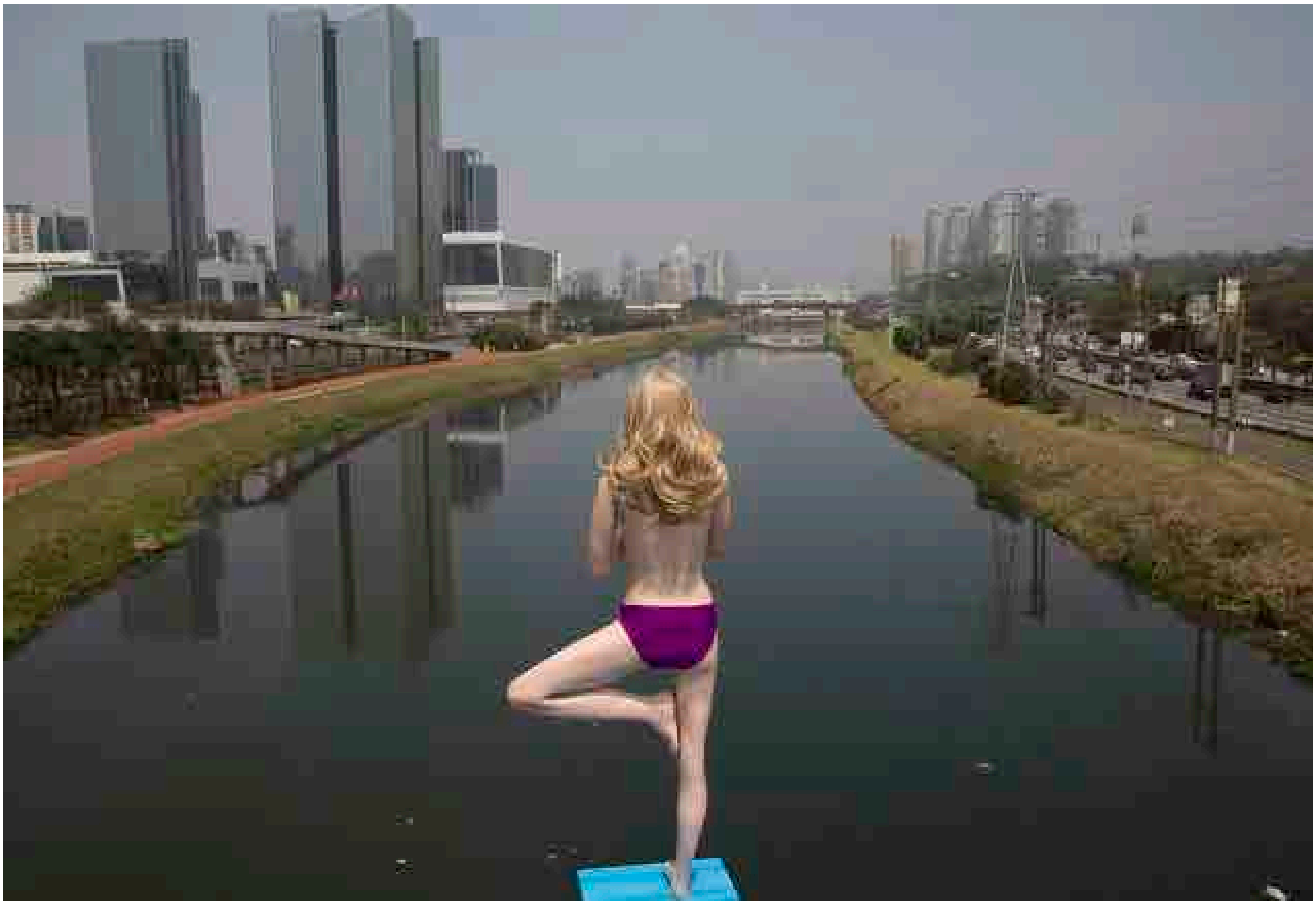
BLUE ARCHES

The Pinheiros as a bridge to improve social accessibility, environmental quality and the connection between people and the water



An art installation by Brazilian artist Eduardo Srur on the Cidade Jardim bridge next to the Pinheiros river on September 18th, 2014. The art installation was created by Srur to urge people not to pollute rivers.
Source: http://avax.news/fact/The_Week_in_Pictures_September_13-September_20_2014_Part_3.html

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2017		

Colophon

Blue Arches

The Pinheiros as a bridge to improve social accessibility, environmental quality and the connection between people and the water

A portfolio from the group D produced as a result to the course AR0086 Infrastructure and Environment Design TUDelft, coordinated by Fransje Hooimeijer and Taneha K. Bacchin.

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A view of the Pinehiros and massive infrastructure along its banks
Source: Authors

Abstract

Sao Paulo, a megacity of almost 11 million inhabitants in its city center, is facing environmental, societal and infrastructural challenges due to its rate of rapid urbanization. The rivers in the Tiete basin reflect the painful truth of unmanageable urban planning and the unawareness of water as a valuable source. The rivers, once the blood vessels of the city, now function as a barrier in the development of the city by their stench and filthy appearance.

An integrated design approach, covering multiple scales and disciplines, aims at tackling the issues by emphasizing the value of water. The Pinheiros should function as a bridge to improve social accessibility, environmental quality, and the connection between people and water.

In a natural environment nothing is straight, everything is connected and balanced in an organic form. In Sao Paulo, as the city has expanded, the urban form has become linear and rigid. The city has modified the natural shape of the river. Blue arches envisions a resemblance of the original meandering shape of the Pinheiros. By connecting blue-green infrastructure on both sides with a green bridge for commuting and leisure, allowing for the meandering shape of the ecological places to cross the river.

Context and Problem Field

As for many cities, the inhabitants of Sao Paulo settled along a watercourse, the Tietê in the 16th century. Rivers were incorporated in the lives of the inhabitants and played an important role in provision of transportation, trading, waste management, communication, food and water. During the industrial revolution, technological developments lead to the water supply system: transport of water over long distances. The rivers, once the lifeblood of the city community, started to lose its importance as the water source.

During the last century the city of Sao Paulo has transformed from an urban settlement to a megacity it is today with nearly 11 million people living in the city center. City expansion has lead to occupation of the river floodplains as built areas and straightening of the originally meandering Pinheiros river. Urban planning has not been able to keep up with the urbanization rate, resulting in uncontrolled urban development as can be seen in the favela-areas of the city.

The value of the rivers in the urban environment diminished to the extent that the Plan of Avenues (Plano de Avenidas) was introduced. A plan for a major road network for the city using the valleys of the river system. The main rivers served as a backbone for traffic while their tributaries served as axes for local traffic (Kathouni).

Sao Paulo faces big challenges with regard to its rivers. The two main rivers Tietê and the Pinheiros have been incorporated by the development of the city. Both rivers have also been channelized, and infrastructure and densely built environment are found along the rivers' banks. The rivers were originally connected, but have been separated with a dam. When the Tietê faces severe overflows, this dam can be opened to allow some water flow to be directed into the Pinheiros river, reversing the (weak) flow direction of the Pinheiros towards the south. In the south, the Pinheiros is connected to the Billings and Guarapiranga water reservoirs, which are used for drinkwater supply and hydroelectricity.

The three main water related issue are: pollution, floods, and drought.
Flooding: The original floodplain of the rivers have been built upon. In case of intensive rainfall, the rivers can't cope with the massive water volumes that runoff from the abundant and highly paved areas. Flooding of "clean" rainwater is not necessarily dangerous. This depends on the functions of the flooded area and the height the water reaches. Flooding of highly polluted water on the other hand is always dangerous, no matter which area is affected or water height is reached.

Drought: A lack of pervious area results in minimal recharge of the groundwater table. Lack of green infrastructure limit the possibility for water retention and natural evaporation processes.

Pollution: The sewer system discharges untreated wastewater on the rivers. In combination with the stagnant river system of the Pinheiros, this results in a highly toxic environment for flora and fauna. If a flooding occurs, the open sewer overflows the streets, creating dangerous situations. The inhabitants are well aware of this pollution problem and often refer to the Pinheiros as an open sewer. The connection with the river as a valuable living conditions is lost.

Another issue related to the connectivity of green spaces in the city. Sao Paulo has a lot of green spots in the city, however, these are mostly separated from each other rather than one big green system. The space between the green spots is often a barrier in the form of concrete environment. This reduces the quality of these green spaces, for example as biodiversity is hard to maintain due to blockage of pollination between the spots.

A last major issue is the socioeconomic divide in the city. The spread of the wealth is very unequal in Sao Paulo, the Gini coefficient is 0,50, way above the international alert index (Unhabitat, 2010a). Also the accessibility of jobs is very unequally spread. While the rich upper class can use a helicopter to avoid the heavily congested traffic, poor people are dependent on this congested road network, public transportation and jobs nearby home to find work. As a consequence, the large majority of the unemployed population in Sao Paulo lives in one of the many poorly and informally constructed favelas (Unhabitat, 2010b).

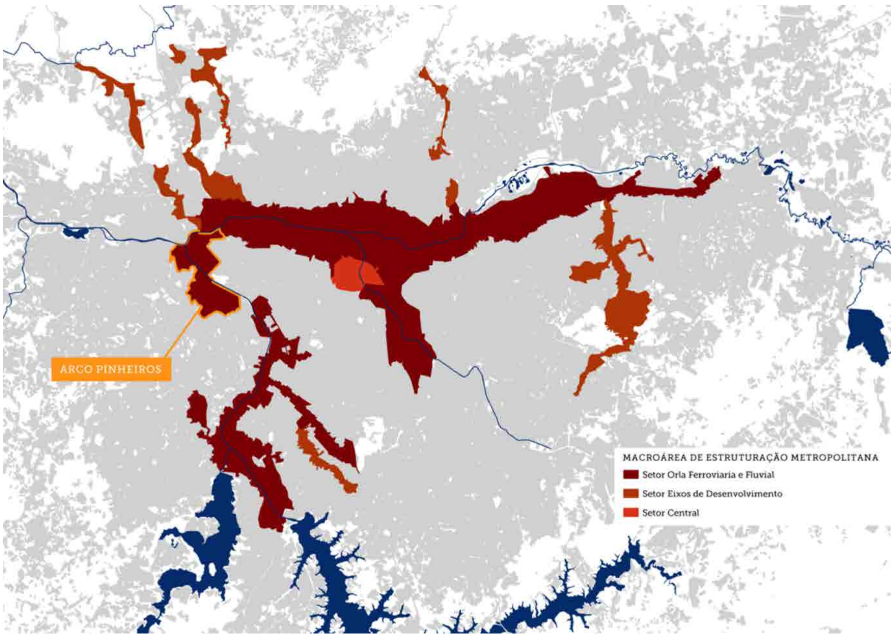


Fig. 01. Arco Pinheiros
Source: http://gestaourbana.prefeitura.sp.gov.br/estruturacao-metropolitana/arco-pinheiros/

Problem statement

In the context analysis many challenges for Sao Paulo are highlighted. This project aims at increasing 'sponginess' within the urban fabric and creating a more attractive urban environment by tackling or reducing the following problems:

- Socioeconomic divide
- Pollution of the Pinheiros
- Occasional flooding
- Lack of environmental networks

Referential Theories

Environment

Macro Scale

Water Sensitive Urban Design

This paper (Hoyer et. al 2011) elaborates on sustainable storm water management in urban environment. It compares the conventional systems with the innovative, new approach of integral urban design. The paper shows how to deal with rainwater, treatment, infiltration, evaporation, conveyance and retention of storm water.

Rational method

The rational method is a simplified method to give a rough estimate for a design peak runoff rate, which is expressed by the following equation: $q = CiA$. In which:

q = design peak runoff rate [m3/s]

C = runoff coefficient

i = rainfall intensity [m/s] for a duration equal to the time of concentra tion

A = sub catchment area [m2]

The definition of runoff is the amount of precipitation that exceeds the demand of interception, evaporation, infiltration and depression storage and will flow over the surface. An estimate of this amount can be given based on the surface cover. In case of green areas, a larger part of the precipitation is used for interception, evaporation, infiltration and depression storage compared to an asphalt cover. And thus a smaller part of the precipitation is runoff. The runoff coefficient (C) captures this difference in surface cover. An estimate of the area contributing to the runoff is calculated by multiplying the surface area with the runoff coefficient. The total peak runoff depends on the design rainfall intensity (derived from the

Intensity-duration-frequency information), which depends on the size of the catchment and the desired protection level. The simplistic FAA-formula is used to estimate the time of concentration. The time of concentration is the time needed for a water particle to flow from the most remote point to the outlet point (into Pinheiros). If the duration of the rainfall event equals the time of concentration, theoretically all parts of the catchment contribute to the discharge at the outlet.

Climate app

The Climate App, developed by several Dutch organisations gives an insight in feasible measures for projects with specific climate adaptation goals. This is further expanded on in the design section related to the macro scale.

Mobility

Meso Scale

A short literature overview is given with relevant theories regarding the calculations done for meso scale. The book of Ortúzar & Willumsen (2011) is the source used for this part, as it gives a good overview on the aspects of transportation modeling that are used in this report.

The main practice in transportation modeling comes back to what is often called the four-stage model. This modeling practice consists of the following four stages:

- Trip generation
- Trip distribution
- Modal split
- Assignment

Before this, zones have to be defined. The whole area of interest is divided into smaller sub-areas. Usually the decision on the definition of zones is based on which data is available. For example, often data on zip code areas are available, and hence these are often used as areas. Besides this, usually external zones are defined, these will be treated later on in this paragraph.

In the first stage of the four-stage model, trip generation, the modeler tries to estimate the total amount of trips departing and entering each zone. Often the terms productions and attractions are used for this. For each zone the amount of productions and attractions are determined. Productions are the trips originating from a zone, and attractions are the trips coming into a zone. Often linear regression models are used for this, although other methods are available. Two main factors which determine the amount of productions and attractions one can expect in a zone are the amount of inhabitants and the amount of jobs. This is relevant data when estimating commuter flows, when estimating recreational flows the amount of shops in a place matters too for example. It's relevant whether one looks at the morning peak or the evening peak. During the morning peak, the commuting productions of a zone come from inhabitants going to their work. During the evening peak, the commuting productions of a zone relate to the amount of employees in the zone returning back home.

The next stage is the trip distribution. In this stage the productions and attractions are coupled, so the aim is to estimate to which zones the productions go to, and which zones the attractions come from. The main factor relevant for this is the distance or the time it takes to travel from one zone to the other. The further away, the less attractive this zone is, and relatively less trips are expected between these two zones. A deterrence function is used to express the attractiveness of each zone based on the travel time or distance. This can for example be a negative exponential or power function. Other factors can be taken into account too, like travel costs, or in the case of public transport the amount of transfers. Then there are external zones too. These are zones outside the area of interest, but which are necessary because some trips go from the area of interest towards elsewhere and vice versa. Usually counts and roadside interviews on main highways entering the area of interest are used to estimate these amounts.

The third stage is the modal split. The aim is to estimate which percentage of the amount of trips between each combination of zones is performed with which mode, like the car, the bike, and public transport. This stage can be performed simultaneously with the trip distribution phase. This gives a more realistic representation, as the mode and destination choice are often made together. To do so, the travel impedance between each zone needs to be determined for each mode separately.

The last stage, which is not used in this report, is the trip assignment stage. In this stage, all the trips between each combination of zones are loaded onto the traffic network. This way one can see which roads have a lot of pressure on it and are therefore expected to be congested.

Connecting People

Micro Scale

The proposal aims to introduce a network of open spaces within Sao Paulo. Not only will this new blue-green infrastructure provide more nature to accommodate water, it can also provide a network of multi user spaces. Re-introducing green spaces within the dense urban fabric and navigating through the network in the city is aimed to create the concept of 'the open city'. This essay published by Richard Sennett in November 2006, he describes the differences between the closed or brittle city and the open city. The open is city was urbanists and planners should aim to propagate. He further describes the 4 attributes of such a space.

Passage territories

Over here he emphasizes the need to design the 'passage' from the place to place. Or the transition from a certain use to the next.

Incomplete form

Providing a non-rigid form that has the room to grow and be added or acted upon by inhabitants over a period of time.

Narratives of Development

Urban designers and planners are always emphasizing the narrative behind their designs, placing actors in time and linking them to spatial interventions. In an open city, the narrative should be created not only by the designer but also be acted upon by inhabitants.

Democratic Space

In an open city when the principles of porosity of territory, narrative indeterminacy and incomplete form are implemented, democratic spaces are created.

Keeping this concepts in mind, the open space network has been designed. Not only do we need pervious areas for water infiltration, but also public spaces that are acted upon by citizens and reshaped as per their needs. This has been demonstrated at the macro, meso and micro scale in our proposal.

Design Strategy

Macro Scale

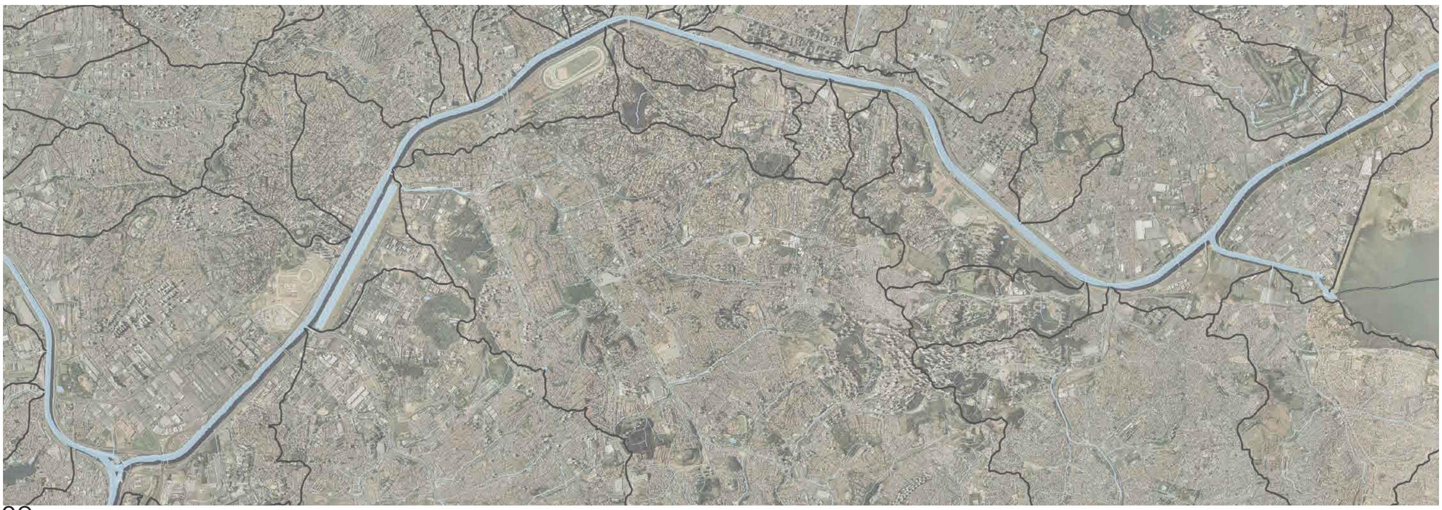
State of the System

(1) Stagnant and polluted river

(2) Lack of ecological networks

(3) Disconnection of people to the river

Design Objectives and Interventions	**Design Contraints**
(1) Improve water system	
(a) Treatment of black water before discharging in river (b) Maintenance of river system by dredging and natural cleaning of the water by green zones (c) Automated lock system based on the amount of rainfall or water level in drinking water reservoir	(a)Large amount of investment is required to change the existing sewage system (b)Keeping track of illegal connections of the sewage system to the river (c)Accessibility to the river for maintenance (d)The intensity of the currents problems may change in the future due to climate change etc.
(2) Increase high quality green spaces to connect local ecology	
(a) Treatment of black water before discharging in river (b) Maintenance of river system by dredging and natural cleaning of the water by green zones (c) Automated lock system based on the amount of rainfall or water level in drinking water reservoir	(a)Large amount of investment is required to change the existing sewage system (b)Keeping track of illegal connections of the sewage system to the river (c)Accessibility to the river for maintenance (d)The intensity of the currents problems may change in the future due to climate change etc.
(3) Identify opportunities to increase liveability, accessibility and environmental quality for inhabitants	
	(a)Lack of awareness about the importance of the river for improved quality of living conditions



Meso Scale

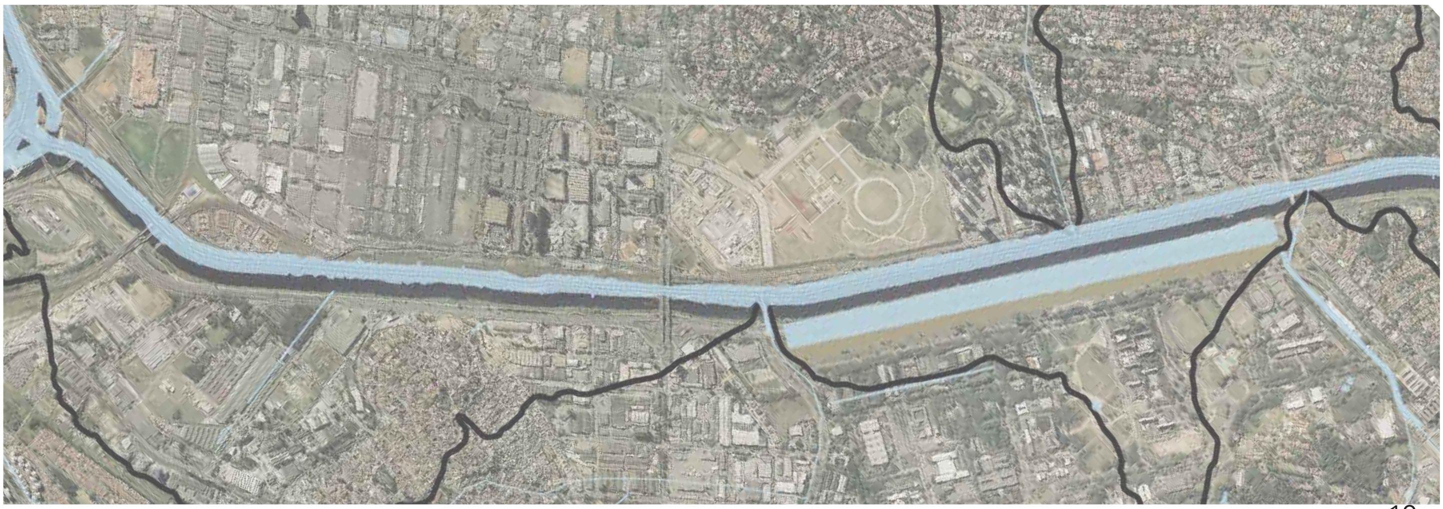
State of the System

(1) Jaguare is very poorly connected to other side of the Pinheiros

(2) Network currently mainly designed for private car usage

(3) Not capitalizing on the opportunity for water transport in the Pinheiros

Design Objectives and Interventions	Design Contraints
(1) Improve mobility of residents in Jaguare to the rest of the city and commercial areas	
(a) Improve access to transit network for people living in Jaguare (b) Expand existing rail and biking network	(a) Integrating the existing infrastructure and enhancing the connection to the river
(2) Expand the network to accommodate other modalities	
(a) Expand existing rail and biking network (For example making use of abandoned rail tracks on west side of the Pinheiros) (b) Introduce sharing scheme such as car pooling	(a) Strong car lobbying
(3) Revitalizing the ship sluices along the Pinheiros	
(a) Introduce local ports along the river	(a) Highly polluted river (b) Lack of mechanical system to support access to the river



Micro Scale

State of the System

(1) Lack of access to high quality environmental spaces for people from Jaguare

(2) The negative perception of the river by the locals (for instance, people view it as an open sewer)

Design Objectives and Interventions

(1) Provide access to high quality environmental spaces for people

(a) Providing local ecological zones

(b) Provide access to riverfront

(c) Provide residents of Jaguare access to Ceasa train station

(d) Separate people from car traffic

Design Contraints

(a) Water in the river is still very polluted

(b) Car sounds and emissions cannot be fully evaded on the bridge

Design Objectives and Interventions

(2) Create awareness about the local importance of the river

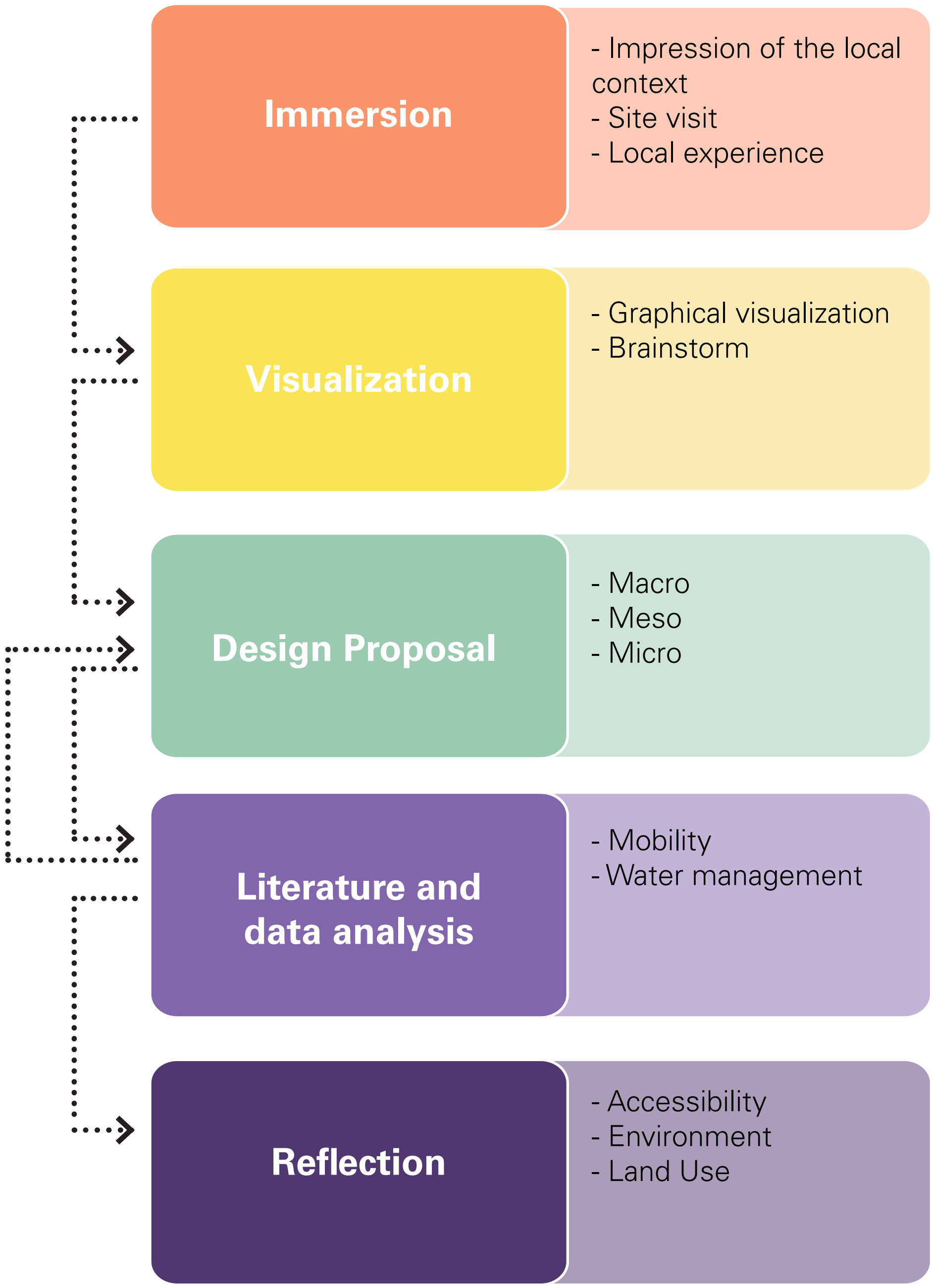
(a) Úsing the 'Pinheiros Bridge' as an educational and recreational experience

Design Contraints

(a) The bridge may be used differently than the design intention

While in Sao Paulo, initial designs have been developed. In the above tables the strategies used to form the designs are summarized. For each of the three scales the process was similar. First, undesired characteristics of the current situation were identified defining the 'State of the System'. These led to desired improvements, the objectives, for which already possible interventions were written down. Next, possible constraints were identified which could make it hard to allow for these improvements to be realized. The identified current state, objectives and constraints for each of the three scales are highlighted.

Design Process



This chapter goes more into depth on the process. The very beginning of the project was in the form of an 'immersion' phase. Site visits were done to experience the city and get an impression of its beauty and urban problems. This helped a lot in having a very concrete image of the current situation, and in coming up with realistic design interventions. For example, the car-oriented design on the bridges and the pollution and separation of the river were experienced in real life.

Next, brainstorm sessions were held to conceptualize and classify the problems and to come up with possible design interventions. This brainstorm process was iterated for each of the three scales. With extensive data unavailable, mapping was the main tool used. Drainage basins, green patches, the road and rail network were identified on the base maps. This helped in having a good impression of the current state, and its undesired characteristics. Using these maps and further brainstorming, the first ideas to intervene in the system were thought up.

These first ideas were then further developed into a concrete design. The aim was to combine the desired interventions into a coordinated whole. This was done at three scales, each having a different focus. For instance, at the macro scale the focus was on environmental challenges. The meso scale tackled mobility and accessibility and the micro scale the connection to the Pinheiros.

Once back in Delft, further literature analysis was done, and calculations to test the assumptions made for the design on macro and meso scale were carried out. Using these new insights, reflection on the proposed design as well as recommendations were made on the suitability of the designs.

Macro Scale

In the macro scale, the whole 25 km of the Pinheiros River is considered in terms of water management and environmental issues and opportunities. On this scale the project aims at increasing the sponginess and liveability of the urban environment. By doing so, the main problems: pollution, flooding and lack of environmental networks can be tackled or reduced.

Blue graph

Urban water management deals with different forms of water in the urban environment: storm water, drinking water, wastewater, artificial and natural water bodies (Hoyer et al., 2011). Water in the urban environment, in any form, used to be considered as a nuisance, health risk and hazard (Ashley et al, 2014) and was also dealt with accordingly. In that sense, water management was more an unavoidable result of city development instead of a valued design aim. During the last decades the view on water management is shifting towards a proactive approach of dealing with water by integrating urban planning and water management. Water is recognised as a valuable resource and enhances the living environment (Hoyer et al., 2011).

One example of traditional urban water management is the underground conveyance of natural channels. Underground drainage systems, often referred to as the conventional storm water management approach, provide the means to efficiently collect and transport runoff as quickly as possible towards an outlet point. This is also the case in the reviewed project area. The main tributaries of the Pinheiros are hidden under roads in underground pipes for storm water collection. These roads indicate, since water flows towards the lowest point in the catchment, the lowest parts of the sub catchments. Runoff within the area is likely to flow towards and along these roads to the Pinheiros River.

Urban planning has not been able to keep up with the pace of urban expansion, resulting in a lack of adequate infrastructure. The rivers in Sao Paulo used to flood the riverbanks every year (Teixeira dos Santos and Amaral Haddad, 2014). While the floodplains of the rivers have been built upon, there is no mitigation for the water retention in wet season. The surface cover of the sub catchments is almost impervious, which leads to a decrease in space for water storage. As explained at the theoretical framework of the rational method, more impervious area results in more runoff compared to greener areas. If the drainage networks and rivers cannot cope with the runoff, parts of the city are not able to drain causing water on the streets and the rivers are likely to flood. In figure 4 the underground rivers that follow the outline of the roads, the largest outlet nodes and the identified green spaces are displayed.

A simplified calculation of the runoff by the Rational Method confirms the

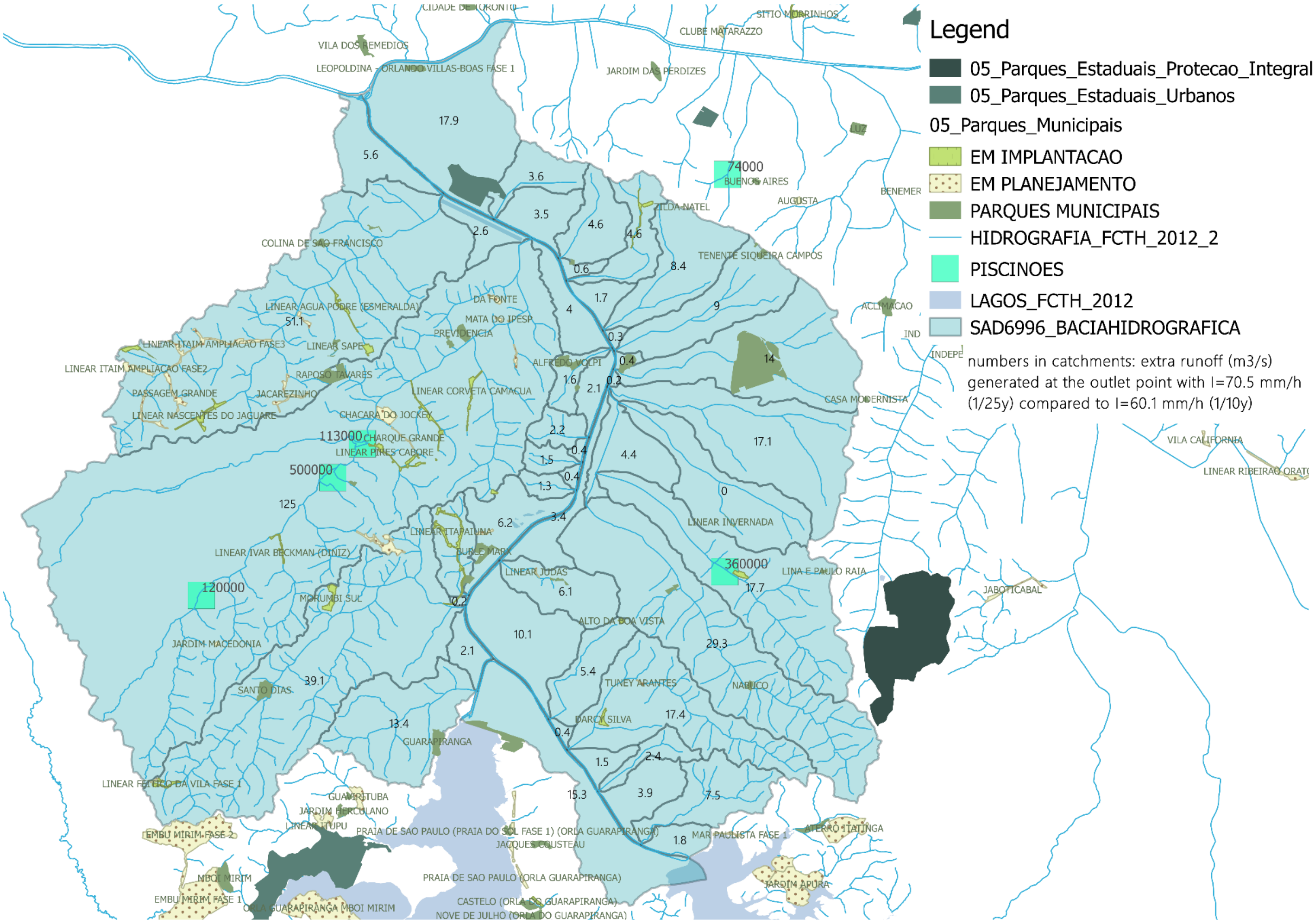


Fig. 02. Result of Rational Method (as explained in Apendix 2)

Fig. 03. Bamai Channel in China. Source: Van Timmeran, 2017

estimate of the catchments with the largest discharge on the river Pinheiros. Assuming that the current storm water system is designed for a rainfall intensity with a ten year probability, an additional water storage need is determined based on the difference of a rainfall intensity with a probability of occurring once every twenty-five years. The method is presented in Appendix 1A, the outcome of the calculation is presented in Figure 2. The largest catchment, according to the calculation result, discharges 125 m3/s more at the outlet point at the peak of the rainfall event compared to the intensity with a return period of 10 years. There are multiple methods to design for this new standard.

An interesting political and technical perspective is the definition of protection level. The question rises whether flooding could somehow be acceptable. There might be a difference in acceptable protection levels based on the location, water depth on the streets, the water quality and the duration of the flooding. For example If a rainfall event with a return period of 25 years, that strikes the current system, results in flooding and blockage of the traffic arteries might be unacceptable compared to when a similar flooding strikes the public playgrounds. Flooding of the latter might be acceptable if the water is relatively clean, but unacceptable if it is severely polluted. Acceptance of the level of protection makes inhabitants more aware of the effects of water management and could lead to reduced costs. Once the protection level is clear, the system can be adjusted to the new design standard. In case of exceedance of this new design standard, other measures have to be considered to reduce damage. Possible measures are:

1. Create extra storage possibilities on streets or green areas, green areas will be discussed in the next paragraph;

2. Create higher barriers at doorsteps to prevent flooding of houses and other buildings;

3. Adjust vital infrastructure parts (main roads, emergency routes etc. to decrease probability of flooding.

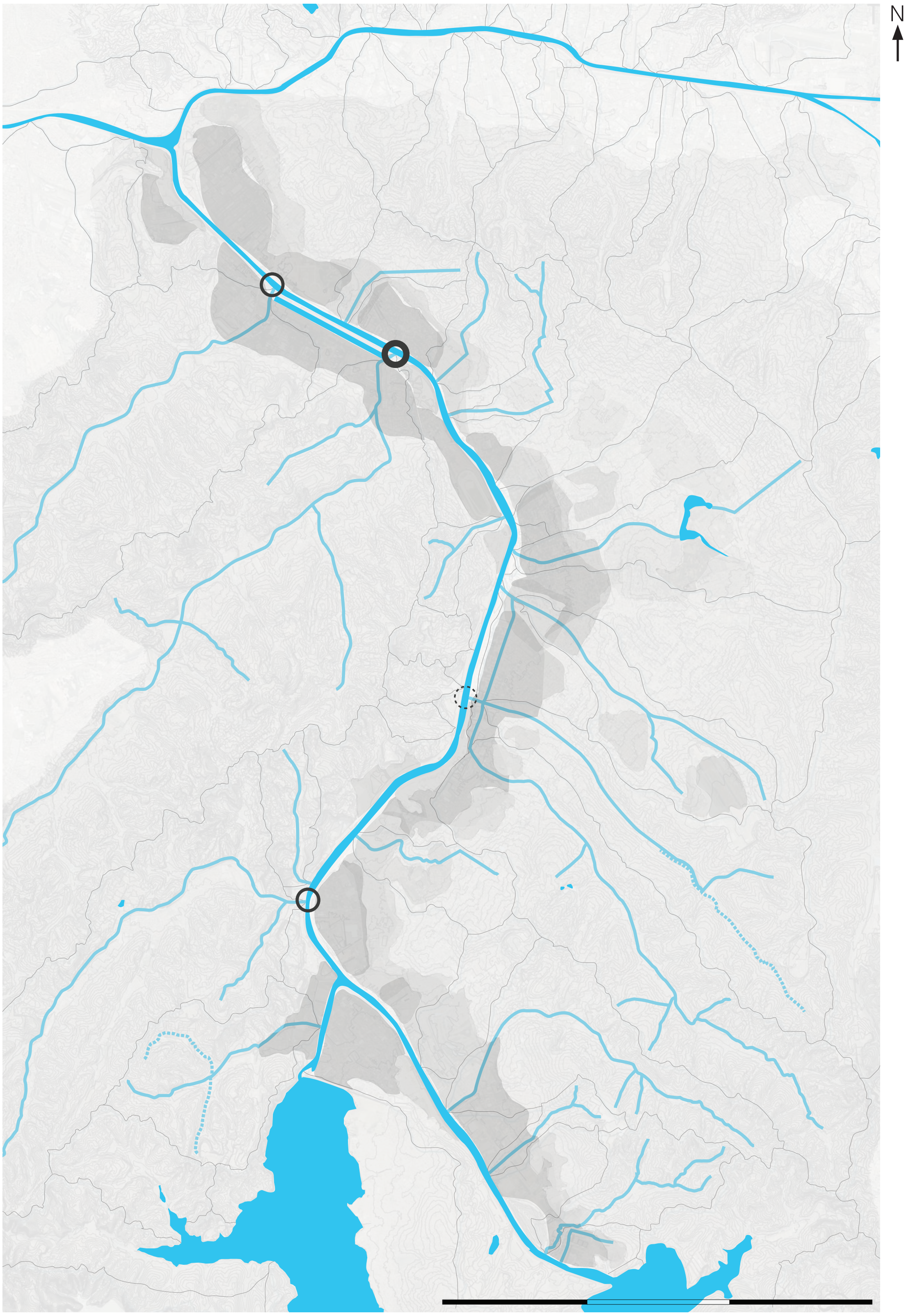


Fig. 04. Blue Graph, Pinheiros River. Source: Authors

Flat slope

Gentle slope

Steep slope

Streams that are roads

1

2

3

Ranking based on intensity of water discharged from the basin

Green graph

Increasing the sponginess of the city aims at creating adaptive systems. Sponginess is especially useful in cases of exceedance of the design parameters. For example: water storage opportunities (detention or permeable pavement) can prevent flooding of the streets.

A method to increase the sponginess is sustainable storm water management that aims at mimicking the natural water cycle for the urban environment (figure 5). In this method evaporation and infiltration processes are improved by implementation of green or blue areas and pervious cover are measures, often referred to as SUDS (Sustainable Urban Drainage Solutions).

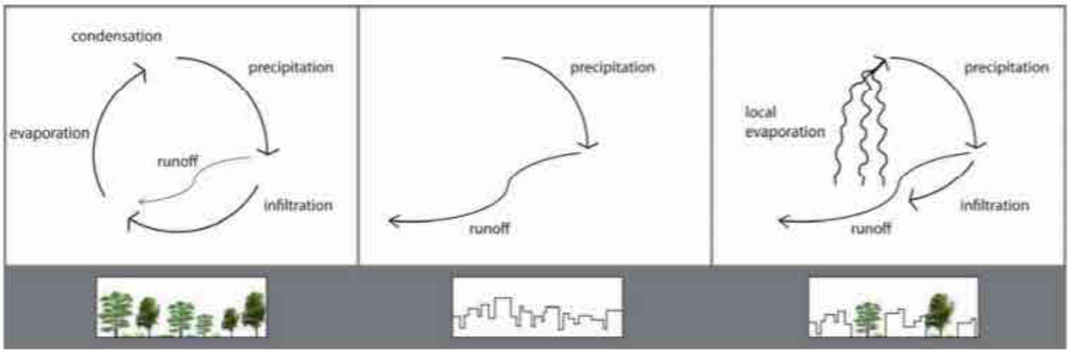


Fig 05. Mimicking the natural water cycle in urban environments.
Source: Hoyer et al., 2011

Besides the increased effect of sponginess of green areas, these areas are important in other perspectives. According the ecologists, these scattered green patches within the urban environment may provide the only opportunity for corridors, connectivity and wildlife movement (Ignatieva, Stewart and Meurk, 2010). Another point of view is the aesthetic, climate and recreational value that is assigned to these green areas.

Figure 6 shows the present green areas in the project area. There are no linkages between the existing green areas. Linkages between green patches, creating green networks could enhance the living environment for inhabitants and increase biodiversity (Ignatieva, Stewart and Meurk, 2010).

A remark needs to be placed at the implementation of green areas and pervious covers. The soil type has to be suitable for infiltration and retention of water. Nearly impervious soil types, such as clay and rock, are for example not suitable for infiltration measures.

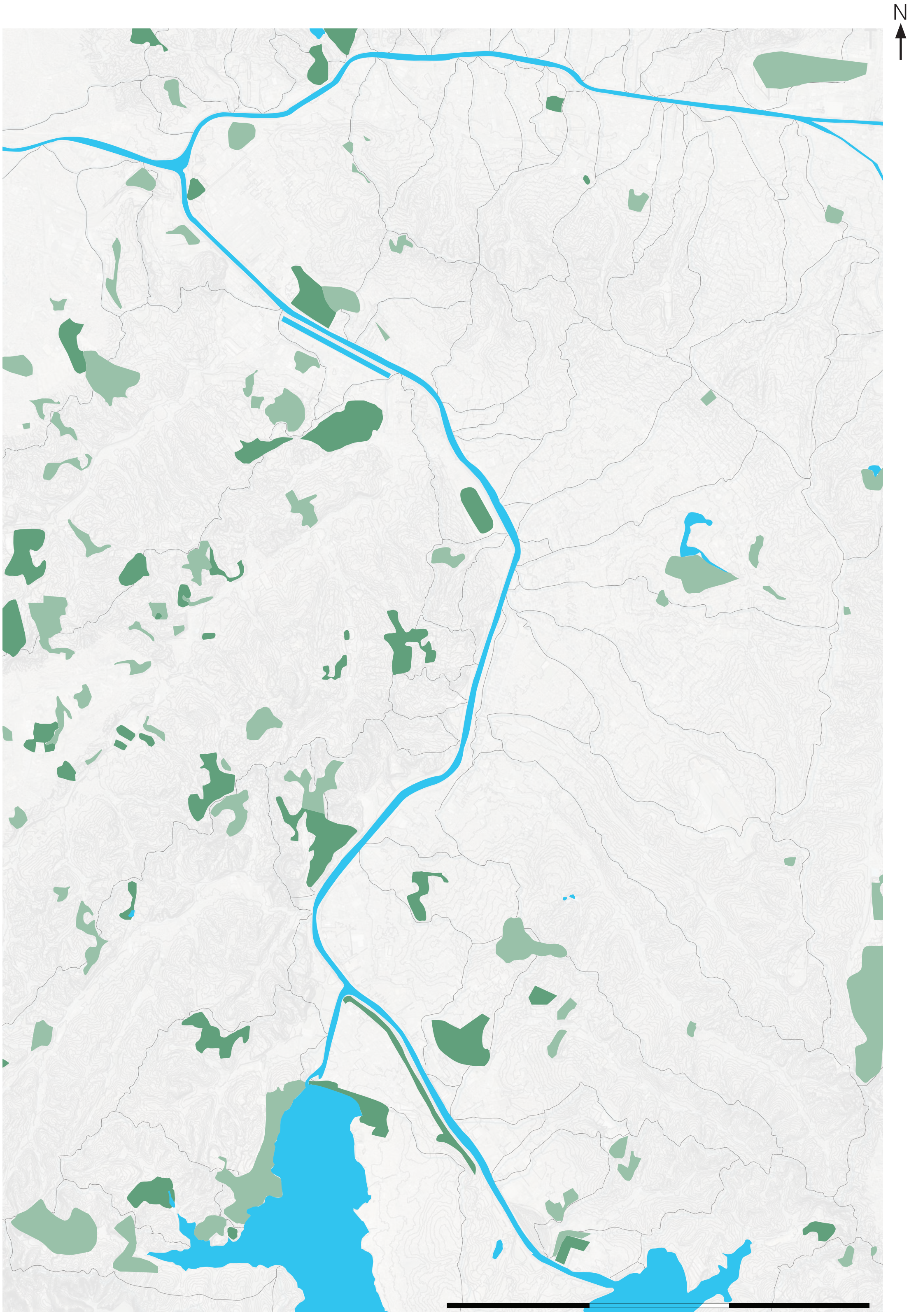


Fig. 06. Green Graph, Pinheiros River. Source: Authors

Dense Vegetation

Light Vegetation

Green-blue infrastructure matrix

The result of overlapping the green and blue graph is displayed in figure 7. Taking the desired green connections and the history of the Pinheiros River into account, the vision for the project area is as follows:

In a natural environment nothing is straight, everything is connected and balanced in an organic form. In Sao Paulo, as the city has expanded, the urban form has become linear and rigid. The city has modified the natural shape of the Pinheiros. We envision restoring – resembling – the original meandering shape of the river. The Blue Arches concept will result in a connected network of blue-green infrastructure opportunities that connect the inhabitants to the river and increase the sponginess of the urban environment.

Traditional stormwater systems are not flexible to adapt to new situations. Dealing with an extra amount of water, as calculated by the rational method, could be realized only by expansion of the stormwater system. However replacing or expanding the current system is a costly and intensive operation. Streets are blocked during the works causing hinder and traffic problems. And only expanding the current system does not contribute to the aim of increasing the sponginess. A more adaptive and natural solution can be found in a combination of sustainable urban drainage measures with the traditional measures. A part of the measures could contribute to the increased connection of ecological networks.

A collective of Dutch companies has developed a climate app. In this app, solution are proposed to increase the adaptivity of urban environments by taking into account the adaptation target, soil types, developments strategy, land use and slopes. The possible solutions are listed in Appendix 1B. The most interesting and relevant solutions for the different adaptation solution concerning urban planning and water management are displayed and elaborated in the table below. These solutions are recommended to analyse in depth to confirm the applicability and determine the contribution to the sponginess of the urban environment.

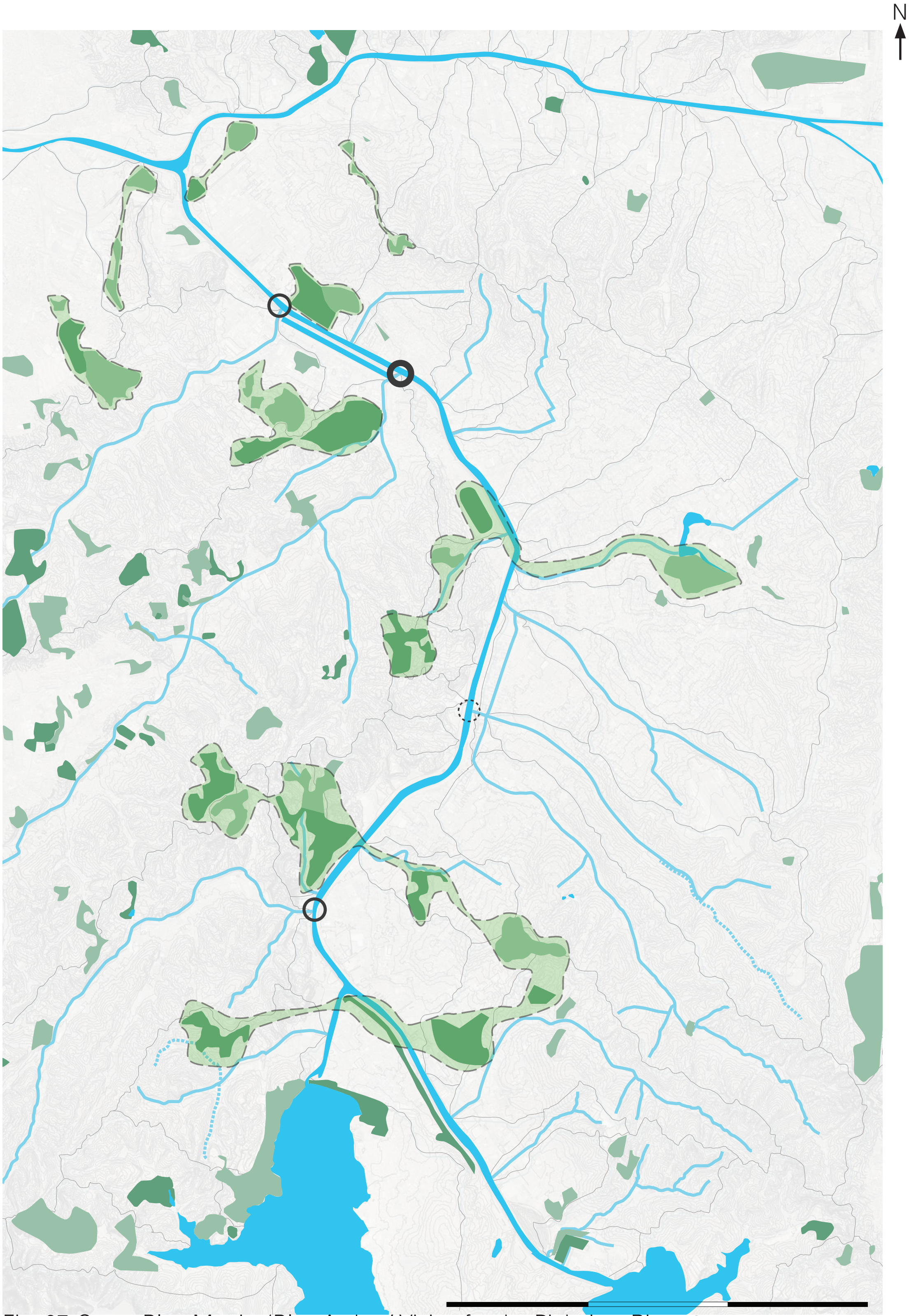


Fig. 07. Green-Blue Matrix, 'Blue Arches' Vision for the Pinheiros River. Source: Authors

Dense Vegetation

Light Vegetation

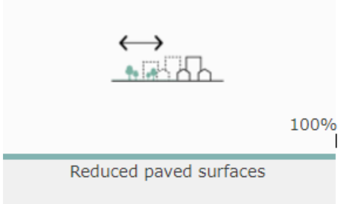
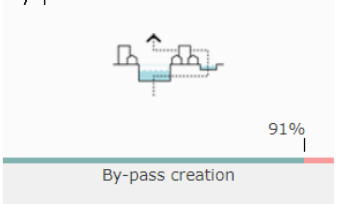
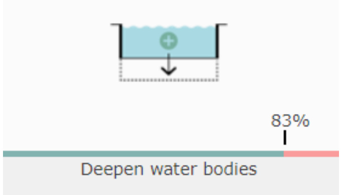
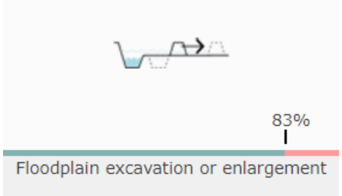
Streams that are roads

1

2

3

Ranking based on intensity of water discharged from the basin

Adaptive Solution	**Description** (as per the climate app)	**Relevance to Sao Paulo**	**Target**
Reduced Paved Surfaces 	Paved surfaces like roofs, roads and parking lots, reduce the infiltration capacity of the soil and increase the surface water runoff. As a consequence, flood risk and the need for additional water retention capacity is increased. By decreasing the total area of paved surfaces, more water can infiltrate the soil and green space is created. This has a positive effect on the heating of a city. Green areas help cooling the area by providing shade and the possibility of evapotranspiration.	Voids have to be available to implement	Pluvial flooding / Drought / clay & rock soil
By-pass Creation 	Creating a bypass for a river or canal can reduce flood levels in a specific location. A bypass provides extra discharge capacity for the river or canal. Thereby known bottlenecks can be solved.	Applicable downstream and land possibly available at CEAGESP Area	Pluvial flooding / clay soil
Gutter 	A gutter is a non-permeable open drain to collect transport rainwater. Usually a gutter runs along a road. It is connected to either a manhole or a surface water body.	Interesting along large roads, but no surface water body to connect to. Possible to connect other networks	Pluvial flooding / rock soil
Protection vital services 	Life support facilities and dangerous goods like nuclear plants should be well defended against climate extremes. This vital infrastructure should be up and running even during extreme conditions.	Applicable in combination with emergency supplies and utilities and as part of discussion for protection level	Fluvial flooding / clay & rock soil
Deepen water bodies 	To mitigate droughts sufficient water can be stored during the wet period, so it becomes available during a drier period. To maximize storage capacity the volume of water bodies can be increased. One way is by increasing the depth of rivers, canals and ponds.	Might be a possibility for the entire water system. Also maintaining the water depth by dredging will contribute to the retention capacity	Fluvial flooding / Drought / clay & rock soil
Floodplain Enlargement 	The floodplain can be enlarged by lowering the level or increasing the width of the floodplain. Enlarging the floodplain will create more room for the river thereby increasing the discharge capacity and provide upstream retention.	Applicable in the areas to be redeveloped and low lying areas, Room for river	Fluvial flooding / clay soil
Green shores 	Adding green in the streetscape reduces the impact of the heat island effect. Trees provide shade and transform the heat through their capacity of evapotranspiration. This greening can be done by tree lines along streets or by creating parks in the urban area.	Applicable in streets and possibly also along the riverbanks creating ecological networks	Fluvial flooding / Drought / clay & rock soil

Reflection on the proposal

The concept of Blue Arches was proposed after the immersion and visualisation phase. The green-blue infrastructure matrix and the idea of the originally meandering river led to the vision that the existing urban fabric can be reshaped to fit the Blue Arches. After review of the data, basic calculations and the theoretical framework this vision needs to be slightly adjusted to the existing situation. Although the Blue Arches initially were visualised as green networks, contributing to the increased sponginess, these arches should also have a blue (or grey) component in order to supply for enough water storage possibilities. Analysis of the soil map showed that the clayish river basin and rocky soil types are not suitable for natural infiltration processes. The land use map and the urban fabric learned that the originally fluent arches have to be reshaped in order to fit the existing urban fabric (more straight lines). The proposal needs some adjustments to fit the existing situation, however the concept of connecting green patches, increasing the sponginess and connecting people is still feasible within the concept of Blue Arches.

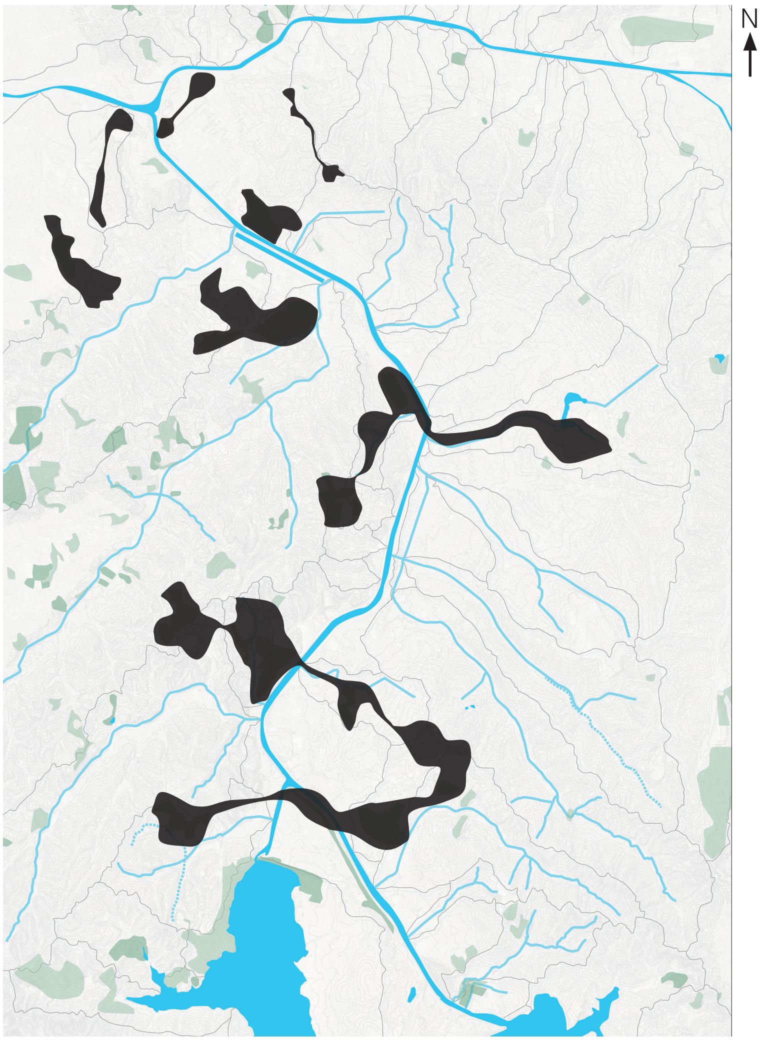


Fig. 08 . Concept Blue Arches Source: Authors

Meso Scale

The design intervention that is proposed is shown graphically in figure 11. The main idea of the proposal is a wide bridge for pedestrians and bicyclists between Jaguaré and the Ceasa train station in Ceagesp. To complement this connection, the old abandoned tram tracks that used to make a connection between the train station Estação Presidente Altino and Jaguaré will be used again. On the Jaguaré side of the bridge, also an open recreational green space is created. Furthermore, the bridge will have a lot of flora on it, and roads east and west of the river are redesigned with more green to allow for more connectivity of these spaces. Specifications of and reasons for each part of the design are treated below.

Bridge

This bridge is proposed mainly to increase the accessibility of inhabitants of Jaguaré to jobs. Especially given that the Ceagesp area is being redeveloped, and hence more jobs are expected here in the future (Prefeitura de Sao Paulo, 2016a), a better connection between Jaguaré and Ceagesp is crucial. This way the Ceagesp area also has better access to a large basin of potential employees, and hence private investors of this area may have interest in building this connection too.

Maybe even more important, this will make a much more direct connection of inhabitants of Jaguaré to the train network of Sao Paulo. The travel time between Jaguaré and the Ceasa train station will decrease enormously. This way even more jobs throughout the whole city can be reached within shorter travel times. Businesses and shops located in Jaguaré also become much more accessible to customers throughout the city.

It was deliberately chosen not to allow for cars to enter the bridge. This way it will be a pleasant, healthy and safe environment for pedestrians and bicyclists, and the recreational green space will have a higher quality too. The bridge will go over the highway on the Jaguaré side which is located along the Pinheiros river. As a consequence the space on the bridge will be somewhat separated from car traffic, although a full evasion of noise and air pollution is not realistic of course.

Tram

It is proposed to refurbish the old tram tracks, which is inspired by the Palimpsest project proposal (Ganança et al., 2017). By doing so, a larger part of Jaguaré can benefit from shorter travel times in public transport, by connecting the most eastern and western parts of the neighborhoods to the bridge with this tramway. By connecting it to the bridge, there's a quick access to the Ceasa train station. In the other direction though, there'll also be a shorter connection with the Estação Presidente Altino train station. This way not only train line CPTM L09 is in quick reach, but also train line CPTM L08. The tram also offers a quick connection with the industrial sites northwest and southeast of Jaguaré. Also other parts of the city near a

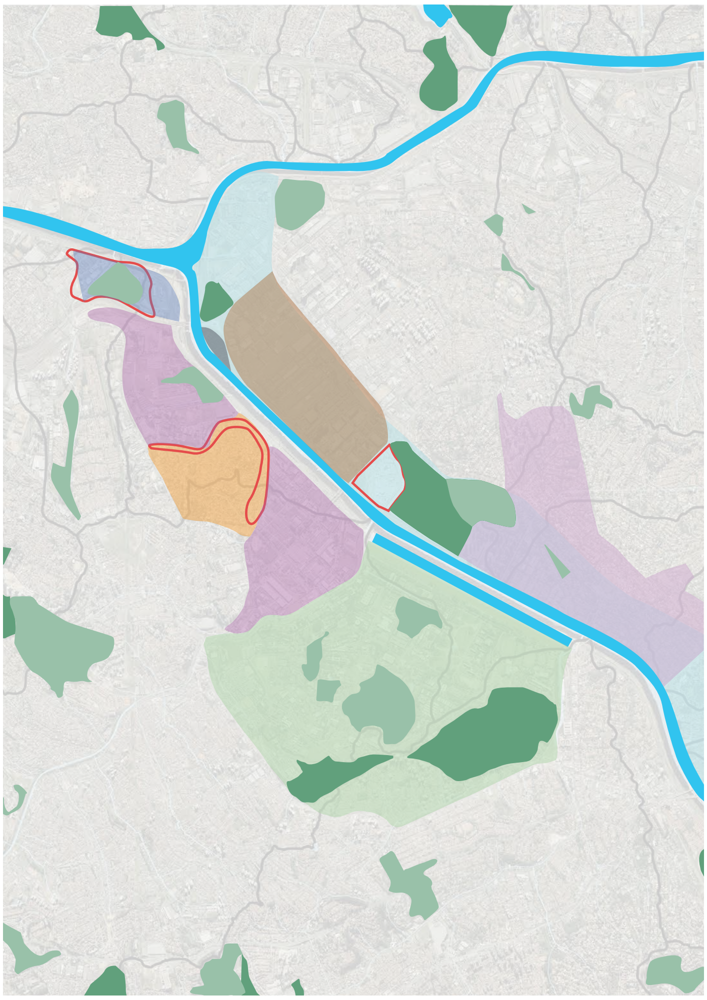


Fig. 09. Existing Land Use and Regulations
Source: Authors

Fig. 10. Concept at Meso Scale
Source: Authors

- Light Industrial Areas
- Jaguare
- CEAGESP
- Future Housing Development
- Future Logistics Hub
- Alto Di Pinheiro
- Floodbasin
- Priority for Social Development
- University of Sao Paulo
- Dense Vegetation
- Sparse Vegetation

train station will have a significantly better connection to not only Jaguaré, but also these industrial sites.

The tram would have a stop at the west side of the bridge and not go over it, still allowing for people to transfer to the train station with a walk of just around 200 meters through a pleasant green environment. The exact locations of other stops would require further analysis of what is possible and where demand is.

By significantly reducing public transport travel times, it is expected that some car trips will now be replaced with tram/train trips. This way some of the pressure can be taken off the road system, perhaps lowering the amount of congestion. Especially the amount of demand of cars entering and exiting the highway is expected to reduce. This way less turbulances occur in traffic, and the chances of jam breakdowns are decreased too (Elefteriadou et al., 2011).

Green

The bridge will be a very green environment. This is not only done to make it a pleasant environment for people commuting and recreating on it, but also to make better connections between green spots in the city. Besides green on the bridge, also a design intervention on some road arteries is proposed. The idea is to have more trees and plants in between or next to the roads. This way pollination can happen over a much larger area of the city, enhancing biodiversity. With more green along these roads, these places become more pleasant for pedestrians too.

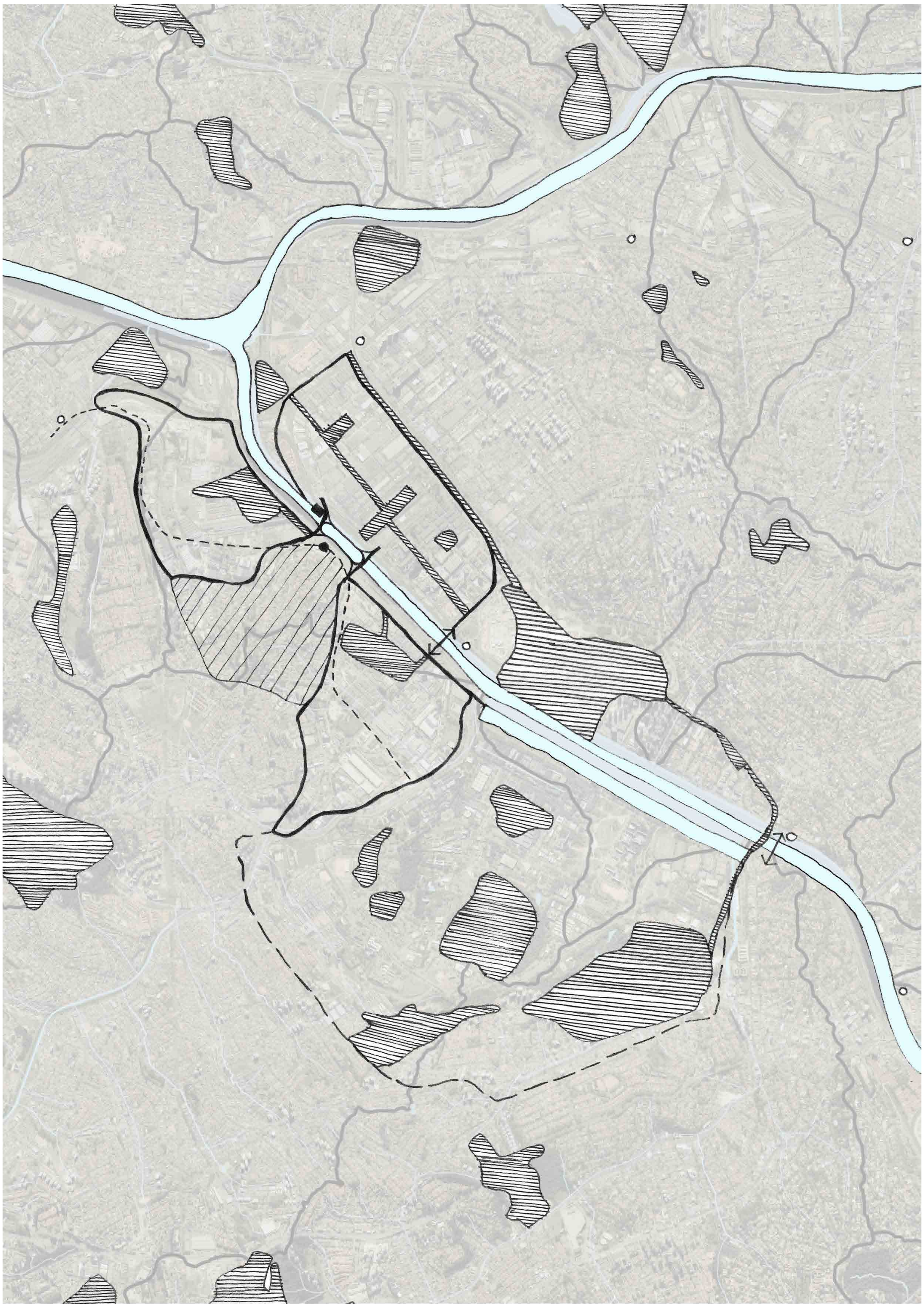


Fig. 11. Proposal at Macro Scale. Source: Authors

▢	Mixed Use Dev	— —	Tramway
▨	Jaguare	•	Tram Stop
▤	Pervious Areas	◦	Train Stop
⬚	USP	↔	Existing links

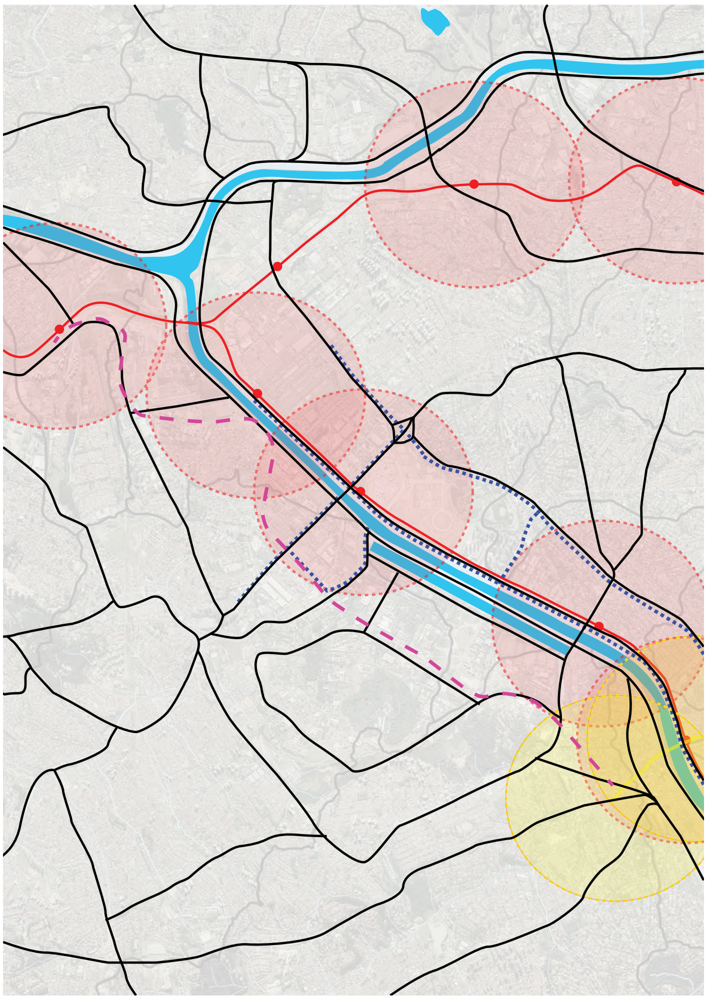


Fig.12. Existing Transportation Network
Source: Authors

Highway

Train

Abandoned Tramway

Cycling Pathway

Catchment Railway Stop

Catchment Metro Stop

Note: Accessibility contour of 1km

Accessibility and Demand

This section shows the calculations in relation to accessibility and demand. The theories as described by Ortúzar & Willumsen (2011) are used. For the first step of trip generation, population and employment data had to be found. To keep the model relatively simple, only commuter flows are determined. Based on (relatively old) data, this is still expected to give information on almost half of all trips made (Swait & Ekseland, 1995). A morning peak model is estimated, so more population leads to more productions. The best data available on population and employment that was found only gave densities (figure 13 and 14).

Because the data is given in density (#/ha), the size of each zone had to be determined.(appendix 2D) First the area was divided into zones, based on the areas for which figure 13 and 14 give separate data. The defined zones are shown below in figure 15.

The zones 1 to 11 are the zones of interest for the meso scale in this report, the last 6 kilometers of the Pinheiros river. Because many trips will go to other zones than these eleven, some ‘external zones’ (E1 to E15) have been defined too. It should be stated though that these external zones are modeled the same as the other zones, since this data is available anyway. No good data was found on the area further outside of this. Hence the outcomes will only relate to commuter flows between these zones and not to traffic going outside or coming from outside this modeled area. Making the rough assumption that each job and each inhabitant leads to 0,8 trips in a morning peak (below 1, since some will go or come from outside the modeled area), the following productions and attractions are found for each zone (table 2). The attractions are scaled towards the productions, such that the total amount of attractions equals the total amount productions, which is important for the trip distribution stage. It was decided to scale towards productions, since household data (population density) is often the most accurate (Ortúzar &

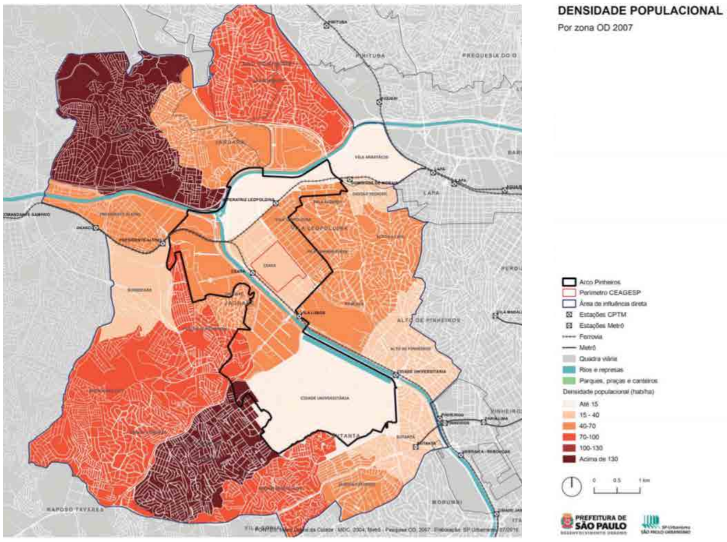


Fig. 13 . Population Density in Sao Paulo
Source: Prefeitura de Sao Paulo, 2016b

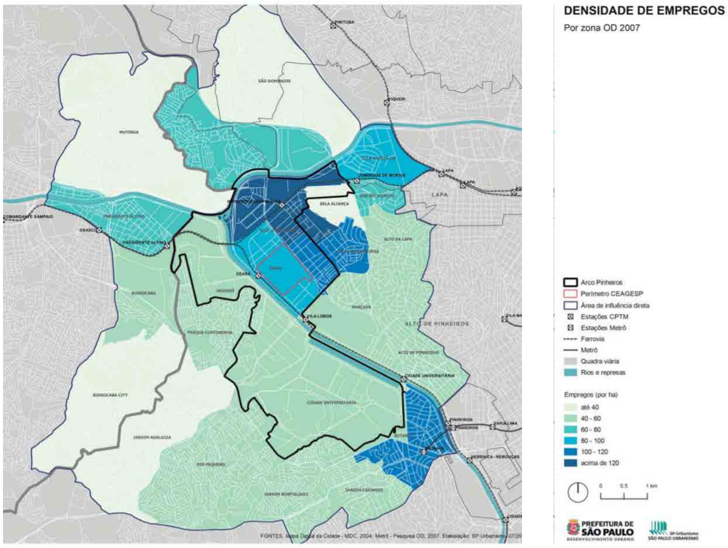


Fig. 14. Job Density in Sao Paulo
Source: Prefeitura de Sao Paulo, 2016b

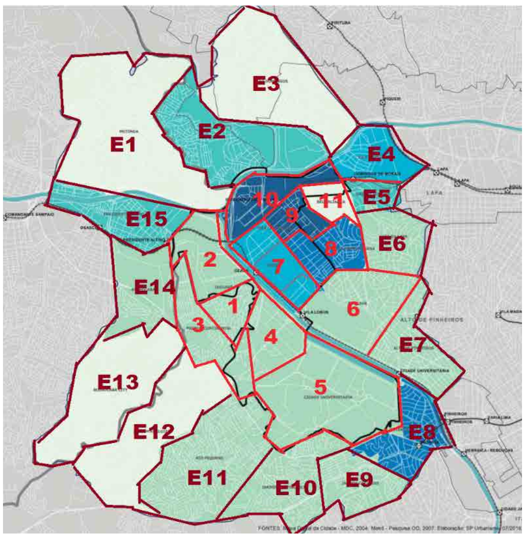


Fig. 15. The defined zones.
Source: Prefeitura de Sao Paulo (2016b)

After this, the trip distribution stage begins, which is modeled simultaneously with the modal split in this report. To do so, using Google Maps, the travel time from the center of each zone to the center of each other zone on an average Tuesday morning around 7:30AM was determined for both the car and for public transport. If no public transport option was given by Google Maps, the walking time was used. For simplicity's sake, a symmetrical travel time matrix was assumed, so the travel time for A to B equals the travel time from B to A. For the same reason, intrazonal travel time of 5 minutes have been assumed for each zone.

Then a deterrence function had to be determined, a simple negative square function was chosen, a regularly chosen function for quick trip distribution modeling (Ortúzar & Willumsen, 2011). This led to the travel time matrix and the skim matrix shown in appendix 2A and 2B.

One iteration of the 'doubly constrained gravity model' was then performed. Table 2 shows us that the total amount of trips originating from zone 1 should be 6.600. This 6.600 is then divided by the sum of the skim matrix values of each zone combination with as origin zone 1. This way the factor is obtained with which each cell should be multiplied. This is then repeated for all other zones too. After this, the first part of the iteration is done. The sum of all trips going to zone 1 should be 7.024. So a similar calculation is done this way too, which is the second part of the first iteration. In turn, this gives us the OD matrix, so the expected amount of trips by car and by public transport made between each zone (see appendix 2C).

With the travel impedances in the skim matrix and the amount of jobs in each zone, a job accessibility score can be calculated for each zone too. (Geurs & Ritsema van Eck, 2001) The values of the skim matrix are simply multiplied with the accompanying amount of jobs of the destination zone. The sum us a score for each zone for job accessibility by car and by public transport. The results of the analysis are treated in the next paragraph.

Outcomes of the Calculation

In the previous paragraph it has been explained how the accessibility to jobs per zone can be calculated. The results are shown below in table 1. Please do note that this is just a score, it has no real measure unit, it doesn't tell the exact amount of jobs an inhabitant of a zone has access to.

As can be seen in table 1, Jaguaré (zone 1) has quite a poor accessibility of jobs, both by car and by public transport. The proposal of this report features no improvements to car traffic but only to public transportation and walking. The proposal ('after' scenario) has been implemented by decreasing the public transportation travel times in the matrix between those zones that are expected to benefit from the bridge and tramway (appendix 2A).

Zone	Mode	Before & After	Mode	Before	After	Increase
1	Car	1.332	PT/Walking	549	881	60,52%
2	**Car**	**3.254**	**PT/Walking**	**652**	**709**	**8,69%**
3	Car	3.080	PT/Walking	583	703	20,55%
4	**Car**	**3.426**	**PT/Walking**	**678**	**700**	**3,14%**
5	Car	2.243	PT/Walking	1.120	1.120	0,00%
6	**Car**	**4.014**	**PT/Walking**	**826**	**830**	**0,44%**
7	Car	4.351	PT/Walking	1.044	1.069	2,39%
8	**Car**	**4.184**	**PT/Walking**	**1.155**	**1.155**	**0,00%**
9	Car	3.526	PT/Walking	1.120	1.120	0,00%
10	**Car**	**4.218**	**PT/Walking**	**2.086**	**2.101**	**0,72%**
11	Car	4.241	PT/Walking	485	505	4,07%

Table 1 The job accessibility by car and public transport in the eleven zones of interest.

Zone	Productions	Attractions
1	6.600	7.024
2	**11.000**	**11.707**
3	13.600	9.365
4	**8.800**	**9.365**
5	3.000	23.413
6	**13.200**	**14.048**
7	4.400	16.858
8	**8.800**	**20.604**
9	6.600	18.263
10	**2.100**	**42.613**
11	6.600	2.810
E1	**75.400**	**12.175**
E10	20.400	14.048
E11	**52.200**	**21.072**
E12	27.200	7.492
E13	**27.200**	**7.492**
E14	5.500	11.707
E15	**13.200**	**19.667**
E2	19.800	29.501
E3	**30.600**	**8.429**
E4	1.500	21.072
E5	**3.300**	**9.834**
E6	11.000	11.707
E7	**4.400**	**9.365**
E8	4.400	20.604
E9	**8.800**	**9.365**
Total	389.600	389.600

Table 2 The productions and attractions of each

Mode	Before		After	
Car	287.929	73,90%	286.677	73,58%
PT/Walking	**101.671**	**26,10%**	**102.923**	**26,42%**

Table 3 The expected modal split in the observation area before and after the design intervention.

As expected, the accessibility of jobs by public transportation from Jaguaré increases strongly. Some other zones benefit too.

Using the trip distribution matrix (appendix 2C) of the new situation with the bridge, one can find the expected numbers of commuters using this bridge in the morning. This number amounts to 2.275 commuters. This is found by summing up the amount of commuters using public transportation between each zone which would likely include a transfer from the Ceasa train station to the new tram. Also the amount of walkers and tram users between Jaguaré and Ceagesp (zones 1 and 7) are included in this. This last number is quite low in the table, but this is for a large part because only one iteration of the doubly constrained gravity model has been performed, and because an increase of jobs in Ceagesp due to the expected redevelopment hasn't been taken into account.

Then, lastly, also the expected new modal split of trips within the whole observation area (including external zones) can be determined. Shown in table 3, one can see that the percentage does decrease, although slightly. When looking at the amount of travelers though, over 1.000 commuters are expected to switch from the car to public transportation. This is not a major amount that will solve a lot of congestion. However, this does only include trips for a commuting purpose, so more trips for other purposes are expected to have a switch from car to public transportation too. Besides, a lot of these trips would use an on-ramp and off-ramp of the 116 highway. With just a several hundred less commuters in the morning, the chances of a breakdown towards a congested state could be postponed some minutes on some days with this as the amount of turbulences on the highway decreases.

Reflection on the Proposal

The outcomes of the calculations mainly support the proposed design intervention regarding mobility on the meso scale.

One can see that Jaguaré indeed has a very poor accessibility to jobs, both by car and by public transport. With the bridge and tramway, this accessibility increases quite substantially. Some other zones benefit from the design intervention too. The accessibility to jobs by car in Jaguaré is very poor too, but it has been decided to focus on increasing public transport for this zone, due to its positive connotation with social equity. The car provides less accessibility to the weaker in society, like the poor, the young, the elderly and the disabled.

It is expected that people will use this bridge for commuting purposes, as it provides a transfer between the Ceasa train station and the tramway, and therefore relatively low travel times by public transport.

Although only to rather small extents, a modal shift towards public transportation can be expected between some zones as a consequence of the better performance regarding travel time of public transportation. To make real changes in the modal split and congestion, more public transport interventions are desired in other places to make it more competitive with the car.

Given how poor the accessibility to jobs is in zone 11 by public transport, also after the design intervention, it may have been better to involve some improvements to the access to train stations from this zone too. One could think of more dedicated bus lanes in this zone, allowing for faster bus transport to a train station for example. The accessibility to jobs by car is really high in this zone though, but as explained, this doesn't provide a lot of accessibility to the weaker in society.

Micro Scale

In the micro scale, the concept of connecting patches and axis of green-blue infrastructure has been carried forward from the macro and meso scale. The proposed link will connect Jaguare to the newly redeveloped CEAGESP. This will add another east-west connection along the Pinheiros at a crucial point. This will mobilize residents in Jaguare to the rest of the city (by linking them to CEASA train station). Once the tramline is refurbished, the tram stop at Jaguare will be an additional link of public transport connecting the neighborhood to the existing light industrial (proposed mixed use development) areas on either side of it.

The micro scale detail focuses on the bridge and uses on either side of the base. The link will be for pedestrians and cyclists only. Users will also be provided access to the riverfront after the soil has been remediated and the pollution levels have decreased. Recreational areas or 'urban parks' can be found on either end of the bridge thus making it an attractive place for residents in the neighborhood. These parks will be raised above the water and will also provide a view point onto the Pinheiros.

Another important goal of the micro scale is to enhance the connection between people and the water. One crucial way to ensure that the river is maintained and used for transportation and recreation is to ensure that residents of Sao Paulo are aware of the importance of Pinheiros. The disconnection from the water caused by massive infrastructure on either side of the river as well as long term pollution can be changed by providing more access points to the riverfront. Residents cannot be expected to embrace and use the river if they don't have a physical connection to it. This link can be an example of what this connection can look and feel like.

The individual features that have been taken into account are shown in figure 16 and described further.

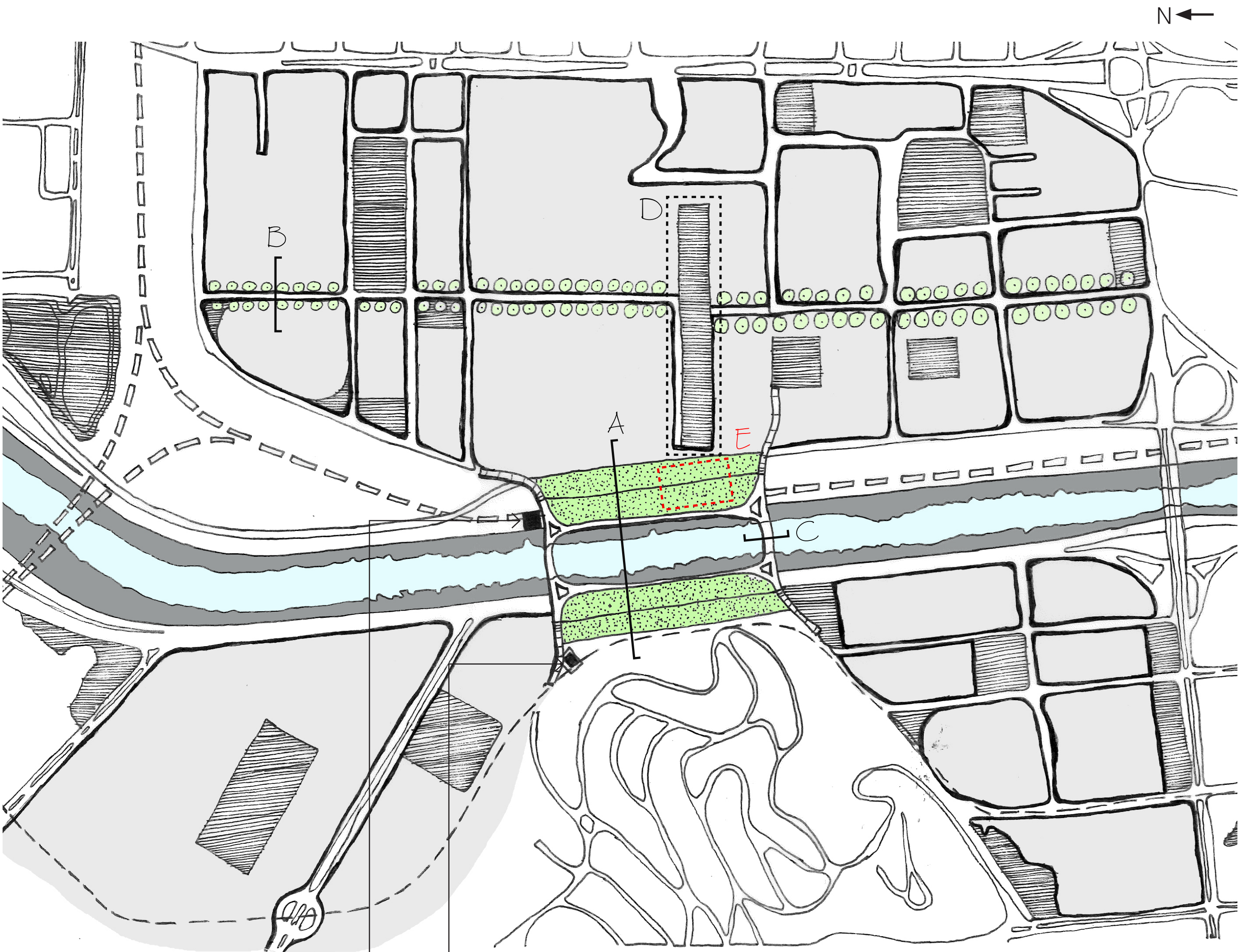


Fig. 16. Proposal at Micro Scale. Source: Authors

Mixed Use Development

Recreational Area

Pervious Areas

Roads

Railway

Refurbished tramway

CEASA train station

Newly proposed tram station

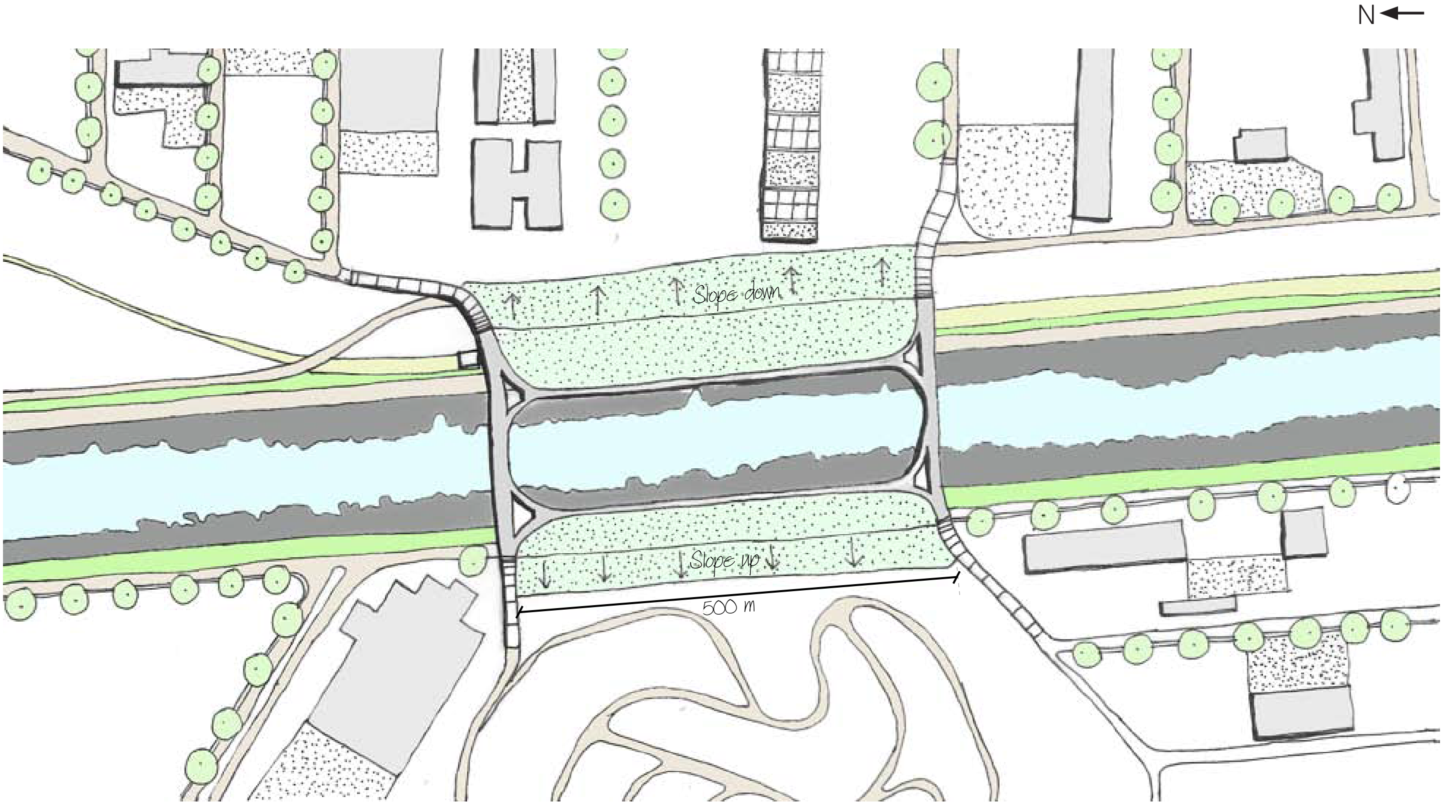


Fig. 17. Detailed Plan. Source: Authors

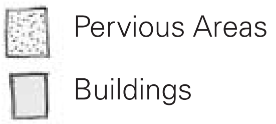


Fig. 18. Section at A. Source: Authors

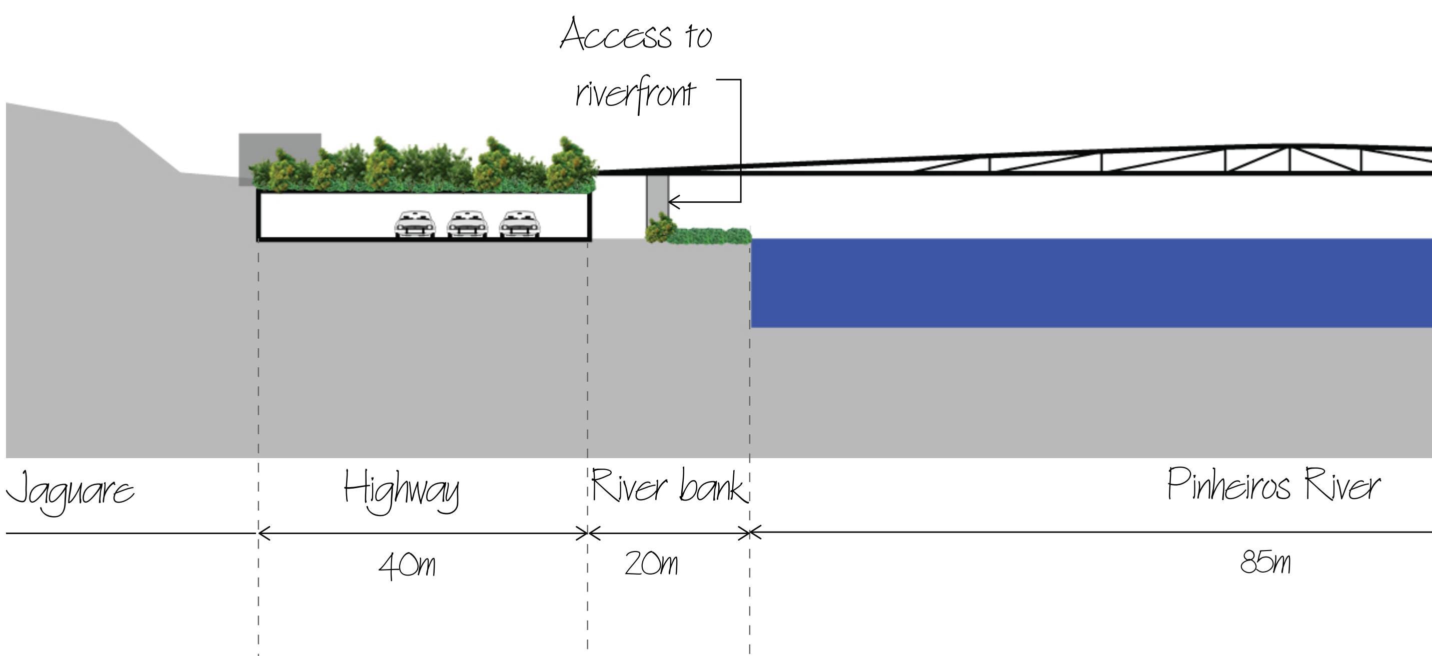


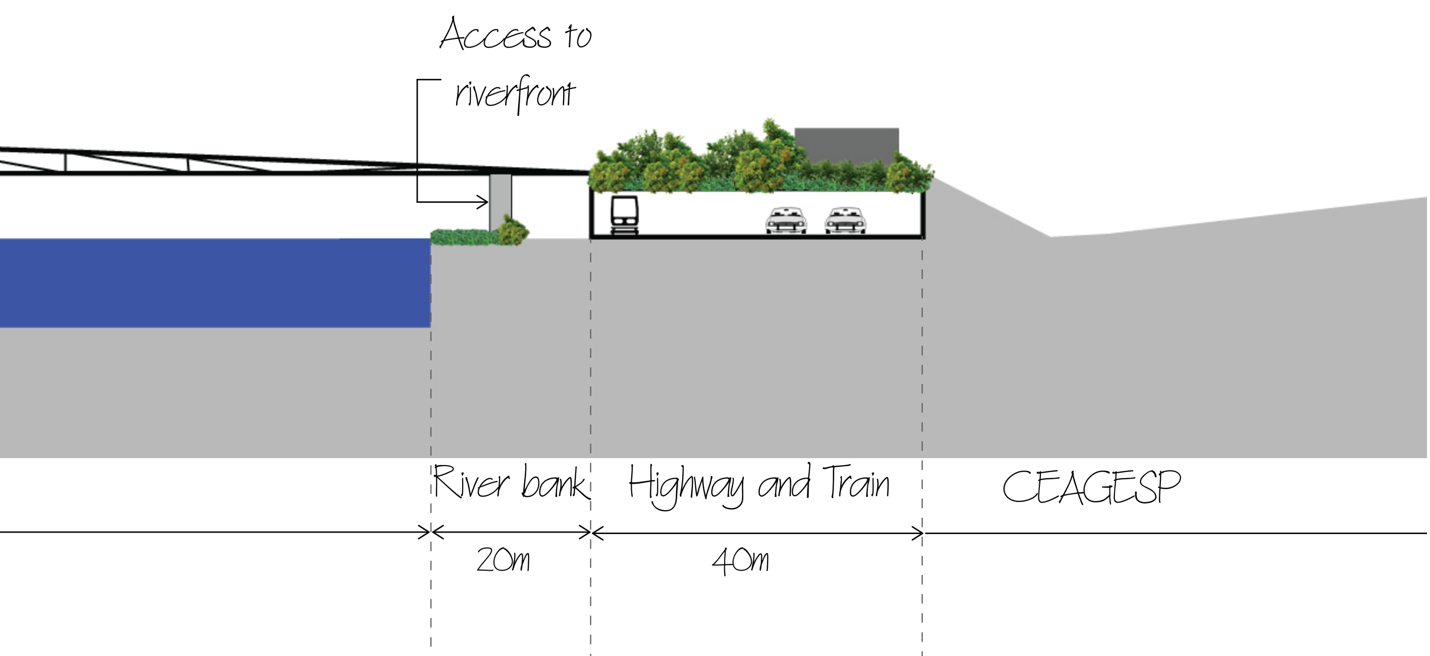
Fig. 19 The Hovenring, Netherlands
Source: http://imgur.com/FdMaIAQ

Fig. 20 lujiazui elevated walkway, Shanghai
Source: http://acdn.architizer.com/thumbnails-PRODUCTION/41/21/4121ebfb81ba9b630322a49d47a6937c.jpg

The bridge spans the Pinheiros River which is about 90m wide. The oval shape of the bridge is a deliberate attempt to cover a longer span along the river front. About half a kilometer long the edge along the water will be the edge to recreational areas on the slope on either side of the bridge. This provides more opportunities for access and viewpoints onto the Pinheiros and shapes the beginning of recreational zones. From here one can also access the bottom of the riverfront at the water edge. This can be implemented at a later time once the water has been cleaned and the soil is remediated.

The recreational zones are lifted above the existing highway and train track by 'uptopping' the current infrastructure thus forming an over ground tunnel for infrastructure. This way pedestrians can access the riverfront without the massive infrastructure being in the way. Also since it stretches out for 500 m, there is a considerable buffer from the noise and emissions from cars below. Another important connection made by the bridge is connecting Jaguare and the proposed tramway to Ceasa train station.

The impression residents would have of the circular pedestrian bridge is similar to examples shown in figure 19 and figure 20 from Shanghai and Netherlands repectively.



Detail at C

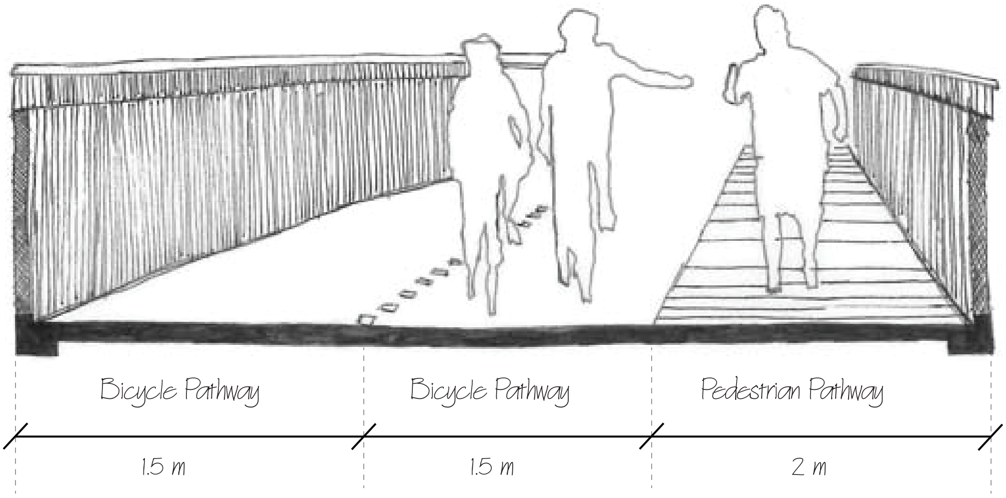


Fig. 21. Section at C. Source: Authors

While on the bridge there would be a close interaction between cyclists and pedestrians. The width of the walkway is proposed to be about 6 meters distributed among cyclists and pedestrians. (figure 21)

The edge of this pathway parallel to the riverfront would also be the beginning to the recreational areas. Being at the heart of heavy urbanization, these 'urban parks' are envisioned to provide the much needed open space for Jaguare and CEAGESP. (figure 22) Apart from installing vegetation within these 'urban parks', facilities such as a football field and outdoor amphitheater can also be built. Another way to raise awareness about the riverfront is to use the urban parks to create an educational experience bridging the gap between people and river. Raising an awareness about pollution in the river and its importance to Sao Paulo can be propagated through having a large recreational zone on either side of Pinheiros. This can be a small step and an example on spreading this awareness to the rest of the city as well as along the riverbanks. In the future, the entire riverfront along the Pinheiros is envisioned to be reserved for recreational use.

Detail at E

Fig. 22.Urban Park by the waterfront
Source: http://riverlifepgh.org/riverfront-guide/allegheny-riverfront-green-boulevard/

Fig. 23. Recreational Area
Source: https://www.pintest.com/watergroen/waterpleinen/

Fig. 24. CEAGESP Market Roof
Source of base image: http://www.bbc.com/news/uk-england-london-29627906

Fig. 25. São Paulo Museum of Modern Art Pavilion, Ibirapuera Park
Source: Authors

Detail at D

The existing market roof in CEAGESP can be retained and converted to a 'green roof' with vegetation (figure 24) . This can help to connect vegetation at a different elevation within the neighborhood and add to perviousness within the area. Moreover, not demolishing but re-developing while maintaining the overall structure will have a lower monetary cost. The area underneath the market roof can be converted to a public space, as seen in Ibirapuera Park. The outdoor pavilion connected to the Sao Paulo Museum of Modern Art designed by Oscar Niemeyer (figure 25) is a successful example of such a space within the city. Although massive it connect multiple uses and is a busy place bustling with activity.

The main street within CEAGESP (figure 26) can be retained but converted into a boulevard that prioritizes pedestrians. With vegetation on both sides and a bio swale running in the middle of the street, the perviousness and water filtration capacity of the street can be increased. This also improves and increases pedestrian connectivity as the street section remains a constant along the entire length of the neighborhood.

Detail at B

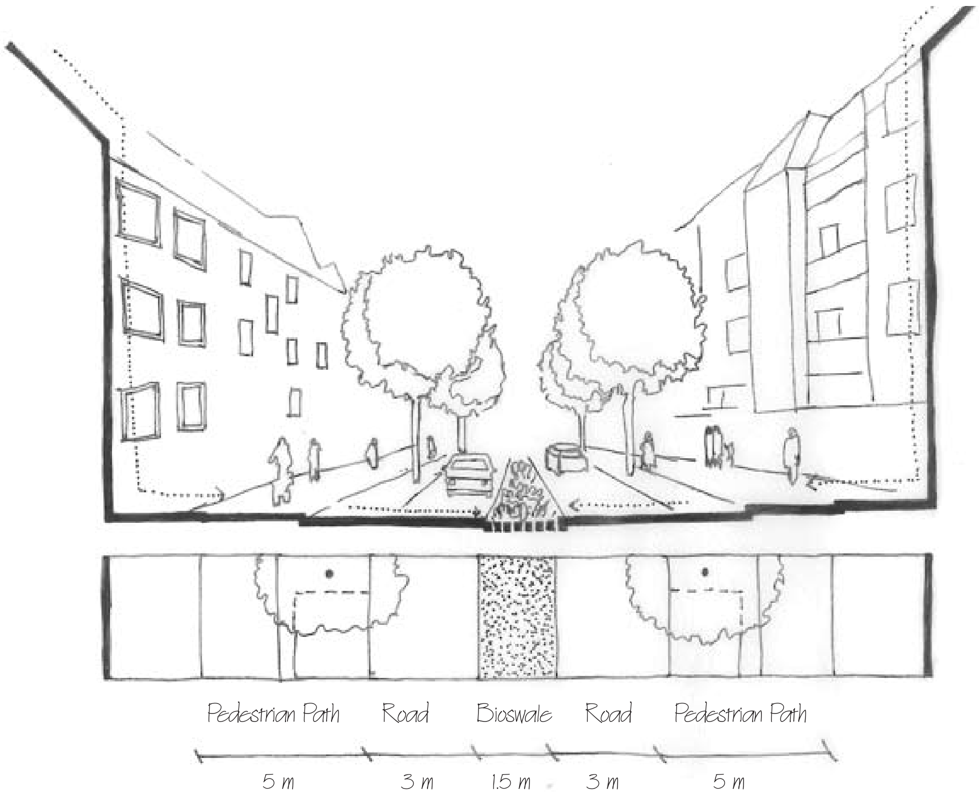


Fig. 26.Section at B.
Source: Authors

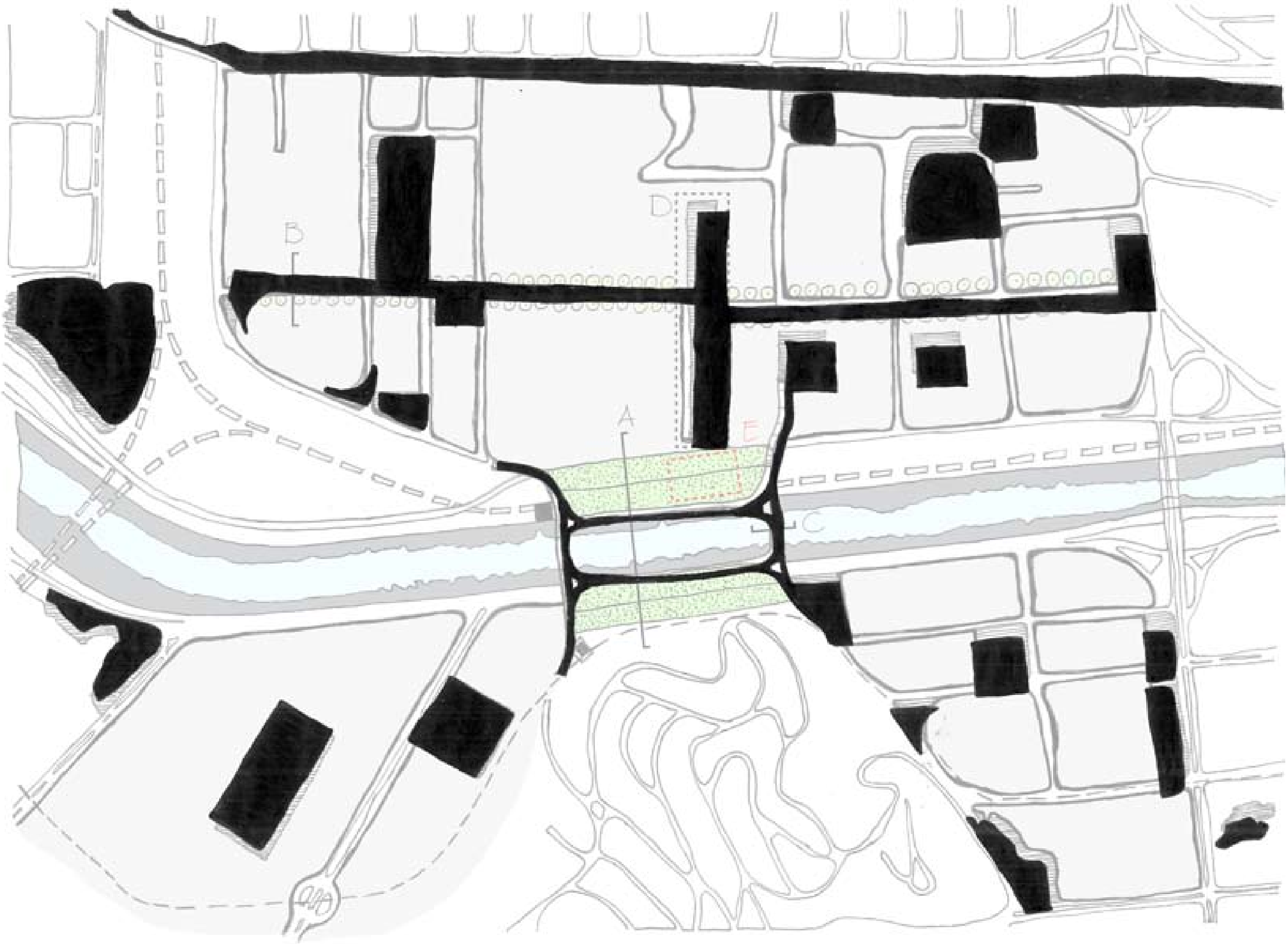


Fig. 27 Concept at Micro Scale
Source: Authors

The proposal provides for recreational areas on the same section of the river bank along the Pinheiros along a stretch of 500m. After a closer look at existing land uses surrounding the area is it clear that it a much needed open space within the dense urban fabric. Providing recreational uses that can also be an option for water retention is appropriate given the soil type and elevation of the land. Being within a floodplain, it is not advisable to have more intensive uses so close to the river edge.

A major feature of the link at this scale is to connect people to the water, but it is not feasible for possible many years until the water within the Pinheiros is not cleaned up. Moreover, the soil along the riverbed also has to be remediated before it is safe to be accessed. This will require a large investment and cooperation among many stakeholder, which is something that was easily overlooked in the initial ideas.

A possibility of introducing an important public transport link as well a recreational area will improve conditions for Jaguare as well as the newly developed CEAGESP. While this might integrate well within a newly designed neighborhood, there are always chances of this intervention gentrifying Jaguare. Measures to keep this within check need to be in place as well.

The link won't be complete by just building the bridge, it needs the uptopping of the highway, followed by the recreational areas, access to the riverfront and refurbishing the tramline. The design objectives will be achieved once it is fully operational. This cannot be termed as a 'quick win' project and will need to be revised during the phasing plan to achieve smaller objectives at every step.

Reflection

The vision of Blue Arches is projected on three scales. The macro scale emphasizes the use of blue-green networks to provide sustainable water management solutions. Social inequity and mobility is addressed on the meso scale. The micro scale focusses on the perspective of the users. Blue Arches should introduce a certain level of service to be an addition to the users.

Green and water abundance in the living spaces enriches life in the city. Living in areas surrounded by green areas reduces the stress level. Main condition for this green spaces is that it does not decrease the level of social safety and that people value the green and blue space accordingly. On the contrary of the health benefits of green spaces, blue spaces as in open water can introduce health risks. When not properly managed, stagnant or polluted water can result in illness of people in contact with the water.

Linkage of Jaguare and CEAGESP provides spatial and social equality. The bridge functions as a recreational and commuting area where people from different social classes meet and pass each other. The financial and business district become within reach for the Jaguare area, enhancing their perspective of income and development. The middle point of the link gives a tremendous oversight of the rich and clean Pinheiros River, the connected green area and the skyline of Sao Paulo.

Maintenance of the green and blue spaces is key to prevent the spaces for becoming dumping sites, polluted puddles or creepy dark corners. Besides societal investments, also economical investments have to be considered for green and blue networks. Admittedly maintenance is a constraint for implementing green and blue areas, due to the costs that and administration that comes with it.

The vision of Blue Arches can contribute to the connection of people and the pleasant living and working environment if the green-blue measures, the bridge and the Pinheiros River are designed and maintained properly and the areas are intended for public use.

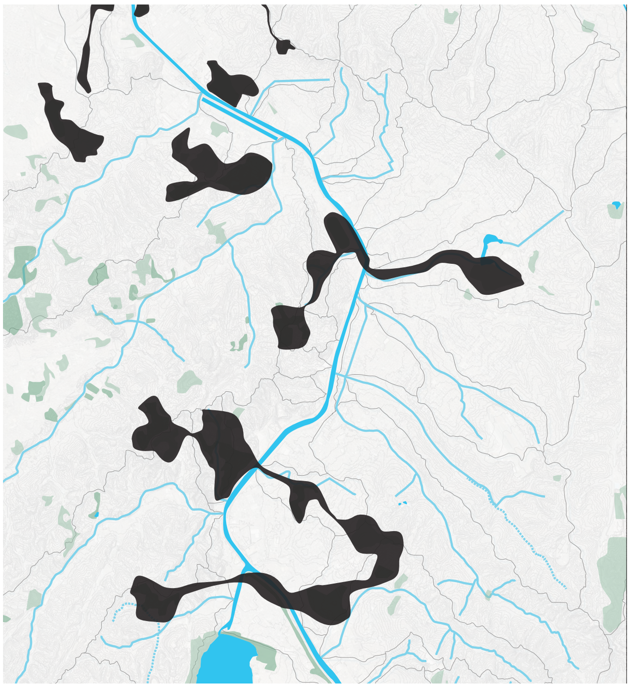


Fig. 28 Concept at Micro Scale
Source: Authors

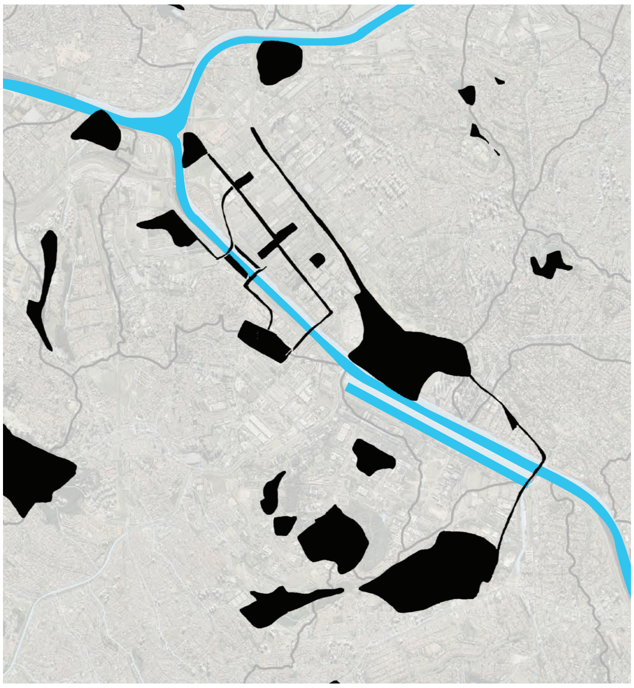


Fig. 29 Concept at Meso Scale
Source: Authors

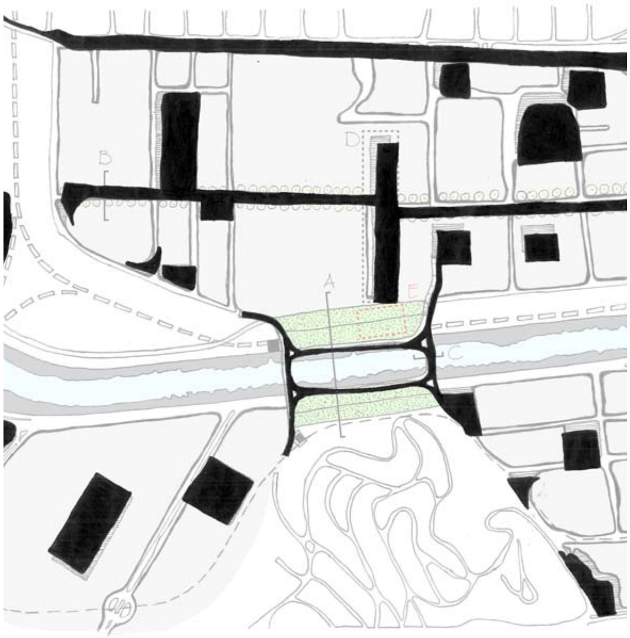


Fig. 30 Concept at Micro Scale
Source: Authors

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Appendix 1 : Water Management

Appendix A : Runoff calculation using the Rational Method

Rainfall-runoff processes

Runoff calculated by the rational method is the part of the precipitation that flows over the surface. Only if the precipitation exceeds the demand for interception, evaporation, infiltration and depression (surface) storage, runoff occurs. The rate and volume of the runoff depends on the characteristics of the catchment (slope, surface cover, size and shape) and of the storm event (intensity, duration and area extent).

The rational method is a quick and simplified method to give a rough estimate for a design peak runoff rate. One of the simplifications of the method is the assumption that the rainfall intensity is equal for the entire catchment over the whole duration, while in reality the intensity can vary enormously. The runoff can be calculated by the following formula: q = CiA. In which:

q = design peak runoff rate [m3/s]

C = runoff coefficient [-]

i = rainfall intensity [m] for a duration equal to the time of concentration [s]

A = sub catchment area [m2]

A number of steps is carried out to give a rough peak runoff per sub catchment.

1. Determine surface cover of the catchment area using the land use GIS map.

The four largest catchments are divided into smaller catchments based on the water course map. This step is carried out to establish a higher accuracy in establishment of the surface cover and therefore the runoff coefficient. Figure 31 presents the sub catchments considered.

2. The numbers of the land use map represent a type of land use. For each subcatchment the percentage of cover for the four most common land use types within the area are estimated. For each type of land use, a runoff factor (derived from the table in document Rain Data_Rational Method_short manual.doc, provided as lecture material) is assigned based on the description of the land use and the assumption that all the areas are sloped. In reality not all areas are sloped, but this gives a safety margin in the calculation of the runoff. Table A shows the runoff factors.

3. An estimate of the area contributing to the runoff is calculated by multiplying the surface area with the runoff coefficient. Similarity in surface cover between the smaller subcatchments and the regular catchments is used to determine the runoff coefficients for the entire catchment, as shown in figure 32.

4. The total peak runoff depends on the design rainfall intensity (de-

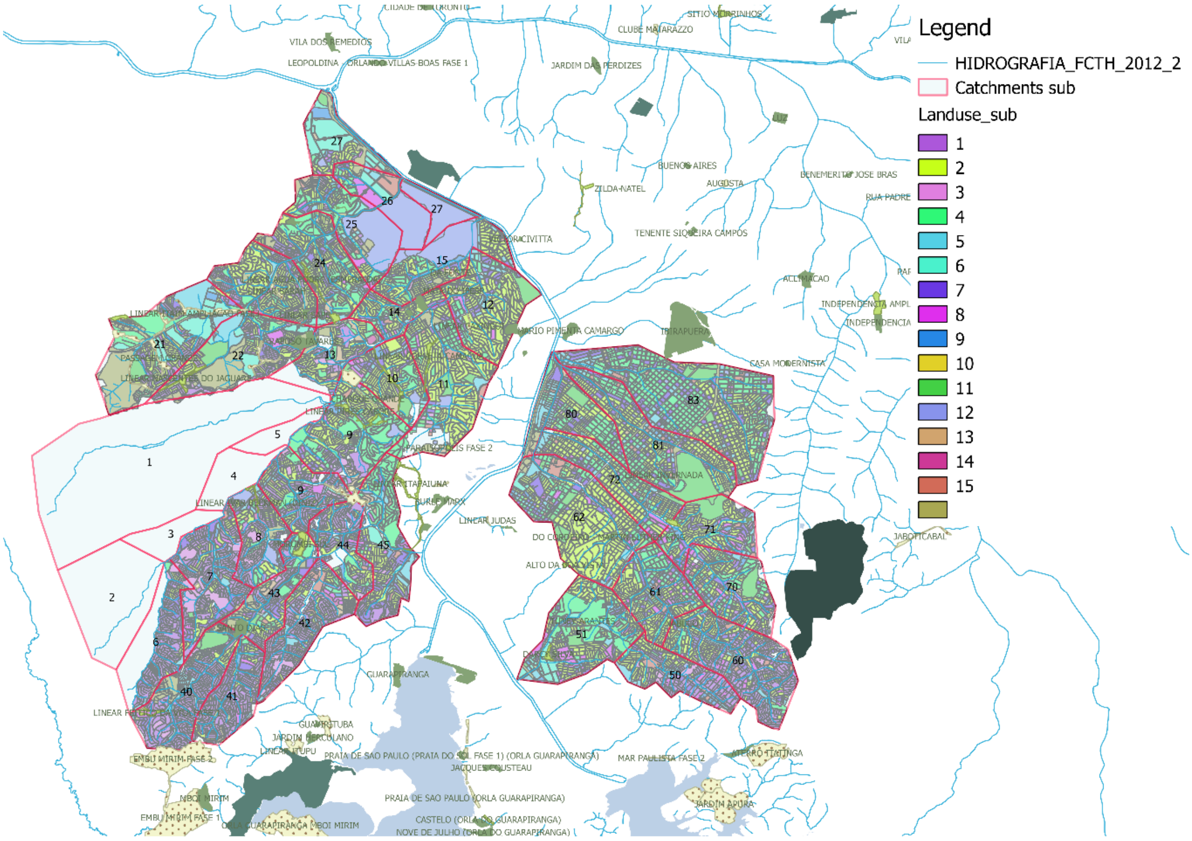


Fig. 31. Land use in subdivision of four largest catchments

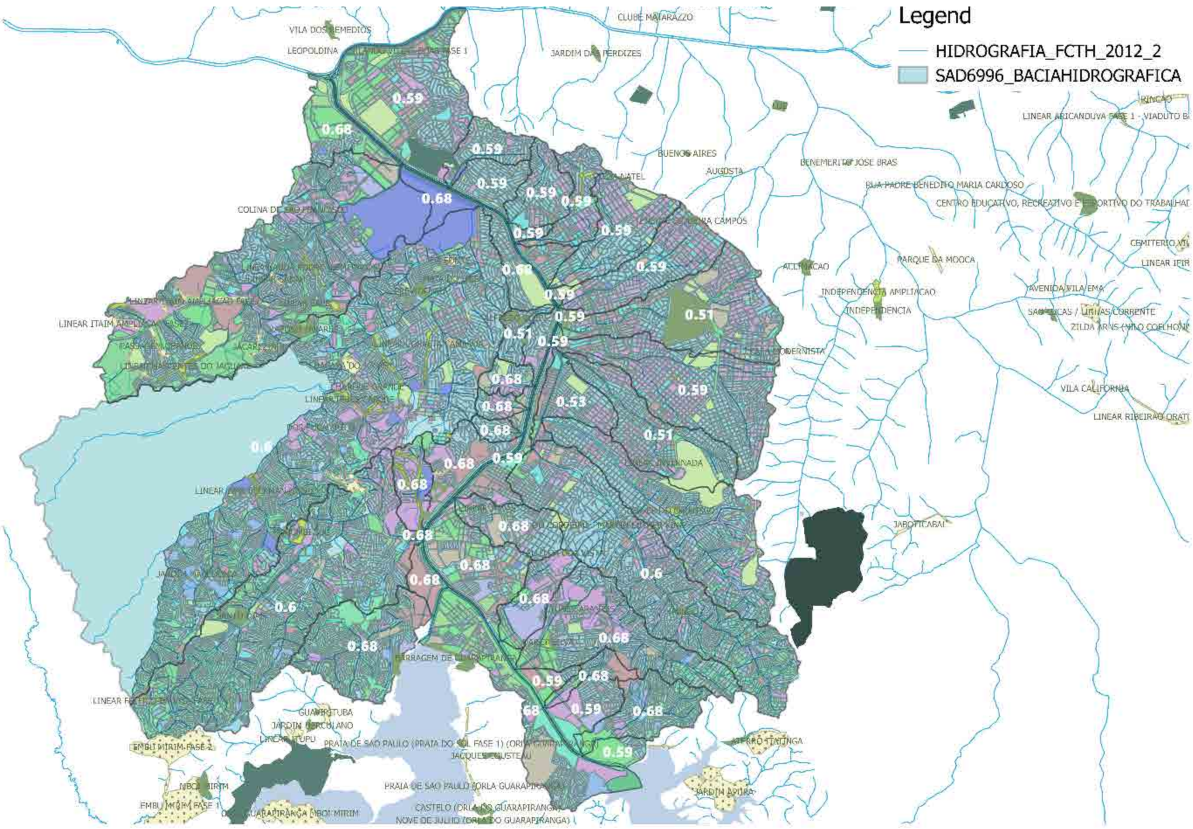


Fig. 32. Calculated and assigned runoff coefficients based on landuse

rived from the Intensity-duration-frequency information), which depends on the size of the catchment and the desired protection level. The simplistic FAA-formula is used to estimate the time of concentration. The FAA-formula is as follows:

FAA equation: t = G (1.1 - c) L0.5 / (100 S)1/3

In which:

G = constant (1.8)

t = time of concentration: the time needed for a water particle to flow from the most remote point to the outlet point (into Pinheiros). If the duration of the rainfall event equals the time of concentration, theoretically all parts of the catchment contribute to the discharge at the outlet.

c = runoff coefficient

L = length of the most remote point to the outlet point

S = slope of the catchment

The largest catchment Corrego Pirajussara is used to determine the time of concentration. The length from the most remote point to the outlet point is set to be 14,000 m. Using the slope (average at 0.268) and the runoff coefficient of 0.6 the time of concentration for the catchment is 63.9 minutes. Considering the inaccuracy, estimates and safety margins already taken into account, for practical reasons t is set to be 60 minutes.

5. In the lectures it is mentioned that a design value for storm water runoff is often settled at a return period of 10 years. Based on this lecture it is assumed that the stormwater system in Sao Paulo is designed for this return period. The extra amount of water to deal with taking climate change and urban expansion into account is the difference between the new design value return period 25 years and the “standard” 10 years. The value for a return period of 10 years is 60.1 mm and the value for a return period of 25 years is 70.5 as showed in table B (source: Rain Data_Rational Method_short manual.doc)

6. The runoff for both values is determined by using the formula of the rational method: q = CiA. The difference in discharge (m3/s) for both design values is displayed in figure 33. This value gives the peak discharge at the outlet point of the catchment that is not conveyed by the storm water system.

Nr.	Description	runoff coefficient
7	residencial + com/service	0,80
15	sem predominancia	0,60
4	R.V. Medio/Alto Padrao	0,60
2	R.H. Medio/Alto Padrao	0,60
5	Comercio e servicos	0,85
8	Residencial + Ind/Armazens	0,85
11	Equipamentos Publicos	0,45
6	Industrias e armazens	0,90
3	R.V. Baixo Padrao	0,80
12	Escolas	0,60
1	R.H. Baixo Padrao	0,80
unknown		0,80

Table A. Land use and corresponding runoff coefficient

Duração t (minutos)	Período de Retorno T (anos)								
	2	5	10	15	20	25	50	100	200
10	16,2	21,1	24,4	26,2	27,5	28,5	31,6	34,6	37,6
20	24,9	32,5	37,6	40,4	42,4	44,0	48,7	53,4	58,1
30	30,3	39,8	46,0	49,5	52,0	53,9	59,8	65,6	71,4
60	39,3	51,8	60,1	64,7	68,0	70,5	78,3	86,0	93,6
120	46,8	62,1	72,2	78,0	82,0	85,1	94,6	104,0	113,4
180	50,5	67,3	78,4	84,7	89,1	92,4	102,9	113,2	123,5
360	55,7	74,9	87,5	94,7	99,7	103,6	115,4	127,2	139,0
720	60,2	81,5	95,6	103,6	109,2	113,5	126,7	139,9	153,0
1080	62,5	85,1	100,1	108,6	114,5	119,0	133,1	147,0	160,9
1440	64,1	87,7	103,3	112,1	118,2	122,9	137,6	152,1	166,5

Table B. Data rainfall intensity-duration-frequency for Sao Paulo

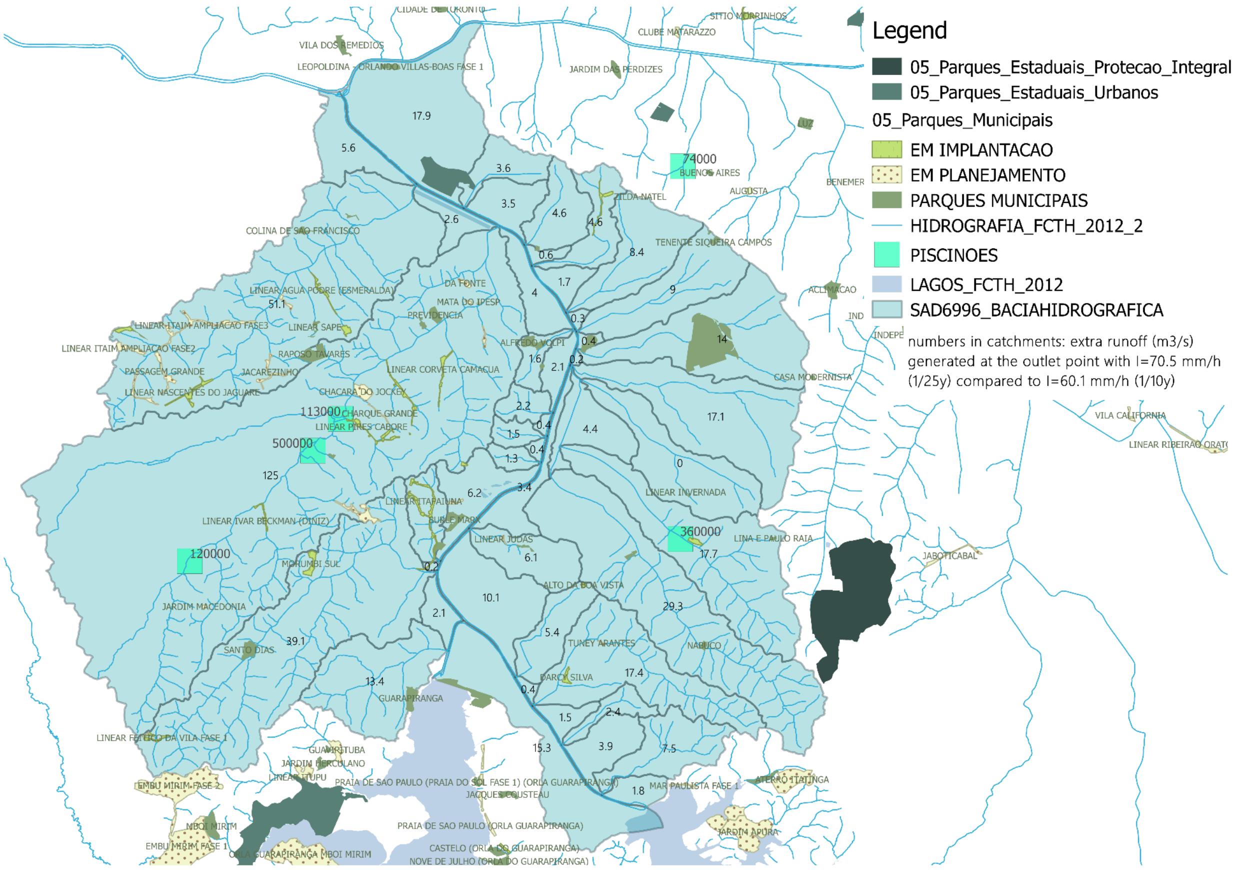
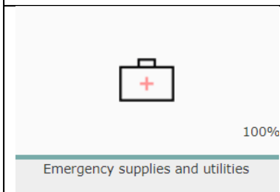
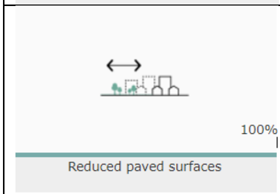
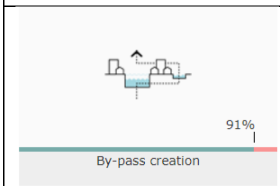
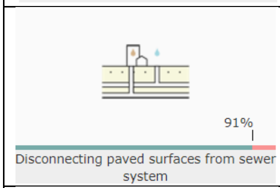
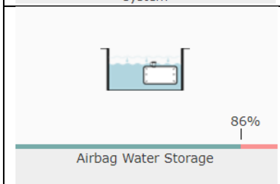
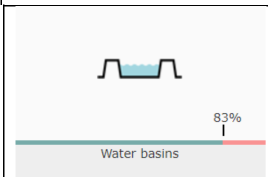


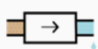
Fig. 33. Difference in discharge (m3/s) between I=60,1 mm (1/10y) and I=70,5mm (1/25y)

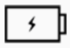
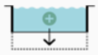
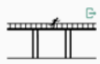
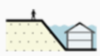
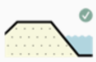
Appendix B : Sustainable Urban Drainage Solutions

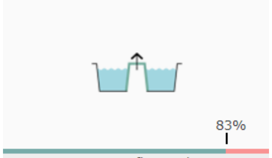
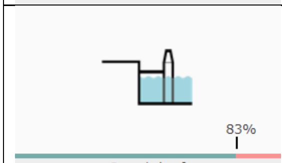
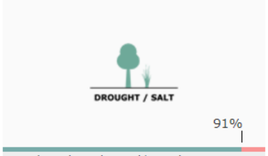
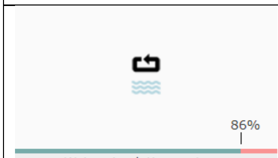
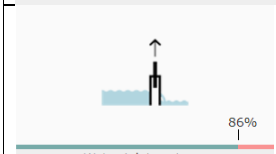
The climate app (climateapp.nl) is developed by a collective of Dutch companies. Through a selection of different conditions, the app calculates the applicability of certain measures based on the initial conditions. A wide range of possible solutions including the relevance is the output of the app. Only the solutions with a relevance of 80% or more for flooding and drought related issues are considered.

Input: City centre – Sloping area – city scale – improving existing situation

Adaptation solution & relevance	Description (www.climateapp.nl)	Remark for Sao Paulo	Adaptation target
	Emergency supplies and utilities are necessary in case of a flood emergency. It should consist of food and drinks, first aid kit and other provisions to survive or continue operating for instance a hospital or business.	Necessary in worst case scenario.	Pluvial / Fluvial flooding / Drought / clay & rock soil
	Paved surfaces like roofs, roads and parking lots, reduce the infiltration capacity of the soil and increase the surface water runoff. As a consequence, flood risk and the need for additional water retention capacity is increased. By decreasing the total area of paved surfaces, more water is can infiltrate the soil and extra green space is created. The increase in green space also has a positive effect on the heating of a city. Green areas help cooling the area by providing shade and the possibility of evapotranspiration.	Voids have to be available to implement	Pluvial flooding / Drought / clay & rock soil
	Creating a bypass for a river or canal can reduce flood levels in a specific location. A bypass provides extra discharge capacity for the river or canal. Thereby known bottlenecks can be solved.	Applicable downstream and land possibly available at CEAGESP Area	Pluvial flooding / clay soil
	Disconnecting paved surfaces from sewer system means to reduce the amount of clean runoff water collected in combined sewer systems. Instead of collecting runoff in the sewer, the runoff is transported to surface water, collected for water reuse or infiltrated into the soil. This way the risk of pluvial flooding is reduced.	Sao Paulo already has separate sewer system, but lack of surface water to discharge into	Pluvial flooding / clay & rock soil
	Airbag Water Storage can be used to increase the water storage capacity without changing the level of the water. To achieve this result a bag is located under water and fastened to a structure to prevent it from floating. When the level of the water body rises due to heavy rainfall, the airbag is emptied to an extent that the rise of the water level is eliminated. The airbag can be re-inflated when storage is no longer needed. The static water level during heavy rainfall and the increased water storage within the area, are the main advantages of the Airbag Water Storage measure.	Lack of storage capacity in relation to water levels. Considered not applicable for Sao Paulo	Pluvial flooding / clay & rock soil
	Water basins are retention ponds constructed to store water. Water storage can be used to reduce the impact of flood events or to store water for dry periods.	Implementation difficult on sloped areas	Drought / clay soil

 86% Check valve, non-return valves	A check valve or non-return valve is installed in pipes which are vulnerable for backflow in flood conditions. Backflow is known to take place in toilets and sewer systems. The valve will block flow if water flows in the wrong direction.	The area is almost completely sloped, risk of water flowing in the wrong direction is small	Pluvial / Fluvial flooding / clay & rock soil
 86% Network of waterways	A network of water ways is mainly focussed on connecting water bodies which are located near each other. By connecting them with culverts and canals a larger water system is created. This increases the storage capacity of the system and thereby reduces the flood risk.	Might be interesting to investigate possibilities of connecting the underground rivers, but expensive	Pluvial flooding / Drought / clay & rock soil
 86% Pumping station	A pumping station is used to discharge water out of an area. It can be used to transport sewer water in pressure mains. Another option is use in polder systems to pump water from a low lying area into a main water body like a river or a lake. It is always applied when no natural flow of water is possible.	Almost complete area is sloped, but if flooding area is redeveloped might be interesting to consider polders	Pluvial flooding / clay & rock soil
 86% Rain water tanks	A rainwater tank (sometimes called a rain barrel in North America, or a water butt in the UK) is a water tank used to collect and store rain water runoff, typically from rooftops via rain gutters. Stored water may be used for watering gardens, agriculture, flushing toilets, in washing machines or washing cars during dry periods.	Interesting, but must be applied on large scale to have proper contribution. Who pays, maintains, connects?	Pluvial flooding / clay & rock soil
 86% Gutter	A gutter is a non-permeable open drain to collect transport rainwater. Usually a gutter runs along a road. It is connected to either a manhole or a surface water body.	Interesting along large roads, but no surface water body to connect to. Possible to connect other networks	Pluvial flooding / rock soil
 91% Protection life support facilities and dangerous goods	Life support facilities and dangerous goods like nuclear plants should be well defended against climate extremes. This vital infrastructure should be up and running even during extreme conditions.	Applicable in combination with emergency supplies and utilities and as part of discussion for protection level	Fluvial flooding / clay & rock soil
 91% Temporary flood protection (including sand bags, inflatable constructions and	Temporary perimeter flood barriers consist of complete removable components, which are installed following a flood warning and dismounted after the end of a flood period. The temporary flood protection is especially interesting for use in the urban context as it takes less space than a permanent flood protection. Most likely the temporary measures are stored in special locations.	Applicable short or long term solution for high risk locations	Fluvial flooding / clay & rock soil
 83% Use of native species	Use of native plant species in green areas is a good option in many ways. Native species are already adapted to the local climate and its extremes. In arid countries native species re better capable of withstanding the heat.	This is already the case in Sao Paulo	Drought / clay & rock soil
 83% Use of treated wastewater	Using treated waste water can be a method to reduce freshwater consumption and limit the need for freshwater retention in lakes and ponds. Wastewater can be treated to certain degrees. Water can be treated up to the point that is can be used for irrigation, flushing, fire suppression and industrial cooling. In some cases wastewater will even be preferred for irrigation over other water resources, since wastewater has a high nutrient load. Waste water can also be purified up to the point that is becomes suitable to drink. Various techniques can be used to achieve this high treatment grade including, ozonation, UV treatment, chlorination, membrane treatment, reverse osmosis, and others.	Tap water is already not meant for drinking water. Long term project to improve this system. Not relevant now	Drought / clay & rock soil

 86% Power generators	Power generators are a backup for the public power supply in case of flood events. Some vulnerable or vital objects need to be operational at all time. For instance life support systems in hospitals or vital infrastructure like storm surge barriers.	Applicable short or long term solution for high risk locations	Fluvial flooding / clay & rock soil
 83% Deepen water bodies	To mitigate droughts it is necessary that sufficient water can be stored during the wet period, so it becomes available during a drier period. To maximize storage capacity the volume of water bodies can be increased. One way to increase the storage volume is by increasing the depth of rivers, canals and ponds. The amount of water which can be stored in this way can become available when water is scarce. The water bodies are refilled when water is abundant during wet periods. Increased helps reducing flood risk as rivers are able to transport a larger amount of water and ponds and lakes have a larger retention capacity.	Might be a possibility for the entire water system. Also maintaining the water depth by dredging will contribute to the retention capacity	Fluvial flooding / Drought / clay & rock soil
 83% Evacuation routes at elevated level	Evacuation routes at an elevated level are necessary to as a route for safe evacuation in flood events. They should be constructed above the highest expected flood level. People affected by the floods can use the routes to reach safe (higher) ground.	Applicable in the flood prone areas	Fluvial flooding / clay & rock soil
 83% Floodplain excavation or enlargement	The floodplain can be enlarged by lowering the level or increasing the width of the floodplain. Enlarging the floodplain will create more room for the river thereby increasing the discharge capacity and provide upstream retention. The risk of flooding is decreased as the capacity of the river to convey water is increased.	Applicable in the areas to be redeveloped and low lying areas, Room for river	Fluvial flooding / clay soil
 83% Green shores and riverbanks	Adding green in the streetscape reduces the impact of the heat island effect. Trees provide shade and transform the heat through their capacity of evapotranspiration. This greening can be done by tree lines along streets or by creating parks in the urban area.	Applicable in streets and maybe also along the riverbanks creating ecological networks	Fluvial flooding / Drought / clay & rock soil
 83% Safe ground for flood events	Safe grounds are (isolated) parts of ground that are out of reach of high water levels in case of a flood event. These safe grounds can be naturally formed at random locations in flood risk plains or artificially shaped at specific places in the public space.	Applicable and also suggested by team of masterplan proposal, but expensive	Fluvial flooding / clay & rock soil
 83% Unbreakable dike	An unbreakable dike is an over-dimensioned dike which will protect low lying land for a longer time span than a traditional dike. Most likely the dike is higher and wider than required by design standards. An unbreakable dike requires less maintenance during its lifetime.	Applicable but not desired due to lost connection of people with water	Fluvial flooding / clay soil

 Compartments in inflowing large waters	The compartments will divide large water surfaces into smaller and better controllable segments. These segments are connected with each other through a system of interacting locks or dams. A smaller amount of water can cause damage to low level terrain in case of a dike breach.	Is already in place at Pinheiros, but might need improvement	Fluvial flooding / Drought / rock soil
 Quay/wharf	A Quay or wharf is a structure on the shore of a harbour or on the bank of a river or canal. I can be a good flood protection in locations where available space is limited. Quays are mostly reinforced concete structures.	Applicable but not desired due to lost connection of people with water	Fluvial flooding / rock soil
 Select drought and/or salt-resistant plants	Increasing droughts and progressing saltwater intrusion also has an impact on the vegetation. Drought or salt-resistant crops are more resilient in periods of drought when water is scarce and seawater intrudes further land-inwards. Choosing these crops will not lead to yield reductions and makes farmers or parks more resilient to the impacts of increasing droughts.	Applicable, but more relevant for rural area	Drought / clay & rock soil
 Water circulation systems	Water circulations systems connect the water flow of neighbouring water bodies. The main goal is prevent stagnant water and to create larger surface water areas to store water in extreme flood conditions. Circulation can be done actively with the use of pumps.	Applicable for Pinheiros if water quality is improved, long term	Drought / clay & rock soil
 Water inlet systems	Implementing a system of water inlets enables the management of water levels throughout a water system. From large infrastructural works to small inlets on the field of a farmer, inlets can be implemented on various scales. Examples of inlets are gates, adjustable weirs or dams with an inlet and diversion channels. The ability to discharge water into the preferred channels allows an area to distribute water to areas where it is most needed. It is therefore a preferred solution when long periods of drought are a major issue in the area.	Applicable, but more relevant for rural area	Drought / clay soil
 Use of groundcover and shrubbery (instead of unplanted surface)	Using groundcover and shrubbery has a few benefits compared to unplanted surfaces. By reducing the velocity of the water on the surface, trees and shrubs improve the infiltration of the water. In addition, plants improve the infiltration rate of the soil. In short, planted surfaces improve the infiltration capacity of the surface and thereby reduce the chance of flooding. Planted surfaces also cool the environment through evapotranspiration and by providing shade. Planted surfaces thereby have the ability to reduce the heat island effect and reduce peak summer temperatures by 1 to 5 degrees Celsius. As it provides shade reduce surface runoff as their features reduce the velocity of the water on the surface. This ability is especially interesting in urban areas where heat reduces the livability of the city.	Voids have to be available to implement	Drought / clay & rock soil

Appendix 2 : Mobility and Accessibility

Appendix A : The travel time matrices

Table 4 -The travel time matrix (in minutes) before the design intervention.

		E1	E3	E2	E15	2	10	E4	E5	E6	11	9	8	7	1	3	E14	E13	E12	E11	4	6	5	E10	E9	E8	E7
E1	Car	5	20	10	15	20	15	20	25	25	25	20	25	20	30	20	20	20	35	35	20	25	30	35	35	25	25
	PT/walking	5	60	30	40	90	45	60	60	60	60	60	60	50	75	90	90	90	90	90	60	60	80	100	100	100	90
E3	Car	20	5	10	20	15	15	10	15	10	10	15	15	20	20	15	25	30	30	30	15	20	25	35	35	20	25
	PT/walking	60	5	30	70	70	35	40	45	40	40	45	50	40	75	75	90	120	75	80	60	60	90	100	75	80	70
E2	Car	10	10	5	15	10	30	15	15	15	10	15	15	10	30	20	20	25	30	30	15	20	25	30	30	20	20
	PT/walking	30	30	5	70	75	30	40	35	35	35	50	55	50	60	75	90	120	90	90	55	60	90	100	90	90	80
E15	Car	15	20	15	5	10	10	15	20	20	20	20	20	15	15	10	10	15	25	25	15	25	25	25	20	15	15
	PT/walking	40	70	70	5	35	45	55	55	60	55	50	55	40	50	45	30	50	80	80	45	55	60	75	60	50	40
2	Car	20	15	10	10	5	15	20	20	20	20	20	15	15	10	5	15	20	20	20	5	15	15	20	15	10	10
	PT/walking	90	70	75	35	5	50	60	55	60	55	50	55	45	25	30	45	90	75	80	40	60	60	75	70	55	45
10	Car	15	15	30	10	15	5	15	15	15	15	10	10	5	30	15	25	25	25	20	10	10	20	25	25	15	15
	PT/walking	45	35	30	45	50	5	40	35	35	30	20	35	20	45	55	70	100	75	70	35	40	70	90	70	55	55
E4	Car	20	10	15	15	20	15	5	5	5	10	15	15	15	35	15	20	25	25	30	15	15	25	25	20	15	20
	PT/walking	60	40	40	55	60	40	5	20	30	25	40	50	55	70	65	75	100	100	90	55	60	90	100	90	75	70
E5	Car	25	15	15	20	20	15	5	5	5	5	10	10	15	35	15	20	25	30	30	15	10	20	25	25	20	15
	PT/walking	60	45	35	55	55	35	20	5	10	15	30	35	40	60	60	70	100	85	80	45	40	75	100	65	65	60
E6	Car	25	10	15	20	20	15	5	5	5	5	10	10	15	30	15	25	25	25	25	15	10	20	25	20	20	15
	PT/walking	60	40	35	60	60	35	30	10	5	15	30	30	45	45	55	65	100	75	80	35	35	65	90	65	60	55
11	Car	25	10	10	20	20	15	10	5	5	5	5	5	15	25	20	25	25	25	25	15	10	20	25	20	20	15
	PT/walking	60	40	35	55	55	30	25	15	15	5	20	30	35	55	60	75	100	80	75	40	45	75	95	70	70	60
9	Car	20	15	15	20	20	10	15	10	10	5	5	5	10	25	20	25	25	25	25	15	10	25	30	25	20	15
	PT/walking	60	45	50	50	50	20	40	30	30	20	5	20	25	30	55	70	100	75	65	35	35	75	90	80	55	50
8	Car	25	15	15	20	15	10	15	10	10	5	5	5	10	25	15	20	25	20	20	10	5	20	25	20	15	15
	PT/walking	60	50	55	55	55	35	50	35	30	30	20	5	25	45	45	55	100	60	60	25	20	65	80	70	55	50
7	Car	20	20	10	15	15	5	15	15	15	15	10	10	5	25	15	25	25	25	20	10	10	20	25	20	15	15
	PT/walking	50	40	50	40	45	20	55	40	45	35	25	25	5	30	45	60	95	65	65	25	35	60	80	60	50	45
1	Car	30	20	30	15	10	30	35	35	30	25	25	25	25	5	10	20	25	25	20	10	20	30	25	20	15	20
	PT/walking	75	75	60	50	25	45	70	60	45	55	30	45	30	5	25	45	90	45	30	25	40	35	60	55	50	50
3	Car	20	15	20	10	5	15	15	15	15	20	20	15	15	10	5	5	15	15	15	10	15	20	20	20	15	15
	PT/walking	90	75	75	45	30	55	65	60	55	60	55	45	45	25	5	20	40	65	65	30	50	60	60	70	60	50
E14	Car	20	25	20	10	15	25	20	20	25	25	25	20	25	20	5	5	10	20	20	15	20	25	25	25	25	20
	PT/walking	90	90	90	30	45	70	75	70	65	75	70	55	60	45	20	5	30	75	70	40	55	75	65	80	70	60
E13	Car	20	30	25	15	20	25	25	25	25	25	25	25	25	25	15	10	5	15	15	20	25	25	25	25	25	25
	PT/walking	90	120	120	50	90	100	100	100	100	100	100	100	95	90	40	30	5	60	60	90	100	90	80	90	75	90
E12	Car	35	30	30	25	20	25	25	30	25	25	25	20	25	25	15	20	15	5	5	20	25	20	15	15	20	20
	PT/walking	90	75	90	80	75	75	100	85	75	80	75	60	65	45	65	75	60	5	30	45	60	60	50	45	45	60
E11	Car	35	30	30	25	20	20	30	30	25	25	25	20	20	20	15	20	15	5	5	15	15	15	10	15	20	15
	PT/walking	90	80	90	80	80	70	90	80	80	75	65	60	65	30	65	70	60	30	5	45	55	60	40	60	60	70
4	Car	20	15	15	15	5	10	15	15	15	15	15	10	10	10	10	15	20	20	15	5	10	15	15	15	10	10
	PT/walking	60	60	55	45	40	35	55	45	35	40	35	25	25	25	30	40	90	45	45	5	30	45	65	55	45	35
6	Car	25	20	20	25	15	10	15	10	10	10	10	5	10	20	15	20	25	25	15	10	5	15	20	15	10	5
	PT/walking	60	60	60	55	60	40	60	40	35	45	35	20	35	40	50	55	100	60	55	30	5	60	75	60	55	35
5	Car	30	25	25	25	15	20	25	20	20	20	25	20	20	30	20	25	25	20	15	15	15	5	15	10	10	15
	PT/walking	80	90	90	60	60	70	90	75	65	75	75	65	60	35	60	75	90	60	60	45	60	5	50	40	30	40
E10	Car	35	35	30	25	20	25	25	25	25	25	30	25	25	25	20	25	25	15	10	15	20	15	5	10	15	20
	PT/walking	100	100	100	75	75	90	100	100	90	95	90	80	80	60	60	65	80	50	40	65	75	50	5	40	40	60
E9	Car	35	35	30	20	15	25	20	25	20	20	25	20	20	20	20	25	25	15	15	15	15	10	10	5	15	15
	PT/walking	100	75	90	60	70	70	90	65	65	70	80	70	60	55	70	80	90	45	60	55	60	40	40	5	25	35
E8	Car	25	20	20	15	10	15	15	20	20	20	20	15	15	15	15	25	25	20	20	10	10	10	15	15	5	5
	PT/walking	100	80	90	50	55	55	75	65	60	70	55	55	50	50	60	70	75	45	60	45	55	30	40	25	5	30
E7	Car	25	25	20	15	10	15	20	15	15	15	15	15	15	20	15	20	25	20	15	10	5	15	20	15	5	5
	PT/walking	90	70	80	45	45	55	70	60	55	60	50	50	45	50	50	60	90	60	70	35	35	40	60	35	30	5

Table 4 -The travel time matrix (in minutes) after the design intervention. In yellow, the travel times that have been manually decreased.

		E1	E3	E2	E15	2	10	E4	E5	E6	11	9	8	7	1	3	E14	E13	E12	E11	4	6	5	E10	E9	E8	E7
E1	Car	5	20	10	15	20	15	20	25	25	25	20	25	20	30	20	20	20	35	35	20	25	30	35	35	25	25
	PT/walking	5	60	30	40	90	45	60	60	60	60	60	60	50	75	90	90	90	90	90	60	60	80	100	100	100	90
E3	Car	20	5	10	20	15	15	10	15	10	10	15	15	20	20	15	25	30	30	30	15	20	25	35	35	20	25
	PT/walking	60	5	30	70	70	35	40	45	40	40	45	50	40	75	75	90	120	75	80	60	60	90	100	75	80	70
E2	Car	10	10	5	15	10	30	15	15	15	10	15	15	10	30	20	20	25	30	30	15	20	25	30	30	20	20
	PT/walking	30	30	5	70	75	30	40	35	35	35	50	55	50	60	75	90	120	90	90	55	60	90	100	90	90	80
E15	Car	15	20	15	5	10	10	15	20	20	20	20	20	15	15	10	10	15	25	25	15	25	25	25	20	15	15
	PT/walking	40	70	70	5	20	45	55	55	60	55	50	55	40	25	25	30	50	80	80	45	55	60	75	60	50	40
2	Car	20	15	10	10	5	15	20	20	20	20	20	15	15	10	5	15	20	20	20	5	15	15	20	15	10	10
	PT/walking	90	70	75	20	5	50	60	55	60	55	50	55	45	15	30	45	90	75	80	40	60	60	75	70	55	45
10	Car	15	15	30	10	15	5	15	15	15	15	10	10	5	30	15	25	25	25	20	10	10	20	25	25	15	15
	PT/walking	45	35	30	45	50	5	40	35	35	30	20	35	20	20	55	70	100	75	70	35	40	70	90	70	55	55
E4	Car	20	10	15	15	20	15	5	5	5	10	15	15	15	35	15	20	25	25	30	15	15	25	25	20	15	20
	PT/walking	60	40	40	55	60	40	5	20	30	25	40	50	55	25	40	75	100	100	90	55	60	90	100	90	75	70
E5	Car	25	15	15	20	20	15	5	5	5	5	10	10	15	35	15	20	25	30	30	15	10	20	25	25	20	15
	PT/walking	60	45	35	55	55	35	20	5	10	15	30	35	40	25	40	70	100	85	80	45	40	75	100	65	65	60
E6	Car	25	10	15	20	20	15	5	5	5	5	10	10	15	30	15	25	25	25	25	15	10	20	25	20	20	15
	PT/walking	60	40	35	60	60	35	30	10	5	15	30	30	45	45	55	65	100	75	80	35	35	65	90	65	60	55
11	Car	25	10	10	20	20	15	10	5	5	5	5	5	15	25	20	25	25	25	25	15	10	20	25	20	20	15
	PT/walking	60	40	35	55	55	30	25	15	15	5	20	30	35	20	40	75	100	80	75	40	45	75	95	70	70	60
9	Car	20	15	15	20	20	10	15	10	10	5	5	5	10	25	20	25	25	25	25	15	10	25	30	25	20	15
	PT/walking	60	45	50	50	50	20	40	30	30	20	5	20	25	30	55	70	100	75	65	35	35	75	90	80	55	50
8	Car	25	15	15	20	15	10	15	10	10	5	5	5	10	25	15	20	25	20	20	10	5	20	25	20	15	15
	PT/walking	60	50	55	55	55	35	50	35	30	30	20	5	25	45	45	55	100	60	60	25	20	65	80	70	55	50
7	Car	20	20	10	15	15	5	15	15	15	15	10	10	5	25	15	25	25	25	20	10	10	20	25	20	15	15
	PT/walking	50	40	50	40	45	20	55	40	45	35	25	25	5	15	45	60	95	65	65	25	35	60	80	60	50	45
1	Car	30	20	30	15	10	30	35	35	30	25	25	25	25	5	10	20	25	25	20	10	20	30	25	20	15	20
	PT/walking	75	75	60	25	15	20	25	25	45	20	30	45	15	5	15	45	90	45	30	15	30	35	60	55	50	35
3	Car	20	15	20	10	5	15	15	15	15	20	20	15	15	10	5	5	15	15	15	10	15	20	20	20	15	15
	PT/walking	90	75	75	25	30	55	20	20	55	40	55	45	45	15	5	20	40	65	65	30	50	60	60	70	60	50
E14	Car	20	25	20	10	15	25	20	20	25	25	25	20	25	20	5	5	10	20	20	15	20	25	25	25	25	20
	PT/walking	90	90	90	30	45	70	75	70	65	75	70	55	60	45	20	5	30	75	70	40	55	75	65	80	70	60
E13	Car	20	30	25	15	20	25	25	25	25	25	25	25	25	25	15	10	5	15	15	20	25	25	25	25	25	25
	PT/walking	90	120	120	50	90	100	100	100	100	100	100	100	95	90	40	30	5	60	60	90	100	90	80	90	75	90
E12	Car	35	30	30	25	20	25	25	30	25	25	25	20	25	25	15	20	15	5	5	20	25	20	15	15	20	20
	PT/walking	90	75	90	80	75	75	100	85	75	80	75	60	65	45	65	75	60	5	30	45	60	60	50	45	45	60
E11	Car	35	30	30	25	20	20	30	30	25	25	25	20	20	20	15	20	15	5	5	15	15	15	10	15	20	15
	PT/walking	90	80	90	80	80	70	90	80	80	75	65	60	65	30	65	70	60	30	5	45	55	60	40	60	60	70
4	Car	20	15	15	15	5	10	15	15	15	15	15	10	10	10	10	15	20	20	15	5	10	15	15	15	10	10
	PT/walking	60	60	55	45	40	35	55	45	35	40	35	25	25	15	30	40	90	45	45	5	30	45	65	55	45	35
6	Car	25	20	20	25	15	10	15	10	10	10	10	5	10	20	15	20	25	25	15	10	5	15	20	15	10	5
	PT/walking	60	60	60	55	60	40	60	40	35	45	35	20	35	30	50	55	100	60	55	30	5	60	75	60	55	35
5	Car	30	25	25	25	15	20	25	20	20	20	25	20	20	30	20	25	25	20	15	15	15	5	15	10	10	15
	PT/walking	80	90	90	60	60	70	90	75	65	75	75	65	60	35	60	75	90	60	60	45	60	5	50	40	30	40
E10	Car	35	35	30	25	20	25	25	25	25	25	30	25	25	25	20	25	25	15	10	15	20	15	5	10	15	20
	PT/walking	100	100	100	75	75	90	100	100	90	95	90	80	80	60	60	65	80	50	40	65	75	50	5	40	40	60
E9	Car	35	35	30	20	15	25	20	25	20	20	25	20	20	20	20	25	25	15	15	15	15	10	10	5	15	15
	PT/walking	100	75	90	60	70	70	90	65	65	70	80	70	60	55	70	80	90	45	60	55	60	40	40	5	25	35
E8	Car	25	20	20	15	10	15	15	20	20	20	20	15	15	15	15	25	25	20	20	10	10	10	15	15	5	5
	PT/walking	100	80	90	50	55	55	75	65	60	70	55	55	50	50	60	70	75	45	60	45	55	30	40	25	5	30
E7	Car	25	25	20	15	10	15	20	15	15	15	15	15	15	20	15	20	25	20	15	10	5	15	20	15	5	5
	PT/walking	90	70	80	45	45	55	70	60	55	60	50	50	45	35	50	60	90	60	70	35	35	40	60	35	30	5

Appendix B : The skim matrices

Table 4 -The skim matrix, before the design intervention.

		E1	E3	E2	E15	2	10	E4	E5	E6	11	9	8	7	1	3	E14	E13	E12	E11	4	6	5	E10	E9	E8	E7
E1	Car	0,0400	0,0025	0,0100	0,0044	0,0025	0,0044	0,0025	0,0016	0,0016	0,0016	0,0025	0,0016	0,0025	0,0011	0,0025	0,0025	0,0025	0,0008	0,0008	0,0025	0,0016	0,0011	0,0008	0,0008	0,0016	0,0016
	PT/walkin	0,0400	0,0003	0,0011	0,0006	0,0001	0,0005	0,0003	0,0003	0,0003	0,0003	0,0003	0,0003	0,0004	0,0002	0,0001	0,0001	0,0001	0,0001	0,0001	0,0003	0,0003	0,0002	0,0001	0,0001	0,0001	0,0001
E3	Car	0,0025	0,0400	0,0100	0,0025	0,0044	0,0044	0,0100	0,0044	0,0100	0,0100	0,0044	0,0044	0,0025	0,0025	0,0044	0,0016	0,0011	0,0011	0,0011	0,0044	0,0025	0,0016	0,0008	0,0008	0,0025	0,0016
	PT/walkin	0,0003	0,0400	0,0011	0,0002	0,0002	0,0008	0,0006	0,0005	0,0006	0,0006	0,0005	0,0004	0,0006	0,0002	0,0002	0,0001	0,0001	0,0002	0,0002	0,0003	0,0003	0,0001	0,0001	0,0002	0,0002	0,0002
E2	Car	0,0100	0,0100	0,0400	0,0044	0,0100	0,0011	0,0044	0,0044	0,0044	0,0100	0,0044	0,0044	0,0100	0,0011	0,0025	0,0025	0,0016	0,0011	0,0011	0,0044	0,0025	0,0016	0,0011	0,0011	0,0025	0,0025
	PT/walkin	0,0011	0,0011	0,0400	0,0002	0,0002	0,0011	0,0006	0,0008	0,0008	0,0008	0,0004	0,0003	0,0004	0,0003	0,0002	0,0001	0,0001	0,0001	0,0001	0,0003	0,0003	0,0001	0,0001	0,0001	0,0001	0,0002
E15	Car	0,0044	0,0025	0,0044	0,0400	0,0100	0,0100	0,0044	0,0025	0,0025	0,0025	0,0025	0,0025	0,0044	0,0044	0,0100	0,0100	0,0044	0,0016	0,0016	0,0044	0,0016	0,0016	0,0016	0,0025	0,0044	0,0044
	PT/walkin	0,0006	0,0002	0,0002	0,0400	0,0008	0,0005	0,0003	0,0003	0,0003	0,0003	0,0004	0,0003	0,0006	0,0004	0,0005	0,0011	0,0004	0,0002	0,0002	0,0005	0,0003	0,0003	0,0002	0,0003	0,0004	0,0006
2	Car	0,0025	0,0044	0,0100	0,0100	0,0400	0,0044	0,0025	0,0025	0,0025	0,0025	0,0025	0,0044	0,0044	0,0100	0,0400	0,0044	0,0025	0,0025	0,0025	0,0400	0,0044	0,0044	0,0025	0,0044	0,0100	0,0100
	PT/walkin	0,0001	0,0002	0,0002	0,0008	0,0400	0,0004	0,0003	0,0003	0,0003	0,0003	0,0004	0,0003	0,0005	0,0016	0,0011	0,0005	0,0001	0,0002	0,0002	0,0006	0,0003	0,0003	0,0002	0,0002	0,0003	0,0005
10	Car	0,0044	0,0044	0,0011	0,0100	0,0044	0,0400	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0400	0,0011	0,0044	0,0016	0,0016	0,0016	0,0025	0,0100	0,0100	0,0025	0,0016	0,0016	0,0044	0,0044
	PT/walkin	0,0005	0,0008	0,0011	0,0005	0,0004	0,0400	0,0006	0,0008	0,0008	0,0011	0,0025	0,0008	0,0025	0,0005	0,0003	0,0002	0,0001	0,0002	0,0002	0,0008	0,0006	0,0002	0,0001	0,0002	0,0003	0,0003
E4	Car	0,0025	0,0100	0,0044	0,0044	0,0025	0,0044	0,0400	0,0400	0,0400	0,0100	0,0044	0,0044	0,0044	0,0008	0,0044	0,0025	0,0016	0,0016	0,0011	0,0044	0,0044	0,0016	0,0016	0,0025	0,0044	0,0025
	PT/walkin	0,0003	0,0006	0,0006	0,0003	0,0003	0,0006	0,0400	0,0025	0,0011	0,0016	0,0006	0,0004	0,0003	0,0002	0,0002	0,0002	0,0001	0,0001	0,0001	0,0003	0,0003	0,0001	0,0001	0,0001	0,0002	0,0002
E5	Car	0,0016	0,0044	0,0044	0,0025	0,0025	0,0044	0,0400	0,0400	0,0400	0,0400	0,0100	0,0100	0,0044	0,0008	0,0044	0,0025	0,0016	0,0011	0,0011	0,0044	0,0100	0,0025	0,0016	0,0016	0,0025	0,0044
	PT/walkin	0,0003	0,0005	0,0008	0,0003	0,0003	0,0008	0,0025	0,0400	0,0100	0,0044	0,0011	0,0008	0,0006	0,0003	0,0003	0,0002	0,0001	0,0001	0,0002	0,0005	0,0006	0,0002	0,0001	0,0002	0,0002	0,0003
E6	Car	0,0016	0,0100	0,0044	0,0025	0,0025	0,0044	0,0400	0,0400	0,0400	0,0400	0,0100	0,0100	0,0044	0,0011	0,0044	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0025	0,0016	0,0025	0,0025	0,0044
	PT/walkin	0,0003	0,0006	0,0008	0,0003	0,0003	0,0008	0,0011	0,0100	0,0400	0,0044	0,0011	0,0011	0,0005	0,0005	0,0003	0,0002	0,0001	0,0002	0,0002	0,0008	0,0008	0,0002	0,0001	0,0002	0,0003	0,0003
11	Car	0,0016	0,0100	0,0100	0,0025	0,0025	0,0044	0,0100	0,0400	0,0400	0,0400	0,0400	0,0400	0,0044	0,0016	0,0025	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0025	0,0016	0,0025	0,0025	0,0044
	PT/walkin	0,0003	0,0006	0,0008	0,0003	0,0003	0,0011	0,0016	0,0044	0,0044	0,0400	0,0025	0,0011	0,0008	0,0003	0,0003	0,0002	0,0001	0,0002	0,0002	0,0006	0,0005	0,0002	0,0001	0,0002	0,0002	0,0003
9	Car	0,0025	0,0044	0,0044	0,0025	0,0025	0,0100	0,0044	0,0100	0,0100	0,0400	0,0400	0,0400	0,0100	0,0016	0,0025	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0016	0,0011	0,0016	0,0025	0,0044
	PT/walkin	0,0003	0,0005	0,0004	0,0004	0,0004	0,0025	0,0006	0,0011	0,0011	0,0025	0,0400	0,0025	0,0016	0,0011	0,0003	0,0002	0,0001	0,0002	0,0002	0,0008	0,0008	0,0002	0,0001	0,0002	0,0003	0,0004
8	Car	0,0016	0,0044	0,0044	0,0025	0,0044	0,0100	0,0044	0,0100	0,0100	0,0400	0,0400	0,0400	0,0100	0,0016	0,0044	0,0025	0,0016	0,0025	0,0025	0,0100	0,0400	0,0025	0,0016	0,0025	0,0044	0,0044
	PT/walkin	0,0003	0,0004	0,0003	0,0003	0,0003	0,0008	0,0004	0,0008	0,0011	0,0011	0,0025	0,0400	0,0016	0,0005	0,0005	0,0003	0,0001	0,0003	0,0003	0,0016	0,0025	0,0002	0,0002	0,0002	0,0003	0,0004
7	Car	0,0025	0,0025	0,0100	0,0044	0,0044	0,0400	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0400	0,0016	0,0044	0,0016	0,0016	0,0016	0,0025	0,0100	0,0100	0,0025	0,0016	0,0025	0,0044	0,0044
	PT/walkin	0,0004	0,0006	0,0004	0,0006	0,0005	0,0025	0,0003	0,0006	0,0005	0,0008	0,0016	0,0016	0,0400	0,0011	0,0005	0,0003	0,0001	0,0002	0,0002	0,0016	0,0008	0,0003	0,0002	0,0003	0,0004	0,0005
1	Car	0,0011	0,0025	0,0011	0,0044	0,0100	0,0011	0,0008	0,0008	0,0011	0,0016	0,0016	0,0016	0,0016	0,0400	0,0100	0,0025	0,0016	0,0016	0,0025	0,0100	0,0025	0,0011	0,0016	0,0025	0,0044	0,0025
	PT/walkin	0,0002	0,0002	0,0003	0,0004	0,0016	0,0005	0,0002	0,0003	0,0005	0,0003	0,0011	0,0005	0,0011	0,0400	0,0016	0,0005	0,0001	0,0005	0,0011	0,0016	0,0006	0,0008	0,0003	0,0003	0,0004	0,0004
3	Car	0,0025	0,0044	0,0025	0,0100	0,0400	0,0044	0,0044	0,0044	0,0044	0,0025	0,0025	0,0044	0,0044	0,0100	0,0400	0,0400	0,0044	0,0044	0,0044	0,0100	0,0044	0,0025	0,0025	0,0025	0,0044	0,0044
	PT/walkin	0,0001	0,0002	0,0002	0,0005	0,0011	0,0003	0,0002	0,0003	0,0003	0,0003	0,0003	0,0005	0,0005	0,0016	0,0400	0,0025	0,0006	0,0002	0,0002	0,0011	0,0004	0,0003	0,0003	0,0002	0,0003	0,0004
E14	Car	0,0025	0,0016	0,0025	0,0100	0,0044	0,0016	0,0025	0,0025	0,0016	0,0016	0,0016	0,0025	0,0016	0,0025	0,0400	0,0400	0,0100	0,0025	0,0025	0,0044	0,0025	0,0016	0,0016	0,0016	0,0016	0,0025
	PT/walkin	0,0001	0,0001	0,0001	0,0011	0,0005	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0003	0,0003	0,0005	0,0025	0,0400	0,0011	0,0002	0,0002	0,0006	0,0003	0,0002	0,0002	0,0002	0,0002	0,0003
E13	Car	0,0025	0,0011	0,0016	0,0044	0,0025	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0400	0,0044	0,0044	0,0025	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016
	PT/walkin	0,0001	0,0001	0,0001	0,0004	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0006	0,0011	0,0400	0,0003	0,0003	0,0001	0,0001	0,0001	0,0002	0,0001	0,0002	0,0001
E12	Car	0,0008	0,0011	0,0011	0,0016	0,0025	0,0016	0,0016	0,0011	0,0016	0,0016	0,0016	0,0025	0,0016	0,0016	0,0044	0,0025	0,0044	0,0400	0,0400	0,0025	0,0016	0,0025	0,0044	0,0044	0,0025	0,0025
	PT/walkin	0,0001	0,0002	0,0001	0,0002	0,0002	0,0002	0,0001	0,0001	0,0002	0,0002	0,0002	0,0003	0,0002	0,0005	0,0002	0,0002	0,0003	0,0400	0,0011	0,0005	0,0003	0,0003	0,0004	0,0005	0,0005	0,0003
E11	Car	0,0008	0,0011	0,0011	0,0016	0,0025	0,0025	0,0011	0,0011	0,0016	0,0016	0,0016	0,0025	0,0025	0,0025	0,0044	0,0025	0,0044	0,0400	0,0400	0,0044	0,0044	0,0044	0,0100	0,0044	0,0025	0,0044
	PT/walkin	0,0001	0,0002	0,0001	0,0002	0,0002	0,0002	0,0001	0,0002	0,0002	0,0002	0,0002	0,0003	0,0002	0,0011	0,0002	0,0002	0,0003	0,0011	0,0400	0,0005	0,0003	0,0003	0,0006	0,0003	0,0003	0,0002
4	Car	0,0025	0,0044	0,0044	0,0044	0,0400	0,0100	0,0044	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0100	0,0100	0,0044	0,0025	0,0025	0,0044	0,0400	0,0100	0,0044	0,0044	0,0044	0,0100	0,0100
	PT/walkin	0,0003	0,0003	0,0003	0,0005	0,0006	0,0008	0,0003	0,0005	0,0008	0,0006	0,0008	0,0016	0,0016	0,0016	0,0011	0,0006	0,0001	0,0005	0,0005	0,0400	0,0011	0,0005	0,0002	0,0003	0,0005	0,0008
6	Car	0,0016	0,0025	0,0025	0,0016	0,0044	0,0100	0,0044	0,0100	0,0100	0,0100	0,0100	0,0400	0,0100	0,0025	0,0044	0,0025	0,0016	0,0016	0,0044	0,0100	0,0400	0,0044	0,0025	0,0044	0,0100	0,0400
	PT/walkin	0,0003	0,0003	0,0003	0,0003	0,0003	0,0006	0,0003	0,0006	0,0008	0,0005	0,0008	0,0025	0,0008	0,0006	0,0004	0,0003	0,0001	0,0003	0,0003	0,0011	0,0400	0,0003	0,0002	0,0003	0,0003	0,0008
5	Car	0,0011	0,0016	0,0016	0,0016	0,0044	0,0025	0,0016	0,0025	0,0025	0,0025	0,0016	0,0025	0,0025	0,0011	0,0025	0,0016	0,0016	0,0025	0,0044	0,0044	0,0044	0,0400	0,0044	0,0100	0,0100	0,0044
	PT/walkin	0,0002	0,0001	0,0001	0,0003	0,0003	0,0002	0,0001	0,0002	0,0002	0,0002	0,0002	0,0002	0,0003	0,0008	0,0003	0,0002	0,0001	0,0003	0,0003	0,0005	0,0003	0,0400	0,0004	0,0006	0,0011	0,0006
E10	Car	0,0008	0,0008	0,0011	0,0016	0,0025	0,0016	0,0016	0,0016	0,0016	0,0016	0,0011	0,0016	0,0016	0,0016	0,0025	0,0016	0,0016	0,0044	0,0100	0,0044	0,0025	0,0044	0,0400	0,0100	0,0044	0,0025
	PT/walkin	0,0001	0,0001	0,0001	0,0002	0,0002	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0002	0,0002	0,0003	0,0003	0,0002	0,0002	0,0004	0,0006	0,0002	0,0002	0,0004	0,0400	0,0006	0,0006	0,0003
E9	Car	0,0008	0,0008	0,0011	0,0025	0,0044	0,0016	0,0025	0,0016	0,0025	0,0025	0,0016	0,0025	0,0025	0,0025	0,0025	0,0016	0,0016	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0400	0,0044	0,0044
	PT/walkin	0,0001	0,0002	0,0001	0,0003	0,0002	0,0002	0,0001	0,0002	0,0002	0,0002	0,0002	0,0002	0,0003	0,0003	0,0002	0,0002	0,0001	0,0005	0,0003	0,0003	0,0003	0,0006	0,0006	0,0400	0,0016	0,0008
E8	Car	0,0016	0,0025	0,0025	0,0044	0,0100	0,0044	0,0044	0,0025	0,0025	0,0025	0,0025	0,0044	0,0044	0,0044	0,0044	0,0016	0,0016	0,0025	0,0025	0,0100	0,0100	0,0100	0,0044	0,0044	0,0400	0,0400
	PT/walkin	0,0001	0,0002	0,0001	0,0004	0,0003	0,0003	0,0002	0,0002	0,0003	0,0002	0,0003	0,0003	0,0004	0,0004	0,0003	0,0002	0,0002	0,0005	0,0003	0,0005	0,0003	0,0011	0,0006	0,0016	0,0400	0,0011
E7	Car	0,0016	0,0016	0,0025	0,0044	0,0100	0,0044	0,0025	0,0044	0,0044	0,0044	0,0044	0,0044	0,0044	0,0025	0,0044	0,0025	0,0016	0,0025	0,0044	0,0100	0,0400	0,0044	0,0025	0,0044	0,0400	0,0400
	PT/walkin	0,0001	0,0002	0,0002	0,0005	0,0005	0,0003	0,0002	0,0003	0,0003	0,0003	0,0004	0,0004	0,0005	0,0004	0,0004	0,0003	0,0001	0,0003	0,0002	0,0008	0,0008	0,0006	0,0003	0,0008	0,0011	0,0400

Table 4 -The skim matrix, after the design intervention.

		E1	E3	E2	E15	2	10	E4	E5	E6	11	9	8	7	1	3	E14	E13	E12	E11	4	6	5	E10	E9	E8	E7
E1	Car	0,0400	0,0025	0,0100	0,0044	0,0025	0,0044	0,0025	0,0016	0,0016	0,0016	0,0025	0,0016	0,0025	0,0011	0,0025	0,0025	0,0025	0,0008	0,0008	0,0025	0,0016	0,0011	0,0008	0,0008	0,0016	0,0016
	PT/walkin	0,0400	0,0003	0,0011	0,0006	0,0001	0,0005	0,0003	0,0003	0,0003	0,0003	0,0003	0,0003	0,0004	0,0002	0,0001	0,0001	0,0001	0,0001	0,0001	0,0003	0,0003	0,0002	0,0001	0,0001	0,0001	0,0001
E3	Car	0,0025	0,0400	0,0100	0,0025	0,0044	0,0044	0,0100	0,0044	0,0100	0,0100	0,0044	0,0044	0,0025	0,0025	0,0044	0,0016	0,0011	0,0011	0,0011	0,0044	0,0025	0,0016	0,0008	0,0008	0,0025	0,0016
	PT/walkin	0,0003	0,0400	0,0011	0,0002	0,0002	0,0008	0,0006	0,0005	0,0006	0,0006	0,0005	0,0004	0,0006	0,0002	0,0002	0,0001	0,0001	0,0002	0,0002	0,0003	0,0003	0,0001	0,0001	0,0002	0,0002	0,0002
E2	Car	0,0100	0,0100	0,0400	0,0044	0,0100	0,0011	0,0044	0,0044	0,0044	0,0100	0,0044	0,0044	0,0100	0,0011	0,0025	0,0025	0,0016	0,0011	0,0011	0,0044	0,0025	0,0016	0,0011	0,0011	0,0025	0,0025
	PT/walkin	0,0011	0,0011	0,0400	0,0002	0,0002	0,0011	0,0006	0,0008	0,0008	0,0008	0,0004	0,0003	0,0004	0,0003	0,0002	0,0001	0,0001	0,0001	0,0001	0,0003	0,0003	0,0001	0,0001	0,0001	0,0001	0,0002
E15	Car	0,0044	0,0025	0,0044	0,0400	0,0100	0,0100	0,0044	0,0025	0,0025	0,0025	0,0025	0,0025	0,0044	0,0044	0,0100	0,0100	0,0044	0,0016	0,0016	0,0044	0,0016	0,0016	0,0016	0,0025	0,0044	0,0044
	PT/walkin	0,0006	0,0002	0,0002	0,0400	0,0025	0,0005	0,0003	0,0003	0,0003	0,0003	0,0004	0,0003	0,0006	0,0016	0,0016	0,0011	0,0004	0,0002	0,0002	0,0005	0,0003	0,0003	0,0002	0,0003	0,0004	0,0006
2	Car	0,0025	0,0044	0,0100	0,0100	0,0400	0,0044	0,0025	0,0025	0,0025	0,0025	0,0025	0,0044	0,0044	0,0100	0,0400	0,0044	0,0025	0,0025	0,0025	0,0400	0,0044	0,0044	0,0025	0,0044	0,0100	0,0100
	PT/walkin	0,0001	0,0002	0,0002	0,0025	0,0400	0,0004	0,0003	0,0003	0,0003	0,0003	0,0004	0,0003	0,0005	0,0044	0,0011	0,0005	0,0001	0,0002	0,0002	0,0006	0,0003	0,0003	0,0002	0,0002	0,0003	0,0005
10	Car	0,0044	0,0044	0,0011	0,0100	0,0044	0,0400	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0400	0,0011	0,0044	0,0016	0,0016	0,0016	0,0025	0,0100	0,0100	0,0025	0,0016	0,0016	0,0044	0,0044
	PT/walkin	0,0005	0,0008	0,0011	0,0005	0,0004	0,0400	0,0006	0,0008	0,0008	0,0011	0,0025	0,0008	0,0025	0,0025	0,0003	0,0002	0,0001	0,0002	0,0002	0,0008	0,0006	0,0002	0,0001	0,0002	0,0003	0,0003
E4	Car	0,0025	0,0100	0,0044	0,0044	0,0025	0,0044	0,0400	0,0400	0,0400	0,0100	0,0044	0,0044	0,0044	0,0008	0,0044	0,0025	0,0016	0,0016	0,0011	0,0044	0,0044	0,0016	0,0016	0,0025	0,0044	0,0025
	PT/walkin	0,0003	0,0006	0,0006	0,0003	0,0003	0,0006	0,0400	0,0025	0,0011	0,0016	0,0006	0,0004	0,0003	0,0016	0,0006	0,0002	0,0001	0,0001	0,0001	0,0003	0,0003	0,0001	0,0001	0,0001	0,0002	0,0002
E5	Car	0,0016	0,0044	0,0044	0,0025	0,0025	0,0044	0,0400	0,0400	0,0400	0,0400	0,0100	0,0100	0,0044	0,0008	0,0044	0,0025	0,0016	0,0011	0,0011	0,0044	0,0100	0,0025	0,0016	0,0016	0,0025	0,0044
	PT/walkin	0,0003	0,0005	0,0008	0,0003	0,0003	0,0008	0,0025	0,0400	0,0100	0,0044	0,0011	0,0008	0,0006	0,0016	0,0006	0,0002	0,0001	0,0001	0,0002	0,0005	0,0006	0,0002	0,0001	0,0002	0,0002	0,0003
E6	Car	0,0016	0,0100	0,0044	0,0025	0,0025	0,0044	0,0400	0,0400	0,0400	0,0400	0,0100	0,0100	0,0044	0,0011	0,0044	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0025	0,0016	0,0025	0,0025	0,0044
	PT/walkin	0,0003	0,0006	0,0008	0,0003	0,0003	0,0008	0,0011	0,0100	0,0400	0,0044	0,0011	0,0011	0,0005	0,0005	0,0003	0,0002	0,0001	0,0002	0,0002	0,0008	0,0008	0,0002	0,0001	0,0002	0,0003	0,0003
11	Car	0,0016	0,0100	0,0100	0,0025	0,0025	0,0044	0,0100	0,0400	0,0400	0,0400	0,0400	0,0400	0,0044	0,0016	0,0025	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0025	0,0016	0,0025	0,0025	0,0044
	PT/walkin	0,0003	0,0006	0,0008	0,0003	0,0003	0,0011	0,0016	0,0044	0,0044	0,0400	0,0025	0,0011	0,0008	0,0025	0,0006	0,0002	0,0001	0,0002	0,0002	0,0006	0,0005	0,0002	0,0001	0,0002	0,0002	0,0003
9	Car	0,0025	0,0044	0,0044	0,0025	0,0025	0,0100	0,0044	0,0100	0,0100	0,0400	0,0400	0,0400	0,0100	0,0016	0,0025	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0016	0,0011	0,0016	0,0025	0,0044
	PT/walkin	0,0003	0,0005	0,0004	0,0004	0,0004	0,0025	0,0006	0,0011	0,0011	0,0025	0,0400	0,0025	0,0016	0,0011	0,0003	0,0002	0,0001	0,0002	0,0002	0,0008	0,0008	0,0002	0,0001	0,0002	0,0003	0,0004
8	Car	0,0016	0,0044	0,0044	0,0025	0,0044	0,0100	0,0044	0,0100	0,0100	0,0400	0,0400	0,0400	0,0100	0,0016	0,0044	0,0025	0,0016	0,0025	0,0025	0,0100	0,0400	0,0025	0,0016	0,0025	0,0044	0,0044
	PT/walkin	0,0003	0,0004	0,0003	0,0003	0,0003	0,0008	0,0004	0,0008	0,0011	0,0011	0,0025	0,0400	0,0016	0,0005	0,0005	0,0003	0,0001	0,0003	0,0003	0,0016	0,0025	0,0002	0,0002	0,0002	0,0003	0,0004
7	Car	0,0025	0,0025	0,0100	0,0044	0,0044	0,0400	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0400	0,0016	0,0044	0,0016	0,0016	0,0016	0,0025	0,0100	0,0100	0,0025	0,0016	0,0025	0,0044	0,0044
	PT/walkin	0,0004	0,0006	0,0004	0,0006	0,0005	0,0025	0,0003	0,0006	0,0005	0,0008	0,0016	0,0016	0,0400	0,0044	0,0005	0,0003	0,0001	0,0002	0,0002	0,0016	0,0008	0,0003	0,0002	0,0003	0,0004	0,0005
1	Car	0,0011	0,0025	0,0011	0,0044	0,0100	0,0011	0,0008	0,0008	0,0011	0,0016	0,0016	0,0016	0,0016	0,0400	0,0100	0,0025	0,0016	0,0016	0,0025	0,0100	0,0025	0,0011	0,0016	0,0025	0,0044	0,0025
	PT/walkin	0,0002	0,0002	0,0003	0,0016	0,0044	0,0025	0,0016	0,0016	0,0005	0,0025	0,0011	0,0005	0,0044	0,0400	0,0044	0,0005	0,0001	0,0005	0,0011	0,0044	0,0011	0,0008	0,0003	0,0003	0,0004	0,0008
3	Car	0,0025	0,0044	0,0025	0,0100	0,0400	0,0044	0,0044	0,0044	0,0044	0,0025	0,0025	0,0044	0,0044	0,0100	0,0400	0,0400	0,0044	0,0044	0,0044	0,0100	0,0044	0,0025	0,0025	0,0025	0,0044	0,0044
	PT/walkin	0,0001	0,0002	0,0002	0,0016	0,0011	0,0003	0,0025	0,0025	0,0003	0,0006	0,0003	0,0005	0,0005	0,0044	0,0400	0,0025	0,0006	0,0002	0,0002	0,0011	0,0004	0,0003	0,0003	0,0002	0,0003	0,0004
E14	Car	0,0025	0,0016	0,0025	0,0100	0,0044	0,0016	0,0025	0,0025	0,0016	0,0016	0,0016	0,0025	0,0016	0,0025	0,0400	0,0400	0,0100	0,0025	0,0025	0,0044	0,0025	0,0016	0,0016	0,0016	0,0016	0,0025
	PT/walkin	0,0001	0,0001	0,0001	0,0011	0,0005	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002	0,0003	0,0003	0,0005	0,0025	0,0400	0,0011	0,0002	0,0002	0,0006	0,0003	0,0002	0,0002	0,0002	0,0002	0,0003
E13	Car	0,0025	0,0011	0,0016	0,0044	0,0025	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016	0,0044	0,0100	0,0400	0,0044	0,0044	0,0025	0,0016	0,0016	0,0016	0,0016	0,0016	0,0016
	PT/walkin	0,0001	0,0001	0,0001	0,0004	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0006	0,0011	0,0400	0,0003	0,0003	0,0001	0,0001	0,0001	0,0002	0,0001	0,0002	0,0001
E12	Car	0,0008	0,0011	0,0011	0,0016	0,0025	0,0016	0,0016	0,0011	0,0016	0,0016	0,0016	0,0025	0,0016	0,0016	0,0044	0,0025	0,0044	0,0400	0,0400	0,0025	0,0016	0,0025	0,0044	0,0044	0,0025	0,0025
	PT/walkin	0,0001	0,0002	0,0001	0,0002	0,0002	0,0002	0,0001	0,0001	0,0002	0,0002	0,0002	0,0003	0,0002	0,0005	0,0002	0,0002	0,0003	0,0400	0,0011	0,0005	0,0003	0,0003	0,0004	0,0005	0,0005	0,0003
E11	Car	0,0008	0,0011	0,0011	0,0016	0,0025	0,0025	0,0011	0,0011	0,0016	0,0016	0,0016	0,0025	0,0025	0,0025	0,0044	0,0025	0,0044	0,0400	0,0400	0,0044	0,0044	0,0044	0,0100	0,0044	0,0025	0,0044
	PT/walkin	0,0001	0,0002	0,0001	0,0002	0,0002	0,0002	0,0001	0,0002	0,0002	0,0002	0,0002	0,0003	0,0002	0,0011	0,0002	0,0002	0,0003	0,0011	0,0400	0,0005	0,0003	0,0003	0,0006	0,0003	0,0003	0,0002
4	Car	0,0025	0,0044	0,0044	0,0044	0,0400	0,0100	0,0044	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0100	0,0100	0,0044	0,0025	0,0025	0,0044	0,0400	0,0100	0,0044	0,0044	0,0044	0,0100	0,0100
	PT/walkin	0,0003	0,0003	0,0003	0,0005	0,0006	0,0008	0,0003	0,0005	0,0008	0,0006	0,0008	0,0016	0,0016	0,0044	0,0011	0,0006	0,0001	0,0005	0,0005	0,0400	0,0011	0,0005	0,0002	0,0003	0,0005	0,0008
6	Car	0,0016	0,0025	0,0025	0,0016	0,0044	0,0100	0,0044	0,0100	0,0100	0,0100	0,0100	0,0400	0,0100	0,0025	0,0044	0,0025	0,0016	0,0016	0,0044	0,0100	0,0400	0,0044	0,0025	0,0044	0,0100	0,0400
	PT/walkin	0,0003	0,0003	0,0003	0,0003	0,0003	0,0006	0,0003	0,0006	0,0008	0,0005	0,0008	0,0025	0,0008	0,0011	0,0004	0,0003	0,0001	0,0003	0,0003	0,0011	0,0400	0,0003	0,0002	0,0003	0,0003	0,0008
5	Car	0,0011	0,0016	0,0016	0,0016	0,0044	0,0025	0,0016	0,0025	0,0025	0,0025	0,0016	0,0025	0,0025	0,0011	0,0025	0,0016	0,0016	0,0025	0,0044	0,0044	0,0044	0,0400	0,0044	0,0100	0,0100	0,0044
	PT/walkin	0,0002	0,0001	0,0001	0,0003	0,0003	0,0002	0,0001	0,0002	0,0002	0,0002	0,0002	0,0002	0,0003	0,0008	0,0003	0,0002	0,0001	0,0003	0,0003	0,0005	0,0003	0,0400	0,0004	0,0006	0,0011	0,0006
E10	Car	0,0008	0,0008	0,0011	0,0016	0,0025	0,0016	0,0016	0,0016	0,0016	0,0016	0,0011	0,0016	0,0016	0,0016	0,0025	0,0016	0,0016	0,0044	0,0100	0,0044	0,0025	0,0044	0,0400	0,0100	0,0044	0,0025
	PT/walkin	0,0001	0,0001	0,0001	0,0002	0,0002	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0002	0,0002	0,0003	0,0003	0,0002	0,0002	0,0004	0,0006	0,0002	0,0002	0,0004	0,0400	0,0006	0,0006	0,0003
E9	Car	0,0008	0,0008	0,0011	0,0025	0,0044	0,0016	0,0025	0,0016	0,0025	0,0025	0,0016	0,0025	0,0025	0,0025	0,0025	0,0016	0,0016	0,0044	0,0044	0,0044	0,0044	0,0100	0,0100	0,0400	0,0044	0,0044
	PT/walkin	0,0001	0,0002	0,0001	0,0003	0,0002	0,0002	0,0001	0,0002	0,0002	0,0002	0,0002	0,0002	0,0003	0,0003	0,0002	0,0002	0,0001	0,0005	0,0003	0,0003	0,0003	0,0006	0,0006	0,0400	0,0016	0,0008
E8	Car	0,0016	0,0025	0,0025	0,0044	0,0100	0,0044	0,0044	0,0025	0,0025	0,0025	0,0025	0,0044	0,0044	0,0044	0,0044	0,0016	0,0016	0,0025	0,0025	0,0100	0,0100	0,0100	0,0044	0,0044	0,0400	0,0400
	PT/walkin	0,0001	0,0002	0,0001	0,0004	0,0003	0,0003	0,0002	0,0002	0,0003	0,0002	0,0003	0,0003	0,0004	0,0004	0,0003	0,0002	0,0002	0,0005	0,0003	0,0005	0,0003	0,0011	0,0006	0,0016	0,0400	0,0011
E7	Car	0,0016	0,0016	0,0025	0,0044	0,0100	0,0044	0,0025	0,0044	0,0044	0,0044	0,0044	0,0044	0,0044	0,0025	0,0044	0,0025	0,0016	0,0025	0,0044	0,0100	0,0400	0,0044	0,0025	0,0044	0,0400	0,0400
	PT/walkin	0,0001	0,0002	0,0002	0,0005	0,0005	0,0003	0,0002	0,0003	0,0003	0,0003	0,0004	0,0004	0,0005	0,0008	0,0004	0,0003	0,0001	0,0003	0,0002	0,0008	0,0008	0,0006	0,0003	0,0008	0,0011	0,0400

Appendix C : The OD matrices

Table 4 -The OD matrix (expected amount of travelers) after the first iteration, before the design intervention.

		E1	E3	E2	E15	2	10	E4	E5	E6	11	9	8	7	1	3	E14	E13	E12	E11	4	6	5	E10	E9	E8	E7
	Car	20854	591	890	308	152	32	20	30	97	54	85	65	44	72	196	101	667	161	233	118	104	17	112	55	36	
	PT/walking	20854	66	99	43	8	4	2	5	17	9	9	11	7	12	10	5	33	24	35	13	18	2	14	7	2	
	Car	707	5130	483	94	147	18	44	45	328	183	82	98	24	89	189	35	161	119	172	114	88	13	61	30	31	
	PT/walking	79	5130	54	8	7	3	3	5	21	11	9	9	6	6	8	3	10	19	24	7	10	1	7	6	2	
	Car	9446	4281	6451	558	1102	15	65	150	487	609	273	326	322	131	355	184	774	398	575	380	294	44	276	135	102	
	PT/walking	1050	476	6451	26	20	15	9	28	89	50	25	24	13	33	25	9	34	44	64	28	33	3	25	15	5	
	Car	2767	705	472	3309	726	87	43	56	181	100	101	121	94	346	936	484	1416	378	545	250	124	29	262	201	120	
	PT/walking	389	58	22	3309	59	4	3	7	20	13	16	16	13	31	46	54	127	37	53	28	26	5	29	22	11	
	Car	646	520	441	343	1206	16	10	23	75	42	42	89	39	323	1554	89	331	245	354	935	143	33	170	148	112	
	PT/walking	32	24	8	28	1206	1	1	3	8	6	7	7	4	52	43	10	16	17	22	15	9	2	12	7	4	
	Car	4765	2159	203	1424	556	601	74	171	553	307	698	833	1463	149	717	133	878	650	1467	970	1334	77	452	221	206	
	PT/walking	529	397	203	70	50	601	10	31	102	77	175	68	91	66	53	17	55	72	120	79	83	6	35	28	15	
	Car	1271	2304	386	300	148	32	317	729	2360	328	147	175	77	52	340	99	416	308	309	204	281	23	214	164	98	
	PT/walking	141	144	54	22	16	4	317	46	66	52	21	16	6	13	18	7	26	19	34	15	18	2	13	8	4	
	Car	316	397	150	66	58	12	123	283	916	509	128	153	30	20	132	38	162	83	120	79	246	14	83	41	21	
	PT/walking	55	44	27	9	8	2	8	283	229	57	14	13	4	7	8	3	10	10	17	9	15	1	5	6	2	
	Car	368	1042	174	76	67	14	143	330	1067	593	150	179	35	32	154	29	188	139	201	92	286	17	97	74	25	
	PT/walking	64	65	32	8	7	3	4	82	1067	66	17	20	4	14	11	4	12	15	20	17	23	2	7	7	3	
	Car	81	228	86	17	15	3	8	72	234	130	131	156	8	10	19	6	41	31	44	20	63	4	21	16	5	
	PT/walking	14	14	7	2	2	1	1	8	26	130	8	4	1	2	2	1	3	3	5	3	3	0	1	1	0	
	Car	1025	826	311	136	120	57	28	147	476	1058	1069	1274	140	82	154	51	336	249	359	165	511	19	120	85	44	
	PT/walking	114	92	28	22	19	14	4	16	53	66	1069	80	22	57	20	7	21	28	53	30	42	2	13	8	6	
	Car	638	804	303	133	207	56	28	143	463	1030	1040	1240	136	80	267	78	327	378	546	361	1987	29	168	129	77	
	PT/walking	111	72	23	18	15	5	2	12	51	29	65	1240	22	25	30	10	20	42	61	58	124	3	16	10	6	
	Car	1055	478	721	249	219	236	29	67	218	121	275	328	576	85	282	52	346	256	578	382	525	30	178	136	81	
	PT/walking	169	120	29	35	24	15	2	9	24	22	44	52	576	59	31	9	24	38	55	61	43	3	17	15	7	
	Car	288	294	49	153	303	4	3	8	33	27	27	32	14	1299	390	50	213	157	355	235	81	8	109	84	50	
	PT/walking	46	21	12	14	48	2	1	3	15	6	19	10	10	1299	62	10	16	49	158	38	20	6	19	11	4	
	Car	521	420	89	277	973	13	14	33	108	34	34	72	32	261	1255	648	474	351	507	189	115	15	137	67	40	
	PT/walking	26	17	6	14	27	1	1	2	8	4	4	8	4	42	1255	41	67	19	27	21	10	2	15	5	3	
	Car	906	263	155	482	188	8	14	32	67	37	38	70	20	113	2180	1127	1855	344	496	146	113	17	153	75	25	
	PT/walking	45	20	8	54	21	1	1	3	10	4	5	9	3	22	136	1127	206	24	40	20	15	2	23	7	3	
	Car	790	159	86	187	92	7	8	18	59	33	33	39	17	63	211	246	6469	532	769	71	63	15	133	65	22	
	PT/walking	39	10	4	17	5	0	0	1	4	2	2	2	1	5	30	27	6469	33	48	4	4	1	13	5	2	
	Car	209	129	49	55	75	6	6	10	48	26	27	50	14	51	171	50	583	3889	5616	58	51	18	300	147	28	
	PT/walking	32	21	5	5	5	1	0	1	5	3	3	6	2	16	9	4	36	3889	156	11	9	2	27	16	5	
	Car	538	332	125	140	192	23	11	26	122	68	69	128	56	206	441	128	1500	10002	14442	265	365	84	1737	378	71	
	PT/walking	81	47	14	14	12	2	1	4	12	8	10	14	5	92	23	10	94	278	14442	29	27	5	109	24	8	
	Car	514	414	156	121	959	29	14	33	106	59	60	160	70	257	309	71	263	195	500	744	256	26	241	118	89	
	PT/walking	57	26	12	13	15	2	1	4	19	8	11	26	11	41	34	10	13	38	56	744	28	3	13	9	4	
	Car	466	330	124	62	151	41	20	104	338	188	190	905	99	91	195	57	238	177	708	263	1449	37	192	167	126	
	PT/walking	81	37	14	13	9	3	1	7	28	9	15	57	8	23	18	7	15	31	53	29	1449	2	14	10	4	
	Car	959	626	236	183	447	30	22	77	250	139	90	168	74	120	324	107	707	818	2099	347	477	993	1010	1112	373	
	PT/walking	135	48	18	32	28	2	2	5	24	10	10	16	8	88	36	12	55	91	131	39	30	993	91	70	41	
	Car	458	208	106	119	164	13	14	32	104	58	41	70	31	112	211	70	459	945	3071	225	175	72	5908	723	108	
	PT/walking	56	25	10	13	12	1	1	2	8	4	5	7	3	19	23	10	45	85	192	12	12	6	5908	45	15	
	Car	278	126	65	113	177	8	13	20	99	55	36	66	29	107	128	42	279	574	829	137	189	98	898	1757	65	
	PT/walking	34	27	7	13	8	1	1	3	9	4	3	5	3	14	10	4	22	64	52	10	12	6	56	1757	24	
	Car	868	615	232	320	633	34	38	49	157	88	88	187	82	302	363	67	444	514	743	491	675	156	635	311	937	
	PT/walking	54	38	11	29	21	3	2	5	17	7	12	14	7	27	23	9	49	102	83	24	22	17	89	112	937	
	Car	352	160	94	130	257	14	9	35	114	63	64	76	33	69	147	43	180	209	536	199	1097	28	145	126	381	
	PT/walking	27	20	6	14	13	1	1	2	8	4	6	7	4	11	13	5	14	23	25	16	22	4	16	23	11	

Table 4 -The OD matrix (expected amount of travelers) after the first iteration, after the design intervention. The yellow cells show the OD combinations which have an expected growth in size.

	E1	E3	E2	E15	2	10	E4	E5	E6	11	9	8	7	1	3	E14	E13	E12	E11	4	6	5	E10	E9	E8	E7
Car	20.911	593	892	309	151	33	20	30	97	54	85	65	45	66	195	102	670	162	234	118	104	17	112	55	36	
PT/walking	20.911	66	99	44	7	4	2	5	17	9	9	11	7	11	10	5	33	24	35	13	18	2	14	7	2	
Car	709	5.151	484	94	146	18	44	45	330	182	82	98	24	81	188	35	162	119	173	114	88	13	61	30	31	
PT/walking	79	5.151	54	8	7	3	3	5	21	11	9	9	6	6	8	3	10	19	24	7	10	1	7	7	2	
Car	9.472	4.299	6.466	560	1.097	15	65	150	489	608	275	327	323	120	354	185	776	399	576	381	295	44	277	136	102	
PT/walking	1.052	478	6.466	26	20	15	9	28	90	50	25	24	13	30	25	9	34	44	64	28	33	3	25	15	5	
Car	2.719	694	464	3.258	708	86	42	54	178	98	100	119	93	310	914	478	1.393	371	536	246	122	28	258	197	118	
PT/walking	382	57	21	3.258	177	4	3	7	20	13	16	16	13	112	146	53	125	36	52	27	25	5	29	22	11	
Car	637	514	435	339	1.181	16	10	23	74	41	42	88	39	291	1.524	89	327	242	349	923	141	33	168	146	110	
PT/walking	31	24	8	85	1.181	1	1	3	8	5	7	7	4	129	42	10	16	17	22	14	9	2	12	7	4	
Car	4.739	2.151	202	1.420	549	599	73	169	551	304	695	829	1.454	135	708	133	874	647	1.459	965	1.328	77	449	220	205	
PT/walking	527	395	202	70	49	599	10	31	101	76	174	68	91	304	53	17	55	72	119	79	83	6	35	28	15	
Car	1.265	2.297	384	300	147	32	314	721	2.354	325	147	175	77	47	336	99	415	307	308	204	280	23	213	163	97	
PT/walking	141	144	54	22	16	4	314	45	65	52	21	16	6	92	47	7	26	19	34	15	18	2	13	8	4	
Car	315	397	149	65	57	12	122	280	915	505	128	153	30	18	131	38	161	83	120	79	245	14	83	41	21	
PT/walking	55	44	27	9	8	2	8	280	229	56	14	12	4	36	18	3	10	10	17	9	15	1	5	6	2	
Car	369	1.046	175	77	67	14	143	328	1.072	592	150	179	35	29	153	29	189	140	202	93	287	17	97	74	25	
PT/walking	64	65	32	9	7	3	4	82	1.072	66	17	20	4	13	11	4	12	16	20	17	23	2	7	7	3	
Car	80	228	86	17	15	3	8	71	233	129	131	156	8	9	19	6	41	30	44	20	62	4	21	16	5	
PT/walking	14	14	7	2	2	1	1	8	26	129	8	4	1	14	5	1	3	3	5	3	3	0	1	1	0	
Car	1.028	830	312	137	119	58	28	147	478	1.056	1.073	1.279	140	75	154	51	337	249	360	165	512	19	120	85	44	
PT/walking	114	92	28	22	19	14	4	16	53	66	1.073	80	22	52	20	7	21	28	53	30	42	2	13	8	6	
Car	640	807	304	133	206	56	28	143	465	1.027	1.044	1.244	136	73	266	78	328	379	547	362	1.993	29	168	129	77	
PT/walking	111	73	23	18	15	5	2	12	52	29	65	1.244	22	23	30	10	20	42	61	58	125	3	16	11	6	
Car	1.044	474	713	247	215	235	29	66	216	119	272	325	569	76	277	52	342	253	571	378	520	30	176	135	80	
PT/walking	167	118	29	35	24	15	2	9	24	22	44	52	569	212	31	9	24	37	54	60	42	3	17	15	7	
Car	257	263	44	137	268	4	3	7	30	24	24	29	13	1.057	346	45	190	140	317	209	72	7	97	75	44	
PT/walking	41	19	11	49	119	8	6	13	13	37	17	9	35	1.057	154	9	15	43	141	93	32	5	17	10	4	
Car	507	409	86	270	939	13	14	32	105	33	33	70	31	231	1.211	634	462	341	493	183	112	15	133	65	39	
PT/walking	25	16	6	43	26	1	8	18	8	8	4	8	3	103	1.211	40	65	18	26	20	10	2	15	5	2	
Car	908	264	155	484	187	8	14	32	68	37	38	71	20	104	2.172	1.136	1.862	344	497	146	113	17	153	75	25	
PT/walking	45	20	8	54	21	1	1	3	10	4	5	9	3	20	136	1.136	207	24	41	21	15	2	23	7	3	
Car	792	160	87	187	92	7	8	18	59	33	33	39	17	58	210	248	6.493	534	771	72	63	15	133	65	22	
PT/walking	39	10	4	17	5	0	0	1	4	2	2	2	1	4	30	28	6.493	33	48	4	4	1	13	5	2	
Car	210	130	49	55	74	6	6	10	48	26	27	50	14	47	171	50	585	3.898	5.629	58	51	18	301	147	28	
PT/walking	32	21	5	5	5	1	0	1	5	3	3	6	2	15	9	4	37	3.898	156	11	9	2	27	16	5	
Car	540	334	125	141	191	23	11	26	123	68	69	129	56	189	439	129	1.506	10.025	14.476	266	366	85	1.740	379	71	
PT/walking	82	47	14	14	12	2	1	4	12	8	10	14	5	84	23	11	94	278	14.476	30	27	5	109	24	8	
Car	510	412	155	121	945	29	14	32	105	58	59	159	70	233	305	71	261	193	496	739	254	26	239	117	88	
PT/walking	57	26	12	13	15	2	1	4	19	8	11	25	11	104	34	10	13	38	55	739	28	3	13	9	4	
Car	466	331	124	62	150	41	20	104	339	187	190	906	99	83	194	57	239	177	709	264	1.451	37	192	167	126	
PT/walking	81	37	14	13	9	3	1	6	28	9	16	57	8	37	17	8	15	31	53	29	1.451	2	14	10	4	
Car	961	628	236	184	445	30	21	77	251	139	90	168	74	110	323	108	709	820	2.104	348	479	995	1.012	1.116	374	
PT/walking	135	48	18	32	28	2	2	5	24	10	10	16	8	81	36	12	55	91	132	39	30	995	91	70	42	
Car	459	208	107	120	163	13	14	32	105	58	41	70	31	103	210	70	461	947	3.078	226	175	72	5.919	725	108	
PT/walking	56	26	10	13	12	1	1	2	8	4	5	7	3	18	23	10	45	85	192	12	12	6	5.919	45	15	
Car	279	127	65	114	176	8	13	19	99	55	36	66	29	98	128	43	280	576	831	137	189	98	899	1.763	66	
PT/walking	34	28	7	13	8	1	1	3	9	4	3	5	3	13	10	4	22	64	52	10	12	6	56	1.763	24	
Car	871	617	232	322	630	34	37	48	158	87	89	188	82	276	361	68	446	515	744	492	677	156	636	312	941	1
PT/walking	54	39	11	29	21	3	1	5	18	7	12	14	7	25	23	9	50	102	83	24	22	17	89	112	941	
Car	353	160	94	130	255	14	9	35	114	63	64	76	33	63	146	43	181	209	536	200	1.098	28	145	126	381	
PT/walking	27	20	6	14	13	1	1	2	8	4	6	7	4	21	13	5	14	23	25	16	22	4	16	23	11	

Appendix D : Population and Employment

Zone	Population density (#/ha)	Job density (#/ha)	Area (ha)	Population	Employment
E1	145	20	650	94.250	13.000
E3	**85**	**20**	**450**	**38.250**	**9.000**
E2	55	70	450	24.750	31.500
E15	**55**	**70**	**300**	**16.500**	**21.000**
2	55	50	250	13.750	12.500
10	**7,5**	**130**	**350**	**2.625**	**45.500**
E4	7,5	90	250	1.875	22.500
E5	**27,5**	**70**	**150**	**4.125**	**10.500**
E6	55	50	250	13.750	12.500
11	**55**	**20**	**150**	**8.250**	**3.000**
9	55	130	150	8.250	19.500
8	**55**	**110**	**200**	**11.000**	**22.000**
7	27,5	90	200	5.500	18.000
1	**55**	**50**	**150**	**8.250**	**7.500**
3	85	50	200	17.000	10.000
E14	**27,5**	**50**	**250**	**6.875**	**12.500**
E13	85	20	400	34.000	8.000
E12	**85**	**20**	**400**	**34.000**	**8.000**
E11	145	50	450	65.250	22.500
4	**55**	**50**	**200**	**11.000**	**10.000**
6	55	50	300	16.500	15.000
5	**7,5**	**50**	**500**	**3.750**	**25.000**
E10	85	50	300	25.500	15.000
E9	**55**	**50**	**200**	**11.000**	**10.000**
E8	27,5	110	200	5.500	22.000
E7	**27,5**	**50**	**200**	**5.500**	**10.000**
Total				487.000	416.000