TOD concept in China according to the five

Ds, with adaptations to the Chinese context. Since few case studies exist in China, Hong Kong is regarded as the benchmark for how to implement TOD in China. But how the successful developments actually look in real life is difficult to read from the research. Therefore a real life case study of a successful TOD development will be undertaken in Hong Kong. The analysis will be made using the principles of the five 5 Ds: Density, Diversity, Design, Distance, and Destination accessibility. The case study will examine how aspects of the built environment are designed, such as streets, pedestrian environment, station accessibility, local shops, local services and other functions, height and size of the buildings, block size etc. The case study of Hong Kong will then be used to outline some general design principles according to the five Ds. But before Hong Kong design principles can be imported to the Nanjing case, certain local planning aspects need to be examined. The next part of the literature review will shortly introduce some of the most important aspects found in the literature regarding Chinese urban planning aspects.

CONTEMPORARY URBAN PLANNING IN CHINA

SUPERBLOCKS

As noted earlier in the literature review, Cervero and Murakami (2009) points out that the common Chinese practice of building superblocks may work against the implementation of TOD. Let's take a closer look at this aspect of Chinese planning and how it works in reality.

The by far most common phenomenon in contemporary urban planning in China today is the superblock. According to Monson (2008), the superblock is a practical way of planning which satisfies both the state and the developer. Monson argues that it creates ease of transactions between state and developer while conforming to the values of the state and the collective culture of China. A superblock is typically between 8 to 40 hectares in size, with the larger sizes being mostly found on the periphery of urban areas. The superblocks can often be very monotonous, as they are often standardized and repetitive in their form. The superblocks are always built as gated communities, with a wall surrounding the entire block, with only a few openings. It is a tabula rasa approach to planning, where existing structures and conditions are neglected. The way it normally works is that the local government makes a land use plan, typically made up of a grid network dividing the land into large plots. The local governments for the municipalities in China rely heavily on income from selling land. Each of these large plots is then sold to developers. The government builds the arterial roads while the developer handles the internal road network of the plots. It is up to the developer to decide how to develop the plot, but they must conform to the planning regulations of the local government. These regulations often stipulate a 15 metre setback of the build-

ings from the street, creating a green buffer zone. The higher the building, the greater the setback must be. This is also the case in Nanjing's planning law (Nanjing Planning Bureau, 2012). Monson points out that this way of planning usually means an extra road that encircles the block alongside the main arterial road, doubling the amount of street length needed. According to Monson this way of planning is practical and logic from an economical point of view. In order to gain as much profit as possible the whole process has been simplified as much as possible. The larger the block is, the greater the number of apartments, and the greater the profits. It makes rapid planning and constructing easier, without much complication that can arise from more complicated projects. Much of the planning and architecture work in China is done by state owned Local Design Institutes, often called LDI's, These institutes provide cheap standardized construction drawings. According to Monson the LDI system was created to have as much efficiency as possible, to rely on finished standardized templates rather than on new design innovation. The result is often repetitive monotonous architecture and streetscapes. In any project, a LDI is normally a mandatory partner. Monson points out that changing this planning paradigm can be difficult, since this system has worked very well at least from the state and developer's point of view. However, from an environmental and social point of view, the same thing cannot be said. Little attention is given to public spaces, and they are often left to deteriorate after a development is finished.

However negatively superblocks may be described, there are some aspects of them that need to be considered when making a design proposal in China. Hassenpflug (2010) describes in his book, *The Urban Code of China*, some crucial aspects of Chinese building and planning traditions that has to be taken into account.

BUILDING ORIENTATION

When looking at a satellite photo of a Chinese city it is easy to spot that nearly all buildings are orientated towards the south. The photo may resemble one of Le Corbusier's utopian dreams, with tall buildings placed on equal distances from each other in a green landscape. Much of Chinese planning today could be said to be modernism taken to its fullest extent. However, the practice of orientating residential buildings to the south is in fact deeply rooted in Chinese tradition. Deviating from this practice would according to Hassenpflug not be recommended. For various reasons, southern orientation has always been an important part of Chinese urban history. One reason is for indicating hierarchy, an aspect visible in for example traditional courtyard houses where the most important part of the house, where the elderly lived, would face south. Another reason for southern orientation is the practice of Feng Shui which controls many aspects of Chinese planning tradition. Without going too deeply into the theory and history behind this, it is clear that orientating residential buildings to the south is

a requirement. In fact without special permission, which is rarely given, local governments will not allow too much deviation from the southern angle. (Hassenpflug, 2008)

Nanjing planning law does have extensive rules regarding sunlight and building orientation. A certain amount of daylight must reach each apartment and the law has many regulations how close buildings may stand to each other depending on their height. (Nanjing Planning Bureau, 2012)

A technique available for planners to create blocks is the use of commercial buildings, which does not have any orientation requirement. In Chinese cities it is a common sight to see commercial buildings placed along the east and west borders of a block, removing the need for creating an encircling wall, yet another crucial aspect of Chinese planning.

WALLS

Throughout Chinese urban history, walls have been one of the most dominant aspects of the Chinese city. From city walls to sealed residential quarters, the wall is ever present in both the old and the contemporary Chinese city. As Xu (2000) underlines, walls have not only served as a physical barrier, but also a social one. They are a symbol indicating the hierarchical Chinese society:

From a Chinese perspective, an architectural space had to be defined nominally and physically, so that it could be distinguished both in concept and in reality from other spaces of different categories, defined likewise, and so that the human environments could be maintained in order. The most convenient and probably preferable way to accomplish this materially was to enclose the space with walls. What seems to have been distinctive was (and still is) the ubiquity of various kinds of walls in China's landscape . . . Walls in China, in fact, became an important part of the vehicle used to distinguish different categories in an ordered human environment, and the social and conceptual function of walls outweighed their physical function of defense and obstruction; that is, they have physically bounded the spaces that they enclosed, but more importantly they symbolized the manner of classification in the organization of society (Xu, 2000, pp196–197)

Walls were also present during the Mao era. While Beijing's city walls were being demolished, new walls were erected. The work unit, danwei, became the new paradigm of urban planning. The danwei is based on the neighborhood unit which origins can be traced back to the United States, where Clarence Perry was the main proponent. It is an idea to gather all necessary functions within a neighborhood, to create a community. The neighborhood unit concept was introduced in China in the late 1940's as a means to organize urban functions effectively. The danwei is also based on the Soviet micro-district, which is a largely similar concept to the neighborhood unit. The Chinese

version of the micro-district, the danwei, is a large block which contains all services, workplaces and housing for its residents. The majority of Chinese citizens belonged to a work unit, where they lived, worked and retired. The work unit provided social benefits such as providing health care, school and retirement benefits. Each work unit was surrounded by walls. Even though the government initially opposed these walls, the work unit leaders would illegally erect them, soon all work units were planned with walls from the beginning. Chinese cities were in the 1960's transformed to a cellular pattern composed of these work units. The city was a collection of independent communities with few connections between each other, a city of walls. This can still be seen in China today, in the typical new developments made up of gated communities. (Lu, Duanfang, 2005)

With the market reform and opening up of China from 1978, the work units have started to disappear. Many still remain, although in a different form. Yet the practice of building walls still remains strong, perhaps stronger than ever before. The gated community has become the only way of building residential areas today. A new residential block without gates is inconceivable in contemporary China. A typical gated community has two metre high walls encircling the compound, often equipped with electrical fences and security cameras. There are usually not more than two entrances to the compound, each with its own guards. Creating more entrances would be problematic, since the guard's salary are shared by the compound's residents, who are unwilling to spend money in order to have more gates. There would also be questions regarding security. While security is said to be the main reasons behind the dominance of the gated community in China today, many argue that it is mostly due to social reasons, to create social barriers and indicate a place in the social hierarchy (Campanella, 2008) (Hassenpflug, 2010).

Whatever the underlying reasons for the gated community in China are, it is a complicated subject. And as researchers underline, these aspects must be considered when planning for a design proposal in China.

CHAPTER 3: METHODOLOGY

The aim of this thesis is to design a new neighborhood in Hexi New Town, Nanjing, based on the concept of transit-oriented development. The long term goal is to reduce car dependency by designing a built environment that encourages mass-transit use over private car use. The literature review clearly established the significance of this task. The available research on the topic in a Chinese context show a clear consensus regarding the opportunities of implementing the transit-oriented development concept in China. However, it is underlined that a generic model of transit-oriented development should not be used. Although TOD is pointed out as having much promise in China, it is not possible to directly transfer American or European principles of TOD, they have to be adapted to the Chinese context. Since there is limited research on this topic in a Chinese context, many researchers look to Hong Kong as a benchmark for a successful TOD strategy, given for example the similar culture and problems with population growth (Cervero & Day, 2008) (Zhang & Lin, 2011) (Zhang M. , 2007) (Cervero & Murakami, 2009) (Curtis, Renne, & Bertolini, 2009).

Therefore, in order to synthesize design principles relevant for a Chinese city like Nanjing, this thesis chose the method of a case study of Hong Kong. Several transit-oriented developments in Hong Kong, that has been studied in previous research and concluded to be successful examples of the transit-oriented development concept, were chosen as case studies. All of the case studies were made on-site by the author. All maps, photos and 3D models are made by the author. Relevant statistics, such as population density, was obtained from Hong Kong planning authorities. Other statistics, such as Floor Area Ratio, was calculated by the author based on available statistics on the gross floor area of each building.

This thesis was based on the theoretical framework of the five Ds as described in the introduction. These principles are the most commonly used in research regarding transit-oriented development, and was therefore chosen as the theoretical framework for this thesis. All of the case studies as well as the final analyze and evaluation of the design proposal, were made based on the five Ds.

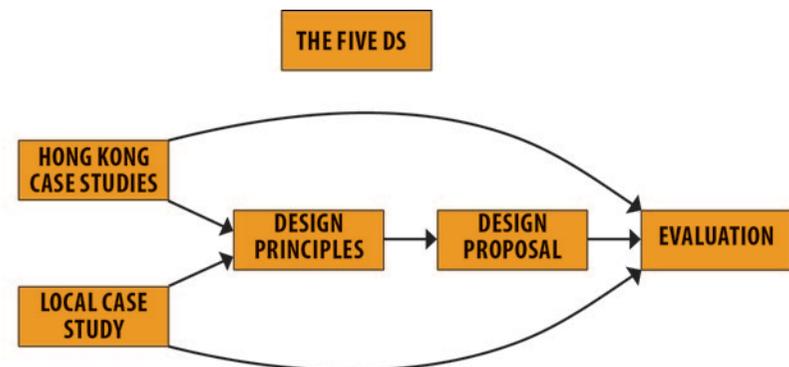
The case studies looked specifically at urban design aspects of the built environment that relates to the five Ds. The purpose of the case study is to synthesize a set of general design principles for the design of the Nanjing case, to be used when answering the main research question. The case study used both qualitative and quantitative measures. Quantitative measures were mainly used for the Ds Density, Diversity, Distance

and Destination accessibility. Density measured population density, dwelling unit density and floor to area ratio. Due to time limitations, the cases of Chai Wan and Heng Fa Chuen measured only population density. The Po Lam case was chosen as a more detailed density study, using all of the measurements. Diversity were measured not in exact calculations, but by illustrating it with the use of detailed maps. Distance to transit were measured as the proportion of population within a 200 metre and a 500 metre radius of a mass-transit station. These distances were chosen based on the use of them in other research of Hong Kong (Tang et al. 2004). Destination accessibility was also measured visually, with the use of detailed maps. Some features of the Design aspect were also quantitatively measured, such as block size and street width. However, the other parts of the Design aspect are qualitative urban design elements that are not easily measured, for example the design of the pedestrian- and bicycle environment. In order to analyze these aspects, visits to each of the case studies were made. Photos and sketches were used to illustrate the key findings regarding qualitative urban design elements.

These measurements were then used also for case study of a local case, a typical district in Hexi New Town. This was done to establish a local context, to get an understanding of the main differences between the Hong Kong case studies and the chosen study area. Because Hong Kong design principles may not be directly imported to Nanjing, certain elements in Hexi New Town were analyzed according to the findings of the chapter “Contemporary Urban Planning in China” in the literature review.

The key findings from the Hong Kong and Hexi New Town case studies were then used to synthesize a set of design principles, sorted according to the five Ds. Based on these a design proposal was made.

Finally the design proposal was analyzed according to the five Ds. The results were then compared with those of the Hong Kong and Hexi New Town case studies. This was done to evaluate the results of the design proposal, and to draw conclusions from it.



LIMITATIONS OF CHOSEN METHOD

There are some limitations and weaknesses to the chosen method. The five Ds are limited to studying the relationship between the built environment and travel behaviour. The five Ds handle sustainability mostly from a transportation point of view. Other aspects, such as social issues, are not taken into account. For example, the quality of life in a neighbourhood, the opinions of its residents, and social segregation are not measured.

The question of parking availability is also not part of the five Ds. This is an important part in the effectiveness of a TOD neighbourhood. Providing ample parking opportunities often works against the desired benefits of the TOD concept. It is a difficult balance act and could in fact be a question for a whole thesis. If very few parking spaces are provided, will families want to buy apartments there? If ample parking spaces are provided, will the whole concept of TOD fall? These are however questions outside the scope of this thesis. These could be questions for further research, and they are especially interesting in the Chinese context given the rapid increase in car ownership in China.