Transit-Oriented Development in Lima
A TOD strategy and design for mass transit nodes of Metro Line 1

Stephanie van Doorn | Graduation Project MSc - Urbanism | Delft University of Technology | January 23, 2014
Colophon

Transit-Oriented Development in Lima
A TOD strategy and design for mass transit nodes of Metro Line 1
MSc thesis

Stephanie van Doorn
Student number: 1545469
E-mail: jsvandoorn@gmail.com

Keywords
Transit-Oriented Development, informal settlements, redevelopment transit nodes, social-spatial fragmentation, social inequality, Lima Peru

Mentor team
TU Delft, Faculty of Architecture, Department of Urbanism, Chair of Spatial Planning & Strategy
Dr. Ir Ana Maria Fernández-Maldonado
a.m.fernandezmaldonado@tudelft.nl

TU Delft, Faculty of Architecture, Department of Urbanism, Chair of Urban Design
Dr. Ir. Stefan van der Spek
s.c.vanderspek@tudelft.nl

External Examiner
TU Delft, Faculty of Architecture, Department of Architecture, Chair of Urban Design
Dr. Ir. Frank van der Hoeven
f.d.vanderhoeven@tudelft.nl

Faculty of Architecture, Delft University of Technology. MSc Architecture, Urbanism and Building Sciences track Urbanism, studio Explorelab.

This thesis is downloadable for free from the TU Delft library website:
http://www.library.tudelft.nl/collecties/tu-delft-repository/

Delft, January 23, 2014

Cover image: by author
Master thesis

Transit-Oriented Development in Lima
A TOD strategy and design for mass transit nodes of Metro Line 1

Stephanie van Doorn

MSc Architecture, Urbanism and Building Sciences
Track Urbanism
ExploreLab Graduation Studio
February 2013 - January 2014
Acknowledgement

This thesis report summarizes the results of my graduation project for the Master of Science Architecture, Urbanism and Building Sciences at the Faculty of Architecture, Delft University of Technology. At this point I would like take the opportunity to express my gratitude to all those who supported me and made it possible for me to accomplish the work presented in this report.

First of all, I would like to thank my parents and dearest friends for their unconditional love, support and understanding during the graduation period. Further, I would like to take this opportunity to express my sincere gratitude to my mentors Ana María Fernández-Maldonado and Stefan van der Spek for their support and guidance over the last year. Special thanks to Ana María Fernández-Maldonado who made this project possible for me and has supervised me since the very beginning in September 2012. As my first mentor, she has guided me through all the methods and theory necessary for my research, helping and stimulating my knowledge about the subject and the Peruvian urban context. Thanks to Stefan van der Spek for sharing his in-depth knowledge about urban design focused on transit-oriented development. His expertise and advice helped me a lot during the research and design process. I would also like to thank Remon Rooij for his guidance during the first steps of the research and his support in setting up the project. During the past year all these mentors have taught me to incorporate comprehensive urban analysis based on theories to develop urban design skills.

I would like to thank all the experts I met in Lima for their support of my research process, their time and input: Juan Tokeshi and Guiliana Gutiérrez (faculty of Architecture and Urbanism at Universidad Ricardo Palma); Juan Carlos Dextre (faculty of Civil Engineering at Pontificia Universidad Católica del Perú); Aldo Mantovani (faculty of Architecture and Urbanism at Pontificia Universidad Católica del Perú); Mariana Alegre from Lima Como Vamos (observatory that monitors and evaluates citizen’s quality of life); Jessica Tantalean from CICLOLIMA (Non-motorized program from Metropolitan Municipality Lima); Erick Reyes and Felix Paucar from AATE (Autonomous Authority of the Electric Train); and Ramiro García, Cesar Orejón and Jaime Miyashiro from Desco (Urban Program – NGO).

Furthermore, I would also like to thank the Universiteitsfond Delft and Van Eesteren-Fluck & Van Lohuizen Stichting. They made it possible for me to actually travel to Peru to carry-out on-field research and data collection in Lima, enabling me to perform the in-depth analysis and design presented in this report.
Since the 1950s the city of Lima, capital of Peru, has drastically grown both in size and inhabitants due to a process of rapid urbanization, by which the city has expanded horizontally in an informal way. Informal settlements have occupied peripheral areas, producing a centre-periphery pattern of urban development. Because the activity centres remained in the city centre informal settlement dwellers have to travel for long hours to the centre to work.

For more than 20 years Lima has been without mass public transport due to inattention from governmental entities. As a result an extensive informal public transport system established itself. This transit network has grown in amounts of vehicles, routes, competitiveness and an unsafe transit environment over the last years. The entire city is well connected by informal public transport, making it difficult for single mass public transport corridors like Metro Line 1 to compete against the inefficient informal system. Governmental entities of Lima are just starting to implement mass public transport corridors within the city, but a lot of adjustments of the urban environment have to be made to regain lost urban space and ensure the transit efficiency of public transport.

The objective of this graduation project is to develop an approach to tackle public transport related problems of a large city in a developing country, characterized by high levels of informality and socio-spatial segregation, using Transit-Oriented Development. This strategy focuses on the analysis and improvement of Lima's metro line corridor that started operation in 2012, linking the historic city centre, the modern centre and informal peripheries of the city. This approach aims to create different urban transit nodes typologies and urban development opportunities based on theory. The obtained typologies and opportunities have a high potential to develop and integrate the mass public transport network, optimizing land-use efficiency creating and recovering the adjacent urban space. A general vision is developed with three urban design interventions of three metro station areas, which are considering the most significant and representative three different urban patterns of Lima.

This thesis can be considered as an exemplary and results are applicable to other and future urban transit nodes in Lima and other similar metropolitan cities in developing countries.
Contents

Acknowledgement

Summary

1 Defining the subject
   1.1 Problem definition
   1.2 Aim and purpose project
   1.3 Research question and sub-questions
   1.4 Relevance
   1.5 Methodology
   1.6 Theoretical dimension
      1.6.1 Frequent occurring slums
      1.6.2 Transit-Oriented Development
      1.6.3 From TOD analysis and design principles to a TOD vision and design
      1.6.4 Conclusion

2 Opportunities in the regional context
   2.1 Historical dimension
      2.1.1 Urban mobility due to expanding city
      2.1.2 Emerging phenomenon of barriadas
      2.1.3 Public transport transformation
      2.1.4 Upgrading barriadas and self-help
      2.1.5 Crisis and political change
      2.1.6 Conclusion
   2.2 Spatial dimension
      2.2.1 Population concentration and economic activities
      2.2.2 Urban pattern Lima
      2.2.3 Infrastructure
      2.2.4 Mobility and urban transport
   2.3 Socioeconomic dimension
      2.3.1 GDP
      2.3.2 Socioeconomic levels
      2.3.3 Employment
      2.3.4 Education
      2.3.5 Public transport use
      2.3.6 Supplies in and organization of informal settlements
      2.3.7 Conclusion
   2.4 Political & planning dimension
      2.4.1 Political boundaries
      2.4.2 Normative urban planning instruments
      2.4.3 Urban planning background
      2.4.4 Evolution of mass public transport in Lima
      2.4.5 Susana Villarán’s Transport Reform
      2.4.6 Main involved actors in public transport
      2.4.7 Conclusions

3 Metro Line 1 analysis
   3.1 TOD area
   3.2 Metro Line 1 – the transit corridor
      3.2.1 Origins and destinies of metro users
      3.2.2 Frequency and passengers per hour
      3.2.3 Passengers per station
      3.2.4 Passengers per station per hour
      3.2.5 Conclusion
   3.3 Metro Line 1 – the activity corridor with activity centres
      3.3.1 Transit network
      3.3.2 Land-use
      2.2.5 Public space
      2.2.6 Conclusion
3.3.3 Inhabitant and employment density
3.3.4 Household income
3.3.5 District regulations
3.3.6 Elevation of metro and morphology
3.3.7 Public space
3.3.8 Characteristics together
3.3.9 Conclusion

3.4 Station area – position in the network p. 61
  3.4.1 Positioning the stations
  3.4.2 Concepts and opportunities

3.5 Conclusions of analysis towards station types p.66
  3.5.1 Conclusion of analysis
  3.5.2 Thorough analysis of three stations

4 Vision and design proposals p. 75
  4.1 Metro Line 1 vision p. 76
  4.2 Principles and strategies for station areas p. 79
    4.2.1 Principles and strategies Miguel Grau
    4.2.2 Principles and strategies Cabitos
    4.2.3 Principles and strategies Villa El Salvador
  4.3 Design interventions p. 93
    4.3.1 Station area design Miguel Grau
    4.3.2 Station area design Cabitos
    4.3.3 Station area design Villa El Salvador
    4.3.4 Materialization

5 Evaluations p. 121
  5.1 Conclusions p. 122
  5.2 Reflection p. 123

References

Appendix 01 Literature review paper written for the course AR3U022 Theory of Urbanism
Appendix 02 Table of calculations for each station area
Chapter 1 Defining the subject

Many solutions can be given to one problem, but most important is to know what the criteria are for each solution. This chapter defines the problem (1.1), the aim and purpose (1.2), the research questions (1.3), the societal and academic relevance (1.4), the methodology of the research (1.5) and the theoretical framework (1.6) in order to create a general understanding about the topic and main research methods and reasons of this project.
1.1 Problem definition

Traffic in Lima is known as chaotic and with serious congestion problems, noise, high accident rates, environmental contamination and resulting travelling delays. These problems are produced by different factors like the lack of a single responsible authority, high level of informality in the transport system, an excessive amount of public transport vehicles and taxis, the lack of an integral design and system for transport, no facilities for transportation by bicycle, and the evident problems of an 8 million metropolis with a mono-centric urban pattern (Cortés Navarrete, 2012).

The city has grown in a dispersed way with fast growing expansion areas (see figure 1.1.1), establishing an urban pattern of centre-periphery during the last century. These expansions are identified by the lack of public services and public space. As a result many different informal public transport routes and vehicles offer their service for inter-urban displacements. Lima’s expansions also generated informal settlements in the very peripheries that are difficult access by mass public transport; only low capacity vehicles like motor-taxis and microbuses can access these areas. Many of these low capacity public transport routes start in the peripheries and meet with all other informal public transport routes in the city centre. The majority of daily trips is generated by the horizontally expanded city where most of the activities and industries are located in the city centre. Not only the quantity of trips and vehicles is very high, but also the average travelling time of passengers is excessively long, some up to four hours a day. Due to many private public transport companies and their informal system a large number of passengers is required to make profit. This so-called “war of the cents” causes competitive driving behaviour in order to gain more passengers (Vega Centeno et al., 2011). In consequence the number of accidents is extremely high due to systematic over-speeding, and thus causing a dangerous transit environment.

In most cases especially the poor are affected by the spatial size of the city and tend to make longer trips. It is difficult for many informal settlement dwellers to cover the costs for public transport. While transport in general is cheap, the price for the poor is higher because of the longer distances they have to travel. These residents try to pay less or to not pay at all by convincing the public

Figure 1.1.1 Urban growth of Lima since 1935 (Desco, 2005) – elaborated by author
transport driver that they are in an emergency situation or that they just do not have money to pay the (whole) trip. Instead of trying to reduce the costs of the trips by negotiation with the driver, others travel by foot to their destinies, or walk a part of the distance to pay less for the rest of the trip (Avellaneda, 2007).

It is important to bring different functions and activities closer to more suburban and residential areas of the city through an integrated transport system that offers displacements in order to reduce the negative impacts and include people of all income (Vega Centeno et al., 2011). This will encourage a polycentric model of the city, where people will not have to make long trips anymore and will have amenities and jobs closer to their homes.

Nowadays, the oldest informal settlements of Lima are far developed and evolved into more or less legal neighbourhoods. In these settlements is a lot of open space has been reserved for roads, parks and plazas, but their quality is poor (see figure 1.1.2). Asphalted roads built during Lima’s growth expansions since 1960 were mainly constructed in the centre parts of the city and rarely integrated the infrastructure from the city centre to informal settlements (Vega Centeno et al., 2011). Only main roads and highways that pass along peripheral settlements are asphalted, which in a way is an opportunity to integrate these neighbourhoods to the urban transit network.

Metro Line 1 is the second mass public transport line in Lima operating since 2012, going from north to south. The first is a BRT line that was opened to public in 2010, on the west side of Lima parallel to the metro line. The construction of this metro line started in 1986, but was paused from 1990 to 2006 due to diverse political and economic reasons (Fernández-Maldonado, 2009). The metro corridor was chosen without a proper feasibility analysis and was radically imposed into the urban structure without considerations for its integration into its urban surroundings or the transit network. Until this moment there has been no special urban development works done around the metro stations. Public spaces in their direct surroundings have very poor quality. Informal street vendors selling food, newspapers and all kind of products use public space. In general land-use around the metro stations has slowly changed from residential to commercial in formal and informal ways. In the peripheries and some central areas informal businesses have emerged along the metro line. Small restaurants or local commerce replaced the ground floors of homes or emerged onto the streets (see figure 1.1.3). Taxis and motor-taxis have also taken advantage of the location. They often wait for customers parked on principle roads along the metro corridor blocking the traffic flow. The imposed metro line that is not integrated to the urban road and public transport network or its adjacent urban space causes these informal appearances on public space and informal changes of land-use.

Figure 1.1.2 Poor quality of public space in informal settlement district Villa El Salvador (by author)
Summarizing the characteristics at metropolitan scale: the public transport network is not efficient, the peripheries are not integrated into the city and the metro line is imposed and not integrated to its urban context or transit network. There is a need for sustainable daily mobility; reducing greenhouse emissions of urban transport, decreasing transit pressure in the city, minimizing the necessity of travelling long distances and giving preferences to sustainable trips, as trips by foot, bicycle or means of mass public transport (Dextre Quijandría, 2012). At station area scale the characteristics are related to urban design and land-use development: informal land-use especially in peripheral areas, public spaces are insufficient and identified by their poor quality, and there is a necessity for integration and adaptation of the metro stations to its surrounding urban space and integration to an urban mass public transport system.

1.2 Aim and purpose of the project

Aim
To develop a Transit-Oriented Development strategy and design that recognizes the importance and influence of the regional and local context in the use of Metro Line 1 as an enhancement of the efficiency of Lima’s transit network that intensifies multimodal, integrated and efficient transit use, new opportunities due to accessible amenities, jobs and housing, and a better quality of the public environment (see figure 1.2.1). The urban strategy and urban design interventions can be an example for station areas of future metro lines in the city.

Purpose
The purpose of this graduation project is to propose an approach to deal with a TOD development in the context of the city of Lima, which is characterized by high levels of informality, socio-spatial segregation and a mono-centric urban pattern. This strategy should respond to the different socioeconomic groups, distinct ways of living, different use of public space and public transport, and differing public spaces between neighbourhoods. In this strategy the role of the metro line and its direct surroundings performs as a structural core that offers new possibilities to all households throughout the city, it establishes an integrated urban transit network, optimizes land-use efficiency and responds to environmental needs. The urban design interventions of the station areas increase their formal value, and give a potential to regain city identity through identifiable urban spaces.
1.3 Research question and sub-questions

In order to investigate how a Transit-Oriented Development strategy - in the context of a low-income city in a developing country - can be an activator of integrated urban transformations around transit nodes, the following research questions will be answered.

Main research question:

‘To what extent can Transit-Oriented Development be used to improve Lima’s urban transit and urban space strengthening the efficiency of Metro Line 1 with an integrating and recovering approach?’

In order to answer the main research question there are five sub questions defined that help to get a grip on the guiding components of the graduation project:

[Historical dimension]
‘How has Lima’s public transport system developed in the twentieth century?’

[Socioeconomic dimension]
‘How are the features of the current public transport system in Lima answering the demands of the different income groups in the city?’

[Spatial dimension]
‘How is and what defines the current urban structure of Lima?’

[Political and planning dimension]
‘What are the spatial planning challenges and strategic interventions needed to activate urban transit and spatial developments?’

[Theoretical dimension]
‘Which aspects of Transit-Oriented Development are specifically applicable to low-income cities like Lima?’

1.4 Relevance

Societal relevance

The socio-spatial trend of the informal (use of) public space and public transport is highlighted in this thesis to point out the general problematic character of the city of Lima. This informality started already during the rapid growth of Lima since 1940’s, and since then the informal character has been aggravated. How the city has end up in this situation is explained in chapter 2 Opportunities in the regional context, but at first it is important to recognize the problems of inhabitants of the city.

The cry for change and research for alternatives has come from experts and public opinion. The recent implementation of mass public transit, a BRT and metro line, has not been stimulating and covering all the travel demands. There is a need of a properly organized infrastructure and a long-term sustainable mobility and a transport plan, in which pedestrians, cyclists and mass transit are prioritized (Ríos, 2012). A plan like this can primarily be achieved by governmental initiative, which has had many setbacks in the past and resulted in low confidence of the people into the government regarding this issue.

The lack of a structured hierarchical infrastructure is seen in the way pedestrians try to cross large primary roads. The deficit of crosswalks has led to a dangerous environment for pedestrians who are sometimes forced to do dangerous stunts to cross packed roads. To prevent this dangerous
traversing fines have been implemented for pedestrians. If a pedestrian is causing a traffic accident due to crossing the street where he is not supposed to do it, it will always be pedestrian's fault. There is an urge to structure infrastructure focussing on pedestrians (El Comercio, 2011). Also cyclists are getting in the spotlight; in order to stimulate bicycle use some district municipalities are enabling bicycle parking at metro and BRT stations (El Comercio, 2012).

The importance of the capacity of massive public transport systems is referred to when comparing the situation in Lima to the Metrocable of Medellin, Colombia (Conor, 2010). Lima could learn from the positive effects observed when connecting informal peripheries to the formal centre with public mass transport in Medellin. Informal settlement dwellers gained a new and easier option to travel by the Metrocable and thus public transport created new opportunities for them. This means that mass public transport can lead to social inclusion, something Lima is still lacking.

The former mayor of Bogotá, Colombia, Enrique Peñalosa, now international planning consultant of Bogotá, sees the city’s investments as social equalizers:

‘... We want society to be as egalitarian as possible. For this purpose, quality of life distribution is more important than income distribution. The equality that really matters is that relevant to a child: access to adequate nutrition, recreation, education, sports facilities, green spaces and a living environment as free of motor vehicles as possible. The city should have abundant cultural offers; public spaces with people; low levels of noise and air pollution; and short travel times.’ - Enrique Peñalosa, former mayor of Bogota (Cervero, 2009)

In general the quality of public space in Lima is poor. Therefore it is necessary to find out ways of improving the quality of public space. A way of improving the quality of public spaces is to embrace the urban history. The city has a lot of historical layers that should be also encountered in new designs to create and recover identity and quality of life (El Comercio, 2013). Currently the tendency in Lima is to construct by destructing history and memories, a principle that has to change.

Academic relevance

This graduation project will contribute to the body of knowledge on Transit-Oriented Development. The elaborations presented in this thesis explore new principles and strategies to deal with TOD in a low-income city in a developing country, where informality is prevailing in many aspects. This research project’s aim is to enrich the general and academic debate about how specific planning tools and spatial interventions can be integrated in an informal context. There are many examples of implementing TOD in western countries and Asian cities, but only little research has been done for Latin America (Cervero, 2009). This thesis provides an extensive analysis of the complex urban mobility tissue of Lima towards principles of physical interventions by means of TOD, which can be used as a case study for other Latin American cities.
1.5 Methodology

The methodology of this thesis illustrated in figure 1.5.1 shows the close interrelation between the analytical framework including the strategy and design development with the theoretical framework. Most elements of analysis, strategy and design are based on the theory of Transit-Oriented Development that addresses the low-income city context of Lima, which is explained in section 1.6 Theoretical dimension.

Different networks define the structure of Lima. These are usually independent working networks that are defined in their own context like transit, commercial, social or administrative networks. The subject is defined by the context and focus of the thesis and is further explored in the analytical and theoretical dimension. For the theoretical dimension information is needed on analysis approaches of TOD, concepts and theories to consider after a TOD analysis and design principles. This theory is the structured core for the analysis, which is mainly obtained through the literature review paper that was written for the course AR3U022 Theory of Urbanism. This paper contains six steps that have to be followed from analysis to the development of an integrated TOD strategy and design. These steps are integrated in the methodology line. The six steps do not have to be followed in the same order as long as all the steps are taken in the end. The fifth step, TOD design, can already start when analysing the regional context and be evaluated according to analysis and concepts that will be obtained during the first four steps.

The dimensions of the sub research questions are also integrated:

The historical dimension gives attention to the growth of Lima since mid twentieth century regarding invasions from the hinterland, the growing need of displacement that caused lots of informal public transport companies in metropolitan Lima.

The socioeconomic dimension focuses on the socioeconomic groups in Lima, the use of public transport by different socioeconomic classes and organization of informal settlements.

The spatial dimension describes the condition and use of public space,
transit use, participants of urban mobility and different urban structures.

The political and planning dimension clarifies the urban planning background of metropolitan Lima, planning instruments, development of public transport planning and current plans and actors.

And the theoretical dimension explores and adjusts features of TOD analysis and design in order to be applied to the context of Lima.

1.6 Theoretical dimension

This graduation project is about creating a Transit-Oriented Development design and vision in the context of Lima, which includes informal settlements. In order to explain the objectives and scope of this project it is necessary to define some crucial concepts as informal settlements and Transit-Oriented Development (TOD). It is also important to describe the specific aspects of TOD analysis and design principles in order to develop a TOD strategy on a metropolitan scale and a TOD design on local scale, which are applicable in the case of a low-income city in a developing country as Lima.

1.6.1 Frequent occurring slums

Lima is a low-income city in a developing country characterized by levels of informality and socio-spatial segregation where many informal settlements define the urban pattern. The type of informal settlement mostly found in Lima is the one of frequent occurring slums, which has a higher potential to integrate within the urban mobility network. Spatial differentiations identify distinct settlements. This representative settlement studied is consolidating, in peripheral areas, informal, but upgraded and accommodates considerable low-income households.

Consolidating settlements have been recognized, tolerated and accepted over time. Their potential for improving is generally high, due to previous upgrading it can even generate real benefit when integrating the settlement to the transport system, consolidating urban space and creating qualitative public space. The settlements are located in the periphery where the housing prices are reasonable, but the low level of access and high costs of transport is a significant problem. Households can only spend 30 per cent of their incomes on their travels to jobs, markets, education centres and services. The potentiality for these settlements is the provision of an efficient and effective infrastructure and public services. The settlements are informal, because residences had no knowledge of permissions that should have been obtained when constructing a dwelling. Many of these settlements are therefore well established, but are viewed as informal. This is why land buyers who are aware of its potentialities for development can buy these lands for lower-than-market price. The settlements are generally upgraded; in
partnership with city authorities and/or NGOs residents have confronted their problems. Therefore these settlements have better facilities and urban services than other settlements (UN-Habitat, 2003).

Although these settlements have a potential to upgrade and integrate into the bigger network of the region, the residents are poor and it is difficult for them to cover the costs for public transport. They try to pay less or to not pay at all by convincing the public transport driver they have an emergency or that they just do not have money to pay the (whole) trip. Another alternative for these dwellers is to travel by foot to their destinies, or a part of the distance to their destinies to pay less for the rest of the trip (Avellaneda, 2007).

1.6.2 Transit-Oriented Development

Different authors have interpreted the definition of Transit-Oriented Development in distinct ways. Bernick and Cervero’s definition comes closer to what we can interpret as TOD and what is applied for this graduation project (1997):

‘A compact, mixed-use community, centered around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more. The transit station is what connects village residents to the rest of the region… The surrounding public space serves the important function of being a community gathering spot, a site for special events, and a place for celebrations - a modern-day version of the Greek agora.’ (p. 5)

Transit-Oriented Development is a concentration of jobs, housing and retail and/or commercial activities – mixed-use development – within a walking and cycling distance of a transit station. These concentrations are located at strategic points along regional transit systems. They have a pedestrian-friendly design and invite people to walk and cycle, use public transport more and car less. Inhabitants will also be motivated to walk or cycle, because services are located within walking distance from their homes, see figure 1.6.1 (CTOD, 2013; Calthorpe Associates, 2002). This mixed-use centre encourages people to live near transit nodes and to decrease their reliance on trips by car (Carlton, 2007). A TOD can also be seen as an urban planning and design model around transit nodes with regional perspectives. It has compact mixed-use neighbourhoods, and safe and active public spaces that favour social interaction (EMBARQ, 2011). TOD happens on different scales and with different land uses, depending on the context (CTOD, 2011).

The basic components of TOD are thus: compact development, diversity and mix of uses and pedestrian-friendly design (Calthorpe Associates, 2002). The benefits of a TOD that could be achieved and are relevant in low-income cities are: the enhanced access to transit by households of all incomes, reduced transportation costs giving access to local and regional amenities and to more job opportunities; TOD creates a sense of community and identity of place (CTOD, 2013). Due to improved mobility options, traffic congestion will be reduced, which in its turn reduces greenhouse gas emissions and air pollution. Altogether this contributes to a healthier lifestyle that is also encouraged by inviting pedestrian to walk and bicycle routes (CTOD, 2011). Due to less travel time, caused by an improved mobility network, people will have more time at home with their families (Calthorpe Associates, 2002).

1.6.3 From TOD analysis and design principles to a TOD vision and design

Six steps are gathered from different TOD analysis and design approaches. Different approaches are combined into one approach that can be applied to the context of a low-income city in a developing country as Lima. This strategy of six steps is obtained through the literature review paper that was written for the course AR3U022 Theory of Urbanism.
The six steps are formulated in order to develop an integrated TOD design and vision. Figure 1.6.2 gives a schematic overview of these steps. The first three steps are meant define the TOD area and to understand the regional and local context of this area. The fourth step creates concepts and recognizes opportunities for a TOD design. The fifth step contributes with guiding principles to generate a TOD design, and in the last step the TOD design is evaluated on the former analysed context, acquired concepts and principles of the first, fourth and fifth step, through critical reflection.

I Identify opportunities in the regional context

Opportunities have to be recognized in different aspects that play a role in generating a TOD like political, social, environmental and economic aspects (EMBARQ, 2011). The political aspect is important implementing TOD. It differs in every country, but has to be taken into account. Usually there has to be a political will to implement TOD. TOD has to happen in accordance with administrative periods and it has to be a priority in governmental schedules to initiate such development.

How to develop a TOD design depends not only on the political context, but also on the socioeconomic and historical context of the region. These aspects should also be analysed in order to create an integrated TOD design.

II Define the local and regional TOD area

The size and shape of TOD on the local scale is the project area, the walkable area around transit stations (EMBARQ, 2011). This is defined by most authors as a half-mile or a 400-500 metre radius (CTOD, 2013; EMBARQ, 2011; CTOD, 2011). In this radius the highest development densities are situated, but these distances should not be seen as clear demarcated barriers. There should be a gradual intensification approaching the transit station. Behind the dense core, secondary employment and residential areas are located, which cover areas up to 1 mile or more (1,600 metres) from the transit station (Calthorpe, 2002). To create an integrated TOD with its surrounding area a radius of 1,200 metres will be used as in the Stedenbaan project (Balz et al., 2009).

The transit line as a whole can be structured on regional scale, recognizing activity centres, activity corridors and transport corridors (Curtis, 2009):

- **Activity corridors** are centred on main arterial roads or public transport lines using 400 metres on either side of the transport line.
- **Activity centres** are developed in and around activity corridors. They concentrate on daily activity needs, also on small-scale employment and services, which a situated within a walking distance of the transit node.
- **Transport corridors** form a network of one or more activity corridors, being main distributors for inter-urban displacements.

III Analyse station area

The station area has to be analysed based on existing local characteristics. It is also important to identify the position of each station within the network. This will help to recognize the needs, opportunities and threads of this area. The characteristics of the area to be analysed are (CTOD, 2011):

- **Land-use**: mapping employment centres, residential areas, amenities and retail/commercial areas.
- **Parcel utilization**: identifying vacant and underutilized land, also identifying properties that can be redeveloped in a near future.
- **Block size**: measuring the block sizes as a criteria for walkability; areas with small block sizes tend to be more pedestrian-friendly, but larger block sizes can indicate availability of larger development sites.
In order to measure the position of transit stations an inventory of the existing relations between the spatial conditions and networks are needed (Balz et al., 2009). The results of this inventory will be shown in the next step presenting concepts and opportunities for each recognized transit station. A set of indicators is used, which describe the positions and characteristics of transit stations expressed in percentage values, see also figure 1.6.3 (Atelier Zuidvleugel, 2006). The calculation methods are defined in section 3.4 Station areas - position in the network. Some of these indicators have been adapted to the developing country context:

- **Degree of access by public transport (APT):** network value, each connection of public transport is valued separately, overlying massive public transport as BRT systems, light rail or metro and underlying more informal public transport as buses, microbuses and mini-vans.

- **Degree of access by car (AC):** network and accessibility value, there are four types of positions in the network, without taking traffic congestion into account: stations with no connection to regional or national road network; station with a connection to the regional road network; stations with a connection to the national road network; and stations well-connected to regional and national road network.

- **Local densities of inhabitants and jobs (DIJ):** inhabitant and job density, the amount of people working and living around the transit stations. The extremes found in Dutch metropolitan context were from 30 to 390 inhabitants and employees per acre built area.

- **Degree of mixed-use (DMU):** the ratio of residents and employees in station areas, 100 per cent means there are as many inhabitants as employees.

*IV Establish general objectives and opportunities*

In order to establish objectives and opportunities some general concepts have to be obtained at local and regional scale. These concepts will result in new opportunities for the sites. The local scale generates concepts for activity centres and the regional scale for activity corridors and transport corridors. Opportunities for the activity centres or station areas can be derived from the spatial inventory of transit stations from the previous step. Some concepts and opportunities from the Stedenbaan project are recognized in the contexts of low-income cities in developing countries. These are the following concepts, also shown in figure 1.6.4 (Balz et al., 2009):

- **Cities of the Future – Developing Sub-centres** are extensions of the city centre or smaller centres. They have a high population or employment density, are cheaper mono-functional sites, are well integrated into the road network or are close to primary roads. Opportunities: They can develop into an urban area with its own identity, a mixed-use area with offices, small business and local services.

- **Regional Crossroads – Metropolitan Crossroads** are located close to highway and primary roads intersections. They have a good access from all parts of the city, but only by car. Opportunities: They can develop into an interregional service centre that has to survive independently from the city centre because its distance from it. Business and local industry would be an adequate option combined with enhanced access by public transport.

- **Regional Hubs – Metropolitan Hubs** are smaller centres, but are not intensively used as the city centre. They are well accessible by either car or informal public transport, and are well integrated in the transit network. Opportunities: They can
develop into experimental new employment and mixed-use areas, only with a unique identity to attract a mix of regional and interregional services, workplaces and housing. These can exist because of good services with dual access and acceptable prices.

- **City Centres** have high employees and inhabitants density, are highly accessible by different modes of informal public transport, but are less accessible by car. Opportunities: The first priority is to optimize the transit network, creating a new hierarchal network where public transport users, cyclists and pedestrians are equal to motorists.

- **Business Sites – Residential Sites** are located along principle roads, have a low inhabitant and employee density with small businesses and local commerce, and are better accessible by car than by informal public transport. Opportunities: These sites can develop into more intensively used employment areas, where new connection to public transport can add value to the location.

- **Outskirts of Cities – Peripheries of Cities** are located distant from the city centre. They are identified by high inhabitant densities and monofunctional sites that are difficult access by car or informal public transport. Urban space and built environment is (used) informal and unfinished. Opportunities: The residential areas can be restructured consolidating the existing urban fabric and new functions as small local businesses and commerce can be added.

For the activity corridor the Network City concept is chosen. In this concept, the region is seen as programmatic whole where the main goal is to form networks. A maximum of diversity of services and locations is stimulated within the regional TOD area. This area is based on high accessibility especially by the public transport network, with an extensive variety of housing, employment and recreation (Balz et al., 2009). Two other concepts proposed by Balz et al. are the Densification and Sustainability concept, where densification and preservation of historical landscapes are the main goals. These concepts could be used but not as main goals. A reliable goal for a low-income city in a developing country is to create a network in order to enhance the efficiency of new developments including and influencing households of all incomes.

The transport corridor concept is a concept where opportunities depend on the transit corridor type. Three main corridor types are recognized (CTOD, 2013):

- **Destination connectors** connect residential neighbourhoods to different activity centres, involving employment, medical, educational and commercial centres, and result in ridership in both directions throughout the day. Opportunities: Station areas that are described as ‘destinations’ have a high potential for new development. Destinations would be areas with high walkability and activity centres that are well connected to its surrounding neighbourhoods. Higher density development can occur along the destination connector, caused by an increased demand for accessible job opportunities and activity centres.

- **Commuters** are serving only one bigger activity centre, usually a central business district. The transit service is clearly more frequent and used during peak business hours than during off-peak hours. Opportunities: New development is appropriate to be residential with moderate densities, dependent on the proximity to the city centre. Enhanced streetscape, pedestrian and bicycle access to the stations will result in higher ridership. Also transit feeder service like buses in suburban areas is convenient.

- **District circulators** are serving within an activity centre that can be a city centre, commercial, medical or educational area, and also connecting to other activity centres. Opportunities: Connecting district circulators to the regional transportation network will increase transit ridership. Enhancing streetscapes will stimulate pedestrian activity within the district. Connecting to significant destinations with available land for development will attract

---

Figure 1.6.4: Six potential developments (Atelier Zuidervegel, 2006; p. 97)
market-rate development.

**V Principles to create a TOD design**

Former steps have helped to discover needs and opportunities for a TOD in its regional and local context. This step is aiming to create a TOD design. Circulation, urban design, infrastructure design and land use indicators and principles for a TOD designs are explained in this step, which have to be considered during the design process.

**Circulation principles** are aiming to strengthen connectivity between the location of a TOD and its surrounding area. This should encourage walkability in the neighbourhood, but not exclude car accessibility. It is required to create an interconnected street system, with small block sizes that shorten walking distances between destinations in a TOD. It is important to have a traffic calming street design to drive at desirable speeds or along suggested routes. To goal is to increase pedestrian safety, comfort and enjoyable walking routes by creating wide enough sidewalks including landscaping and amenities. It should facilitate safe and direct bicycle networks to access the mixed-use core and transit station from surrounding areas, providing parking and bike storage at the transit stations (Calthorpe Associates, 2002).

**Infrastructure design** is especially needed in cities where transit rules are neglected. To encourage acceptable driving behaviour the road profile could for example be narrowed to 4-4.5 metres for two-way traffic. Visual narrowing of the profile can also be achieved by planting many trees along the road. Also streetlights can be adjusted, because the smaller the lamppost is the slower motorists will drive. Implementing perpendicular parking also reduces the driving speed (Bach et al., 2006).

**Urban design principles** are presented to reinforce pedestrian-oriented and transit-supportive quality of the area. These principles include building design, public space design and station design. The last can be considered ideally when the transit line is being designed and does not already exist (Calthorpe Associates, 2002).

- **Building design**: Buildings should be placed in a street-oriented manner with visible and accessible entries. Architectural variation within buildings and among buildings in the same block is important to bring identity and character to the area and stimulates walking interest.

- **Public space design**: Streets should be safe, active and comfortable spaces with amenities encouraging this as street trees, sidewalk furniture, art installations, retail kiosks or outdoor eating areas. Also buffering sidewalks from the streets encourages this. There should be a civic plaza at transit stations to stimulate sense of place and social interaction, and to create a place for events, socializing and small-scale retail activity. This plaza should be large enough but should maintain connections to its surroundings. Using a landmark feature like a historic building, library or tower gives identity to the area.

- **Station design**: The station should be connected to adjacent spaces and buildings to orient passengers and to integrate them in the community. Station amenities are necessary at larger stations like a larger or indoor waiting area and small retail activities. Through distinctive and unique architecture the station can become a community landmark as an identity for the community to associate with. Parking and loading areas should be taken into account; site for park-and-ride, kiss-and-ride and bus lanes with stops.

Urban design principles for an industrial mixed-use area are needed when transforming an industrial site into a mixed-use area. Most important are the block sizes, because in order to create a pedestrian-friendly neighbourhood the blocks should not be too large. As block sizes for smaller industrial users on the ground floor block sizes of 110x110 metres are recommended and for larger users of 180x180 metres. When blocks are as large as 300x300 metres, midblock pedestrian passageways are suggested. To make the area more attractive for pedestrians retail or showrooms should be accommodated facing the major pedestrian streets. Loading docks should be facing the rear of the site. The industrial mixed-use area needs a highway or primary road access. The blocks sizes gradually turn smaller further away from the highway (Cotter, 2012).
Land use principles are outlined to strengthen efficiency of the TOD area (Calthorpe Associates, 2002).

- **Mixed-use cores** contain a variety of uses within the 400-500 metre radius or walking distance; retail uses, high density of employment and institutional uses and housing in order to create a vibrant and always living district. Residents can support small-scale retail activity. Activities directly around the transit station should be active; highly transit-oriented uses like daycare and commercial activities like newspaper or flower kiosks. A minimum residential density of 30 units per acre is favoured in more urban areas and 8-12 units per acre in suburban areas.

- **Secondary employment and residential areas** beyond the mixed-use core supplement this core. It consists of residential and employment developments, encouraging small retail activities but without competing with the mixed-use core. A minimum residential density of 20-30 units per acre is desired in urbanized areas and 10-15 in outer suburban districts.

**VI Evaluation TOD design**

The last step consists of an evaluation of the obtained TOD design. This assessment can be achieved by analysing the integration of the TOD design within its political, socioeconomic and historical context, which is established in the first step. The design has to fit in the context, including households of all income. The TOD design also has to be verified to see to what extent the design meets the concepts of activity centres, activity corridors and transport corridor, established in step four, and the circulation, urban design and land use principle from step five.

1.6.4 Conclusion

The aim of this theory research was to develop an approach to create a TOD vision and design, which can be applied in a low-income city in a developing country. The steps taken are very similar to approaches used for TOD analysis and design in developed countries, but the context here is different and so are the potentialities and aims of TOD, too. The steps presented provide a mobility network that is an integrated inclusive system with different means of public transport. Connecting the most peripheral residential areas to bigger transit stations and also including households of all incomes. For example, implementing a fixed price could be important to increase informal settlement residents’ opportunities to access employment, recreation, commercial and amenity centres.

The sub research question answered in this section is: Which aspects of TOD are specifically applicable to low-income cities as Lima? There are several analysis and design approaches applicable, but only when adjusting to the context. Especially the concepts and opportunities derived from the analysis of Atelier Zuidvleugel are completely adjusted to the context of Lima. These changes are partly based on analysis of the context analysis of Lima in chapter 2 **Opportunities in the regional context**, theory on informal settlements and on general known characteristics of low-income cities in developing countries and Lima.

These new concepts and opportunities for station areas will also add to the existing body of knowledge about TOD analysis and design. For another assured and complete evaluation of the TOD design the evaluation method of ITDP (2013) could be used in order to measure influence of the TOD design; to what extend the design reduces car use, and increases transit use, cycling and walking. This measurement is obtained from scoring criteria assessing walkability, bicycle use, connectivity, transit distances, mixed-use, density, compactness and the shift from car to public and non-motorized transport. Due to time constrains this evaluation method cannot be used for this graduation project.
Chapter 2 Opportunities in the regional context

Every city has its own unique geographic location and history influencing its development until today. This chapter outlines the main characteristics of Lima focusing on its historical (2.1), spatial (2.2), socioeconomic (2.3) and political and planning dimension (2.4) in order to identify opportunities for and external influences on Metro Line 1 and its urban station areas.
2.1 Historical dimension

2.1.1 Urban mobility due to expanding city

Since mid nineteenth century principle roads and train tracks were developed between Lima-Callao and Lima-Chorrillos, together with sewage systems, street lighting, parks and plazas. Also district municipalities were organized (IMP, 2012). A significant increase of population was provoked by these infrastructural developments and the demolition of the former city walls. Population density increased and resulted in a society with different classes where rich people lived next to the poor. The new elite tried to look for new forms to affirm their social distinctions by means of social segregation (IMP, 2012).

Urban mobility changed from displacement by foot to displacements by train and by tram in the beginning of the twentieth century. The electric tram network was inaugurated in 1904, replacing the former train with subsequently bus lines running parallel to these tramlines. This network was the main transport mode for urban displacement and transportation of goods for export to the port, which contributed to the economic wealth. Due to the tramlines sub-centres on the coastline expanded. Three tramlines connected three sub-centres Chorrillos, Miraflores and the port of Callao (see figure 2.1.1). The new elite moved to these sub-centres. New activities and industries emerged along the tramline to the port of Callao (Vega Centeno et al., 2011).

The urbanized area slowly expanded between the three sub-centres along the tramlines resulting in a triangle-shaped metropolitan area with the former centre as main city centre. The urban area increased in size from 1.292 acres in 1908 to 2.037 acres in 1931. The city growth brought along the construction of highways to other cities in Peru with Lima being the road network hub. In consequence migration to the capital city increased (Vega Centeno et al., 2011).

2.1.2 Emerging phenomenon of barriadas

In 1940 only 8 per cent of Peru’s population lived in the city and by 1972 this value had increased to more than 23,7 per cent already (Vega Centeno et al., 2011). Lima’s population growth was caused by migration from overpopulated countryside districts. Too many people migrated to Lima and the city was not capable of offering low-rent housing to all migrants. Because of the lack of housing in Lima migrants settled on vacant land far away from the centre or land initially too difficult to access like the steep hills close to the centre. This unplanned urbanization is known as the phenomenon of **barriadas**, the informal settlements of Lima. Migrants settled on the land before having constructed a place to live. The **barriadas** constituted major part of the city’s growth during this period, further resulting in the different lifestyles, behaviours and cultures that can be observed in the city, today. Many of these informal settlement dwellers worked as informal street vendors in the city centre selling goods and services (Driant, 1991). These informal urbanizations developed in the peripheries of the city centre that was located in between the tramline’s triangle.

Driant defines the phenomenon of **barriadas** as (1991):

‘A set of houses formed from the occupation of land by families on their own initiative or the initiative of the public authorities. The land does not have at the time of occupation any urban equipment or qualification with the exception of, in some cases, a simple outlined allotment. The allocation, the provision of public services and facilities and the construction of housing, are held subsequent to the occupation of land, in a slow process, different from one slum to another, and whose initiative and even accomplishment, is generally carried out by the population, a part of the family or the organization of settlers.’ (p.20)
The more the city grew the more socially segregated it got between 1940 and 1980. Important new roads and boulevards were built during the 1960s to connect the new (informal) urbanizations outside the centre’s triangle. These roads were fundamental to steer new urban growth in residential areas of the socioeconomic higher class, but did not connect and integrate all barriadas to the centre (Vega Centeno et al., 2011).

2.1.3 Public transport transformation

The public transport network collapsed due to the high demand of displacement that could not be solved by the existing public transport in 1965. At this time sub-centres kept growing in and around the triangle of the tramlines. Economic activities of the city were and still are located in this triangle being home to the average medium and higher social class. This economic development attracted also people from the lower class, who had to locate themselves in more peripheral areas of lower land value. The mobility demands grew rapidly as the city expanded to its peripheral areas. This necessity of mobilization stimulated the construction of more roads, and eventually new urban developments arose along these roads (Vega Centeno et al., 2011).

Around 1966 the phenomena of the microbuses appeared, which are smaller buses used for public transport operated by private companies. These buses differed by their informality regarding the organization of their committees, the employment of the workers and the structure of the routes. This informal public transport network had more than 400 routes through the city, covering almost 90 per cent of the travel demand. Because of increasing demand for public transport by people living in the peripheries or informal settlements and the incapability of the government to provide these services the microbus system was able to establish itself as a decent transport alternative (Vega Centeno et al., 2011).

Metropolitan Municipality Lima created the Administration for Municipal Transport of Lima (APTL) in 1965, which introduced high capacity buses into the city. Later on this entity transformed into the National Company of Urban Transport (ENATRU), one of the first massive rapid transit buses operator in Latin America. Parts of the bus routes were established on segregated lanes. Like the old trams the bus system did not cover even 20 per cent of the demand and disappeared early 1990s due to President Fugimori’s public transport liberation (Vega Centeno et al., 2011)

2.1.4 Upgrading barriadas and self-help

When more people from the Andes invaded peripheral land between 1971 and 1980, more informal settlements appeared and the municipality tried to organize the new arrivals by already subdividing plots of land and letting people occupy these for free (Driant, 1991). The neighbourhoods were allotted, but public spaces as infrastructure, parks and plazas, were left open for use. The municipality did not equip these spaces, but due to uniformly sized lots and plenty of open space reserved for future amenities and infrastructure the barriadas became an ordered neighbourhood, which would have better possibilities for upgrading and development in the future.

John F.C. Turner, a scholar focusing on housing in developing countries, had worked for different neighbourhood upgrading projects in Lima between 1957 and 1965. His housing approach was based on human self-fulfilment and housing as an expression of personal values, which was taken into account for housing policies during the 1970s. This self-help approach encouraged poor residents to build their own houses progressively in a community participatory way (Fernández-Maldonado, 2007).

Mid-80s the promotion of self-help and neighbourhood upgrading in informal
settlements shifted towards a more radical approach: providing property rights to residents in low-income settlements in order to incorporate these settlements into the whole housing system. When granted property rights dwellers could not be removed and could use their homes to obtain credit to initiate businesses. In consequence the economic welfare of dwellers would improve. The Peruvian economist Hernando de Soto influenced this approach of giving property right to informal settlement dwellers in order to gain healthier lifestyle and better economic wealth. Informal settlement dwellers had created informal jobs on the street in the city centre and had also transformed their neighbourhood into informal production and commercial sites. Soto’s vision was used for three national regulations on Popular Mortgage, Urban Land Registry and Credit Insurance in 1988. Eventually these new regulations did not have the expected results. Soto then advised to give property titles to these dwellers, making the country capital rich. The government initiated the COFOPRI program (Committee for the Formalization of Private Property), financed by the World Bank, which was a program to provide property titles to informal settlement dwellers. Of the 134,000 land titles given, 100,000 lots did not have basic services. Also many lots located in risk areas were given property titles (Fernández-Maldonado, 2007).

2.1.5 Crisis and political change

Lima kept growing and the urban structure changed. In the following years infrastructure improvements of transport and telecommunication systems and investments in massive commercial centres or shopping malls, which first appeared in the centre and later along important avenues in the peripheries, were made. The political and economic centre, social, entertainment and educational facilities and services were concentrated in the city centre. In the emerging areas the peripheries developed as residential areas, without any integration to the centre because of its social differences, fragmentation and segregation (Vega Centeno et al., 2011).

Peru was affected by an economic crisis and political terrorism that started in the end of the 1980s, which eventually led to a hyperinflation. During this period the government was not capable of maintaining public order and security. In consequence public companies collapsed. Rebel groups violently took possession of parts of national territory, destructing infrastructure, properties and people's lives. This period finally stopped in 1992 having caused many deaths and significant damage. This made it difficult for Lima to recover from its weak productive capacity (Fernández-Maldonado, 2007).

In 1990 the government freed itself from its responsibilities and regulations for public transport and housing. The government privatised the current failing public transport system of high capacity buses. The image of the crisis drastically changed by 1991. Private transport companies were free to set their own fees, had free access to routes, were free to use any vehicle except trucks and two wheeled vehicles for public transport and were permitted to import second hand vehicles to offer public transportation. In other words, the government handed the responsibility for public transport over to the private informal sector. This gave the lower class the opportunity to solve their own necessity of displacements the same way how they had previously done it with the necessity of housing in the city. To answer the demand of mobilization by cheap means private transport operators self-organized cooperative routes, which were fixed routes going from peripheral settlements to the city centre (Vega Centeno et al., 2011).

Public transport was in hands of the free market resulting in an unorganized system causing several traffic related problems in the city like congestions, traffic chaos, accidents or environmental pollution. After the public transport...
network was declared in state of emergency in 1999 a Metropolitan Transport Committee (TRANSMET) was inaugurated, which was in charge of coordinating the different transport enterprises. Their coordination project for improvement started to work out when a technical revision of vehicles was reintroduced in 2004 and finally was fully implemented in 2007 (Fernández-Maldonado, 2009).

2.1.6 Conclusion

Lima has grown in population from 662,000 inhabitants in 1940 to 8,472,935 inhabitants in 2007, see figure 2.1.4 (AATE, 2012). The city has grown to almost 13 times since 1940. In 1891 Lima occupied 1,000 hectares, in 1940 5,600 hectares and in 1993 the city had expanded to approximately 66,400 hectares (see figure 2.1.5). These expansions established the former and modern centre as main activity centres with the informal peripheries surrounding it without extensive integration into the centre due to social differences, fragmentation and segregation. Economic crises, political change and informality have affected Lima over time. Many of these influences are still reflected in the urban structure, urban lifestyle and the current public transport system of today.

The sub research question answered in this section is: How has Lima's public transport system developed in the twentieth century? The public transport system was affected by many changes during this period mainly due to political incapacity of providing a decent public transport system caused by economic crisis. The urban and population growth demanded more displacement methods than were provided by the government. The government implemented different mass public transport systems like tramlines and high capacity buses on segregated lanes. The tramlines did not answer the displacement demands of citizens and eventually collapsed due to economic crisis. In 1990 the government freed itself from its responsibilities for public transport and housing, and privatised public companies including the failing high capacity bus system. Because public transport was in hands of the free market the informal unorganized public transport grew and established itself as main provider of public transport. This new and current informal system is cheap and its routes cover almost the whole metropolis, but caused problems like congestions, traffic chaos, accidents and environmental pollution.
2.2 Spatial dimension

2.2.1 Population concentration and economic activities

Peru is situated in South-America bordering Ecuador, Colombia, Brazil, Bolivia and Chile with a 3,080 km coastline along the Pacific Ocean in the West. As 2007 Peru has a population of 28 million inhabitants from which 8.5 million live in Lima. Almost 30 per cent of the nation’s population lives in the capital city (AATE, 2012). The cities that follow Lima in number of inhabitants are Arequipa, Trujillo and Chiclayo, but none of these passes the one million mark.

Three different landforms are recognized in Peru. Along the coastline most area is covered by a sandy and stony desert. Eastwards the Andes Mountains divide the coastline from the rainforest, source of the Amazon river. Lima is located on the coast, but near the Andes Mountains and on its foothills.

2.2.2 Urban pattern Lima

Lima, the capital city of Peru, is situated on the country’s coast with the Pacific Ocean on the west and the Andes Mountains on the east side. Towards the East the city is located in the river valleys of rivers Chillón, Rímac and Lurín. Hills and mountains surround the city with moderate to steeper slopes (IMP, 2012).

The urbanized areas of the provinces of Lima and Callao merged during the twentieth century and today form the metropolitan area Lima. Lima has expanded enormously during the twentieth century due to migrations from the hinterland, as explained in the former section. These expansion areas can be recognized in the city’s urban structure with the historical city centre and the modern centre as main activity centres and the informal peripheries (see figure 2.2.1). Greater part of the urbanized area is located on sandbanks that are situated between the coastal beaches and the foothills of the Andes Mountains. Some parts of the peripheries are located unsafely on steep foothills. Lima’s urban space is strongly characterized and influenced by its climate that is in general arid but humid and is characterized by its rainfall deficiency during the whole year.

As of 2012 the estimated population of metropolitan Lima is about 9.45 million inhabitants. The area of the two provinces together is 280,000 hectare (JICA, 2013). The metropolitan area has 49 districts, 43 in the province Lima and 6 in
the province Callao. Urbanized area of Metropolitan Lima stretches over an area of 80,000 hectares, 100 kilometres long in north-south direction and almost 60 kilometres in width in east-west direction (AATE, 2012). This constitutes an average density of 118 inhabitants/hectare.

In order to picture the size of Lima, the metropolitan area is compared to the Randstad. The metropolitan area of Randstad, the Netherlands, has 7.80 million inhabitants dispersed over a broader surface area of 828,700 hectare and 430,000 hectare of urban area, which gives an average density of 18 inhabitants/hectare (Regio Randstad, 2012). The urban area of the Randstad is more than five times bigger than the urban area of metropolitan Lima (see figure 2.2.2), but the amount of inhabitants is more than one million less in the Randstad. In territory metropolitan Lima fits in the urban area of Rotterdam and The Hague and its surrounding urbanized land.

2.2.3 Infrastructure

Metropolitan Lima is home of the province’s and country’s political and administrative body, the country’s principal port and airport, which makes it very important for the city to be well connected through the urban transit network. This network includes mobility, public transport and infrastructure. The primary infrastructure of metropolitan Lima has a spatial mono-centric structure. The road structure is radial and directs from the peripheries of Lima and other provinces to the centre of the city (see figure 2.2.3). This structure causes congestions in the centre area due to restricted circulation possibilities (IMP, 2012).

2.2.4 Mobility and urban transport

According to the Urban Transport Master Plan (JICA, 2013) there are estimated to be 15.9 million daily trips done by citizens in metropolitan Lima. About 25 per cent of these trips are done by foot. Out of motorized trips almost 72 per cent of the daily travels are made by public transport (see figure 2.2.4). Many and different types of vehicles participate in urban transport. For public transport a total of approximately 49,799 vehicles is counted, which cover 405 routes.
Different types for urban transport are recognized in the city (JICA, 2013):

- Taxis and collective taxis, approximately 230,000 taxi vehicles are calculated.
- The rural pickup truck or the so-called ‘combi’ is a minivan with a capacity of 15 to 24 passengers. They are covering 170 routes with 17,712 vehicles.
- The microbus with a capacity of 37 to 50 passengers has 168 routes and 23,667 vehicles.
- The bus with a capacity up to 80 passengers has 67 routes and 8,400 vehicles.
- The collective taxi serves as a mean for public transport travelling over already set and established routes. The route collective taxis is marker by improvised signs.
- A Bus Rapid Transit called ‘El Metropolitano’, which has a capacity of 160 passengers, only operates on 1 route with 300 vehicles.
- The Metro line 1 that has a capacity of up to 200 passengers operates on a 21.5 kilometres long corridor.

Motor-taxis also take part in urban transit, especially in the peripheries. People in these areas can afford this transport mode due to its low costs. In 2006 an amount of 22,348 motor-taxis were counted. Motor-taxis are restricted in some central districts. In two districts where they are prohibited they still appear informally, see figure 2.2.6 (Secretaría Técnica del Consejo de Transporte de Lima y Callao, 2007).

The Metropolitano and Metro Line 1 are the only massive public transport modes in Lima and were introduced recently in 2010 and 2012. They are managed by different governmental entities; the BRT by the Metropolitan Municipality Lima and the metro by the Ministry of Transport and Communications. The BRT-line has several feeder-buses departing from its end stations and one departing from the central station to connect to a metro station (see figure 2.2.7). The fee charged for the BRT is 2 Nuevos Soles, equivalent to 53 Euro cents, and for using the feeder-bus an extra 1 Nuevo Sol, 27 cents, is asked. The use of Metro
Line 1 costs 1.5 Nuevos Soles, 40 Euro cents. The metro is being extended by 13.5 kilometres new tracks at the moment. Also four new metro lines are being proposed by the Ministry of Transport and Communications, see figure 2.2.8 (AATE, n.d.).

2.2.5 Public space

Different scales of public spaces are recognized in metropolitan Lima. The metropolitan municipality manages seven metropolitan and eight zonal parks and district municipalities manage local parks. In general zonal parks are bigger than metropolitan parks and require an entrance fee. They can therefore not be considered as public space anymore, but they are important recreational areas for the citizens (IMP, 2012).

A deficit of green areas in the city is a general characteristic of the city. This phenomenon has been observed since the nineteenth century: a lack of interest and absolute thoughtlessness about urban and public greenery. This careless thinking but also the rapid population growth, less rapid spatial growth of the city and the appearance of informal settlements with only poorly built housing has led to a very low rate of 2.8 square metres of urban green per inhabitant, while eight is recommended. The lack of public green for a long while has made inhabitant believe the absence green areas in a metropolitan city is normal. There is not only a deficiency of green in Lima, but also of public spaces in general. 68.3 per cent of the neighbourhoods are lacking public spaces, while also 70 per cent is built informally and spontaneous. The current tendency in Lima is to privatise public space, like using physical barriers, close streets and placing fences that surround public parks and plazas in order to restrict use and control space. Another manner of restricting use in public parks is by placing signs in parks where playing ball or standing on the grass is prohibited (see figure 2.2.9). The quality of many public spaces is also rather poor. Lack of street furniture, recreational areas and greenery is a frequent occurring characteristic of public spaces (Ludeña, 2013).
The quality of public spaces in peripheral areas of Lima is very poor, as is shown in the reports of urban studies in the south through the NGO Desco by Takano and Tokeshi (2007), and Cabrera and Villaseca (2007). The first report shows the quality of public space and the second describes the use of public space. Due to the deficit of resources there is a lack of equipment in public spaces. A high percentage of spaces do not have basic supplies like water connections to irrigate plants and public lighting. The lack of an organization by a municipal entity in these peripheral and poorer neighbourhoods has led to responsibility conflicts and finally to self-organization. Residents living in the same block or area have privatized public parks or plazas and streets for personal and commercial purposes. The privatization of public space has resulted on the one hand into a safer controlled space by the residents, but on the other hand it is not welcoming to residents from other blocks or neighbourhoods. Public spaces are not part of a network at higher scales of interconnected spaces that create dynamic flows in the city in an integrated way (Takano and Tokeshi, 2007). The use of public spaces and its equipment and sports facilities is more focussed on men and children. Almost every local park or plaza has a football court and some have playgrounds for children, but none has equipment concentrated on women that should have benches and spaces for social interaction or volleyball courts. The spaces where women usually meet are in the front yard of their homes or just inside the homes (Cabrera and Villaseca, 2007).

In general public space is well used considering its poor condition in most areas. It is in the culture that people take walks and meet outside and especially because of the favourable climate this occurs frequently. Also many households are not provided by a decent private garden and thus use public space as a garden’s extension to play and recreate. Whenever there is a possibility to sit, relax or play in public areas it is usually well used, regardless the condition or its distance from home. Some public spaces are used for weekly or monthly events with attraction from other districts in the city. Different types of public space are shown in figure 2.2.10, regardless of its condition it is well used.

2.2.6 Conclusion

The sub research question answered in this section is: What defines the current urban structure of Lima? There are different aspects that characterized the spatial structure of the city. The urban pattern is primarily defined by its coastal location and the historical urban growth: the historical centre, the modern centre and the peripheral urban areas. Public spaces are different between these urban areas in amount and spatial condition. The use of public spaces is the same in the metropolis. The mono-centric road structure and the amount of and many different public transport vehicles define the use of urban space by motorized transport. Also the new mass public transport systems that have their corridors parallel to each other explain recent aspirations to change the current informal public transport system.
2.3 Socioeconomic dimension

2.3.1 GDP

The gross domestic product in Peru was 153,845 million US Dollar in 2010 (120,845 million Euro), 5,291 US Dollar (4,153 Euro) per capita (World Trade Organization, 2011). The national annual growth in 2007 was 7.1 per cent, per capita this was 5.9 per cent (JICA, 2013). The provinces Lima and Callao produce together 47 per cent of the GDP in the country. When we add the GDP of 4 per cent of the other provinces in the region of Lima it means that the regions of Lima and Callao produce 51 per cent of the GDP (AATE, 2012). There is no other large metropolitan area in Peru that competes with metropolitan Lima as shown in figure 2.3.1. This data also explains the unbalanced economic wealth in the country. There are higher levels of poverty in the hinterland and north and south of Lima (AATE, 2012).

2.3.2 Socioeconomic levels

The share of the socioeconomic level per capita is shown in figure 2.3.2, which is examined in 2011 (JICA, 2013). There are five socioeconomic groups recognized that describe the monthly income per capita:

- Group A: > 1,700 Nuevos Soles, 450 Euro
- Group B: 900 – 1,700 Nuevos Soles, 240-450 Euro
- Group D: 380 – 550 Nuevos Soles, 100 – 145 Euro
- Group E: < 380 Nuevos Soles, 100 Euro

Figure 2.3.3 is showing the distribution of the socioeconomic groups in metropolitan Lima. In the central area of the city socioeconomic groups A and B are dominating. In the expansion cones socioeconomic groups C and D can mainly be found and in some peripheral parts group E appears. It is a gradual change from groups A and B in the centre to group E in the peripheries. The socioeconomic groups are strongly related to car ownership as is shown in figure 2.3.4.
2.3.3 Employment

The amount of employees in all work sectors is taken into account in the national census in 2007, which is translated into the amount of employees per hectare that is shown in figure 2.3.5 (JICA, 2013). There is a very dense area of work centres in the centre part of the city, especially in the old city centre. The peripheral areas have a very low rate of employees per hectare, to some extend due to less urbanized area and inhabitants, but highly probable because most work opportunities are located in the centre.

2.3.4 Education

Education in Lima is subdivided in primary and secondary education that are merged into one school, superior education including universities, and technical productive education. A quarter of the population in metropolitan Lima are students (JICA, 2013). The amount of students is shown in figure 2.3.6. In the centre area of the city a higher amount of educational centres is located. This does not mean more students reside in these places, but that many students come from other districts to study in the centre. The most peripheral areas have a low amount of students per hectare. Very low rates can be explained by the fact that a bigger part of these districts is not urbanized, thus less people live here.

2.3.5 Public transport use

As explained in the former section, most of the daily-motorized trips are covered by public transport. Figure 2.3.7 shows the distribution of passengers by economic income. 37.4 per cent of the households using public transport earn less than 1030 Nuevos Soles (272 Euro). This covers the lower socioeconomic groups C, D and E. It is remarkable that many households from the higher social class are using public transport, compared to other (western) countries.

Not only the amount of people using public transport is high, also travel times people have to make are very high with some people travelling up to four hours a day. Figure 2.3.8 illustrates the average travel time...
people take in different districts. In the most peripheral areas people tend to travel longer. Work and education centres that are located in the centre part of the city are the reason for this. Also the high amount of vehicles and congestions in the city explain why it takes one to one and a half hours to travel 30 to 50 kilometres to the city centre.

2.3.6 Supplies in and organization of informal settlements

The informal settlements of Lima are mostly located in peripheral areas on steep hills as mentioned in the former sections. They are not only characterized by its difficult to access location, low soil quality, disintegration with the city centre and lack of public space, but also the lack of water and sewage supply that causes many health problems in these areas and the absence of public services like garbage collection, public safety and health centres. Most of the informal settlement dwellers have formal electricity connection they pay for. In general, tanks with water and pylons are the main source for water supplies to these areas (see figure 2.3.9). A direct underground connection is difficult due to the hilly locations. Using latrines or simply throwing wastewater on public roads solves the sewage absence. Most recent informal settlements are hosting the third generation of the former migrants. They usually stay close to their families in settlements in the same district. The close organization of informal settlements is exceptional. After land is claimed, dwellers organize the water and electricity supply, waste collection and eventually announcing land titles to the district municipalities together within the community. They also organize themselves as a community to construct the settlement and to keep it clean and safe. Usually they take turns or pick fixed dates to serve as the community’s watchmen or support the cleaning team. This is only possible due to their close relation. They know each other and help their neighbour when needed (Desco, 2008).

2.3.7 Conclusion

The sub research question answered in this section is: how are the features of the current informal public transport system answering the demands of different income groups in the city? In general the driver of transportation demand by households is the need to travel to the city centre to work, study or get to other facilities. Because main activities are located in the centre part of the city, travel times increase due to congested roads leading to the centre. Most poor households in the peripheries are affected by these long trips. Richer households live in the modern centre and can access these amenities faster. Almost all households of different income groups use this informal public transport. There is an important amount of informal and formal jobs generated by the informal transport system. The schedule of the service effectively covers 24 hours a day and the frequency is also continuous. This transportation system has a low cost and it is an important social solution for the lower class in the city. Informal settlements in the peripheries are characterized by their poor quality of housing and public space, but they are facilitated with primary supplies. These settlements are often not well connected by public transport due to their location that is difficult to access.
Peru and especially Lima has grown more or less without any steering urban development plans. This had many reasons, for example the incapacity of dealing with migration to the capital city, which is why a lot of informality emerged. Another reason is that there are different administrative entities in the same city managing the same areas, also as the different district municipalities in Lima that are encouraging segregation and differentiation between districts. The city could not be seen as a whole but as a combination of different smaller neighbourhoods.

2.4.1 Political boundaries
Peru is divided into 25 regions, each region is divided into provinces and each province has its districts (see figure 2.4.1). The Regional Government governs the regions, Provincial Councils are managing the provinces and district municipalities the districts. In total there are 195 provinces and 1833 districts in Peru. The Province of Lima, where the capital city is located, is an exception. Here every district has its own municipality and the region, province and the district Cercado de Lima of Lima are being managed by one entity, Metropolitan Municipality Lima. Also the region Callao is unique. It is a region that contains only one province, the Constitutional Province of Callao.

The Province of Lima and Callao is seen as a unified metropolitan area in a physically and functionally manner. The international airport is for example located in the Province of Callao, but also the main port of the city. The ‘metropolitan area of Lima’ means thus the Province of Lima and Callao together.

2.4.2 Normative urban planning instruments
The territory of metropolitan Lima is regulated through different normative instruments and municipal entities, as the Organic Law of Municipalities, National Building Regulations, etc. Each municipality uses technical normative instruments in order to manage territory and create developing plans in the province of Lima, which are municipal zoning plans and regulations. Zoning plans offer the different land-uses that may occur in each part of the district. It shows for example where it is allowed to have a local commercial store and where it is only allowed to be residential. The regulations define the building characteristics as the use, height and open areas of a building and the compatibility between different uses on a specific place (AATE, 2012). Each district municipality in the Province of Lima has its own zoning plan, which has to be approved by the Metropolitan Municipality Lima in order to manage growth developments in the city.

2.4.3 Urban planning background
Urban development plans were formulated for the first time for the metropolitan area of Lima by the Ministry of Development and Public Works in 1948 (JICA, 2013). But the first real integral plan was the Metropolitan Development Plan for Lima-Callao in 1980, created by the Provincial Council of Lima and the Ministry of Housing during that time. The report of this plan included in different volumes among others territorial, economic, social and management aspects. The main contribution of this report was the zoning plan for Lima, which in conceptual aspects has been in force until recent years. Conceptual aspects as the urban expansion zones and major facilities are still being followed. The zoning plan, the Metropolitan Road Plan of 1971, is still recognizable in the actual street network like can be seen on principal peripheral roads and road crossings (AATE, 2012).

Subsequent to the Metropolitan Development Plan for Lima-Callao of 1980 the so-called PLANMET, Plan of Metropolitan Development 1990-2010, was elaborated by the Metropolitan Municipality Lima and approved by the Council in 1989 (see figure 2.4.2). This plan was a management plan for the metropolitan growth of the Provinces of Lima and Callao for 1990-2010. As normative
Instruments zoning plans for the city in coordination with the different districts and the Metropolitan Road Network were developed and are still in force. Many road proposals have been readjusted over time, as well as the public transport system that was proposed have been redefined after analysis by other institutions (AATE, 2012). It can be noted that most of the projects of this plan were not completed and this plan failed to establish itself as a guiding instrument for the city’s growth (Vega Centeno et al., 2011).

In general both Metropolitan Development Plans were important plans, in despite of many proposals could not be accomplished due to different reasons: lack of proper supervision, resources to carry out the structuring projects, but most crucial the informal growth of the city through informal settlements (AATE, 2012).

The following plan ‘Plan of Lima 2006-2021’ also elaborated by the Metropolitan Municipality Lima was an updated version of PLANMET, but this plan was never finished due to the lack of resources. Instead, the Metropolitan Municipality Lima completed the ‘Regional Plan of Concerted Development of Lima 2012-2025’ in October 2012, which also contained the part of the Plan of Lima 2006-2021 (Prado, 2013). This was approved by the Metropolitan Municipality Lima under the administration of mayor Susana Villarán in 2011. This plan is not including the region Callao, only the Province of Lima. Different institutions provided data and analysis to the Metropolitan Municipality Lima in order to make the Regional Plan of Lima. The key principle and an innovative strategy by the municipality was the dialogue with residents of the Province of Lima, based on district reunions, surveys and group workshops, studies on special topics and a permanent coordination between the district mayors and residents in order to have public discussions, the residents’ opinions and initiatives on certain topics and new inputs for the planning and implementation of the plan (Instituto Metropolitano de Planificación, 2012).

The vision of this Regional Plan is fundamentally based on population’s ideals and aspirations for the city like increasing safety, an inclusive, sustainable, democratic and productive city, a tourist attractor and a meeting point of cultural diversity. The objectives of this plan on (public) transport are to develop a sustainable urban mobility network through an Intermodal Urban Transit System and a rearrangement of public transport and metropolitan mobility through an Integral Urban Public Transport Reform (Instituto Metropolitano de Planificación, 2012).

2.4.4 Evolution of mass public transport in Lima

Since 1904 electric trams operated by a public company have been used in Lima. Subsequently bus lines running parallel to the tramlines were launched, which were also operated by a public company. Due to the high demand of transport trips both public companies collapsed in 1965. In 1966 microbuses appeared, but were operated by private companies. These buses were smaller vehicles and differentiated by their informality. In 1970 these microbuses covered almost 90 per cent of the demand. End of 1960s the metropolitan municipality inaugurated high capacity buses with its own corridors on partly segregated lanes. But once again this system did not cover the demand and only capacity for about 20 per cent of the demand. Eventually the high capacity buses disappeared in 1990 due to government’s liberation of public companies (Vega Centeno et al., 2011).

Due to the economic crisis of the 1980s the current public transport system collapsed. The crisis made it also difficult to afford a car. In 1991 this situation changed drastically. Under president Fujimori the government freed itself from its responsibility of providing public transport in 1990. This meant that the government privatised the current failing public transport system, but also allowed the import of second hand vehicles for public transport use. The lack of an organized public transport system and regulations meant that
the public transport sector was in hands of the free market. This resulted in massive congestions, traffic chaos, accidents and environmental pollution. The Metropolitan Transport Committee (TRANSMET) was established after public transport was declared to be in a state of emergency in 1999. Since then this committee has been in charge of the coordination between different public transport entities. After 2004 the improvements of transit came to fruition. In the aftermath the technical revision of vehicles was re-introduced and completely implemented by 2007 (Fernández-Maldonado, 2009).

In 2004 the International Agency of the Japanese Cooperation (JICA) elaborated an Urban Transport Master Plan for the Metropolitan Region Lima-Callao. This proposed plan included a massive transport system and was never approved by the Metropolitan Municipality Lima or other institutions, but was and still is used for the development plans for the metropolitan area of Lima by the municipality. This can be seen in the Regional Plan of Concerted Development 2012-2025, and other (governmental) institutions. Especially the database of this report, which is renewed in 2013, is often used or taken into account as an argumentation for transformation and new developments.

Due to the results of the Urban Transport Master Plan and the successful Bus Rapid Transit of Curitiba the Metropolitan Municipality Lima launched a BRT project (Fernández-Maldonado, 2009). This massive public transport system was introduced in Lima by the municipality in 2011. This BRT, called ‘Metropolitano’, is located along the highway Paseo de la República crossing the city from north to south covering 26 km and 35 stops (JICA, 2013). At the end stops of the BRT-line feeder buses are deployed. There are in total 17 feeder busses covering almost the whole northern cone of the city and a small part of the southern cone. The construction was initiated in 2007 during the administration of mayor Luis Castañeda Lossio and started operation in 2010. The Metropolitano was realised with the funds of the Municipality of Lima and also financed by the Inter-American Development Bank. The World Bank contributed public amenities to the surroundings of the Metropolitano in the entire intervention area, consisting of street furniture, construction of new roads for private transport, electricity, water and telephone networks, and landscape treatment (Instituto Metropolitano PROTRANSPORTE de Lima, n.d.). The Metropolitan Municipality Lima has put PROTRANSPORTE (the Metropolitan Institute PROTRANSPORTE of Lima) in charge of the operation of this BRT-line. The Metropolitano is serving 5 per cent of the daily trips by public transport with positive results; the travel time is being reduced from a two-hour journey to a 25-minute trip. The journey is safer, there are fewer accidents and it is still cheap (Cisneros Vitor, 2013).

The construction of Metro Line 1 started already during the eighties initiated by President Alan García during his first administration in 1986. He chose this corridor without doing any feasibility analysis. Because of the lack of funds the construction of the metro line, which was only 9.2 kilometres long, was stopped in 1990 (Fernández-Maldonado, 2009). During García’s second administration in 2006 the construction continued and was expanded to a 21.5 kilometres long corridor with 16 metro stops.

In 2010 the Ministry of Transport and Communication announced a future basic network of five metro lines, a system for Lima and Callao that was approved by president García. In 2012 the Autonomous Authority of the Electric Train (AATE), which is under the control of the Vice Ministry of Transportation, re-inaugurated the Metro Line 1. AATE is in charge of the planning, coordination, monitoring, control and execution of the metro (JICA, 2013). The metro line is being extended with additional 13.5 kilometres of tracks and 10 stops more. It will result in a corridor of 35 kilometres with 26 stops that will be fully functional by April 2014 (TERRA NOTICIAS, 2013).

The Ministry of Transport and Communication and the Metropolitan Municipality Lima has further planned to build a corridor from east to west. In 2012 a debate was held whether to contrast a BRT line or a metro line for this corridor. Eventually the metro was selected. The ministry is now planning to start the constructions of this east-west corridor that will be Metro Line 2 in 2014 (JICA, 2013).

In September 2013 a new feeder bus connection from the BRT station Estación Central to the metro station Gamarra was launched by the Metropolitan Municipality Lima (PROTRANSPORTE1, 2013). This is the first feeder bus from the BRT that does not depart from an end station. It is important to note that this
new development was initiated by the Metropolitan Municipality Lima without any cooperation with the Autonomous Authority of the Electric Train. It is also remarkable that they do not advertise this new connection to the city centre at all. The Metropolitan Municipality Lima on the other hand is promoting its new feeder bus connection to the Emporium of Gamarra intensively. This is due to the fact that this feeder bus is financed by the municipality and not by the Ministry of Transport and Communication, but it is not stimulating to obtain an integral public transport system or planning board.

2.4.5 Susana Villarán’s Transport Reform

The Transport Reform is a process that is meant to restructure and reorganize the public and private transport system in Lima through different complementary measures. Mayor Susana Villarán initiated the Transport Reform in 2012, which has been included to the Regional Plan of Concerted Development of Lima 2012-2025.

Villarán had the urge to do something about the transit chaos and the high amount of taxis in the city. In 2011 Villarán started the reorganization of the most congested and dangerous avenues. She suggested to restrict empty taxis going into the city centre and to introduce a unique ticket for public transport that would be used in a new Integrated System of Transport (SIT) in the whole city, including the BRT-line Metropolitano and the Metro Line 1 (Peru21, 2011). The reorganization of roads and ideas of a new integrated transport system have been the incentive to introduce the current Transport Reform.

The municipality is making several concessions to the private public transport sector, in order to establish an organized, integrated and formal public transport network. Despite of the municipality's aim to develop an integrated transit system, the municipality is not coordinating its actions with the Autonomous Authority of the Electrical Train that is in charge of managing Metro Line 1.

The objective of the Transport Reform is to eliminate current transit aspects as chaos, congestion, mistreatment of public transport users, accidents and environmental pollution and to improve the liveability and quality of life in Lima by giving people's short travel time, safety and an organized city back. The Transport Reform is incorporating the Intermodal Urban Transit System that has been mentioned in the Regional Plan of Concerted Development of Lima 2012-2025. The name of this system has been changed for the Transport Reform into the Integrated Transit System (SIT). The Transport Reform has different steps in order to establish its objectives. These steps are (LimaTV, n.d.):

- Reducing the oversupply of vehicles, through ordinance 1538, with the aim to eliminate the combis that have a low capacity, are old and polluting the environment.
- Introducing the so-called 'bus patrón', which is a standard public transport bus that will be established with a higher capacity and is less contaminating.
- Reorganization of avenues, establishment of bus stops and decreasing delays at these stops with the intention to improve the fluency of transit, executed by the Urban Transport Management (GTU).
- Adaptation of 53 new partnerships with the participation of 208 public transport companies that will give a qualitative service.
- Streamlining the supply of vehicles, forbidding very old public transport vehicles on the roads.
- Taxi registration, in order to reduce the amount of illegal taxis in the city.
- Regulations for employees of public transport who will work on a schedule and will have employment rights.
- The development of the Integrated Transit System (SIT), a public transport hierarchy will be established with new transit routes, creating a safe, fast and organized system. This system is also including the non-motorized transport program Ciclolima that promotes bicycle use as a transport mode. The transport systems will be established through public concessions. The public transport hierarchy includes and is managed by:
  - mass systems: Metro Line 1 (AATE) and the BRT Metropolitano (PROTRANSPORTE)
  - 5 complementary corridors (PROTRANSPORTE)
  - 4 integration corridors (GTU)
- feeder bus connections departing from the integration corridors (GTU)
- non-motorized transport program, bicycle and pedestrian paths, stairs (PETNM and district municipalities)

2.4.6 Main involved actors in public transport

There are different authorities managing and regulating transport in the city. In the metropolitan area of Lima there are four different authorities: Metropolitan Municipality Lima, Ministry of Transport and Communication, Municipality Callao and Region Callao. Each of these authorities has a different vision about how to manage public transport and what kind of transport means are supposed to be used in the city. Often different plans are developed independently without consulting with the other administrative authorities. As a result there is a lot of disagreement when one authority is proposing a transport system to the city. An example is the east-west corridor that the Metropolitan Municipality Lima and the Ministry of Transport and Communication proposed with their own massive public transport system, the BRT and metro. Both authorities had to discuss this and choose one transport system to cover this route, which eventually was the metro. In the development plans of both authorities new lines provided are suggested with some of these new BRT and metro lines still overlapping each other.

The Metropolitan Municipality of Lima covers the transport system together with the Metropolitan Transport Committee of Lima (TRANSMET), which includes more authorities (PROTRANSPORTE, n.d.), see also figure 2.4.3:

- Urban Transport Management (GTU): a municipal entity, in charge of improving the transport service and raising awareness of the citizenship.
- Metropolitan Institute Protransporte of Lima (PROTRANSPORTE) and the Autonomous Authority of the Electric Train (AATE): public entities, responsible for respectively highway corridors and the metro;
- Metropolitan Planning Institute (IMP): entity responsible for organizing the general urban planning framework to have an ordered city development.
- Municipal Toll Administration Company (EMAPE): a municipal private company, in charge of improving the road infrastructure.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Government</th>
<th>In Region of Lima</th>
<th>Transport planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>National Government</td>
<td>Ministry of Transport and Communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vice Ministry of Transport</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AATE</td>
<td></td>
</tr>
<tr>
<td>Regional</td>
<td>Regional Government</td>
<td>Metropolitan Municipality Lima</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GTU</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>EMAPE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PROTRANSPORTE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>IMP</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>Provincial Council</td>
<td>District Municipality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>District</td>
<td>District Municipality</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.4.3 Government Region Lima and Transport planning in Peru (by author)

2.4.7 Conclusions

The sub research question answered in this section is: What are the spatial planning challenges and strategic interventions needed to activate urban transit and spatial developments? This examination has shown the lack of cooperation and coordination between governmental entities, on the urban development plans, but also regarding the Transport Reform. The lack of collaborative management is occurring on different scales: between national, metropolitan and district governments. Each district municipality has its own regulations and management approaches. Due to this separate management certain developments can take longer or are executed differently in the relevant districts. An integrated urban planning but also transport system is required in Lima. The different district municipalities have to meet together with the metropolitan municipality and affected transit entities to initiate and organise urban transit and spatial developments. The lower class should not be excluded when implementing the Transport Reform and the benefits of the current informal system, like low travel prices, should be included.
Chapter 3 Metro Line 1 analysis

Different metro station developments are dependent on the function of the metro line, the location in the urban pattern and the interrelation between these. This chapter defines the TOD area (3.1), analyses the metro line as a transit corridor (3.2), as an activity corridor with activity centres (3.3) and positions the station areas in the network (3.4) and concludes this analysis establishing three station area types (3.5).
3.1 TOD area

The TOD area is the area of influence of the metro corridor on its urban context, which is different on regional and local scale. To include influences from a higher scale on the local scale station areas the metro line is examined on regional scale, scale of the whole metro line, as an activity corridor, an activity centre and a transport corridor, which is explained in section 1.6 Theoretical dimension. At this scale the influence radius of 1,200 metres around each station of the metro line is used in order to understand the structure of the line as a whole. Within this radius important networks and issues can be recognized that are influencing the direct surroundings of the station in a 300-400 metre radius.

At local scale the TOD area is the walkable area around transit stations, an area between a 300-400 metre radius from the station, called the local station area. Within this radius urban transformations have direct influence on the use of the metro and the direct station areas as activity centres. Some of these station areas have better chances and more opportunities to develop, because of their well-accessible location and already existing attractions.

Eventually three local station area designs are developed. These designs contain a design intervention for urban space and structure in close by neighbourhood of the metro stations Miguel Grau, Cabitos and Villa El Salvador. A vision for the complete metro line obtained from analysis on both scales underpins these designs. The proposed design interventions at these local station areas are detailed designs of the urban space and structure facing the stations within a maximum radius of 300-400 metres around the station.
3.2 Metro Line 1 – the transit corridor

A transit corridor is a main provider of inter-urban displacements. In this case Metro Line 1 is taken as transit corridor and will be analysed in its tangible function in general. Other transit corridors like commercial or productive primary roads are not being analysed, but taken into account as activity corridors that can influence the metro line on intersecting areas as either a competitive or encouraging activity corridors.

3.2.1 Origins and destinies of metro users

Metro Line 1 is a recently opened mass provider of public transport that operates with a velocity of 40 kilometres per hour. It takes the metro 35 minutes from one extreme to the other (JICA, 2013). Travel time of this corridor by car or informal public transport is usually twice as long. This is the main reason for using the metro instead of informal public transport over this corridor. The purpose of using the metro is in first place to travel to work or education centres. Only 15 per cent of travels are for private reasons (see figure 3.2.1).

Figures 3.2.2 and 3.2.3 show the generation and attraction densities, illustrating the origins and destinies of trips of the metro line. The distributions of the origins and destinies of the passengers using the Metro Line 1 are significantly different; the origins of the trips are distributed in the southern part, while the destinies and attractions are located in the centre of the city (JICA, 2013).

3.2.2 Frequency and passengers per hour

Metro Line 1 is operating every day of the week from 6:00 till 22:00. During peak hours the metro it runs with a frequency of 10 trains per hour and during off peak hours with 6 trains per hour. This schedule has been introduced recently in August 2013. Before this adjustment the metros operated with a frequency of 4 metros per hour, which was not efficient at all (El Comercio®, 2013). Figure 3.2.4 illustrates the amount of passengers during the week, showing two peaks in the morning and afternoon (AATE, 2013). During the weekends the utilization is different. There is only one peak in the afternoon and the amount of passengers is less than compared to weekdays.

3.2.3 Passengers per station

The amount of passengers entering per station per day is illustrated in figure 3.2.5. During the week the passenger volume is very high at end stations Miguel Grau and Villa El Salvador. Also at the station Gamarra, where the textile emporium is located, and at the station La Cultura, the cultural centre where the National Library, the National Museum, the theatre, different ministries and the highway connecting east to west are located, high passenger volumes can be observed. On Saturday passenger
Frequency per hour

Amount of passengers per hour during the week

Amount of passengers per hour on Saturday

Amount of passengers per hour on Sunday

Figure 3.2.4 Amount of passengers per hour (AATE, 2013) – elaborated by author
Amount of passengers per day during the week

Amount of passengers per day on Saturday

Amount of passengers per day on Sunday

Figure 3.2.5 Amount of passengers per station (AATE, 2013) – elaborated by author
Amount of passengers getting in at station Miguel Grau

Amount of passengers getting in at station Gamarra

Amount of passengers getting in at station La Cultura

Amount of passengers getting in at station María Auxiliadora
Figure 3.2.6 Amount of passengers per station per hour (AATE, 2013) – elaborated by author
peaks and the amount of passengers are more or less the same like on weekdays. The station Gamarra, though, has more passengers than during the week. On Sunday the peaks are more or less the similar to Saturdays but the amount of passengers is less (AATE, 2013).

These same graphs also show the data from the previous year in the same month. The amount of people using the metro has been increasing every month since the metro was inaugurated in 2011 (AATE, 2013). The amount of passengers is expected to grow further, especially due to the change of train frequency in August 2013.

3.2.4 Passengers per station per hour

The graphs illustrating the amount of passengers entering each station per hour in figure 3.2.6 show a remarkable detail. There is an obvious daily displacement from south to north, where the city centre and most job centres are located, which can also be identified in figures 3.2.2 and 3.2.3. It is also reasonable to conclude that inhabitants from northern parts of Lima enter the metro at station Miguel Grau in the mornings to get to their destination since the metro line is not (yet) covering the northern parts of the city.

3.2.5 Conclusion

This transit corridor analysis has shown that the use of the metro line is extremely high at specific metro stations that are located at the ends or in highly commercial areas (see figure 3.2.7). People’s travel flows using the metro are for the most part in one direction, from the south to the city centre. Departing from here Lima is identified as a mono-centric city with one direction travel flows. Ideal would be to have a daily total passenger per hour curve as is shown in figure 3.2.4 for every station where the curve shows two peaks instead of one. This would indicate an activity-balanced and more polycentric city.

This metro corridor can be described as a commuter as is described in section 1.6 Theoretical dimension. The commuter serves only one bigger activity centre. This transit service is more used during peak hours than during off-peak hours. One opportunity for this metro corridor is to develop residential areas with higher densities, enhancing access by slow traffic and feeder buses to the stations and thereby encouraging a higher ridership (CTOD, 2013). As is explained in the same chapter, residential areas already have a high inhabitant density and all available construction space has been utilized. One option could therefore be to add small businesses and local commerce to these sites in order to encourage ridership in both directions.
Activity corridors are centred on main arterial roads or public transport lines. In case of Metro Line 1 it is centred around the metro line itself. Other activity corridors on main arterial roads are not specifically analysed, but taken into account. Activity corridor analysis concerns internal and external activities that influence the activity centres and local station areas. Activity centres concentrate daily activity needs like small and large scale commerce or amenities within walking distance from the transit node located in and around an activity corridor. External activities, internal activities and networks are mapped for the whole metro line in order to understand how the stations are related to and defined by its adjacent urban space, transit network and regulations. Activities and networks include for example the land-use, densities, household income and governmental district regulations.

3.3.1 Transit network

In some parts the metro line is located directly along or at primary roads, in others along secondary or tertiary roads (see figure 3.3.1). The stations in the northern and centre part of the line are located in the historical and modern centre. These are better integrated into the road network, connecting to all parts of the city, and are easy accessible by car when congestions are no issue. The stations in the southern part of the metro line are located in the informal peripheries. These are less and almost not integrated into the road network and thus to the city centre.

Two means of mass public transport are distinguished in Lima: the BRT line Metropolitano and Metro Line 1 (see figure 3.3.2). The BRT line is operating parallel to Metro Line 1. From the southern end station of the BRT two feeder buses depart to the east, these come close to some stations metro stations, but never stop at them. These feeder buses stop in the radius of 400-1,200 metres of these stations. Only one BRT feeder bus is connecting the BRT centre station to metro station Gamarra, passing close by the end station Miguel Grau but not stopping within the 400 metre radius.

3.3.2 Land-use

Different uses and activity centres of commerce, industry, education or healthcare are recognized surrounding the metro (see figure 3.3.3). In general commercial activities are situated directly facing the metro line along the whole corridor. The neighbourhoods surrounding the metro often have other functions. The emporium of Gamarra, an immense textile industry cluster, characterizes the northern part in the historical city centre. The centre part in the modern centre is mainly residential with some educational institutions, commercial centres and one large cultural area bordering the historical city centre. The southern part in the informal peripheries is mostly residential with many education centres and is marked by an industrial area called Parque Industrial that is well known for the furniture factories.
Figure 3.3.3 Land-use (www.ipdu.pe) - elaborated by author

Figure 3.3.4 Population density (www.inei.gob.pe) - elaborated by author
3.3.3 Inhabitant and employment density

Population and employment density are spatially segregated. The highest population density is identified in the southern informal periphery and a regular-high density in the northern historical city centre. In the centre area inhabitant density is the lowest (see figure 3.3.4). Land-use and the urban structure can explain these densities.

The amount of employees is extraordinary high in the northern historical city centre due to the textile emporium and in the south because of the industrial park (see figure 3.3.5). In the modern centre area some highly dense employment blocks are situated that are mostly educational institutions, health centres or hospitals and commercial centres. In general the low-density employment area in the modern centre can be identified by its local commercial activities or small offices.

3.3.4 Household income

Spatial socioeconomic differentiation is characterizing the city of Lima, illustrated in figure 3.3.6. The lowest socioeconomic groups are located in the informal peripheries, the highest socioeconomic groups in the modern centre and medium-lower socioeconomic groups are located in the northern historical city centre. This socio-spatial differentiation is also reflected in car ownership per district, as is shown in figure 3.3.7. In the modern centre area the highest percentage of car ownership can be observed.

3.3.5 District regulations

Metro Line 1 and its station areas traverse a total of twelve districts of Lima. Each district in the city has its own regulations for developments, land-use and transit. For example types or colours of pavement and transit designations are different per district, but also motor-taxi regulations differ for every district as can be seen in figure 3.3.8. This is one of the reasons why richer districts in the modern centre with lower densities have more public green and are better connected than districts in the peripheries. Regulations from the district municipalities are mostly concern new developments including...
regulations for building heights, amount of storeys or the relation to public space. The crucial fact that only little district legislation is available for most districts explains the physical condition and use of space in some districts (IPDU, n.d). In general it can be noted that the northern historical city centre and modern centre area have more regulations, but regulations are less respected in the northern part. In the southern informal peripheral area fewer regulations are set by district municipalities. Probably the poor socioeconomic condition of its inhabitants and thus of the municipality is the reason for this.
3.3.6 Elevation of metro and morphology

The metro line is elevated in the whole northern historical city centre and modern centre part. In the northern part the elevation of the metro is extremely high. The metro line runs more than 15 metres above the ground in the northern part, whereas the tracks in the centre part are between 6-8 metres above street-level. In the southern informal periphery metro tracks at ground level create a physical barrier between the two sides of the line that is difficult to cross, and is thus segregating the districts. In the south some tunnels and lots of pedestrian bridges are facilitated to enable interconnections between both sides of the corridor (see figure 3.3.9).

The location of the metro line in its natural morphological setting is shown in figure 3.3.10. The corridor is located between small hills and steep mountains, but the metro line itself is located on flat land.

3.3.7 Public space

The amount of public spaces around the metro line differs in each district. In the northern historical city centre there are almost no public spaces identified. The amount of public spaces becomes gradually more in the modern centre area, which has many public spaces. In the informal southern periphery there are little or no public spaces (see figure 3.3.11). The quality of public spaces in the south is very poor and often it is no more than just open space not used for construction.

3.3.8 Characteristics together

To be able to easily compare every metro station on different subjects, the metro stations’ characteristics are presented next to each other in this sub-section. Characteristics are shown for a radius of 1,200 metres from every station. The different subjects are land-use, socioeconomic levels, inhabitant density, employee density, transit network and public space. Results are based on the maps presented in this section.
Figure 3.3.10 Urban area within its morphological context by Aldo Mantovani – elaborated by author

Figure 3.3.11 Public space versus built area (by author)
<table>
<thead>
<tr>
<th>San Borja Sur</th>
<th>Land-use</th>
<th>Socioeconomic class</th>
<th>Inhabitant density</th>
<th>Employee density</th>
<th>Transit network</th>
<th>Public space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angamos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabitos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ayacucho</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Land-use</td>
<td>Socioeconomic class</td>
<td>Inhabitant density</td>
<td>Employee density</td>
<td>Transit network</td>
<td>Public space</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------</td>
<td>---------------------</td>
<td>--------------------</td>
<td>------------------</td>
<td>-----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Jorge Chávez</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atocongo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Juan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>María Auxiliadora</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3.9 Conclusion

Different typologies of neighbourhoods can be identified in this corridor. The informal southern periphery has a high inhabitant density. Many industrial activities with high employment densities can be identified, while income per capita is low and the area is not connected efficiently to the transit network. A low population density, high income per capita, low employment density and mainly residential neighbourhoods characterize the modern centre. This area is well integrated in the transit network. In the northern historical city centre the inhabitant density is high and it is home to the middle-low class society. Due to the presence of textile industry and other commercial activities the employment density is high. In general this area is also well integrated in the transit network. As a structure the metro line can be identified as a transport corridor with activity centres located directly along the line, whereas bigger activity centres are located at the ends of the line and some in the centre. There are a few arterial roads identified as activity corridors that cross the metro line perpendicularly. These crossings form important nodes for the transit network of the city (see figure 3.3.12).

3.4 Station area – position in the network

3.4.1 Positioning the stations

Each station and its respective station area is analysed thoroughly, taking into account its land use, inhabitant and employment density, socioeconomic groups, district boundaries, but also its location in the urban transit network. This analysis also leads to a position measurement for each station. For this existing relations between the spatial conditions and networks will be expressed as percentages in a diagram as explained in section 1.6 Theoretical dimension. The following indicators and measurements are used to describe the position and characteristics of the metro stations. These are based on the diagram and indicators Atelier Zuidvleugel (2006) has applied in his work, but are adapted for the context of Lima:

*Degree of access by public transport (APT)* is the network value. Each connection of public transport is valued separately, overlying massive public transport like BRT systems, light rail or metro and underlying more informal public transport as buses, microbuses and mini-vans.

- 100%: The station is connected to more metro or BRT lines, which connect to the whole city.
- 75%: The station is connected to part of the city, for example with only one metro or BRT line.
- 50%: The station is connected to a feeder-bus that is linked to another metro or BRT line.
- 25%: The station is connected by informal public transport.
- 0%: The station is not connected to any kind of public transport.

*Degree of access by car (AC)* is the accessibility value. There are four types of positioning and connections to the road network, excluding traffic congestions.

- 100%: The station is connected to primary and secondary roads.
- 75%: The station is connected to a primary road.
- 50%: The station is connected to a secondary road.
- 25%: The station is not connected to primary or secondary roads.
Amenities 400 m around station
Local densities of inhabitants and jobs (DIJ) are the amount of people working and living around the transit stations. The extremes found in Dutch metropolitan context were 30 to 390 inhabitants and employees per acre built area. The extremes in Lima are 100 – 700 inhabitants and employees per block.

100%: 550 - 700 inhabitants and employees per block.
75%: 400 - 550 inhabitants and employees per block.
50%: 200 - 400 inhabitants and employees per block.
25%: 200 or less inhabitants and employees per block.

Degree of mixed-use (DMU) is the ratio of inhabitants and employees in station areas.

100%: ratio of 50-50, as many inhabitants as employees.
75%: ratio of 60-40.
50%: ratio of 70-30.
25%: ratio of 80-20 or less.

Figure 3.4.1 shows the positioning of each station based on the degree of access by car, degree of access by public transport, degree of inhabitant and employee density and degree of mixed-use. A few types of diagrams are distinguished: the highly accessible by car diagram; the high inhabitant and employment density diagram; the high accessible by car and high density diagram; and the high mixed-use diagram. There are different peaks of high inhabitant and employment density and mixed-use degree along the corridor. When describing the stations with its surrounding functions very commercial areas in the northern historical city centre, residential and educational areas in the modern centre, and industrial or productive and residential areas in the informal southern periphery can be differentiated.
3.4.2 Concepts and opportunities

Figure 3.4.2 shows the distribution of different concepts related to the positions of the metro stations. Also in this graph three clear concepts of stations can be identified: in the northern historical city centre and modern centre with Metropolitan Hubs and Residential Sites concepts and in the informal southern periphery the Peripheries of Cities concept, with the exception of two stations Gamarra and Villa El Salvador that are identified as Developing Sub-Centres.

Figure 3.4.3 shows the spatial distribution of the different concepts of metro stations in Lima compared to the concepts of the train stations in the southern part of the Randstad, the Netherlands. The distributions of the Dutch station areas have more variations of concepts, but concepts can be clearly identified within the bigger cities of Rotterdam and The Hague. For these cities the city centres show the elements of the concepts of City Centres, Creative Cities and Cities of the Future. Immediately outside these centre areas the concepts of Outskirts of Cities and Regional Crossroads can be identified. Comparing the situation in Lima to the concept model of the Randstad, there are bigger activity centres that can be identified as Developing Sub-Centres and Metropolitan Hubs scattered along the metro corridor, but at the same time the urban patterns are reflected in these concepts. In the historical city centre the concepts of Developing Sub-Centres, Metropolitan Hubs and Metropolitan Crossroads reflect this bigger activity centre that is well accessible by car. Residential Sites and one Metropolitan Hub characterize the modern centre. Further, the Peripheries of Cities concepts can generally be identified in the informal peripheries.

The City Centres concept, expected to occur in a low-income city of a developing country as explained in section 1.6 Theoretical dimension, cannot be observed for the Metro Line 1 corridor, but probably in the heart of the city centre it does. The characteristics and opportunities of the concepts of each station area can be explained as:

- **Developing Sub-centres** are extensions of the city centre or smaller centres. They have a high population or employment density, are cheaper mono-functional sites, are well integrated into the road network or are close to primary roads. Opportunities: They can develop into an urban area with its own identity, a mixed-use area with offices, small business and local services.

- **Metropolitan Crossroads** are located close to highway and primary roads intersections. They have a good access from all parts of the city, but only by car. Opportunities: They can develop into an interregional service centre that has to survive independently from the city centre because it is distant from it. Business and local industry would be an adequate option combined with enhanced access by public transport.

- **Metropolitan Hubs** are smaller centres, but are not as intensively used as the city centre. They are well accessible by either car or informal public transport, and are well integrated in the transit network. Opportunities: They can develop into experimental new employment and mixed-use areas with a unique identity to attract a mix of regional and interregional services, workplaces and housing. This can be a valid option, because of the combination of good services with dual access and acceptable prices.

- **City Centres** have high employees and inhabitants density, are highly accessible by different modes of informal public transport, but are less accessible by car. Opportunities: The first priority is to optimize the transit network, creating a new hierarchal network where public transport users, cyclists and pedestrians are equal to motorists.

- **Residential Sites** are located along principle roads, have a low inhabitant and employee density with small businesses and local commerce, and are better accessible by car than by informal public transport. Opportunities: These sites can develop into more intensively used employment areas, where new connection to public transport can add value to the location.

- **Peripheries of Cities** are located distant from the city centre. They are identified by high inhabitant densities and monofunctional sites that are difficult to access by car or informal public transport. Urban space and built environment is (used) informal and unfinished. Opportunities: The residential areas can be restructured consolidating the existing urban fabric and new functions as small local businesses and commerce can be added.
Figure 3.4.3 Spatial distribution of the station area concepts of Metro Line 1 compared to the station areas in the southern part of the Randstad, Holland (Atelier Zuidvleugel, 2006) – elaborated by author
3.5 Conclusions of analysis towards three station types

3.5.1 Conclusion of analysis

The transit and activity corridor analysis has confirmed the mono-centric model of Lima. Most travels are directed to the city centre where the main activities are located. The metro line is neither integrated to the urban transit network nor to the urban space. Instead it has been placed on a random corridor through the city and thereby intersecting many complex structures and spaces. The connection between the conclusion of the transit and activity corridor, analysis and further design themes are shown in figure 3.5.1.

Three different station types are recognized based on their positioning in the network and their station area characteristics. These three station types reflect the different urban patterns and socio-spatial segregation in the city. The three metro station areas are the historical semi-informal city centre, the modern centre with formal neighbourhoods of the higher social class and the informal peripheries (see figure 3.5.2). They reflect the spatial growth of the city since the twentieth century, which can be divided in three areas:

- The historical city centre built before 1940
- Formal neighbourhoods of the higher social class developed between 1940-1961
- The informal peripheries that emerged since 1961

3.5.2 Thorough analysis of three stations

From each type of station area one station is chosen for the design intervention. These stations have to be representative for the whole area and exemplary for other stations of the same typology. The selected stations also have special features that require complex solutions. The stations chosen are Miguel Gau, Cabitos and Villa El Salvador. Miguel Grau in the historical city centre is chosen, because of its not extremely high commerce and its location on a primary road as a gate from the north and east to the city centre. A design intervention for Cabitos in the modern centre is being developed, because of its future connection to another metro line. With Villa El Salvador a station within the informal peripheries is chosen, because of its location at the end of the metro corridor and its closeness to an industrial park. In the next graph these stations will be analysed on different themes next to each other to recognize the spatial differences.

The themes analysed are: transit network that describes the integration in the road and public transport network and the elevation of the metro corridor; land-use illustrates the functions of the built environment and the use of public...
space; urban structure explains the socioeconomic groups, inhabitant and employment densities and the quality and height of the built environment; public space shows the quality of public space; and district regulations give attention to the amount of and consideration for regulations.

**Figure 3.5.3 Chosen metro stations for design intervention (by author)**

- **Location:** On the border of the districts Cercado de Lima (Lima centre) to the east and El Agustín to the west side of the station and close to district La Victoria. The metro line is elevated in this section. Separate district governments are reflecting chaotic differences between the two districts at the station.

- **Location:** In district Santiago de Surco on elevated tracks. The station area is also partially part of the districts Miraflores and Surquillo.

- **Location:** In district Villa El Salvador and close to district Villa Maria del Triunfo. The metro line is situated on ground level.
Transit network:
The last section of a highway that is connecting the provinces in the east of Lima ends at the metro station and continues as a secondary road. There are many traffic movements from other parts of the city towards this crossing. Thus, the station area is well accessible by car, but the station itself is not connected to other mass public transport means. The feeder bus from the BRT is passing through the station area but does not stop within the 400 metres radius. There are different road hierarchies crossing the station area. All of them are highly used, but are considered to be chaotic and dangerous. Unclear regulations provoke informal use of roads and sidewalks. Further, the lack of respected crosswalks creates a dangerous environment for slow traffic.

Transit network:
The metro station is located next to the roundabout Óvalo de Higuereta, where three different roads traverse at the roundabout: one primary and two secondary roads. The roads connect to places in all directions of the city, which makes the place highly accessible by car. In two directions underground tunnels cross the roundabout and ensure a rapid transit flow on the roundabout. There are no other means of mass public transport. The roundabout itself is unclear and sometimes chaotic. Many vehicles cross the roundabout in an uncoordinated manner often driving in 4 to 5 lanes in parallel. The unclear lane marking results in unpredictable driving behaviours.

Transit network:
Infrastructure is minimal in this area, due to informality, poor residents and a poor municipality. Some principal roads in the area are asphalted, sidewalks are facilitated in a few streets by households self. The area between asphalted roads and sidewalks or built environment is used for parking or informal business as workshops. These spaces are usually not paved nor equipped with trees and furniture. The area is not well accessible by car or public transport. The metro line is blocking the connection between both sides of the line. There are some pedestrian bridges and one vehicular tunnel in the station area. Motor-taxis are most common vehicles for motorized transport in this area due to their affordability. A BRT feeder bus line is passing a few blocks away and two bus stops are situated about 800 metres away from the metro station.
Land-use

**MIGUEL GRAU**

*Functions:* The station area is characterized by many schools, an important public hospital and commercial activities. In the northern part of the station and the area is mainly residential. The local station area is monofunctional with residential sites and local productive industry.

**CABITOS**

*Functions:* Many education centres and commercial activities characterize the station area. For the commercial centres the formal shopping mall and several semi-formal malls hosting former informal street vendors can be differentiated.

**VILLA EL SALVADOR**

*Functions:* The functions around the station are spatially segregated. On the western side of the metro mainly industrial activities are located like the industrial park where mainly furniture is produced. To the eastern side the area is mainly residential with some local commercial activities. Many residents of the city know the industrial park by name, but due its inaccessibility and informality it is less attractive. Also facilities as the district municipality, police station, health centre, market place and the National Technological University of the Southern Cone are located in the station area.
Use of public space: Along the roads at the metro station taxis and motor-taxis are waiting for customers coming out of the station and thereby blocking the road and obstructing traffic. The images show that traffic rules are being ignored in this area. Informal street vendors are located on sidewalks or on the roads itself selling their products. On the southern part of the station a productive industrial area is located where people sell furniture on sidewalks and roads.

Use of public space: In the direct neighbourhood of the roundabout taxis and informal public transport vehicles are only allowed to station on fixed places. Usually this standard is respected, which leads to a regular to fast traffic circulation. Informal street vendors are not or little seen in this area. A lot of space is left for perpendicular parking next to the roundabout at the commercial area.

Use of public space: Between the road and houses some space is left that is not asphalted, which is sometimes used for car parking. Outside the metro station many informal street vendors are waiting for passengers getting out of the metro to sell food or newspapers. Motor-taxis are stationed on the road blocking the transit flow.
Socioeconomic groups: The income per capita is in both districts the same; 380 to 900 Nuevos Soles (100-245 Euros) per month that include groups C and D.

Socioeconomic groups: Socioeconomic groups A and B characterize the area, which also explains the better quality of built environment and public space.

Socioeconomic groups: Income per capita is equal on both sides of the metro line; less than 380 to 900 Nuevos Soles (less than 100 to 245 Euros) per month, which covers groups C, D and E.
Inhabitant and employment density: In the west in district El Agustín the inhabitant density is higher compared to district Cercado de Lima. Employment density is in general high at the southern part of both districts.

Inhabitant and employment density: Due to the commercial activities in the area the employee density is high, but only in a cluster around the station. For the remaining station area the inhabitant density is regular or low.

Inhabitant and employment density: The western industrial side has a very low inhabitant density but extremely high employment density. For the eastern residential side the inhabitant density is very high and employment density is reasonable.

Quality and height of buildings: In the western part higher buildings with three or more storeys are situated and in the eastern part mostly lower buildings with one or two storeys can be found.

Quality and height of buildings: Building heights differ from one to eight storeys. The permitted amount of storeys of new developments is higher along primary and secondary roads. Most buildings are completely finished and have a decent appearance.

Quality and height of buildings: Large blocks of productive sites characterize the urban fabric of the eastern industrial park with buildings heights that differ from one to two storeys. Buildings in the eastern side have two to five storeys. Buildings in the whole neighbourhood are half built. Generally the ground floor is finished and the upper floors are under construction.
Public space

MIGUEL GRAU

CABITOS

VILLA EL SALVADOR

- 73 -
Quality of public space: The area is identified by the absence of public spaces and greenery. Public space has a very low quality. No parks or plazas can be identified in the local station area. There is vacant land directly next to the metro stop and also a block away from the station that is not being used except for car parking.

Quality of public space: The immense roundabout makes it difficult for pedestrians to cross at points without crosswalks or where crosswalks are ignored by the traffic. Despite of many commercial and educational activities in the area, public spaces along the roundabout are not focussing on pedestrians and do not stimulate the liveability of space. It can be observed that many pedestrians exist and either transfer to public transport, shop or go to school.

Quality of public space: Every bigger block in the residential area a large public plaza or park has in the centre, but the quality is poor. Along the metro line a large empty area is located with only sand and a few almost dead trees, which is not being used.

District regulations: Different districts govern in the station area. Many regulations are set from all these districts for the built environment or traffic signs, but here the conjunction of different district regulations fluidly merge together. Regulations for the built environment are seen in differences of the building heights at primary and secondary roads. All these regulations are in general controlled and respected in this area. The quality of public space and built area reflects the higher amount of resources available to the municipalities.

District regulations: Different districts govern in the station area. This is spatially seen in the height differences of the built environment. In both neighbourhoods many regulations exist due to their location in the historical city centre. Compliance to regulations is hardly controlled and there is still a lot of informality on the streets with space being occupied without authorization by both shops and (motor-)taxi stops. The district municipalities do not have enough resources to provide decent public space, street furniture or traffic regulations.

District regulations: Different districts govern the station area. The little regulations set and the little resources available to the municipalities are reflected in the poor quality of public space, built environment and the poorer socioeconomic groups inhabiting these areas. Public space is only open and empty space. Public space and buildings are used or constructed informally due to the lack of authority.
Chapter 4 Vision and design proposals

Designing urban space around station areas means taking into account different social, economic and normative aspects that relate future opportunities and creation of value of these sites. This chapter proposes a vision for Metro Line 1 (4.1), principles and strategies for each designed station area (4.2), three station area designs (4.3) and the materialization of these urban designs (4.4).
Based on the analysis in the previous chapters, the vision for Metro Line 1 is being formulated. Former analysis included the function analysis of the metro line of section 3.2 Metro Line 1 – the transit corridor, the station area characteristics of section 3.3 Metro Line 1 – the activity corridor with activity centres and the positioning of stations with the obtained concepts and opportunities of section 3.4 Positioning the stations.

The provided vision for Metro Line 1 is derived from the station concepts and their opportunities to develop. Figure 4.1.1 shows possible future developments within the maximum potentialities of each local station area. In some cases more activities or new functions are added. In the first

Figure 4.1.1 Ideal position – vision station areas (by author)
place it is important to create an integrated transit network by connecting each metro station to feeder buses and/or to future metro lines. This is more important than the integration of the road network for car accessibility due to the higher use of public transport. In second place urban space integration, involving redevelopment and the restructuring of local station areas can produce a more activity-balanced corridor. The city’s activities become more polycentric and the model of transit rides per station becomes ideal with two peaks of transit riders at each station (see figure 4.2.2).

This provided vision for the metro line and can only be reached in a step by step process with each step represented by an independent phase. At first the station areas with higher potential to redevelop and restructure should be updated using the different phases described below, also shown in figure 4.2.3:

- In the **first phase** every station should be connected with feeder buses to other districts.
- In the **second phase** stations, where already many activities are taking place like Gamarra, La Cultura, Angamos and Cabitos, should be redeveloped and restructured. These stations are already Metropolitan Hubs. Mixed-use should be stimulated and the number of mass public transport connections should be improved.
- In the **third phase** the Peripheries of Cities should be treated. These areas are informal and sometimes not as spacious as would be ideal, which makes the task very complex. These areas can be consolidated within its urban structure. Station areas with higher density have a higher potential to be transformed into mixed-use areas. Due to the absence of public space and lack of greenery in the peripheries a large recreational park within walking distance from station Pumacahua is proposed in the south. It should be established at a vacant site where only a few transmission towers are located. The industrial park next to stations Parque Industrial and Villa El Salvador (developing sub-centres) should be better accessible on larger and local scale from the stations. To attract more people a mixed-use area can be encouraged.
- In the **fourth phase** Residential Sites and Metropolitan Hubs can be expanded, because of their good accessibility by car and their location in the centre part of the city. This development can only be achieved when the station area had been previously connected to the mass public transport network. These residential sites are generally formalized neighbourhoods where the availability of office space should be improved.

New connections to other metro lines are proposed by the Ministry of Transport and Communications. These are also taken into account. The Metro Line 1 will meet station Cabitos with Line 3 and at La Cultura with Line 4 and a new station for Line 1 connecting to Line 2 will be added between Gamarra and Miguel Grau. The plan is to first construct Line 2 starting in 2014, then Line 4 and eventually Line 3.

The proposed phases should be implemented within a time frame of 15-20 years. The first two phases can be fully realised within 5-7 years, the third phase in the subsequent 5-7 years and the fourth phase in the remaining years. In order to establish developments at each station the Vice Ministry of Infrastructure, which is in charge of Metro Line 1, should coordinate its actions with the district municipalities involved. Together with other investors they should initiate a tendering process to search for contractors to implement the proposed urban development for the station areas. This means that interventions in the station areas of urban transit and urban space will be developed in private-public collaboration.
Amenities 400 m around station
Connected to mass public transit
Car-oriented
High mixed-use degree
High inhabitant and employment density

Figure 4.1.3 Phases of the vision (by author)
4.2 Principles and strategies for station areas

In this section the principles of each station for the themes transit network, land-use, urban structure and public space are compared with each other. Then these principles are explained and underpinned with strategies and criteria per station and theme.

The themes are used to give structure and overview of local station area characteristics and interventions. The theme transit network includes aspects concerning the mobility in the city like connections, different road typologies, elevation of the metro corridor and connections with other mass public transport means. Land-use is focussed on the functions of the urban space, buildings and recreational public space like parks and plazas. Urban structure includes the built area reflecting the use of public space, building heights and densities translated in FSI (floor space index). Public space deals with the amount, quality and use of public space and focuses on recreational public spaces.

The principles for urban interventions for each station to be designed are summarized in next graphs. The integration of the metro line into the transit network is crucial, as is the reorganization of infrastructure into a slow traffic and public transport focussed network. The transformation of each station into a mixed-use area differs depending on scale and internal functions of each local station area. Urban structure interventions differ for metro line focussed, commercial focussed and road network focussed developments. Further the interventions try to create new or different spaces in the urban fabric. The restructuring of public spaces includes the creation of new public spaces, adding quality to these spaces and making connections between public spaces.
Transit network

- Integration of the public transport network
- Clarify different road hierarchies, prioritizing slow traffic and mass public transport

- Reorganize principal road infrastructure
- Enhance slow traffic's crossing possibilities

- Create infrastructure, prioritizing slow traffic and mass public transport
- Enhance the accessibility to the industrial park
- Translate the social network of the community as a pedestrian network
MIGUEL GRAU

Enhance diversity of functions around the station
Reduce informality

CABITOS

Stimulate functions with higher scale of influence

VILLA EL SALVADOR

Diversity of functions on edges of bigger blocks
Enhance the scale of influence of the industrial park
Reduce informality
Urban structure

Densification and height transformations are related to the metro station area and to transit networks and flows.

Increase the quantity of public spaces.

Prioritize the connection with Metro Line 3.

Develop a permeable pedestrian friendly structure.

Connect densification and height with transit networks and flows.

The residential urban pattern and density reflect social relations.
Public space

MIGUEL GRAU

Develop quantitative connected public spaces

Spaces related to its surrounding functions, densities and flows on different scales

CABITOS

Recover and enhance the public space network

Integrate public space to its commercial surroundings

VILLA EL SALVADOR

Add quality to existing public spaces

Develop public spaces relating to its (future) surrounding functions

Develop a connected public space network
4.2.1 Principles and strategies Miguel Grau

Transit network

Principles:
Integration of the public transport network
The area is already well accessible by car, but less by public transport. In order to create an integrated public transport network the metro station should be interconnected with buses connecting the station to its surrounding neighbourhoods, districts and city centre.

Clarify different road hierarchies, prioritizing slow traffic and mass public transport
There are different road hierarchies crossing the station area. These are all highly used, but are chaotic and dangerous. Unclear regulations provoke informal use of roads and sidewalks and the lack of respected crosswalks creates a dangerous environment for slow traffic. Different types of roads should be identified and restructured to create a safer and coherent road network for which recognizing the different needs of pedestrians, cyclists and mass public transport is the starting point for street profile design.

Strategy:
• Connect station to a feeder bus stop.
• Create different road sections for each road typology, maximizing the space available for sidewalks and including cycle paths and bus and taxi stops.

Criteria:
• Feeder bus stops are located within a 100 metre walking distance from the station entrance with different feeder bus lines stopping here.
• Taxi/motor-taxi stops are located within 75 - 200 metre walking distance from the station entrance.
• Secured bicycle parking is available within a 50 metre walking distance from the station entrance.
• Primary road/end of highway: a minimum 2 metre sidewalk on each side of the road, no cycling allowed, at least two lanes in both directions, no parking allowed along the road, equipped with street furniture and street trees every 15 – 20 metres.
• Secondary road: a minimum 2.5 metre sidewalk on each side of the road, a 1 metre wide cycling path drawn on each side of the road, at least one lane in both directions, parking allowed along the road on marked parking places, equipped with necessary street furniture and street trees every 10 - 15 metres.
• Tertiary road: a 2 - 3 metres sidewalk on each side of the road, cycling is allowed on the road, one lane only or in both directions, parking allowed along the road or on marked parking places, necessary street furniture and small street trees every 10 - 15 metres.
• Necessary street furniture includes benches on strategic places (places to stay and with many pedestrian flows) and garbage bins.

Land-use

Principles:
Enhance diversity of functions around the station
The local station area is monofunctional with residential sites and local productive industry. In order to develop into an intensively used employment area the surrounding station functions need to be more
diverse. Additional commercial activities, offices and productive industry should be encouraged.

Reduce informality
Many informal street vendors are selling food, drinks and newspapers on the streets in the local station area. On the southern part of the station a productive industrial area is located where people sell furniture using public space on the sidewalks and roads. In order to reduce this informal use of space the informal street vendors and the people selling furniture on the streets have to be replaced.

Strategy:
• Increase mixed-use degree from 50 per cent to 75 per cent in the local station area
• Create a fixed formal location for informal street vendors and furniture sellers

Criteria:
• In 200 metre walking distance from the station the ground floor facing the station on the secondary road has commerce and offices, the upper floors are also meant for offices and housing.
• Along the primary road, which is the end of the highway, the first floors are reserved for inter-district scale productive industrial activities in a setting of small industrial malls. Upper floors are meant for housing.
• Along secondary roads the ground floor is productive and commercial on district scale, but also 25 per cent is allowed to be residential. Upper floors are residential.
• Along tertiary roads it is mainly residential with little local commercial activities on the ground floors.
• Street vendors are relocated in small kiosk shops on the main square of the metro station. The sale of furniture is moved to small industrial malls.

Urban structure

Principles:
Densification and height transformations are related to the metro station area and to transit networks and flows
Densification transformations of the urban structure are related to the metro station itself. This area is directly influenced by the station and, thus, has better potential to develop. Also transit roads of higher hierarchy have chances to develop, which is why the building height along these roads is allowed to be higher.

Increase the quantity of public spaces
The urban structure is very dense and mostly only built environment. It is necessary to create more public space to recover quality of the environment and life. Existing urban structure has to be used to achieve this.

Strategy:
• Increasing densities directly around the station and along principle roads.
• Open up blocks or use small blocks to create new public space

Criteria:
• Through increasing the floor space index (FSI) in the local station area height and corresponding densities increase. FSI has a maximum value of 6.0 along the secondary roads and around the station. Along the primary road, which also marks the end of the highway, productive sites can be found and therefore the FSI can go up to 3.0. Along tertiary roads, which are mainly residential, FSI can increase up to 3.0.
• Densification starts at the buildings facing the station, then along secondary
roads and finally along primary roads and as last along tertiary roads.

- Use smaller vacant or old collapsing buildings to create different sizes of public space.

Public space

Principles:

*Develop a quantitative connected public space network*

The area is identified by the absence of public spaces and greenery. It is important to add new spaces in order to create a liveable and attractive neighbourhood. To create an integrated mixed-neighbourhood these spaces should be connected.

*Spaces related to its surrounding functions, densities and flows on different scales*

New public spaces have to reflect its adjacent functions. The scale of these spaces is also depends on its location in the urban transit network and functions.

Strategy:

- Develop different types and scales of public spaces.
- Interconnect public spaces with different functions and scales.

Criteria:

- Public spaces of inter-district, district and neighbourhood scale are created. For public spaces the different sizes and scales are 3,000 – 4,500 m² on inter-district scale, 1,000 – 3,000 m² on district scale and 150 – 1,000 m² on neighbourhood scale.
- Public spaces are connected through recognizable paths, street furniture, trees and visual lines.
- An inter-district or district scale public spaces close to the metro station are meant for residents, employees working in the area and visitors. This type of space reveals itself as a large connecting square with for meeting places and small-scale commercial activities.
- Neighbourhood and local scale public spaces are meant for residents and contain small amenities as small football/basketball courts, playgrounds and greenery.

4.2.2 Principles and strategies Cabitos

Transit network

Principles:

*Integration of the public transport network – metro and feeder bus connection*

The area is already well accessible by car, but less by public transport. In order to create an integrated public transport network the metro station should be interconnected to its surrounding neighbourhoods, other districts and the planned Metro Line 3 with bus lines.

*Reorganize principal road infrastructure*

The roundabout, intersection point of 3 roads of different hierarchy, is unclear and sometimes chaotic. Many vehicles cross the roundabout in an uncoordinated manner often driving in 4 to 5 lanes in parallel and thereby cause unpredictable driving
behaviours. In order to optimise this unsafe environment the roundabout infrastructure should be reorganized with clear directional indications and intelligent traffic routing.

*Enhance slow traffic’s crossing possibilities*

It is difficult for pedestrians to cross the roundabout. The crosswalks are not respected and also provoke unexpected behaviour of pedestrians risking their lives and resulting in an unsafe environment for all transit participants including themselves. The crossing possibilities for pedestrians and cyclists should be optimized creating a safer environment for all participants.

**Strategy:**
- Connect the station to a feeder bus stop and to the future Metro Line 3 with different feeder bus lines stopping here.
- Create road sections, maximizing the space available for sidewalks and include cycle paths, public transport stops and crossing possibilities.

**Criteria:**
- The end station of Metro Line 3 is located underground within a 200 metre walking distance from the station entrance. It is located close to the commercial area under the east-west directed secondary road in a longitudinal direction to have future possibilities to extend the metro line.
- The station of Metro Line 3 is connected to the commercial areas and Metro Line 1 through pedestrian tunnels with elevators.
- Feeder bus stops are located within 200 metre walking distance from both metro stations. Due to the large roundabout and different directions of busses the location of different stops can be further away.
- Taxi/motor-taxi stops between 100 - 200 metre walking distance from both metro stations.
- Secured bicycle parking is available within a 50 metre walking distance from both metro station entrances on the medians.
- The roundabout: a minimum 2.0 metre sidewalk, a segregated 2.0 metre wide cycling path next to the sidewalk and with a green strip segregated from the roundabout, no parking allowed, develop a 3 lane structure without traffic lights and giving priority to pedestrians and cyclists.
- Primary road: a minimum 2.0 metre sidewalk on each side of the road, a 2.0 metres wide segregated cycling path in both directions on each side of the road, at least two lanes in both directions, no parking allowed along the road, equipped with necessary street furniture on strategic places and street trees every 15 – 20 metres.
- Secondary road: a minimum 2.5 metre sidewalk on each side of the road, a 1 metre wide cycling path drawn on each side of the road, at least one lane in both directions, parking allowed along the road on marked parking places, equipped with necessary street furniture and street trees every 10 – 15 metres.
- Tertiary road: a 2.0 – 3.0 metres sidewalk on each side of the road, cycling is allowed on the road, a one way road with one lane or one lane in both directions, parking allowed along the road on marked parking places, necessary street furniture and small street trees every 10 – 15 metres.
- Necessary street furniture includes benches on strategic places (places to stay and with many pedestrian flows) and garbage bins separated each in residual waste, plastic, paper and glass.

**Land-use**

**Principles:**
*Stimulate functions with higher scale of influence, due to the future Metro Line 3 connection*

With the new connection to Metro Line 3 the commercial area can expand further and thereby attract housing, services, commercial activities and offices of regional and inter-district scale of influence.
Strategy:
- Increase mixed-use degree from 25 per cent to 50 per cent.
- Develop functions with inter-district and metropolitan scale of influence.

Criteria:
- Around the roundabout and along secondary roads use is mainly commercial on the ground floor. The upper floors of the higher buildings are partly used for commercial purposes and offices. Smaller buildings are mainly used for housing with some office space.
- Encourage functions of inter-district and metropolitan scale of influence by promoting the expansion of commercial buildings by facilitating large spaces. This ensures the future value of the location.

Urban structure

Principles:
Prioritize the connection with Metro Line 3
The connection of the station to the future Metro Line 3 has to be designed according to passenger flow characteristics observed at large interconnections between different modes of transport. The urban fabric has to adapt to its future functions and potentials.

Strategy:
- Use public space and urban fabric for the entrance to the station of Metro Line 3.
- Increase building heights of the commercial area.

Criteria:
- Creating the new entrance to the station can disrupt only the necessary urban fabric.

- Increasing FSI of the commercial area around the station from 1.0 to 3.0 – 6.0. Along the main pedestrian flows the FSI should be highest.

Public space

Principles:
Recover and enhance the public space network
Public spaces within the local station area, used by pedestrians for transit, are too little for the high amount of people. The area is car oriented and has many perpendicular parking places along the commercial area at the roundabout and main road. To create a public space network that strengthens pedestrian flows and the future Metro Line 3 the existing space has to be transformed in public space.

Integrate public spaces to its commercial surroundings
New public space has to reflect the surrounding commercial functions, but attention should also be paid to the connection between two stations, which will add value to the place as a connector plaza.

Strategy:
- Create recognizable public space in the commercial area.
- Redesign public space and infrastructure for the new metro station.

Criteria:
- Public spaces in the commercial area are connected through recognizable paths and street furniture, which is matched to its surrounding functions.
- The underground metro station can be reached by pedestrian tunnels on
the metro station plaza and above the station at the median of the road. The function of the plaza is focussed enabling participants to transit and social interactions. The character of the metro station plaza is an open square accessible from many angles.

4.2.3 Principles and strategies Villa El Salvador

Transit network

Principles:
Integration of the public transport network
The area is not well accessible by public transport. In order to create an integrated public transport network the metro station should be interconnected to its surrounding neighbourhoods and districts by bus lines. Because the station is an end station more buses should depart from this station connecting further districts to the network.

Create infrastructure, prioritizing slow traffic and mass public transport
Infrastructure is minimal in this area, because of the informality, poor residents and a poor therefore municipality. Some principal roads in the area are asphalted. Sidewalks are facilitated in some street by households themselves. The area between asphalted roads and sidewalks or built environment is used for parking, informal businesses or workshops. It is usually not paved and not equipped with trees or street furniture. Infrastructure is needed to consolidate the area and make it more attractive. Slow traffic and public transport have to be prioritized.

Due to the high availability of space sidewalk width can be maximized.

Enhance the accessibility of the industrial park
The whole area is not well accessible by car or public transport. The industrial park is an attractor for people of the whole city, but it is not well accessible through the road network. The industrial park should be expanded and better integrated into the road network so that it gives an identity to the whole neighbourhood,

Translate the social network of the community into a pedestrian network
In general people living in the area use public spaces and streets to interact with another and to travel by foot. Many households are poor and cannot afford other means of transport. This means the area is more pedestrian oriented than car or public transport oriented, which makes it interesting to create a pedestrian network through the residential area connecting all bigger blocks.

Strategy:
- Connect station to a feeder bus stop.
- Create different road sections for each road typology, maximizing the space for sidewalks and pedestrian streets, including cycle paths and bus and motor-taxi stations.
- Connect the industrial park to the metropolitan road network and enhance its local accessibility.
- Pedestrianize entrances of the bigger blocks.
Criteria:

• The feeder bus stop is located within a 100 metre walking distance from station, integrated in the future park along the metro track to not directly disturb the residential area. As this is the end station of the metro line more feeder-buses depart from here to districts in the south.
• Motor-taxi stops are located within 50 - 150 metre walking distance from the station entrance.
• Secured bicycle parking is available within 50 metre walking distance from the station entrance.
• Clear pedestrian route from the station to the industrial park on the east side of the station, marked with urban green.
• Industrial park is accessible with secondary roads that are linked to the primary road that is passing along the park.
• Secondary road along the metro line: a minimum 4.0 metre sidewalk on each side of the road, 2 metres wide segregated cycling path, at least one lane in both directions, parking not allowed, equipped with necessary street furniture and street trees every 15 metres.
• Secondary road: a minimum 3.0 metre sidewalk on each side of the road, a 1.0 metre wide cycling path on each side of the road, at least one lane in both directions, parking allowed along the road on marked parking places, equipped with necessary street furniture and street trees every 15 metres.
• Tertiary road: a 2.0 - 3.0 metres sidewalk on each side of the road, cycling is allowed on the road, one lane only or one lane in both directions, parking allowed along the road, necessary street furniture and small street trees or plants every 10 – 15 metres.
• Pedestrian road: with street furniture and sometimes playgrounds for children and small trees or plants in the middle of the road every 10 metres.
• Necessary street furniture includes benches on strategic places (places to stay and with many pedestrian flows) and garbage bins.
• Eight of the twelve entrances of the residential blocks on west side of the station are accessible by car. Other four entrances are pedestrianized and can have playgrounds and benches as well. They can be used as small local plazas that interconnect all the bigger blocks.

Land-use

Principles:

Diversity of functions on edges of bigger blocks

The functions around the station are spatially segregated. On one side the use is productive industrial and the other residential with small local commerce. The area can extend to a mixed-use area that is more diverse on both sides of the station, with offices, small businesses and local services.

Enhance the scale of influence of the industrial park

Many residents of the city already know the industrial park by name, but due its inaccessibility and informality it is less attractive to go there. In order to attract more people and making it more known in the city the area can be developed into an industrial mixed-use area that also gives identity to the neighbourhood.

Reduce informality

In the local station area many informal street vendors are selling food, drinks and newspapers on the streets. In order to reduce this informal use of space the informal street should be replaced.
Strategy:
• Increase mixed-use degree from 50 per cent to 75 per cent.
• Enhance the scale of influence of the industrial park by transforming it to a mixed-use and liveable attractive area.
• Formalize informality by proposing an alternative for street vendors.

Criteria:
• Along secondary roads in a 200 metre walking distance from the station the ground floor is productive and commercial on inter-district and district scale. The upper floors are residential.
• Along tertiary and pedestrian roads it is mainly residential with little local commercial activities.
• Street vendors are relocated in small shops in the buildings along the metro station.
• In the direct surroundings of the metro station the industrial park transforms into a mixed-use area. On the ground floor productive, industrial and commercial activities are located and housing on the upper floors.

Urban structure

Principles:

Develop a permeable pedestrian friendly structure
Large blocks of productive sites characterize the urban fabric of the eastern industrial park. To create an industrial mixed-use area the urban structure has to encourage a liveable pedestrian friendly neighbourhood.

Connect densification and height with transit networks and flows
Densification of the urban structure is related to adjacent hierarchy of the road network. Higher density buildings will surround roads of a higher hierarchy. In this way shells around residential and productive blocks are created.

The residential urban pattern and density reflect social relations
Social relations in the residential blocks have to be taken into account when restructuring the area. There is a high community spirit that identifies the neighbourhood. The residential blocks will have an introvert structure in order to preserve these social relations, so that social interactions can take place without any interruption of higher scale influences on the borders of these blocks.

Strategy:
• Open up too large sized blocks near the station to create a pedestrian friendly urban structure.
• The urban pattern on the residential sites remains, but the height not necessarily and pedestrian entrances have to be taken into account.
• Increasing densities are centred along principle roads.

Criteria:
• Within the industrial site area close the local station open up blocks that are more than 200 metres long to create a permeable urban structure.
• FSI increases on the industrial site from 1.0 to 3.0 – 5.0, with a higher FSI directly at the metro station.
• In the residential area FSI increases in a ribbon structure along the secondary roads from 1.0 – 2.0 to 4.0 – 5.0.
• Along tertiary roads the FSI can increase with from 1.0 to 2.0 – 3.0.
• Densification first starts along secondary roads and roads facing the metro station and to happen as last along tertiary roads.
Public space

Principles:

*Add quality to existing public spaces*
Public spaces in this area have a low quality. They are mainly filled with sand and dead trees. There are many empty sites in the area, which have a potential to become qualitative public and green spaces that will add to the wealth and attractiveness of the neighbourhood.

*Develop public spaces corresponding to its (future) surrounding functions*
Public spaces in this area have a very poor quality. When generating (new) functions for the area it is important that these spaces will transform, too, and add value to the place and support its adjacent functions.

*Develop a connected public space network*
It is important to interconnect public spaces with the same typology. Public spaces along main roads for example form a long boulevard and public spaces in residential blocks form a pedestrian public space network.

Strategy:
- Develop different types of public spaces.
- Connect these different types of public spaces.
- Provide different amenities to different types of public spaces underpinned by its adjacent functions.

Criteria:
- Inter-district, district and neighbourhood scale public spaces are created. These have different sizes and scales: 3,000 – 4,500 m² on inter-district scale, 1,000 – 3,000 m² on district scale, 150 – 1,000 m² on neighbourhood scale.
- Public spaces in the residential blocks are connected through pedestrian paths.
- A new park along the metro track with an inter-district scale of influence meant for residents, employees working in the area and visitors.
- Neighbourhood and local scale public spaces are meant for residents with amenities like small football/basketball courts, playgrounds, street furniture and including the already existing amenities like a small community centres and kindergartens. These spaces also include amenities for women as a volleyball court and picnic tables/benches that stimulate social interaction.
- Public space on the edges of the residential blocks are reflecting the commercial and productive functions in the adjacent buildings and thus are more focussed on street furniture and street trees.
- Public spaces in the industrial mixed-use area have a local scale character with playgrounds and benches.
4.3 Design interventions

Main design intervention concepts of each station area within the themes are illustrated in the next graphs, which are based on the formulated principles of the former section, the vision for Metro Line 1 and the opportunities of the different station concepts developed in the section 4.1 Metro Line 1 vision. In detail, these concepts are Metropolitan crossroads for Miguel Grau, Metropolitan Hubs for Cabitos and Developing Sub-Centres for Villa El Salvador. As explained in the vision, it is crucial to integrate the metro stations into the transit network. It is also important to improve the quality of this network and create a clear hierarchy of roads for motorized and slow traffic and mass public transport. At each station this task is different due to their current infrastructural conditions.

Design interventions for each theme and each station are illustrated in the following graphs. The urban design interventions are explained separately in the next sub sections. Transit network developments propose new (feeder) bus connections with different routes stopping at the stations, and in the case of station Cabitos the integration of another metro line. At the local station area scale different bus routes connect the station. Bus stops are located near the station entrances and (motor-)taxi stops are located behind the bus stations. Public space interventions are focussed on existing building lines, logical connections and ideal block sizes. The urban structure theme involves building densities that transform around, along and at sites with higher opportunities. Land-use differs at each station, but is mainly transformed into a mixed-use area. Regulations are generally related to normative instruments from different governments in Lima. The municipal government of metropolitan Lima sets regulations and together with the Metropolitan Transport Committee of Lima (TRANSMET) it is in charge of the public transport system including the stations and its urban equipment. Together with the metropolitan municipality Lima district municipalities set regulations for public space, urban structure and land-use.

<table>
<thead>
<tr>
<th>Miguel Grau Metropolitan Crossroad</th>
<th>Cabitos Metropolitan Hub</th>
<th>Villa El Salvador Developing sub-centre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of network</td>
<td>Enhancement accessibility by public transport</td>
<td>Quality of network</td>
</tr>
<tr>
<td>Intensively used employment area with offices and productive industry</td>
<td>New employment and mixed-use area with regional and inter-district services, commerce, offices and housing</td>
<td>Mixed-use area with offices, small business and local services and identified by the productive industrial park</td>
</tr>
<tr>
<td>Densification around the station</td>
<td>Densification of the commercial area</td>
<td>Densification along secondary roads</td>
</tr>
<tr>
<td>Creation of public space</td>
<td>Enhancement quality of public space</td>
<td></td>
</tr>
</tbody>
</table>
4.3.1 Station area design Miguel Grau

The plaza as a gate to the city centre

Station area Miguel Grau is developed into an intensively used employment area with offices and productive industry. Due to its favourable location close to the city centre and along principle roads it is well connected. Mass public transport is added and public spaces are created (see figure 4.3.1).

During the design process many decisions have been made and design solutions have been rejected. Different variations have been tried out to see how the perception of public space would change when adding or removing (parts of) blocks and densities. There are different variations for this station:

- **Station on the squares**
  
  One of the alternative urban structures considered was a design with plazas on both sides of the metro station both equipped with bus stops. In this variant both bus stops were from the same hierarchy, both embarking and disembarking stops that needed the same amount of urban space to fulfil its function (see figure 4.3.2).

  After better analysis of the position of the station areas within the transit system and realizing its proximity to the centre it was concluded that most likely passenger would only travel to the city centre and back. This means that people travelling direction city centre embark the bus at the square. People coming back from the city centre just transfer quickly to the metro. This is the reason why the bus stop and its higher use in the north is reinforced by the square.
• **The public space corridor**
  In this model public space is added in a ribbon structure along the metro line (see figure 4.3.3). Eventually it was decided that this was a too big gesture of public space for the area, due to its inter-district scale of influence it would have. Public space, though, was fundamentally needed on local and neighbourhood scale.

• **Pocket parks**
  This variant was derived from the rejection of the public space corridor. It results in the opposite distribution of parks compared to the public space corridor (see figure 4.3.4). Pocket parks with a small influence scale that could impact the area like in urban acupuncture. This structure could have been used if the whole area was residential and expected to stay mostly residential. The derived opportunities explained in section 4.1.1 Station concepts, though, result in a station concept with an intensively used employment mixed-use area. The concept of pocket parks has therefore been discarded. Due to its new functions different scales of public spaces with different influences and tolerance regarding intense use are necessary in this area.
Figure 4.3.8 Current and proposed section A-A’ 1:500 (by author)

Figure 4.3.9 Current and proposed section B-B’ 1:500 (by author)

Figure 4.3.10 Current and proposed section C-C’ 1:500 (by author)
Transit network

New bus routes are connected to the station creating an integrated and interconnected area. The bus stops are located as close as possible to the station entrance encouraging an efficient transport network. The primary road that ends exactly at the station entrance is not used for public transport. Due to the already complicated crossing at the station area buses are directed towards a parallel road. The bus stop in the north will probably be used by passengers to embark when travelling towards the city centre and the bus stop in the south to disembark when transferring to the metro or visiting the neighbourhood. It is therefore necessary to create a bigger bus stop at the station plaza in the north of the station (see figure 4.3.1). The reorganization of street profiles in the station area focuses on slow traffic on secondary and tertiary roads (see figures 4.3.8, 4.3.9 and 4.3.10).

Public space

Because the area lacks public space the bigger block on the southeast of the station is opened up to create a pedestrian oriented area with different public spaces (see Figure 4.3.12). A smaller block north of the station is solely used for public space as a neighbourhood plaza or park. The block at the bigger road intersection in the north is opened up to generate a plaza giving overview and quality to space. Vacant spaces in the area are used as public space. At the station a plaza is located and a park is developed parallel to the station and between the buildings. The station plaza is characterized as a place to reside, a meeting point giving identity to the place. Its purpose serves mainly people that are passing by or meet. The park between buildings parallel to the station is an introvert meeting and recreational place for employees, residents and visitors of the area (see figure 4.3.13). It is connected to the park through a pedestrian passage and an open commercial building functioning as entrances.
Urban structure

Densification is highest at buildings facing the station and along secondary roads. This densification is gradually decreasing further away from the station. This stimulates the use and attractiveness of the local station area and can generate more local business and office space in the rest of the station area.

Densification phases (see figure 4.3.14): In the first phase building blocks are opened up and commercial buildings facing the station are developed. In the second phase densification of the productive industrial area takes place along the primary road. In the third phase densification along secondary roads with commerce and housing takes place and as last along residential tertiary roads. The last phase only happens if the first phases have been accomplished and are successful. This could be seen as an incentive for neighbouring dwellers or investors to redevelop the houses due to the higher land value.

Figure 4.3.14 Four phases urban structure (by author)

Figure 4.3.15 Impression view 03 – Street parallel to metro line with offices and commerce (by author)

Land-use

Buildings facing the metro station are mainly used for offices some commerce with on the ground levels (see figure 4.3.15). Along secondary roads the
functional use are mixed-use small businesses with housing (see figure 4.3.6). The productive industry area along the primary road in the southeast is restructured into a mixed-use productive industry and housing area. This industry is relocated inside smaller malls in the close by area instead of using the street as a showroom (see figure 4.3.16). Informal street vendors are located in fixed kiosks on their same strategic places near the station entrance on the station plaza (see figure 4.3.17).

*Regulations*

District municipalities set regulations for new building developments. Both districts governing the area apply the same regulations. New building developments along the station are given priority and are allowed to have commerce on the ground floors and offices and apartments on the upper floors. The number of storeys is restricted. These developments occur usually per plot due to different ownerships, which means that newly developed higher and finished buildings can be next to one or two storey buildings and unfinished construction sides. Residents and the district municipality work together with developers and/or the Autonomous Authority of the Electric Train to initiate new building developments.

District municipalities, the metropolitan municipality Lima and a representative group of residents coordinate the development of qualitative public spaces together with urban designers (possibly from municipality). New public spaces cut out of buildings have to be regulated and negotiated with current residents and the metropolitan municipality.
4.3.2 Station area design Cabitos

*Plaza between two metro stations*

Station area Cabitos is developed into an employment and mixed-use area with regional and inter-district services, commerce, offices and housing due to its location. It is situated on a crossing of many principle roads, is well connected to the city centre, next to an existing attractive commercial area and close to a future metro stop of Metro Line 3. Mass public transport is added and public spaces are recovered (see figure 4.3.19).

During the design process different design solutions have been thought of related to the location of the new metro station and the size of the plaza:

- **Super plaza**
  
  This structure provides the connection between the two stations with a huge plaza resulting in a large entrance to the commercial area (see figure 4.3.20).
  
  This structure was refused because of the use of too much space and was a too big gesture as a connector plaza of the stations. A plaza with an open structure was needed that also related directly to its commercial
centre, where the space could also be used by adjacent restaurants and cafes.

• **Metro station under roundabout**
  Due to the spacious roundabout the future metro station was chosen to be located under this infrastructure (see figure 3.2.21). This way the urban fabric did not have to be opened up to create a station plaza. In this structure the pedestrian connection would create a complex system of going up and down in order to reach the station. In despite of the connectivity from all sides of the roundabout this structure was not considered ideal. Many commercial activities are located in the northeast of the station, which offers an opportunity to further develop this commercial area and is therefore a reason to keep the station entrance close to this commercial area.

![Figure 4.3.21 Metro station under the roundabout concept (by author)](image-url)

![Figure 4.3.22 Current situation (by author)](image-url)

![Figure 4.3.23 Impression view 01 – Reorganization of street profiles along the metro line (by author)](image-url)
Figure 4.3.24 Proposed urban design plan (by author)
Figure 4.3.25 Current and proposed section A-A’ 1:500 (by author)

Figure 4.3.26 Current and proposed section B-B’ 1:500 (by author)
Transit network

New bus routes and Metro Line 3 are connected to the station area and create an integrated and interconnected area (see figure 4.3.30). The bus stops are located as close as possible to the station entrances encouraging an efficient transport network. Another entrance is added to the station to create a better connection with the future station and the adjacent commercial area. The new metro station entrance is an architectonic icon for the area (see figure 4.3.28). There are many bus stops in the area due to intersecting roads on the roundabout. Taxi stops are located on pedestrian transferring zones from bus to metro/bus, but exclude a taxi stop at the primary road. The reorganization of street profiles and roundabout infrastructure in the station area focuses on slow traffic’s crossing possibilities (see figures 4.3.24, 4.3.25, 4.3.26 and 4.3.27 and as a reference figure 4.3.29).

Public space

Public space in this area is mainly car and informal public transport oriented. Pedestrian public space is lacking and has to be recovered especially between the two stations. This area needs more pedestrian transferring space with quality and adequate functions. Part of the block between the two metro stations is
opened up, which encourages an efficient connection between the stations used as a station plaza (see figure 4.3.31). This station plaza is characterized as a place with many pedestrian flows, but also as a meeting place that gives identity to the area. Adjacent cafes and restaurants can extend their outdoor cafes on the plaza without disrupting pedestrian flows (see figure 4.3.32). The plaza encourages social interaction without blocking passers-by.

Urban structure

Densification in the area is centred on buildings in the commercial area and buildings that are directly affected by both stations. The rest of the station area is mainly residential and inhabited by the higher social class that probably wants to preserve this residential characteristic. It is thus not interesting to expand the commercial area exceeding the local station area, but instead it has higher potentiality to intensify the commercial activities.

Densification phases (see figure 4.3.33): In the first phase the building between the stations is opened up and densification of buildings facing the station is taking place. In the second phase the buildings in the commercial area are redeveloped into a mixed-use commercial and residential area and in the last phase Metro Line 3 is inaugurated. From the first phase on the urban structure is preparing the local station area for the integration of Metro Line 3.
Land-use

The commercial area is expanded and transformed into a mixed-use area with housing and high-density commercial activities and services that have a regional and inter-district scale of influence (see figure 4.3.34). Due to its location in the transit network and future Metro Line 3 connection the potential of expansion for this area is huge.

Regulations

The district municipality sets regulations for new building developments that fit perfectly in the existing building regulations. New building developments in the commercial area are allowed to have commerce and services on the ground floors and offices, while the use for services and apartments is permitted for the upper floors. There is a restricted amount of storeys. The maximum allowed number of storeys depends on the type of road the building is facing. Building owners or the representative group of residents have to coordinate their actions with developers or the Autonomous Authority of the Electric Train to intensify and increase the density and use of existing buildings in the commercial area.

District municipalities, the metropolitan municipality Lima and a representative group of residents and commercial owners coordinate the development of qualitative public spaces together with urban designers (possibly from municipality). The development of the new station plaza has to be regulated and negotiated with current commercial owners, the district municipality and the Autonomous Authority of the Electric Train.
4.3.3 Station area design Villa El Salvador

The industrial mixed-use park

Station area Villa El Salvador is developed into a mixed-use area with offices, small business and local services and is identified by its productive industrial due to its location. It is situated in the periphery being disconnected from the city centre and the current industrial park. Mass public transport is added and the quality of public spaces is enhanced and includes the development of a recreational park along the metro line (see figure 4.3.36).

During the design process several design solutions related to the industrial park and the development of current vacant public space have been presented:

- The industrial park extension
  The large vacant land along the metro line was used in this variant as an extension of the industrial park. The area would be transformed into a mixed-use commercial, industrial and residential site with offices, small business and local services as generated from the station concepts (see figure 4.3.37).
  This model was rejected in order to develop differently than is currently observed in the city of Lima, where all vacant spaces are fully developed instead of using them as public space generating quality to urban life. Open space should be used to add quality to the built environment.
• **Structure of industrial blocks**

Different sizes of blocks in the industrial area have been analysed in order to discover what would create an optimal pedestrian friendly area. Densification of the existing medium block sizes of 200 metres long blocks, densification of small block sizes of 100x100 metres and large block sizes of 300x300 metres have been explored (see figure 4.3.38). The design criteria used for this decision was the pedestrian permeability of the industrial mixed-use area, which is the reason of choosing the small block sizes.

Figure 4.3.38 Different industrial blocks structure in model (by author)

Figure 4.3.39 Current situation (by author)

Figure 4.3.40 Impression view 01 – Small boulevard along the metro line (by author)
Figure 4.3.41 Proposed urban design plan (by author)
Figure 4.3.42 Current and proposed section A-A’ 1:500 (by author)

Figure 4.3.43 Current and proposed section B-B’ 1:500 (by author)
Transit network

New bus routes are added to the station creating an integrated and interconnected area. The bus stop is located next to the station entrance encouraging an efficient transport network. The road along the metro line on the west is upgraded to a secondary road because of the bus connection and future development of the local station area (see figure 4.3.45). Further, roads in the bigger residential blocks are pedestrianized and thereby connected with each other to encourage the social network in the area. New street profiles in the station area concentrate on slow traffic (see figures 4.3.42, 4.3.43 and 4.3.44).

Public space

The amount of public space in the area is high, but it is not orientated on pedestrian use, yet. The blocks in the industrial site are opened up to strengthen the future mixed-use industrial and housing area. The ideal dimension of blocks in an industrial mixed-use area is derived from analysis of theory (section 1.6 Theoretical dimension), which is pedestrian orientated.

Qualitative public spaces are created along the metro line, along the commercial
residential area and the along industrial residential area. The park along the metro line is characterized as a recreational park used by residents from the district, local employees and visitors (see figure 4.3.36 and 4.3.46). This park is irrigated by billboards that produce potable water from the very humid air (see figure 4.3.47). These billboards can produce up to 100 litres water per day (Peckham, 2013). To irrigate the whole park (1.5 litre per square metre) every day, 15 billboards would be needed. Only 4 billboards would be needed when irrigating every 4 days.

Public space on the edges of residential blocks with commerce is characterized as a small boulevard that is reflecting its adjacent functions. Small diners and cafes can extend their outdoor cafes using 5 metres of the sidewalk (see figure 4.3.48 and 4.3.40). Public spaces in the industrial mixed-use area have a local scale character that is focussed on residents and employees.It is therefore equipped with playgrounds and benches (see figure 4.3.49).

Urban structure

Densification is highest along secondary roads and along the station. These higher densities on the edges of bigger blocks form shells that encourage social interactions and a sense of community inside the blocks.

Densification phases (see figure 4.3.51): In the first phase industrial blocks are opened up and of buildings facing the metro station densification begins. In the second phase densification of commercial edges and productive industry with housing along the secondary roads takes place. At last buildings along tertiary roads are redeveloped. The last phase only happens if the first phases have been accomplished and are successful. This could be seen as an incentive to neighbouring dwellers or investors to redevelop the houses due to the higher land value.
Land-use

Functions on the western side are mainly residential with commercial activities and services on the edges of bigger blocks that involve offices, small businesses and local services. On the eastern side the productive industrial mixed-use area is located. Ground floors are used as showrooms of the industry, which makes the area more attractive to visit and live (see figure 4.3.52).

Regulations

The district municipality sets regulations for new building developments. New building developments along the station and principle roads are given priority and are allowed to have commerce on the ground floors and apartments on the upper floors. The maximum number of stories is restricted and the current location of blocks within the residential area is not changed. These developments can occur per plot due to different ownerships, but alternatively the district municipality or the Autonomous Authority of the Electric Train can also buy these plots to develop the area. In the last case the buildings would be wider and bigger. (Commercial) activities could be accommodated on the ground floors.
Residents and the district municipality work together with developers and/or the Autonomous Authority of the Electric Train to start new building developments. District municipalities, the metropolitan municipality Lima and a representative group of residents and industry coordinate the development of qualitative public spaces together with urban designers (possibly from municipality).

4.3.4 Materialization

Material used for the three different designs are:

Roads are black asphalted and cycle paths are asphalted painted in red.

For sidewalks:

- Red brick tiles are used at the plazas and boulevards of the station areas (see figure 4.3.54). These brick tiles are implemented at sidewalks where facing buildings are developed. The curbs are concrete, yellow where parking is not allowed and 15 centimetres wide. This is recently used in district Surquillo in Lima.
- Poured concrete with marks every 1 metre in the area that is not (yet) developed (see figure 4.3.55). The curbs are concrete, yellow where parking is not allowed and 15 centimetres wide. This is commonly used in Lima.
- Gravel pavement in the park of Villa El Salvador along the metro line (figure 4.3.56).

For tree pits:

- Appropriate sized tree pits with grass at the plazas, boulevards and residential areas of the station areas with a minimum size of 1x1 metre (see figure 4.3.57).
Figure 4.3.63 Detailed urban design model of station Miguel Grau demonstrating the pavement of the sidewalk, the tree pits and benches used.
centimetre wide curbs surround these pits. This type of tree pit is normally used in residential areas in the modern centre of Lima.

- Concrete tree grates along main roads (see figure 4.3.58). In general this type is used along principle roads in Lima.

Lighting:

- Lampposts along primary, secondary and tertiary roads (see figure 4.3.59). These are normally used in the city.
- Lamppost used at the plazas and boulevards (see figure 4.3.60). These are normally used at parks and plazas in Lima.

Furniture:

- Benches used at the plazas and boulevards (see figure 4.3.61). This type of benches has been frequently used in parks and plazas of Lima.
- Green garbage bins on strategic places at the plazas, boulevards and along all roads (see figure 4.3.62). Only this type of garbage bins is found in public spaces of Lima.
- 1 metre long bicycle racks at the stations. These are implemented at some metro and BRT stations.

Figure 4.3.58 Concrete tree gates in district Cercado de Lima (Google Street View)

Figure 4.3.59 10 metre long lampposts in district Cercado de Lima (Google Street View)

Figure 4.3.60 Lampposts (http://limacallao.olx.com.pe)

Figure 4.3.61 Bench (http://limacallao.olx.com.pe)

Figure 4.3.62 Garbage bin (by author)

Figure 4.3.64 Urban design model of station Miguel Grau showing bicycle racks at the station
Chapter 5 Evaluations

This last chapter answers the main research question, concludes main analysis methods and design interventions (5.1) and reflects upon the process of the project (5.2).
5.1 Conclusions

As stated in the problem definition metropolitan Lima is characterized as a horizontally expanded mono-centric city with a centre-periphery pattern that is closely related to its expansion periods. These urban patterns are the historical city centre, the modern centre and the informal peripheries. An integrated mass public transport system is lacking and instead an informal public transport system is covering the travel demand of most households in the city. The informal public transport system is not efficient in the sense of travel time, routes, capacity and amount of vehicles and its profit oriented nature. The advantages are the cheap travel fees and the long routes that connect all parts of the city, which makes the system socially inclusive.

Metro Line 1, recently inaugurated in 2011, crosses the city from the centre to the southern periphery, but is not integrated to the remaining transit network or to its adjacent urban space. In order develop a strategy that gives answer to the current lack of integration through transport, the following research question was stated:

‘To what extend can Transit-Oriented Development be used to improve Lima’s urban transit and urban space strengthening the efficiency of Metro Line 1 with an integrating and recovering approach?’

In order to answer this question an approach was developed to deal with TOD in the context of Lima, a low-income city in a developing country and characterized by high levels of informality and socio-spatial segregation. To strengthen the efficiency of Metro Line 1 a TOD strategy was developed. Given the context, obtained concepts and opportunities were different than expected in theory. An integrating and recovering approach of urban transit and public space was established through following design principles: connecting the stations with mass public transport, creating efficient multi modal nodes with transfer stops close to stations, recovering and increasing qualitative public space at stations, and integrating appropriate functions and densities at stations.

The TOD strategy, derived from the theoretical analysis, included aspects of TOD that helped to create a strategy: different analysis measurements, analysis interpretations as concepts towards a development of opportunities for every type of concept, and principles for urban design. These aspects have been adapted to the context of Lima, because the literature was based on experiences from western countries. This adaptation was based on literature on informal settlements, the research of the historical, spatial, socioeconomic and political and planning dimension in chapter 2 Opportunities in the regional context and the result of the analysis of positioning of station areas in section 3.4 Station areas – position in the network.

The most significant and determined analysis, concept interpretation and development of opportunities for the strategy was based on the Atelier Zuidvleugel’s research and development proposal (2006) of station areas in the southern part of the Randstad in the Netherlands. The stations were analysed on different indicators expressed in percentage values: the degree of access by car and public transport, the local densities of inhabitants and jobs and the mixed-use degree in a radius of 1,200 metres around the station. Based on these indicators different diagrams were created for each station and were compared to existing station concepts and opportunities of each concept. These concepts and opportunities were adapted for this research to the context of a low-income city in a developing country. Based on the opportunities identified for each concept a vision and three different station area designs were developed. Different design principles, strategy and criteria for each type of station were derived from the theoretical analysis and the opportunities identified per station area concept.

From the analysis it was derived that the resulting station area concepts were mainly the ones of Residential Sites, Metropolitan Hubs and Peripheries of Cities. A few were identified as Developing Sub-Centres and Metropolitan Crossroads. These concepts of the stations were used as main criteria for the vision of the metro line.

Three station areas were designed that were based on the opportunities of each station area concept and the different design principles for each station. The main criteria for choosing the station areas was their variety of different urban patterns and their representative design for the three types of urban patterns. The
The three designed stations were Miguel Grau in the historical city centre, Cabitos in the modern centre and Villa El Salvador in the informal periphery:

- Station area of **Miguel Grau**, identified to be a **Metropolitan Crossroad**, is located along principle roads leading to the city centre, which is close by. This station area was developed into an intensively used employment area with offices and productive industry. Mass public transport was added and public spaces were created.

- Station area of **Cabitos**, identified to be a **Metropolitan Hub**, is located on a crossing of many principle roads connecting with the rest of the city, next to an existing attractive commercial area and is close to the proposed station of future Metro Line 3. The station area was developed into an employment and mixed-use area with regional and inter-district services, commerce, offices and housing. Mass public transport was added and public spaces were recovered.

- Station area of **Villa El Salvador**, identified to be a **Developing Sub-centre**, is located in the periphery, disconnected from the city centre and next to an industrial park. The station area was developed into a mixed-use area with offices, small business and local services and was identified by the productive industrial. Mass public transport was added and the quality of public spaces was enhanced and included the development of a recreational park along the metro line.

### 5.2 Reflection

**Theme of the studio and my subject**

The theme of the graduation studio was Explorelab. This is a research driven studio where students can explore their fascination. The fascination I wanted to explore more was informal urbanism related to the issues of how to deal with informality or informal settlements. As a half Dutch-Peruvian student I therefore chose a project in Lima, Peru, that was related to informality.

**The relationship between research and design**

The methodology used for the design was obtained through research. Through literature review different means of analysis were obtained to identify problems or missing links in the context. The same literature review made it possible to recognize different concepts and generate opportunities for each concept. The designs have been obtained using the different concepts and their opportunities that have been identified through analysis. This theory helped to create different steps to obtain the design. Necessary knowledge has also been gained through research focussed on the historical, spatial, socioeconomic and political and planning dimensions of metropolitan Lima. This resulted in an integrated design on all these aspects. This means, while designing there was always a relation on the research that was developed and while it was developed there were some setbacks in design due to unknown functions or relations. Research and design have therefore been coexisting during the graduation project.

**The relationship between the proposed method and the actual process**

The methodology consisted of six steps that were obtained through literature. In the fourth step general objectives and opportunities were established. For this, concepts from Atelier Zuidvleugel’s research and development proposal (2006) were used, but were adapted to Lima’s context before doing the analysis of the historical, spatial, socioeconomic and political and planning dimension of chapter 2 Opportunities in the regional context and the analysis of positioning of station areas in section 3.4 Station areas – position in the network. After the analysis of the positioning of station areas the difference between the western context and the context of Lima became more obvious. This is also the moment when the names of the concepts had changed.
For example, the concept **Outskirts of Cities** in a western country was interpreted as a small town with mainly residents surrounded by a quiet, green and spacious environment. In Lima this concept was represented by a residential high density suburb and was not quiet or green, and was thus renamed as **Peripheries of Cities**. Only in some specific cases the Peripheries of Cities were also spacious. The interpretation of this area was, also as found in literature, a place with an opportunity for local scale commercial development with small businesses. When integrating these station areas to a mass public transit system the opportunity had changed to a higher scale of influence, due to the already high amount of residents living in the peripheries and travelling by public transport. This is how the opportunity for transit node development had increased and led thus to a more efficient use of the Metro Line 1.

Another example, the concept **Cities of the Future** in a western country was identified as an extension of the city with high population density, which is well accessible by car and public transport and has cheaper mono-functional sites. For Lima the interpretation of this concept could not be seen as the concept of a future city, because these sites were places with high density, a high mixed-use degree and were not necessarily well connected. These station areas were more areas with a higher potential to develop due to their current different functions and density, which is why it was renamed as **Developing Sub-centres**. The opportunity for this concept stayed the same because its character as a small developing centre remained.

As last example, the concept **Business Sites** in a western country was characterized as a station area located along main roads or highways, far away from the centre, well accessible by car and with a low density. In the context of Lima these sites were low density areas located along principle roads but with residential character and located in the city instead of outside the city. For this reason the concept was renamed as **Residential Sites**. The opportunity of this concept stayed the same due to its location and new future connection with mass public transport.

**Design intervention variations**

In the beginning of this project two design interventions of the two last metro stations in the south were planned to be designed. These were chosen due to their location in an informal settlement with a significant historical background. These two stations had almost the same surrounding land-use, densities and location in the network. To make the project more interesting another station area was chosen replacing one of the southern stations. This new station had a complete different station area concept than the one in the south. But after analysis of the metro line and the regional context of Lima three urban patterns were identified in the city. These patterns also reflected on densities, income per capita and land-use in the station areas. At this moment a third station was chosen in order to create three designs in the three different urban patterns of the city.

During the design process of the three station areas different ideas and variations of concepts have been thought through. Some of these design solutions have been rejected after more investigation of the current local situation or the consequences on the perception of public space. These different variations and the criteria to rejects these are explained further at the beginning of sections 4.3.1 Station area design Miguel Grau, 4.3.2 Station area design Cabitos and 4.3.3 Station area design Villa El Salvador.

**Concluding**

The process has not been completely linear. The interpretation and names of the concepts and opportunities of station areas had been readjusted after the analysis of the station areas of Metro Line 1. Different variations of urban design interventions have been developed before the appropriate solution was found. Fortunately, this has not caused too much disruption for the graduation project. The graduation project itself has been very interesting with many moments of learning, understanding and applying new aspects of TOD and urbanism in the context of a low-income city in a developing country characterized by informality and socio-spatial segregation. These moments of creating new knowledge have also added to the body of knowledge of urbanism concerning TOD in a city as Lima. This new knowledge and research could also be useful for other similar projects of TOD and transit nodes in a low-income city in a developing country.
References

A


B


C


CURTIS, C. (2009). Implementing Transit Oriented Development through...


Appendix 01

Literature review paper written for the course AR3U022 Theory of Urbanism

Design strategy for Transit-Oriented Development
Transit-Oriented Development design for low-income cities in developing countries

Course AR3U022, Theory of Urbanism
MSc Urbanism, Delft University of Technology
Stephanie van Doorn
1545469 _jsvandoorn@gmail.com
June, 2013
12th Graduation Lab Urbanism Conference

Abstract – Displacement demands are increasing due to fast growing metropolises in developing countries. This affects low-income households; transportation costs augment due to increasing distances, which lead to less accessible jobs and amenities (CODATU, 2012). One way to enhance this accessibility is by Transit-Oriented Development (TOD), which is a concentrated mix of relatively dense and pedestrian-friendly development around transit nodes to promote the use of transit, increase walk and bicycle travel and other alternatives to the use of private cars (Cervero, 2009). The objective of this paper is to develop a strategy to create a TOD design for a low-income city in a developing country. This is important because it includes people of all incomes encouraged by TOD to use transit and activity centres surrounding or close by transit stations. The strategy found through literature review is consisting six steps. The first three steps are meant define the TOD area and to understand the regional and local context of this area. The fourth step creates concepts and recognizes opportunities for a TOD design. The fifth step contributes with guiding principles to generate a TOD design, and in the last step the TOD design is evaluated on the former analysed context, acquired concepts and principles of the first, fourth and fifth step, through critical reflection. These obtained steps will add value to the methodology for my graduation project to obtain a TOD design.

Key words – transit-oriented development, urban design, low-income cities, developing countries, informal settlements

1 Introduction
The world is urbanising increasingly every year; in 2012 52 per cent of the world population lives in cities and it is expected to reach 66 per cent by 2030. Due to economic growth in emerging metropolises an increasing demand of displacements is generated (CODATU, 2012). The distances are augmenting, which is influencing the lower-income population. They have to pay more to cover these longer distances or they are excluded from travelling. People living in peripheries of metropolises are the most affected; job opportunities and amenities in the city are difficult or impossible to reach. The poor should be considered when enhancing a mobility network related to urban development in the city; the costs of public transport trips for them could be saved by having close access to sub-centres by means of walking or cycling, giving these people more job opportunities and facilitate access to amenities (Vega et al., 2011). This should also expand housing options for the urban poor and be focused on modes of transport that are most important for them as walking, cycling, other non-motorized vehicles and public transport (UN-Habitat, 2003). This will lead to the same accessibility to amenities and jobs for all residents of the city, which generates social inclusion, more community spirit and citizenship (Riley et al., 2001).

The aim of this paper is to provide steps to create a Transit-Oriented Development (TOD) design on different scales in a context of a low-income city in a developing country. The approach of this paper in order to develop steps for a TOD design is through a literature review, the authors of the obtained literature are specifically chosen due to their experience of implementing and analysing TOD. Calhorque Associates (2002) gives a broad strategy on design approaches, while Curtis and Balz et al. in ‘Making it happen’ (2009), EMBARQ (2011), CTOD (2011) and Atelier Zuidvleugel (2006) describe specific elements that should be analysed and CTOD (2013) and Balz et al. (2009) explain how to acquire and use opportunities from concepts in order to establish a TOD design. Low-income cities in developing countries usually include informal settlements, that is why this paper will explain in the second section the characteristics and potentials of an informal settlement type, which is frequently occurring in emerging metropolises in developing countries. The third section TOD defines and explains what the benefits are. The fourth section describes six steps to create a TOD design. And as last the conclusions and recommendations will be discussed.

This literature review paper will add value to develop a TOD design for my graduation project. The presented steps to create a TOD design will be a guideline and evaluation criteria for my design intervention.

2 Frequent occurring slums
In emerging metropolises of developing countries a high percentage of inhabitants lives in slums. Spatial differentiations identify distinct slums, in this section frequent occurring settlements in emerging metropolises will be described, which have a higher potential to integrate within the urban mobility network. This representative settlement is consolidating, in peripheral areas, informal, but upgraded and accommodates considerable low-income households. Consolidating settlements have over time been recognized, tolerated and accepted. Their potential for improving is generally high, due to previous upgrading it will even generate real benefit. The settlements are located in the periphery, where the housing is reasonable, but the low level of access and high costs of transport is a significant problem. Households can only spend 30 per cent of their incomes on their travels to jobs, markets, education centres and services. The potentiality for these settlements is the provision of an efficient and effective infrastructure and public services. The settlements are informal due to not have had any knowledge of permissions that should have been obtained when constructing a dwelling. Many of these settlements are therefore well established, but are viewed as informal. This is why land buyers who are aware of its potentialities for development can buy these lands for lower-than-market price. The settlements are generally upgraded; residents have in partnership with city authorities and/or NGOs confronted their problems. Therefore these settlements have better facilities and urban services than other settlements (UN-Habitat, 2003).

Although these settlements have a potential to upgrade and integrate into the bigger network of the region, the residents are poor; it is difficult to cover the costs for public transport. They try to pay less or to not pay at all by convincing the public transport driver they have an emergency or just do not have money to pay the (whole) trip. Another alternative for these dwellers is to travel by foot to their destinations, or a part of the distance to their destinations to pay less for the rest of the trip (Avellaneda, 2007).

3 TOD definition and benefits
Transit-Oriented Development is defined by Bernick and Cervero (1997) as: a compact, mixed-use community, centered around a transit station that, by design, invites residents, workers, and
shoppers to drive their cars less and ride mass transit more. The transit station is what connects village residents to the rest of the region... The surrounding public space serves the important function of being a community gathering spot, a site for special events, and a place for celebrations - a modern-day version of the Greek agora (p. 5).

Transit-Oriented Development is a concentration of jobs, housing and retail and/or commercial activities - mixed-use development - within a walking and cycling distance of a transit station. These concentrations are located at strategic points along regional transit systems, they have a pedestrian-friendly design and invite people to walk and cycle, use public transport more and car less, this is also motivated because services are located within a walking distance from their homes, see figure 1 (CTOD, 2013; Calthorpe Associates, 2002). This mixed-use centre encourages people to live near transit nodes and to decrease their reliance on trips by car (Carlton, 2007). A TOD can also be seen as an urban planning and design model around transit nodes with regional perspectives, has compact mixed-use neighbourhoods, and safe and active public spaces that favour social interaction (EMBARQ, 2011). TOD happens on different scales and with different land uses, depending on the context (CTOD, 2011)

The basic components of TOD are thus: compact development, diversity and mix of uses and pedestrian-friendly design (Calthorpe Associates, 2002). The benefits of a TOD that could be achieved and are relevant in low-income cities are; enhanced access to transit by households of all incomes; reduced transportation costs giving access to local and regional amenities and to more job opportunities; TOD creates a sense of community and identity of place (CTOD, 2013). Due to improved mobility options, traffic congestion will be reduced, which in turn reduces greenhouse gas emissions and air pollution, this contributes to a healthier lifestyle that is also encouraged by inviting pedestrian and bicycle routes (CTOD, 2011).

And due to less travel time, caused by an improved mobility network, people will have more time at home with their families (Calthorpe Associates, 2002).

4 Six steps to create a TOD design

The six steps listed below are formulated in order to develop an integrated TOD design, figure 2 gives a schematic overview of these steps. These steps are gathered from different analyses and strategy approaches and combined into one approach that can be applied in the context of a low-income city in a developing country.

1. Identify opportunities in the regional context

Opportunities have to be recognized in different aspects that play a role in generating a TOD, as political, social, environmental and economic aspects (EMBARQ, 2011). The political aspect is important implementing TOD, it differs in every country, but has to be taken into account. Usually to implement TOD there has to be a political will, in accordance with administrative periods, it has to be a priority in governmental schedules to initiate such development.

How to develop a TOD design depends not only on the political context, but also on the socioeconomic and historical context of the region. These aspects should also be analysed in order to create an integrated TOD design.

2. Define the local and regional TOD area

The size and shape of TOD on the local scale is the project area that is the walkable area around transit stations (EMBARQ, 2011). This is defined by most authors as a half-mile or 400-500 metre radius (CTOD, 2013; EMBARQ, 2011; CTOD, 2011). In this radius the highest development densities are situated, but should not be seen as a clear demarcated barrier, there should be a gradual intensification approaching the transit station. Behind the dense core secondary employment and residential areas are located, these go up to 1 mile or more (1,600 metres) from the transit station (Calthorpe, 2002). To create an integrated TOD with its surrounding area a radius of 1,200 metres will be used as in the Stedenbaan project (Baltz et al., 2009).

The transit line will be analysed as a whole on regional scale. The structure of this can be recognized as activity centres, activity corridors and transport corridors (Curtis, 2009).

Activity corridors are centred on main arterial roads or public transport lines using 1,200 metres on either side of the transport line.

Activity centres are developed in and around activity corridors, concentrate on daily activity needs, also on small-scale employment and services, within a walking distance of the transit node.

Transport corridors form a network from one or more activity corridors, being main distributors for inter-urban displacements.

3. Analyse station area

The station area will be analysed on certain existing characteristics and its position in the network, this will help to recognize the needs, opportunities and threads of this area. The characteristics of the area that will be analysed are (CTOD, 2011):

- Land-use: mapping employment centres, residential areas, amenities and retail/commercial areas.
- Parcel utilization: identifying vacant and underutilized land, also identifying properties that can be redeveloped in a near future.
- Block size: measuring the block sizes as a criteria for walkability; areas with small block sizes tend to be more pedestrian-friendly, but larger block sizes can indicate availability of larger development sites.
- Population density and household income.

To measure the position of transit stations an inventory will be needed of the existing relations between the spatial conditions and networks (Baltz et al., 2009). The result of this inventory will be shown in the next step with concepts and opportunities for each recognized transit station. A set of indicators will be used, which will describe the positions and characteristics of transit stations, expressed as a percentage, see also figure 3 (Atelier Zuidvleugel, 2006). Some of these indicators are adapted to the developing country context:

- Degree of access by public transport (APT): network value, each connection of public transport is valued separately, overlying massive public transport as BRT systems, light rail or metro and underlying more informal public transport as buses, microbuses and mini-vans.
- Degree of access by car (AC): network and accessibility value, there are four types of positions in the network, without taking traffic congestion into account: stations with no connection to
regional or national road network; stations with a connection to the regional road network; stations well-connected to regional and national road network

- Local densities of inhabitants and jobs (DMU): inhabitant and job density, the amount of people working and living around the transit stations. The extremes found in Dutch metropolitan context were 590 – 30 inhabitants and employees per acre built area
- Degree of mixed-use (DMU): the ratio of residents and employees in station areas, 100 per cent means there are as many inhabitants as employees.

4. Establish general objectives and opportunities

In order to establish objectives and opportunities some general concepts have to be obtained at local and regional scale, these concepts will bring new opportunities for the sites. The local scale generates concepts for activity centres and the regional scale for activity corridors and transport corridors.

Opportunities for the activity centres or station areas can be derived from the spatial inventory of transit stations of the previous step. Some concepts and opportunities from the Stedenbaan project that are recognized in the contexts of low-income cities in developing countries, these are the following concepts, also shown schematically in figure 4 (Balz et al., 2009):

- Cities of the future are extensions of the city with high density, are well accessible by car, close to arterial roads, but with cheaper mono-functional sites.

Opportunities: They can develop into an urban area with its own identity, a mixed-use area with offices, small business and local services. Regional crossroads are located very close to major motorway intersections, they have good accesses from all parts of the city, but only by car. Opportunities: They can develop into an interregional service centre that has to survive independently from the city centre because its distance from it. Peripheral retail business would be an adequate option combined with enhanced access by public transport.

Regional hubs are located near city centres, but are not intensively used, they are well accessible by either car or (informal) public transport, and are well integrated in the transit network. Opportunities: They can develop into experimental new employment and mixed-use areas, only with a unique identity to attract a mix of regional and interregional services, workplaces and housing. These can exist because of good services with dual access and acceptable prices.

City centres have high employees and inhabitants density, are highly accessible by different modes of (informal) public transport, but are less accessible by car. Opportunities: The first priority is to optimize the transit network, creating a new hierarchical network where public transport users, cyclists and pedestrians are equal to motorists.

For the activity corridor the Network City concept is chosen, in this concept the region is seen as programmatic whole, where the main goal is to form networks. A maximum of diversity of services and locations is stimulated within the regional TOD area. This area is based on high accessibility especially by the public transport network, with an extensive variety of housing, employment and recreation (Balz et al., 2009). Other two concepts proposed by Balz et al. are the Densification and Sustainability concept, where densification and preservation of historical landscapes are the main goals. These could be used but not as main goals, creating a network to enhance the efficiency of new developments including and influencing households of all incomes is a reliable goal for a low-income city in a developing country.

The transport corridor concept is a simpler concept where opportunities depend on the transit corridor type, three main corridor types are recognized (COTP, 2013):
- Destination connectors connect residential neighbours to different activity centres, involving employment, medical, educational and commercial centres, and result in ridership in both directions throughout the day. Opportunities: Station areas that are described as ‘destinations’ have a high potential for new development, destinations would be areas with high walkability, activity centres that is well-connected to its surrounding neighbourhoods. Higher density development can occur along the destination connector, caused by an increased demand for accessible job opportunities and activity centres.
- Commuters are serving only one bigger activity centre, usually a central business district, the transit service is clearly more frequent and used during peak business hours than during off-peak hours. Opportunities: New development is appropriate to be residential with moderate densities, dependent on the proximity to the city centre. Enhanced streetscape and pedestrian and bicycle access to the stations will result in higher ridership, also transit feeder service like buses in suburban areas is convenient.
- District circulators are serving within an activity centre that can be a city centre, commercial, medical or educational area, and also connecting to other activity centres. Opportunities: Connecting district circulators to the regional transportation network will increase transit ridership. Enhanced streetscapes will stimulate pedestrian activity within the district. Connecting to significant destinations with available for development will attract market-rate development.

5. Principles to create a TOD design

Former steps have helped to discover needs and opportunities for a TOD in its regional and local context. The next step is to create a TOD design. Circulation, urban design and land use indicators and principles for a TOD design are explained in this step, which have to be considered during the design process.

Circulation principles are to strengthen connectivity between all locations in a TOD and its surrounding area. Encouraging walkability in the neighbourhood, but not excluding car accessibility. It is required to create an interconnected street system, with small block sizes that shorten walking distances between destinations in a TOD. It is important to have a traffic calming street design to drive at desirable speeds or along suggested routes. Increasing pedestrian safety, comfort and enjoyable routes by creating wide enough sidewalks including landscaping and amenities. Facilitating safe and direct bicycle networks to access the mixed-use core and transit station from surrounding areas, providing parking and bike storage at the transit stations (Calthorpe Associates, 2002).

Urban design principles are presented to reinforce pedestrian-oriented and transit-supportive quality of the area. These principles include building design, public space design and station design. The last can be considered ideally when the transit line is being designed and not already exists (Calthorpe Associates, 2002). Building design: Buildings should be placed in a street-oriented manner with visible and accessible entries. Architectural variation within buildings and among buildings in the same block is important to bring identity and character to the area and stimulates walking interest. Public space design: Streets should be safe, active and comfortable spaces with
amenities encouraging this as street trees, sidewalk furniture, art installations, retail kiosks or outdoor eating areas. Also buffering sidewalks from the streets encourages this. There should be a civic plaza at transit stations to stimulate sense of place and social interaction, and to create a place for events, socializing and small-scale retail activity. This plaza should be large enough but should maintain connections to its surroundings. Using a landmark feature as an historic building, library or tower gives identity to the area.

Station design: The station should be connected to adjacent spaces and buildings to orient passengers and to integrate in the community. Station amenities are necessary at larger stations as a larger or indoor waiting area and small retail activities. Through distinctive and unique architecture the station can become a community landmark as an identity for the community to associate with. Parking and loading areas should be taken into account; site for park-and-ride, kiss-and-ride and bus lanes with stops.

Land use principles are outlined to strengthen efficiency of the TOD area (Calthorpe Associates, 2002). Mixed-use cores contain a variety of uses within the 400-500 metre radius or walking distance; retail uses, high density of employment and institutional uses and housing in order to create a vibrant and always living district. Residents can support small-scale retail activity. Activities directly around the transit station should be active, highly transit-oriented uses as a day-care and commercial activities as newspaper or flower kiosks. A minimum residential density of 30 units per acre is favoured in more urban areas and 8-12 units per acre in suburban areas.

Secondary employment and residential areas beyond the mixed-use core supplement this core, it consists of residential and employment developments, encouraging small retail activities but without competing with the mixed-use core. A minimum residential density of 20-30 units per acre is desired in urbanized areas and 10-15 in outer suburban districts.

6. Evaluation TOD design

The last step consists of an evaluation of the obtained TOD design. This assessment can be achieved by analyzing the integration of the TOD design within its political, socioeconomic and historical context, which is established in the first step. The design has to fit into the context, also has to include households of all income. The TOD design has also to be verified to what extend the design meets the concepts of activity centres, activity corridors and transport corridor, established in step four, and the circulation, urban design and land use principle from step five.

5 Conclusions

The aim of this paper was to develop steps to create a TOD design, which can be applied in a low-income city or metropolis in a developing country. The steps to accomplish this TOD design are very similar to strategies used for TOD in developed countries, the context is different so the potentialities and aims of TOD too.

The first three steps of this strategy are meant to understand the existing context on regional and local scale and help to achieve an overall perspective of the problems. As discussed in step two, it is very important to analyse the regional context, which is not usual when creating a TOD design for a specific station area. Analysing the regional context before to formulate concepts and recognizing opportunities that could be left without doing this regional context analysis, which could be crucial for the design. The concepts and opportunities for the TOD development in the fourth step can in real be identified by a combination of these given concepts.

The activity corridor concept as discussed in step four, would be the Network City concept; it is more adequate to a low-income city because it encourages transit networks and affect people of all incomes. Guiding principles for the TOD design given in the fifth step in order to generate a well integrated TOD design together with the concepts from the fourth step. The last step evaluates the design according to the context, concepts and principles obtained in former steps.

This strategy to create a TOD design sees the mobility network as a whole integrated inclusive system with different means of public transport. Connecting the most peripheral residential areas to bigger transit stations. Including households of all incomes, for example implementing a fixed price could be important to increase informal settlement residents’ opportunities to access employment, recreation, commercial and amenity centres.

6 Recommendations for the graduation project and further research

The obtained steps for a TOD design through this literature review are an indicator for the methodology of my graduation project. These steps do not have to be followed in the same order as long as all the steps are made in the end.

For further research more activity centre concepts as obtained in step four should be discovered in order to identify other and new opportunities in low-income cities for a TOD design. This will also add to the existing body of knowledge of TOD analysis and design. For an assured and complete evaluation of the TOD design the evaluation method of ITDP (2013) should be used in order to measure influence of the TOD design; to what extend the design reduces car use, and increases transit use, cycling and walking. This measurement is obtained from scoring criteria assessing walkability, bicycle use, connectivity, transit distances, mixed-use, density, compactness and the shift from car to public and non-motorized transport. Due to time constraints this evaluation method cannot be used for my graduation project.

References

Appendix 02
Table of calculations for each station area

<table>
<thead>
<tr>
<th></th>
<th>Miguel Grau</th>
<th>Gamarra</th>
<th>Arriola</th>
<th>La Cultura</th>
<th>San Borja Sur</th>
</tr>
</thead>
<tbody>
<tr>
<td>APT (access by public transport)</td>
<td>%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>AC (access by car)</td>
<td>%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>DIJ (density inhabitants and jobs)</td>
<td>inhabitants density</td>
<td>336</td>
<td>265</td>
<td>477</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>jobs density</td>
<td>139</td>
<td>280</td>
<td>190</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>475</td>
<td>545</td>
<td>667</td>
<td>500</td>
</tr>
<tr>
<td>DMU (degree of mixed-use)</td>
<td>%</td>
<td>50%</td>
<td>75%</td>
<td>100%</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>50%</td>
<td>100%</td>
<td>50%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Table of calculations for each station area.
<table>
<thead>
<tr>
<th></th>
<th>Angamos</th>
<th>Cabitos</th>
<th>Ayacucho</th>
<th>Jorge Chávez</th>
<th>Atocongo</th>
</tr>
</thead>
<tbody>
<tr>
<td>APT (access by public transport)</td>
<td>%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>AC (access by car)</td>
<td>%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>DIJ (density inhabitants and jobs)</td>
<td>inhabitants density</td>
<td>600</td>
<td>140</td>
<td>275</td>
<td>480</td>
</tr>
<tr>
<td></td>
<td>jobs density</td>
<td>90</td>
<td>190</td>
<td>85</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>690</td>
<td>330</td>
<td>360</td>
<td>505</td>
</tr>
<tr>
<td>DMU (degree of mixed-use)</td>
<td>%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-90</td>
<td>40-60</td>
<td>20-80</td>
<td>10-90</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>25%</td>
<td>75%</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

**Annotations:**
- APT (access by public transport)
- AC (access by car)
- DIJ (density inhabitants and jobs)
- DMU (degree of mixed-use)
<table>
<thead>
<tr>
<th></th>
<th>San Juan</th>
<th>María Auxiliadora</th>
<th>Villa María</th>
<th>Pumacahua</th>
<th>Parque Industrial</th>
<th>Villa El Salvador</th>
</tr>
</thead>
<tbody>
<tr>
<td>APT (access by public transport)</td>
<td>%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>AC (access by car)</td>
<td>%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>DIJ (density inhabitants and jobs)</td>
<td>%</td>
<td>75%</td>
<td>100%</td>
<td>75%</td>
<td>75%</td>
<td>50%</td>
</tr>
<tr>
<td>density inhabitants</td>
<td>%</td>
<td>560</td>
<td>560</td>
<td>450</td>
<td>540</td>
<td>400</td>
</tr>
<tr>
<td>jobs density</td>
<td>%</td>
<td>30</td>
<td>70</td>
<td>35</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>%</td>
<td>75%</td>
<td>100%</td>
<td>75%</td>
<td>75%</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>total</td>
<td>%</td>
<td>590</td>
<td>630</td>
<td>485</td>
<td>550</td>
<td>475</td>
</tr>
<tr>
<td>DMU (degree of mixed-use)</td>
<td>%</td>
<td>10-90</td>
<td>10-90</td>
<td>10-90</td>
<td>10-90</td>
<td>10-90</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>