RESILENCIA FRENTE AL CAMBIO CLIMÁTICO EN EL CENTRO DE GRONINGEN

TRABAJO FIN DE GRADO 2016

(FECHA DE DENFESA UNIV. DESTINO: 08/06/2016)

GRADO EN ARQUITECTURA TÉCNICA (MODALIDAD DE INTERCAMBIO-MOVILIDAD) TRABAJO FIN DE GRADO CURSO 2015-2016

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Acknowledgements

This final thesis project was carried out at Hanzehogeschool of Groningen (The Netherlands) to whom we thank for this opportunity they gave us. We really appreciate all the help received from part of the professors, especially to our educational supervisor, Jonathan Tipping, who since the beginning made a huge effort to help us find a thesis and a company to work with. Also, thank Jonathan for helping us during the whole project with information, meetings, encouraging us and being able to answer our questions all day long.

Moreover, we would like to thank Floris Boogaard as well, who helped us with the topic, and giving advice how to aim our work.

Thanks to all the people who, somehow, has taken part of this project, either answering interviews or giving their opinion.

Finally, thanks to all friends and family who helped us in every step and in all the problems we have gone through.

Executive summary

Thermal comfort, climate resilient, heat stress, sustainability are all topics that are nowadays being discussed and debated, not just in a theoretical academic context but in an urgent practical, applied context to tackle problems on the ground. Climate change is something real, something that is here to stay and something to take care of and be concerned about.

From ancient history to today, creating a comfortable, sustainable environment has always been important. However over recent years the urgency of the problems due to our changing climate topic has gradually increased. Today there are numerous studies, articles and news articles that speak about this topic. Our climate is changing and the increasing urban temperatures not only influence our thermal comfort but can also lead to increased mortality, especially among elderly and vulnerable groups. In order to tackle the problem of urban heat stress we need to understand the causes and the processes involved. This research mainly focusses on how the built environment affects the local climate of an inner-city environment. To undertake this we needed to consider many different factors such as air temperature, humidity, wind speed, and the surface material's albedo (or reflective capability).

The focus of this project is the heat stress and thermal comfort in the centre city of Groningen around the Grote Markt. This is not only hugely important historical and cultural area but is also part of a larger redevelopment zone for improving the public space. Our main research question was: ''what are the implications of including green-blue climate resilient features to the municipality of Groningen's inner-city development plan?"

The main goal of the research was to raise **people's aware of the problem** and, once they are aware of it, explain how we can **adapt our urban environment** to face it. It is not a temporary problem if we do not care about it and do something about it. It is a problem which is growing day a day and acting now **may mean a huge difference in the future**.

To answer this we first carried out a background analysis and literature review in order to be aware and fully understand the general problem of heat stress in the Netherlands and all over the world. We were able to use our own country, Spain, as a reference of ways to tackle heat stress. What kind of adaptations do we use? What is the importance of green and blue (water) areas in a Spanish city and what benefits does it bring?.

Secondly, a three layers analysis has been done by analysing the underground infrastructure, networks (traffic analysis, connections) and occupation (what kind of buildings and functions there are in this area and how they work together). We also thought it was important to gain an understanding of the opinions of the public who use the inner-city space. To achieve this street interviews were carried out next to the Grote Markt about people's perceptions of climate resilience options. After being completely familiarized with the area, the problems and people's opinion, to the next phase of the research was to focus on the design of the Grote Markt open space and how changes would affect the local climate.

Three concept proposals were developed based on the results of the survey and spatial analysis. A further analysis of these concepts was then carried out based on the initial and operational costs and the effectiveness of the design. This effect the concepts had on the local climate was investigated using the ENVImet programme that simulates the changes in the local climate of a specified time period.

Our results show that by implementing green blue solutions in a public square like the Grote Markt will have positive effect on the local climate and provide a more comfortable space. All our proposals showed a clear reduction in surface temperatures though less dramatic effect on air temperatures. We found that in old city centres the options are limited due to availability of underground space. We made the assumption that moving large areas of pipes and utilities would not be feasible due to cost. We have found that thermal comfort is a very important factor into our urban planning design and we recommend planners and designers give this topic more effort in order to make our cities more environmental-friendly, comfortable, attractive and, at the end, more liveable places.

1. Introduction

1.1 Background

This final thesis project is part of a larger research project that is being carried by the Gemeente Groningen in order to make the city center more sustainable and liveable. The municipality of Groningen has recently published a conceptual development plan for improving the inner-city of Groningen, this report is called "Bestemming Binnenstad 01/2016".
The main focus of this report is to convert the city center to an environmental friendly downtown area, reducing pollution by rerouting public and private transport. The Gemeente's proposal gives an indication of possible green and blue (water) solutions (both design and construction details) designed to make the city center more liveable and resilient in order to face what will lie ahead in the future in terms of climate change.

The report lacks details on how the municipality will include the green and blue improvements in the city. This is where this final thesis project will concentrate. The focus of the project is to look at the feasibility of including climate resilient options into the current plan. There are many constraints to implement green-blue solutions in the inner city. The main ones being lack of space and money. The research will investigate these issues, along with other factors.

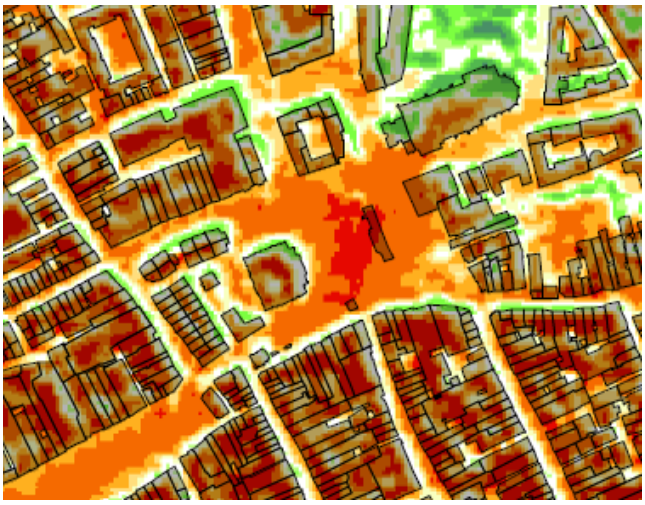


Figure 1: Heat Map of Groningen (Kluck et al, 2015)

As we can see on Figure1 (heat map of Groningen), the Grote Markt is potentially one of the hottest areas from the city center. This heat map is the result of a quick-scan modelling programme that calculates the relative temperatures across a city with the white are being the equivalent of a rural, grassland area. To calculate this the software uses GIS and aerial map data such as surface material, building heights and the amount of water and vegetation (Kluck et al, 2015).

One of the main objectives of this research was to use the available information to develop three concept proposals for a new climate resilient design for the Grote Markt.
The design software Revit was also used to assist with this design and presentation. The concept designs were then analysed using a climate modelling program (Envimet) to check the effectiveness of the solutions.
EnviMet is a software that creates a three dimensional microclimate model designed to simulate the surface plant air interactions in urban environment.
The research also included an estimate of the costs of the capital and maintenance of the different options. A multi-criterial analysis that included rating designs based on specific criteria was also carried out to select the best design option.

1.2 Research questions & sub questions

Main Question:

The primary research question that we have tried to answer in this project is as follows:

''What are the implications of including green-blue climate resilient features to the municipality of Groningen's inner-city development plan?"

To get the final answer to the main question, there are some steps that are needed to be followed in order that nothing important is forgotten. These steps can be written as sub-questions as follows:

The sub-questions are:

1. What are the possible green-blue options for a city like Groningen?
2. What benefit do these features give to an inner-city?
3. What green-blue solutions does the development plan currently include?
4. Which area is suitable for a more detailed study?
5. What are the alternatives for a climate resilient design for the specific urban space selected?
6. What are the effects of these alternatives? (we plan to use models to predict this)

7. What are the detailed costs and benefits for the alternatives?
8. What is the reaction from the various stakeholders to green-blue improvements based on the cost/benefit analysis? Is it worth it to invest in this area?
9. How much will cost to maintain the new green-blue possible options? Is it worth it to invest in these possible options?

2 Literature review

2.1 Problem analysis

First of all there's a need to explain why heat stress and climate adaption have to be something to worry about, since, it could seem odd to talk about heat stress in a cold country such as the Netherlands.

Urban professionals understand the need for climate adaption, but they need arguments and appealing examples to convince others of the urgency to adapt to urban heat risk. In order to get the message across we read articles, reports and documentaries to give good arguments and facts.

Four terms employed extensively in this part of the report merit closer description in the form of a definition. These are the terms 'heat', 'extreme heat', 'heat stress' and 'heat strain'.

'Heat' is 'strong or excessive warmth, particularly with regard to air temperature'.

A definition of heat which uses concrete temperatures has not been found. In the Netherlands, according to the KNMI, a 'heatwave' means that the maximum temperature in De Bilt has been higher than 25ºC for at least five successive days ('summery days') and that within those five days there have been at least three days with temperatures at or above 30ºC ('tropical days').

'Extreme heat' is 'an air temperature above 36ºC (dry air) or a WBGT value greater than 28ºC'.

'Heat stress' is 'the sum of the heat generated in the body (metabolic heat) plus the heat gained from the environment (environmental heat) minus the heat lost from the body to the environment, primarily through evaporation'.

'Heat strain' is 'the bodily response to total heat stress'.

'Heat island effect' is a metropolitan area that is significantly warmer than its surrounding areas due to human activities.

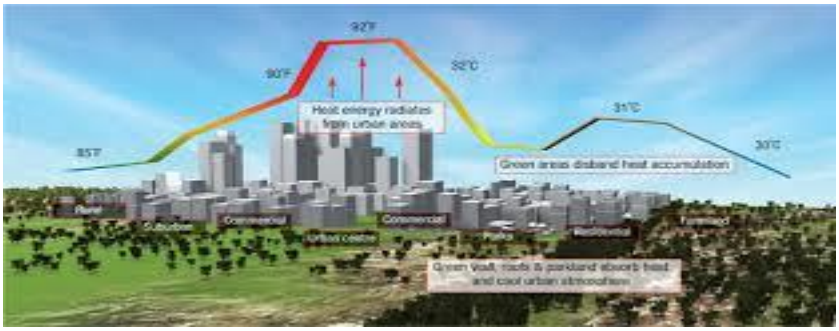


Figure 2: Typical Urban Heat island Effect

According to the United States Environment Protection Agency, in a publication from 2014, for every 1 million people in a city, the temperature of the city may raise 1-3ºC compared to its surrounding areas (rural areas). Normally, the metropolitan area is warmer than the

rest of the city due to human activity, land surfaces, and a high amount of buildings per km2, decreasing green-blue areas so no cooling effect from trees and vegetation.

The heat is absorbed by all materials (asphalt, roofs, facades) and, at night, all surfaces spread out all heat they absorbed, increasing the temperature at night as well. As we will explain in next points, decreasing material's albedo will help with this problem.

Reasons for adaption to heat stress

There is an already existence report about the urgency for a climate-proof and water-robust in the Netherlands called Dutch Delta Programme (2015). This programme concludes that all the built-up areas may be prepared to face rising temperatures and the urban heat island effect. The impacts of heat stress given in that report are:

- A decrease in comfort and liveability of cities
- An increase in heat-related disease and mortality, especially among elderly people (75+)
- An increase in hospital admissions
- A decrease in sleep quality
- A decrease in labour productivity

Scientists have quantified these impacts, especially the impact of heat on mortality. The Netherlands has gone through two heat waves during the 21st century. The first one in 2003 resulted in 1400 to 2000 excess deaths (Garssen et al., 2005), and the second one in 2006 resulted in 1000 death people due to the heat wave (UNISDR, 2007). These figures are remarkable and consequently the heat wave in 2006 was the 4th deadliest natural disaster for 2006 (table 1).

Top 10 Natural disasters by number of deaths - 2006		
Disaster / Month	Country	Number of deaths
Earthquake, May	Indonesia	5778
Typhoon Durian, December	Philippines	1399
Landslide, February	Philippines	1112
Heat wave, July	Netherlands	1000
Heat wave, July	Belgium	940
Typhoon Bilis, July	China, P Rep	820
Tsunami, July	Indonesia	802
Cold Wave, January	Ukraine	801
Flash Flood, August	Ethiopia	498
Typhoon Samoai, August	China, P Rep	373

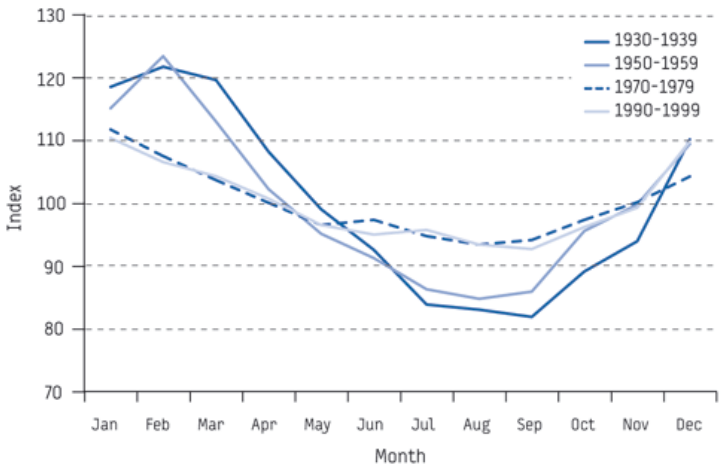
Table 1. Top 10 natural disasters 2006 (Source: UNISDR, 2007)

Moreover, the relationship between climate and excess mortality is a complex one. It can be represented in a graph, with the lowest causes of mortality rate in the Netherlands, in an average daily temperature of 16.5ºC. Summer temperatures are closer to the optimum ones which means that the mortality risk is normally below average in summer and the other way round in winter. As shown in Figure 1, between the 1950s and 1970s there was a huge change, but, since then, it hasn't had any significant change.

The indices in Figure 3 show the degree to which the monthly number of deaths in the relevant decade is higher or lower than the number that would be expected if deaths were spread over the year (a value of 110 representing a 10% higher mortality). The lower summer indices in earlier periods are largely caused by the detrimental effect of cold weather, inflating the average mortality risk. In the Netherlands, as in all other countries with mild climates, annual cold-related mortality is higher than heat-related mortality.

Figure 3

Mortality risk (all ages and causes combined) by month, various periods (monthly average = 100)

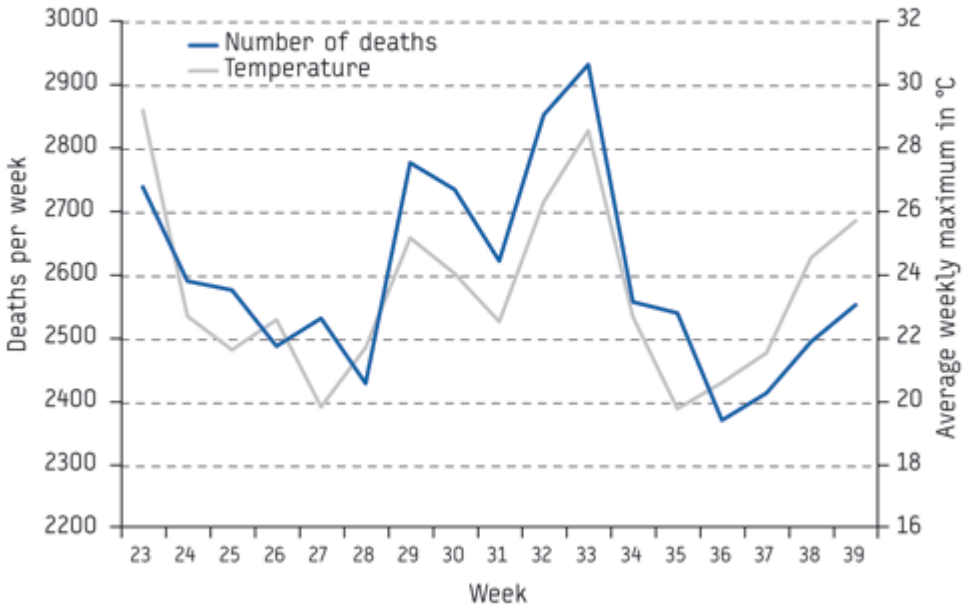


Daanen et al. (2013) quantified the economic impacts of increased temperatures in the Netherlands. The focus was on economic damage related to health and productivity. After an analysis about mortality, morbidity and productivity in the Netherlands the total economic costs were estimated at 100 million Euro per year by 2050. But the most important factor was the decrease in productivity within buildings of 2% per ºC temperature rise above 25ºC.

Impacts of heat on comfort and liveability have not been explored in detail. Anyway, Steeneveld et al. (2011) did some preliminary investigations showing that an average of 7

Figure 4

Mortality and average maximum temperature per week, The Netherlands, June-September 2003



heat stress days occur every year in the Netherlands and this number is being increased every year progressively.

What the future holds

While the 2003 heat wave was unusual in today's climate, Europe is highly likely to face even hotter summers more often in coming decades. Scientists estimate that human activities have already at least doubled the risk of an extreme heat wave.

Unless we make deep and swift cuts in our heat-trapping emissions, Europe could experience a heat wave similar to the one in 2003 every other year by the end of this century. A summer like that of 2003 would be considered ordinary or even cool. Summers in central Europe are expected to feel like those in southern European today.

Climatic variability in summer is projected to increase, with southern Europe experiencing more heat, less precipitation, and more frequent droughts, yet heavier rainstorms when it does rain. Northern Europe can expect more overall precipitation. Smog is also expected to rise, unless we reduce our use of fossil fuels

Ironically, people in cold regions can be most vulnerable to heat waves, because they are not acclimated to extremely hot weather, and because buildings designed for cold climates may not offer protection against extreme heat and high humidity. The elderly and those who do not have access to air-conditioning will likely be less resilient in the face of more frequent heat waves.

Some studies estimate that there are likely to be places on Earth where unprotected humans without cooling mechanisms, such as air conditioning, would die in less than six hours if global average surface temperature rises by about 12.6° F (7° C). With warming of 19.8-21.6° F (11-12° C), this same study projects that regions where approximately half of the world's people now live could become intolerable.

Even as Europeans adapt to hotter summers, rising numbers of heat-related deaths are likely. The 2003 heat wave shows that even high-income countries such as the Netherlands are not currently positioned to cope with extreme weather, a troubling prospect, as research suggests that by as early as the 2040s, if we continue on the current high emissions path, about half the summers in southern Europe are likely to be as warm as the record-breaking heat wave of 2003.

2.2 Benefits/advantages to have Green/blue areas

People find more attractive to live in Green districts than living in another places without green areas, that make us think about all the benefits that include living near nature, in fact on last years the prices of the houses in green districts or along water or areas of vegetation are higher than other places, urban vegetation and water have a direct economic value. "*The effect of attractive nature space on property prices falls from 16% for properties within 0.5 kilometers, to 1.6% for properties up to 7 kilometers away. Our findings advance existing hedonic studies by verifying that economic benefits of living near natural space extend over a larger distances. This has important implications for public policy regarding investment in natural space nearby residential areas" (Michiel N.Daams, Rethinking the economic valuation of natural Land, 2016).*

Nowadays a lot of cities around the world (such as London, Amsterdam, Rotterdam, Singapore) are working to increase and protect the actual existing nature and water spaces , that is because having more green and blue spaces improve the quality of life as well as the city's economic value.

There are some advantages to have more green and blue areas in cities and towns;

Improved flood resilience

The flood resilience can be improved if the vegetation is well structured, it can create a sponge effect on precipitations and reduce floods making it not need to be drained off, it happens the same with water areas that are designed in a way that can recollect the water

Heat alleviation

On hot days, places where is an important amount of vegetation or water areas can cooler 10 degrees than in areas with concrete floor or bricked.

Trees create shades and the ground below them is heated less, all types of green and blue solutions have the capacity to cool in a way of evaporation.

Improved biodiversity

With the addition of new green and water spaces it will be improved the biodiversity, offering habitat to many types of flora and fauna.

Food production

Nowadays the urban food production is becoming a new trend, you can notice because there is an emergence of urban agriculture, city gardening and farmer's markets. There is the necessity of know how our food is produced, the increase of sales of organic products from farmers is growing and this is good for urban farmers.

Improved air quality

There exist a lot of pollution caused by human activity and this cannot be changed, but if there are more vegetation and trees, it can absorb CO2 and sulphur dioxide and this can help to at least bring a degree of improvement. Improve air quality has a good effect on the health of the people.

Energy production from biomass and water

All the green and water areas can be useful for contribute to the town or city's energy supply using the green waste, wood from the urban forest and extracting heat from the surface water. Using these methods it can be used for fermentation or as a fuel.

Social and societal importance

Exist a really important effect of the nature in the humans, many studies has confirm that nature improve quality of life and reduce stress levels.

Green areas can be places where people go to have a nice day or do physical exercise, children can enhance their social skills and concentration in play areas, and there are many activities that public parks and green spaces offer.

Figure 5 ***Community garden 'Emma's Hof' in The Hague, The Netherlands***

With more vegetation and water, the towns and cities reduce health care costs and in long term it can reduces a municipality's management costs. Homes situated near green areas or water have higher price than those homes are not near of green area or water (as we have said in the introduction of this chapter).

There are a lot of benefits for the society and offering people to participle on the design and creation of new areas also create a good feeling to the citizen involvement.

2.3 Possible climate adaptations

When we think in possible options for the City of Groningen we find many possible adaptions that will work really well and could cooler the area, those climate adaptions are the following;

Porous paving materials

Any porous paving materials is suitable for paving; for example, grass concrete pavers, woodchips, shells or gravel materials and precipitation can infiltrate into the ground.

Figure 6 *Different types of porous paving materials*

This adaption has so many advantages because it can be used for many purposes as footpaths, playgrounds, fire service roads, for aeration around trees, car parking, roads…

City trees

One very good option are trees, it offer so many advantages to cities like ; they create shade, offer coolness and also a living space for birds and insects.

The only disadvantage that it can be found is that they grow really slowly, because of this is important to protect the actual trees that are nowadays at the cities.

Figure 7 Bolivar Square, Paris, France

When we want to plant a tree we have to find a good place, it is important to think well before where it can fits better.

Water squares

Water squares are a really good options for not only cooler the city, also it can have an important social effect as well as being a nice decoration for the inner city.

Water squares normally are uses for the inner-city areas with little room for water buffers, in cities where exist densely built-up it is difficult to find room for this and is in those areas where is most needed.

On that cities where there is difficult to find a room for it, they have design a new system, this system made the water square multifunctional, linked it to other functions like playing area, residential area or green areas.

The squares feature lower-lying areas that can be submerged in the case of heavy rainfall. The run-off from the surrounding district is connected to the square by open drains or rainwater drainage systems.
The careful, functional and aesthetic design of such water squares demands a great deal of attention.


Figure 8 *Fountain from Illinois, USA*

After rainfall, the lowest parts of the water square fill up first, and the water in fact remains their longest. The parts that become submerged need to be easy to clean.

Water squares offer different benefits compared with another options:

- Water squares make the dynamics of water visible in the town or city and by doing so can help enhance the aesthetic value.
- Water squares can be combined with other public urban functions and as such create spaces with multiple purposes.
- Properly designed water squares allow for substantial fluctuations in water levels and as such for large volumes of water to be buffered.

One good example is the design for the Bloemhofplein square in Rotterdam. It has the same objective when is empty than when is full of water, being a part of children's game. When it is empty children can play and after the rain shower water can become part of children's game as well.


Figure 9 *Water square Bloemholfplein, Rotterdam, The Netherland*

Maintenance and management are important factors, since the water reaches the square from above the ground and as such is not purified. This means that pollutants such as mud, litter, leaves and branches remain on the square after the water has been pumped away. These pollutants need to be removed as soon as the square is dry, to ensure that the square becomes attractive and usable once more *(Explain in more detail in chapter 4.5.5 Maintenance).*

Green facades

Green facades is an easy way to increase the amount of vegetation in a city and one of the best advantage is that it takes up little space in the urban area, while can cover many vertical meters from a building, the plant doesn't need some much space on the ground, but some space is required for the underground.

Figure 10 - ***City Hall in Vitoria Street, London, United Kingdom***

Vertical vegetation is not only a good way to cooling the city, it's use also to adorn the building facades.

There exist a lot of discussions about the pros and cons of green facades, it has a good effect lowering temperatures and improving the air quality, but to install green façade on buildings it can damage them and nuisance from pests is diminishing.

Evergreen plants can actually protect a building against heavy rain showers and keep the building walls dry. However, buildings which already are affected by rising humidity due to existing construction faults or damage can actually be further damaged by vegetation, as it inhibits the evaporation of moisture.

Changing materials of pavement/walls

Depends of the paving materials it has different effects on surface and air temperature in towns and cities. Paving materials cover the 30-40% of the urban surface, so depending about the type of material we have we will have different thermal comfort. In the summer, for example tarmac and concrete can reach really high temperatures between 45°C and even 70°C, the heat is trapped by the material and pass on to the ground below.

So one easy way to cooler the city is to choose the correct material of pavement, as well the materials from the walls, generally paving materials with light colours has a good influence on keeping the surface temperature down. Light-coloured paving materials, like light clinkers and concrete stone are better than black tarmac.

Green roofs

Green roofs are increasingly used as a building block towards attaining sustainable urban development. Green roofs have many advantages. Besides being attractive, their capacity for rainwater retention, the roof itself heating up less, the underlying construction and spaces, and the surroundings are often a consideration in favour of constructing green roofs. Green roofs can also contribute to a larger biodiversity in the city and capture of particulate matter. Runoff from green roofs is cleaner.

Green roofs' is a collective term which includes moss/sedum roofs, grass/herb roofs and is used for walkable planted roofs and sloping roofs. In principle two kinds of green roofs can be discerned: extensive green roofs and intensive green roofs. The difference lies in the intensity of the required care as well as the different way of constructing. Extensive green roofs are thinner and lighter in construction and generally less costly. Extensive green roofs are easier to realise on existing buildings. Intensive green roofs vary from watered grass/herb roofs to walkable city parks on buildings.

Green roofs can be installed on roofs with slopes ranging from 1o to 35°. At more than 35° extra provisions are required to prevent sliding. Steeper roofs dry out faster due to the faster runoff of rainwater. If the additional provisions to counter sliding tear through the waterproofing roof membrane this will increase the risk of leaks. For rainwater retention, a slope of up to 7° is most efficient.

Creating shade

Creating shade by positioning trees and vegetation strategically on the outsides of the buildings blocking the sun light can be a good way to cool the area, on this chapter we not only talk about trees creating shade, there are so many different options to create shade like temporal structures that cover the streets that we can just collocated on the hot summer days to reduce the feeling of hot (*Example in figure 9 Malaga- chapter2.4 Ways to face heat stress in the urban environment in Spain).*

2.4 Ways to face heat stress in the urban environment in Spain

It is obvious that The Netherlands is not the hottest country neither in the world nor in Europe so it would be very interesting to take a look in other countries in order to observe how they face heat stress in the urban environment.

Since we come from Spain, it will be our focus on this point, in particular the city of Valencia. Even though Valencia is not the hottest city and its temperature average is around 33 degrees in August, last summer, for instance, we reached 45,2º C. We are going to see what kind of infrastructure they use to cool the urban area and make the urban area more liveable and comfortable in hot days.

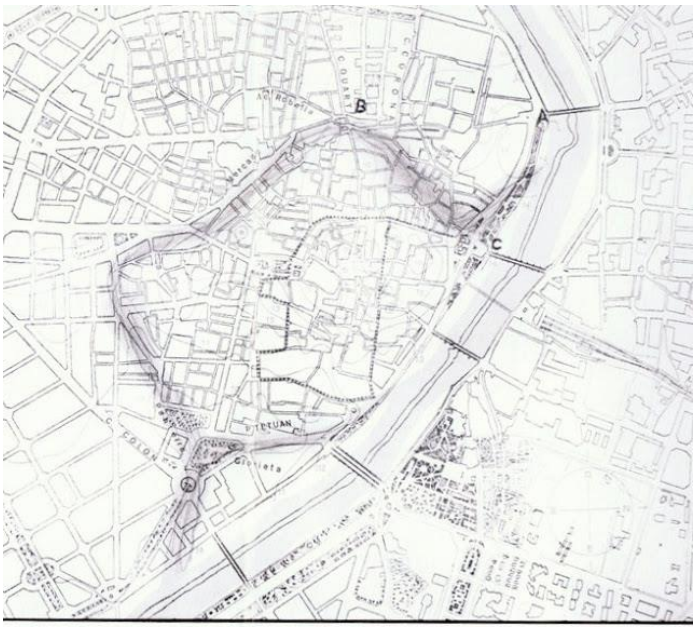


Figure 11 - Map from the city of Valencia, Spain

Valencia was built by the Romanics in the 138 B.C and it was built up next to a river which went around the whole city.As it was in growth they decided to dry up the river and alter the course of its flow. Nowadays Valencia is much bigger and the oldest river course goes through the middle of the city, dividing it in two parts.

Since the river was dried up they made it a huge green/blue area that goes through the city and it is actually one of the best places to relax and enjoy the city.

As a result, this huge green/blue area is a way to cool the whole city, reduce pollution and keep people in touch with nature.

Figure 12- Cauce del Rio, Valencia, Spain

Nonetheless, it is just one part of Valencia but, what do they do to cool the area in the inner city and the other parts?

All the main avenues, thanks to its width, have kind of a park in the middle of the street, separating both directions and connecting them at some points to allow the traffic direction change.

In fact, green parks and streets as well as trees all over the length of the street generate a lot of shadow, nature feeling and

Figure 14 - Gran vía del Marqués del Turia, Valencia, Spain

Figure 13 - Plaza de la Reina, Valencia, Spain

Moreover, besides parks and trees there are other ways to do it. One of the commonly used is to put some fabric roofs between buildings to have shadow all over some street.

There are fountains on some squares and people usually use it to freshen themselves or people can have a drink while their children play in the fountain.

In theme parks and outside cafeterias there are sometimes vaporize systems which scatter across the place vaporized water.

Figure 15 - *Street Marqués de Larios, Málaga, Spain*

Figure 17 - Shopping centre Arena, Valencia, Spain

Figure 16 - Park Juan Carlos I, Madrid, Spain

To conclude, white or light colours are used in the main walls of the buildings because it has less heat absorption and helps with the cool process as well as energy efficiency.

Figure 18 - Valencia, Spain

3. Methodology

3.1 Introduction

This chapter presents the methodology that has been used to answer the main question and sub questions with the help from the literature review. It can be separated in five chapters;

- Literature review)
- Spatial analysis Interviews
- Design (Revit)
- Envi-Met
- Costings
- Multi-Criteria Decision Analysis (MCDA)

Descriptions of these methods are given in the following sections of this chapter.

How these different methods have be used to answer the subquestions and where the results can be found in the report is shown below:

1. What are the possible green-blue options for a city like Groningen?

   Literature Review: chapter 2.3

2. What benefit do these features give to an inner-city?

   Literature Review: chapter 2.2

3. What green-blue solutions does the development plan currently include?

   Spatial Analysis: chapter 4.1

   Design: chapter 4.3

4. Which area is suitable for a more detailed study?

   Background: chapter 1.1

   Spatial Analysis: chapter 4.1

5. What are the alternatives for a climate resilient design for the specific urban space selected?

   Design: chapter 4.3

   MCDA: chapter 5.1

6. What are the effects of these alternatives? (we plan to use models to predict this)

   EnviMet: chapter 4.4

7. What are the detailed costs and benefits for the alternatives?

   Costings 4.5

8. What is the reaction from the various stakeholders to green-blue improvements based on the cost/benefit analysis? Is it worth it to invest in this area?

   Interviews: chapter 4.2

9. How much will cost to maintain the new green-blue possible options? Is it worth it to invest in these possible options?

   Costings: chapter 4.5

3.2 Design

We have done three concept proposal designs of a new square in Grote Mark. Each one with its own cost, 3D analysis, taking into account the underground / ground infrastructure, and people's opinion.

First of all, a shadow analysis was done to find out how the shadow works in that space, in order to place everything in the best spot and make the best of it, taking perfect advantage of shadows.

When developing a design we have to realise that the Grote Markt has many functions, e.g. a market takes place there three days a week, on public holidays such as King's day/night they have concerts, and sometimes there use the whole space for a large fair. This means that concept designs may not be approved by all parties. We acknowledge this concern though the main aim of this thesis is to tackle the heat stress of the area, and transform the city centre in a better place to live that will attractive to people.

All the concept designs have been drawn in 3D using Revit software. This has been done as it allows the shadow analysis to be completed but also that is gives a good visual presentation simulating how it would look like if it was built and therefore easier to compare.

4. Results

4.1 Alternatives

Three concept proposals have been done, each one with different design and use of the surface. This chapter gives an explanation of concept design process for each proposal. Even though, plans are enclosed in the Appendix.

PROPOSAL 1

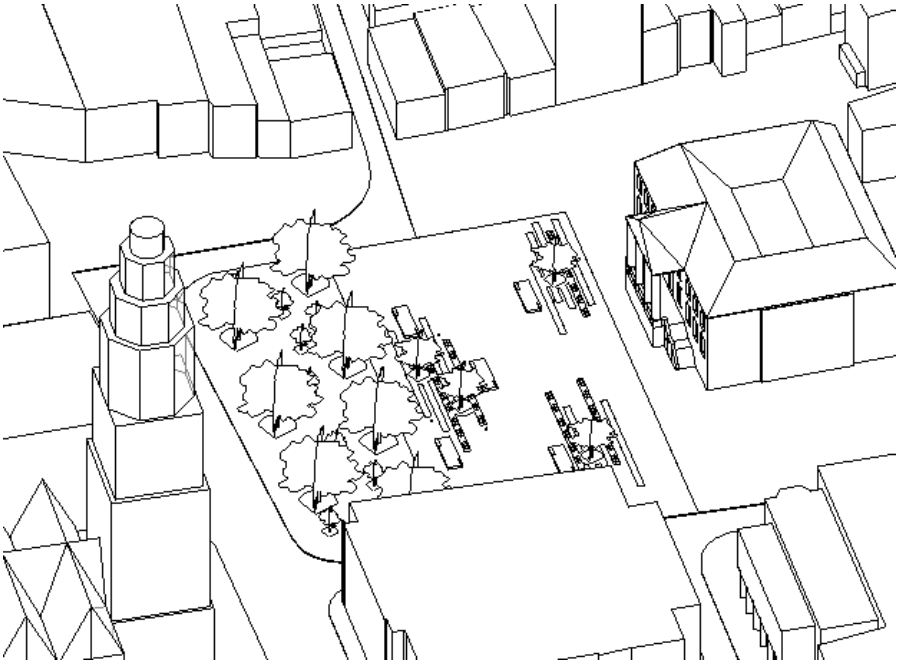
- First of all, why is the design like that?

The first proposal consists of two different areas. Since it is the place of the market, we took it into account, trying not to take up all the space so there is free space to place the temporary buildings, like market stalls, tents, etc.

.

Then, thinking about the effect that it was going to have in the heat map, there was a need to create a green space with a lot of vegetation and trees, which could cool the temperature and give shade. Hence, using the area on the east to create a park was the best idea, since,

after the layer analysis, we observed that there are no pipes, cables, or other things that could cause problems when excavating or in the construction process. Furthermore, that area was perfect since there is freedom to do almost whatever with depth and without restrictions.



Moreover, in the other part there are five benches of white concrete (1,0m x 7,0m x 0,50m) spread all over the area, with trees placed next to those giving shadow to the bench to make it more comfortable.

Nonetheless, some green stripes areas plus changing the ground material pavement to one with higher albedo produce a significant change in the general temperature, because it reflects more light which means that the material absorbs less energy, decreasing the heat island effect. And, by leaving some space free, they still can place some market tents there.

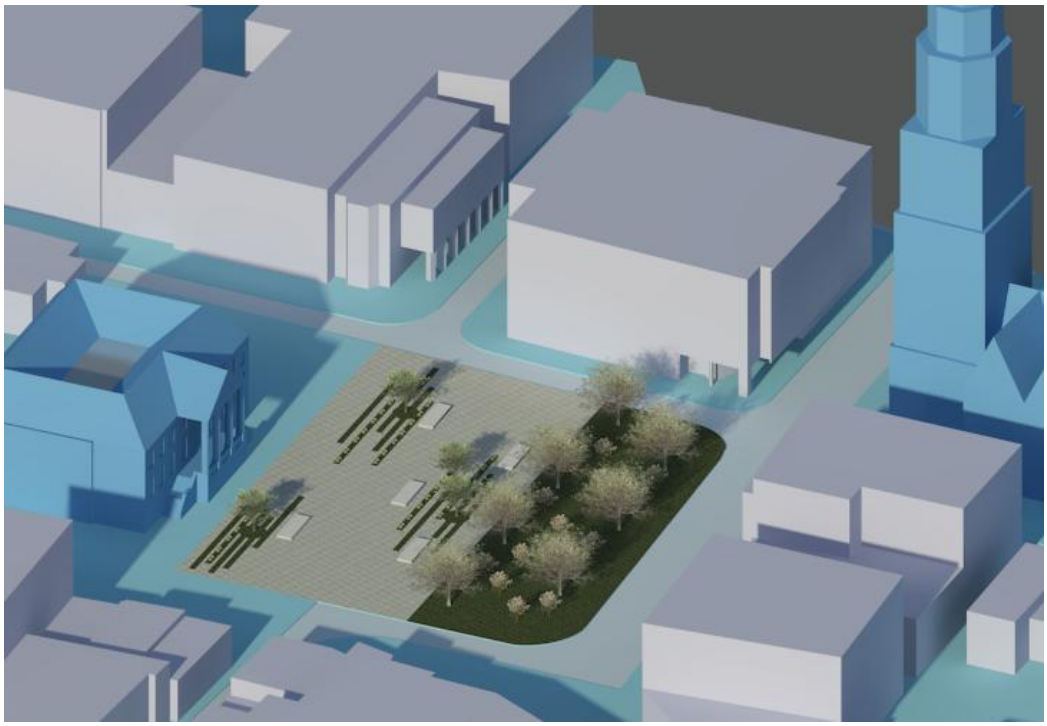
- Characteristics of design and 3dmoled

The vegetation area has a depth of 1,5m, including shrubs, trees (Japanese Cherry, Scarlet Oak and Hawthorn) and all grass on the surface.

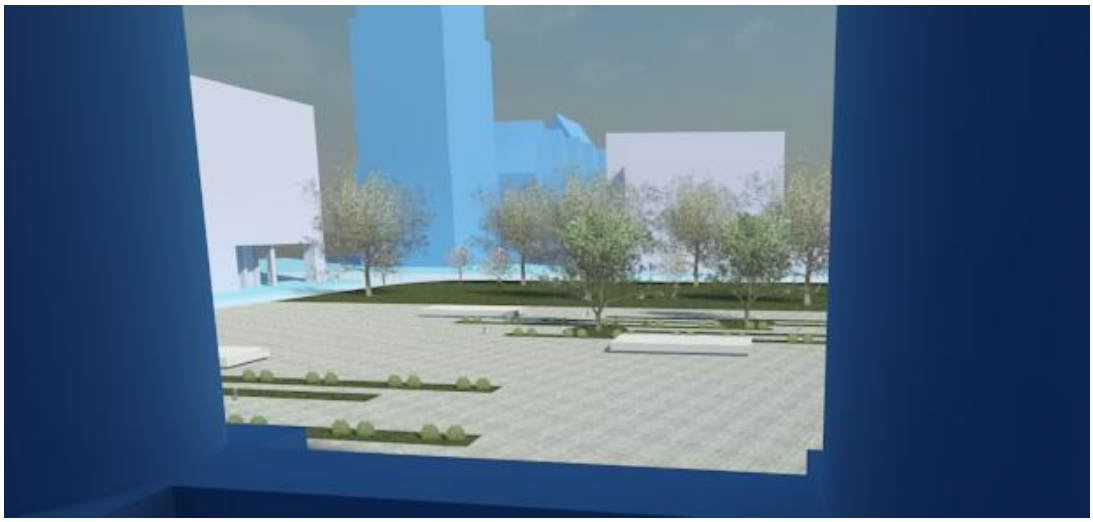
All bench are prefabricated of concrete with dimensions 700x100X50cm.

The material used as pavement is white concrete tiles.

Green stripes next to benches with dimensions 1,0 x 27,0m



Proposal 1 – General View



Proposal 1 – From Cityhall

Proposal 1 – General View

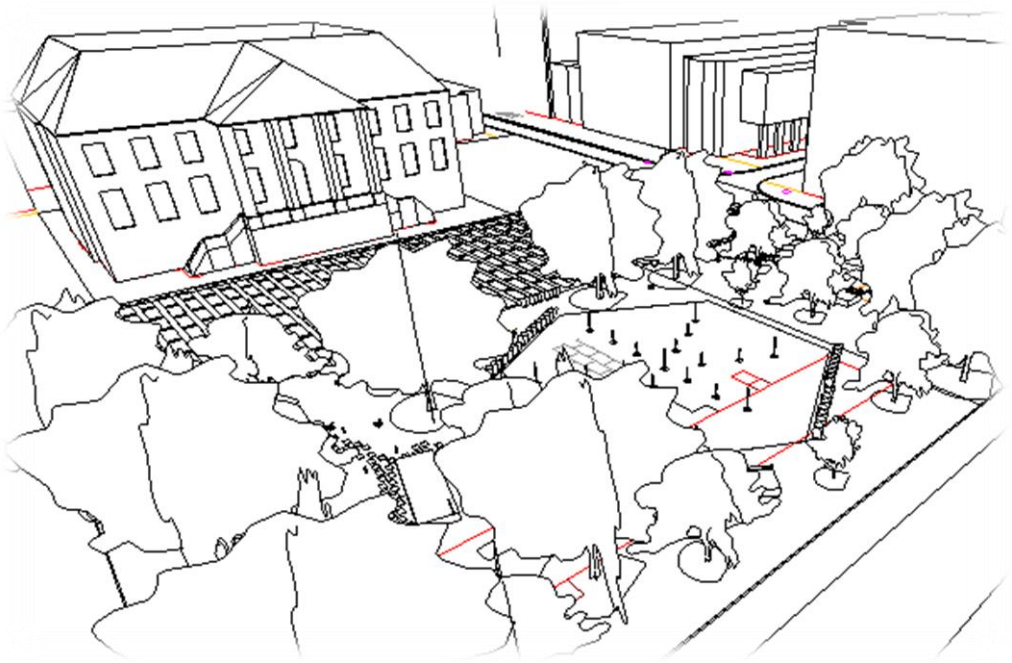
PROPOSAL 2

- Why is the design like that?

After the first proposal, the decision about taking and using the whole area in order to have a bigger impact on the local temperature was made.

That is the main reason why we decided to change everything, even though, it means moving away some events that nowadays take place there.

This proposal involve changing all the pavement to grass and to divide the area in two spaces. On the west area, the idea was to create a green promenade with white concrete pavement blocks (2,70m x 1,0m x 0,05m) placed on the grass. While on the east, an open green space with concrete benches distributed along the area, connecting them with a path of tiles (Segovia slate type. 30x15x1cm). In the middle of the east area there is a hexagonal stream of water fountain and 3 kinds of trees distributed (Japanese Cherry, Scarlet Oak and Hawthorn) all over the green area with shrubs.



Proposal 2 – Draft

Proposal 2 – View from Bench

- 3d model

Proposal 2 – View from street

Proposal 2 – View from street

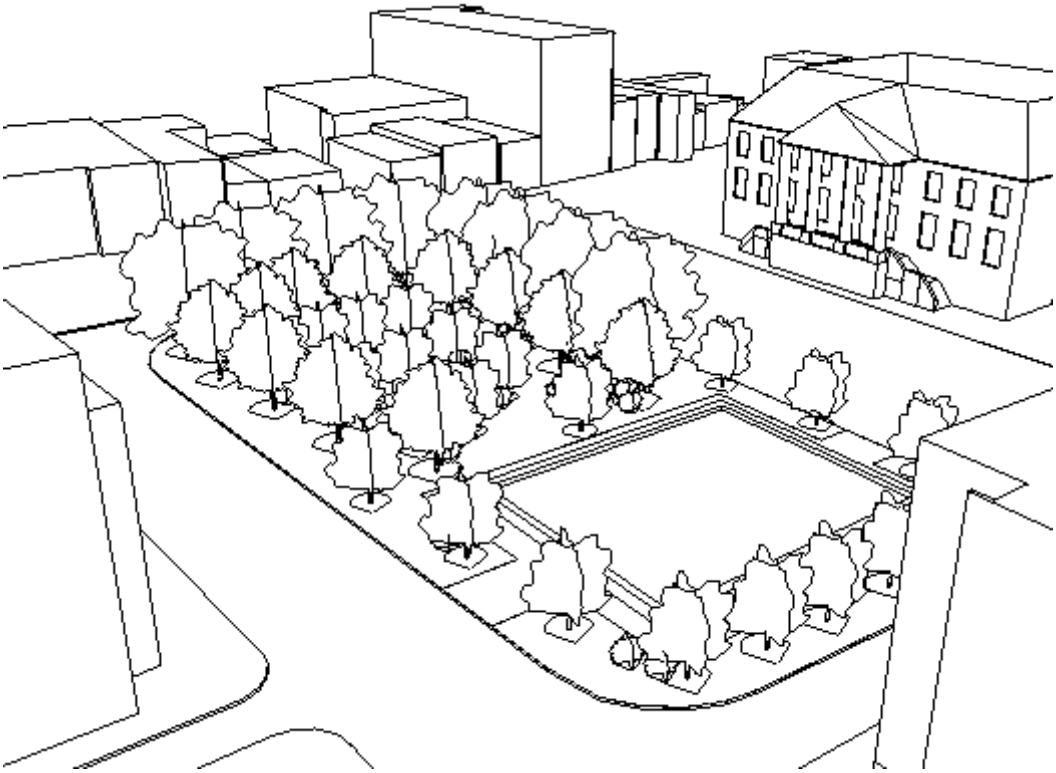
Proposal 2 – View from promenade

PROPOSAL 3

The third proposal is a variety of the second one. The dimension of the promenade stay the same but with some changes in design and dimensions.

The promenade is not made of big concrete blocks anymore but shiny granite (20 x 20 x 2cm) on the grass.

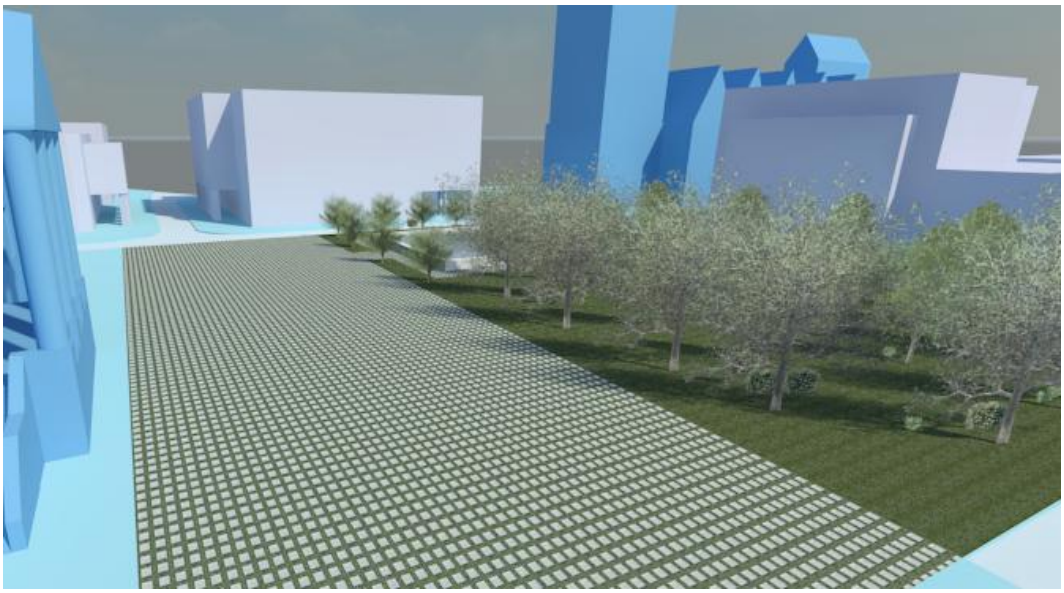
Moreover the green area has much density of trees and vegetation and a rectangular fountain with depth 0,6m.



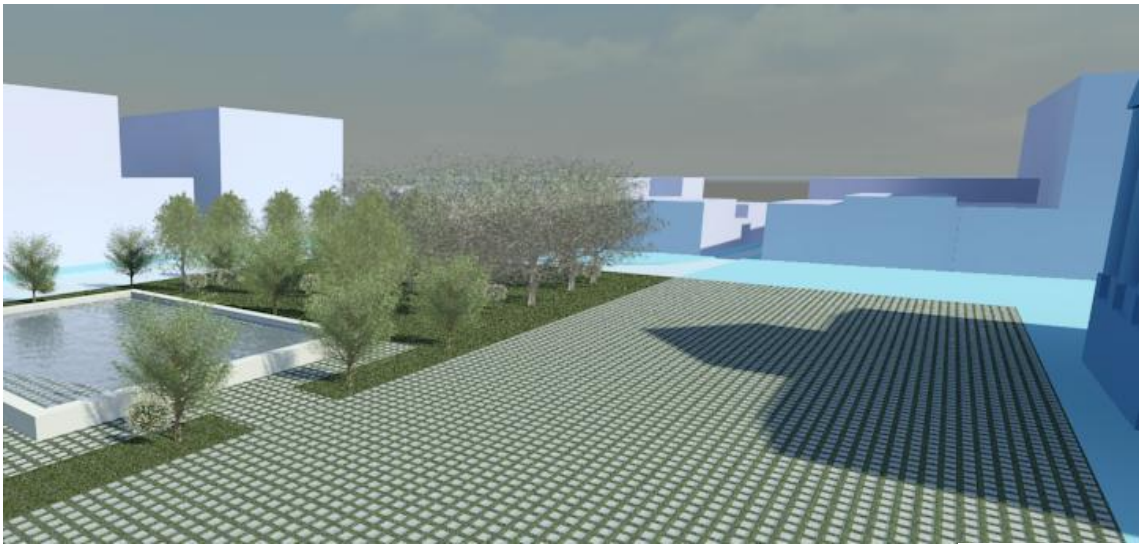
Proposal 3 – Draft

- 3d model

Proposal 3



Proposal 3



Proposal 3

Proposal 3

5. Analysis and design

5.1 Multi-criterial Analysis

Multiple-criteria decision analysis (**MCDA**) is a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments. Whether in our daily

lives or in professional settings, there are typically multiple (conflicting) criteria that need to be evaluated in making decisions.

In order to get a benefit score for each option, it is necessary to establish relative weights to the selected criterial. The purpose of the criteria weights is to enable all scores to be converted to a common scale.

Since the focus of the project is the thermal comfort and climate adaptions, results on ENVI-met have 40% weight in the final score. As has been shown in the spatial analysis, there is a lack of green areas in the city centre, which affects to the heat island effect as well as people's perception of the area so ENVI-met is a heavy point in this multiple-criteria analysis.

Costs is the next one from a scale heavy-light, with 25% weight. It would be easy to improve air temperature, wind speed, and thermal conditions with and undefined budget but it has to be feasible at the end.

Maintenance, design and public opinion is taken into account with a lower weight, since their importance is not that relevant.

Our criterial will be the following:

		Priorities (%)
Criterial 1	Public Opinion	5
Criterial 2	Costs	25
Criterial 3	Maintenance	10
Criterial 4	ENVI-met effect	40
Criterial 5	Design	20
Total		100

5.2Final design

So applying the multiple-criterial to the three proposals, the one that scores higher is the most feasible, suitable and accurate proposal for our final aim.

So the proposal one scores 5,95 out of 10, the second 6,95/10 and the third 7,1/10.

The third one is the best option after applying the multi-criteria analysis.

It was what we expected. The first proposal was designed first, obtaining its ENVI-met results. Then we were able to compare how much everything we designed affected to the

Criterial	**PROPOSAL**								
	1			**2**			**3**		
	1-10	%	Result	1-10	%	Result	1-10	%	Result
1	6	(0,05)	0,3	8	(0,05)	0,4	7	(0,05)	0,35
2	7	(0,25)	1,75	6	(0,25)	1,5	6	(0,25)	1,25
3	7	(0,10)	0,7	6	(0,10)	0,65	6	(0,10)	0,6
4	5	(0,40)	2	7	(0,40)	2,8	8,5	(0,40)	3,4

5	6	(0,20)	1,2	8	(0,20)	1,6	7,5	(0,20)	1,5
TOTAL:			5,95			6,95			7,1

ENVI-met and thermal conditions so in the second and third proposal we had the chance to design something with a bigger impact in results. As we enclosed in appendices the variation on temperature is not spectacular, even though, just 1ºC may mean a real change.

This final proposal has everything to be a feasible proposal to carry on and a perfect option to adopt, since all results are known. Moreover, the obvious lack of green areas in the city centre, which all people interviewed during this project referred to, and the need to adapt to climate changes it is the best moment to invest in something like this solving the lack of green/blue areas, incrementing thermal comfort and giving people what they want.

6. Conclusion

6.1 Remarks

This project goal is to make people realize how climate is changing which can affect to our citizens and their thermal comfort and life as well as giving some solutions to the city centre of Groningen as adaptations on thermal comfort in urban planning and design.

When we were selected to do this project, we were surprised by the topic, since speaking about heat stress and heat waves in the Netherlands, which is a northern country, may sound weird. But honestly, we won interest as we were moving on. As it was intended, the literature review made us realize the importance of climate change even in northern countries so it was not something to worry about just in heat extreme countries.

It was easy to find articles and studies about this problem. Some of them with reliable data and with very interesting points of view, so reading about this problem was the most important part to successfully carry out this project. Once the literature review was done, so the problem was identified, it was time to investigate options and adaptations. It is interesting not just to focus on the Netherlands but world-width. Since understanding the problem as world-width brings more solutions and it is easier to determine vulnerabilities.

As reference, we observed how our own country, Spain, faces this problem. In particular, Valencia, which is our city, and we came up with lots of solutions such as temporary tents from roof to roof to create shade along some streets, green spaces, water vaporizers, green facades/roofs, or simply using materials with higher albedo.

Nonetheless, it was just the beginning. Once the problem was identified as well as vulnerabilities and options/adaptations it was time to find out what the costs are to invest in this problem and, at the same time, if people are interested and willing to pay the cost for climate resilience.

The idea was to interview some random people around the city center to find out how much do they care about this problem, if they are aware of it and it is worth it to invest on it from their point of view. At the same time, one of the questions showed some options and green spaces that are already constructed so they could evaluate and rank them. We were happy about the results. Everyone showed interest for this problem, they are down for helping and they think it is important to invest in something like that and take care of our environment and, at a larger scale, of our planet. After all interviews, it can be stated that people gives a lot of importance to environment and thermal comfort, and they do not see it as a single problem about temperature, but it affects people in physiological terms as well. According to their opinion, it can be said that including green spaces in the city centre and along streets, as well as pedestrian streets transforms the city centre in a much liveable place, cosy and it makes people feel connected with nature, which leads, somehow, even to a stress reduction in their lives.

From this interview, the next step was to design three proposals, which could improve thermal comfort. So far, we had people's opinion and how countries face this problem so we had all things needed to design our proposals.

First of all, a three layers analysis was made. This part was kind of difficult since we needed plans of infrastructure, which are owned by the municipality, and meeting the urban planner or just getting these information attached on an e-mail was a bit messed up. Even though, thanks to our educational supervisor and some other people involved in this project we managed to get it. Nonetheless, it was in Dutch, which is not a language we speak, so we needed help to understand it, and again thanks to Jonathan we got to understand it and took advantage of that information, although we might have gone deeper on this information if it were in English. Nevertheless, the underground surface and distribution of infrastructure such as pipes, cables, etc made feasible all proposals we wanted to do, because, even though there are some infrastructures that could hinder our construction process and increment the final budget, it was not a very circulated area.

Once the three proposal were designed, a study of thermal comfort for each one with the program ENVImet was decisive to be sure that all proposal had an impact on what we were looking for. ENVImet is a program we have never used before so, first weeks we worked on it simulating an easy designed square to get familiarized with the program, and we met some people who was already in touch with this program that helped us on the first steps.

Finally, all proposal were designed and the thermal comfort analysis for all of them was done. It showed interesting data, so it was reliable that what we had done has a real effect in thermal comfort, achieving by it the goals we set for this project.

As conclusion, global warming is happening and we have to keep in mind that a change is needed. There is no doubt that it is something worth it to invest on, since what we change now, either remodelling our cities or changing the following urban planning to make it more sustainable and environmentally friendly, will remain in the future. If it is not now or not us, our future generations will have a bigger problem so in a large scale and long-term it is completely worth it. Even though it is a huge process that we have to go through, the whole world is worried about it and if we all do something, the difference is enormous. So definitely, thermal comfort is linked to living standards and healthy/comfortable living environments, so it has to be a important point to take into account in our urban design and planning. Even though, more research have to be done in the future about this topic.

6.2 Further researches

Taking into account that there are different ways to plant a tree or create a green area it would be interesting to make a research about which one is the best option to organize a green/blue area. If you are going to create a green space such a park, does it matter how you organize the vegetation, trees, use of shades or doesn't the order have an effect in the results/outcome.

Another interesting point could be to investigate whether all solutions and adaptations have the same impact besides the country. What we want to mean is, if the relation between the effect and the environment is something linked as a percentage with the type of weather in the country.

A study about what is actually thermal comfort since that feeling may change from person to person due to different perceptions.

Nowadays, there are many options to face heat stress as showed in this project, but, how much power do these options have in thermal comfort? It would be nice to, somehow, rank all adaptations in effectiveness.

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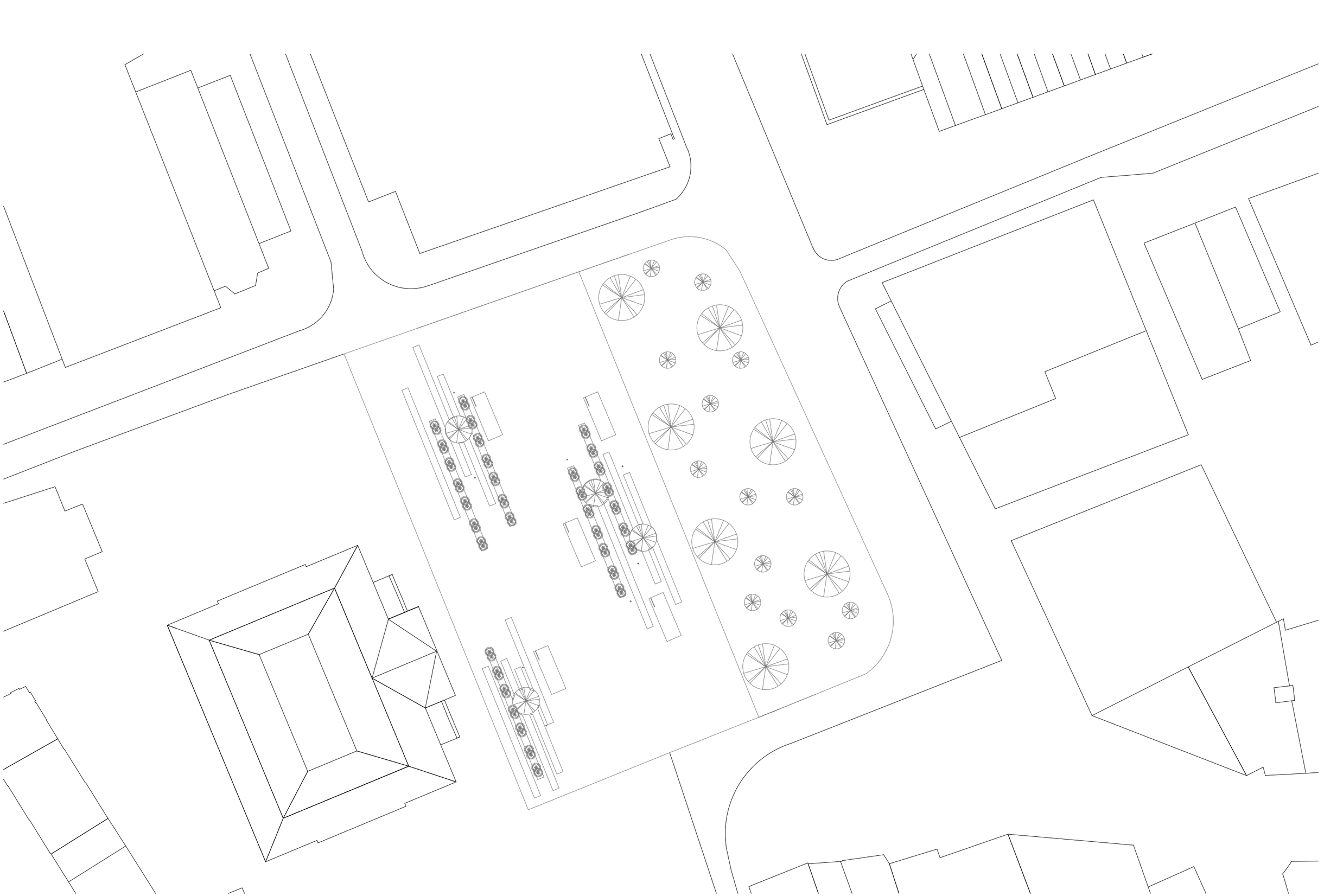
8. Appendix

Annexes 1: Design

-Map proposal 1

-Map proposal 2

-Map proposal 3



Scale 1/500

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N

Hanzehogeschool Groningen
University of Applied Sciences

Appendix_Proposal 1	Student:	Student number:	Group: Spanishteam
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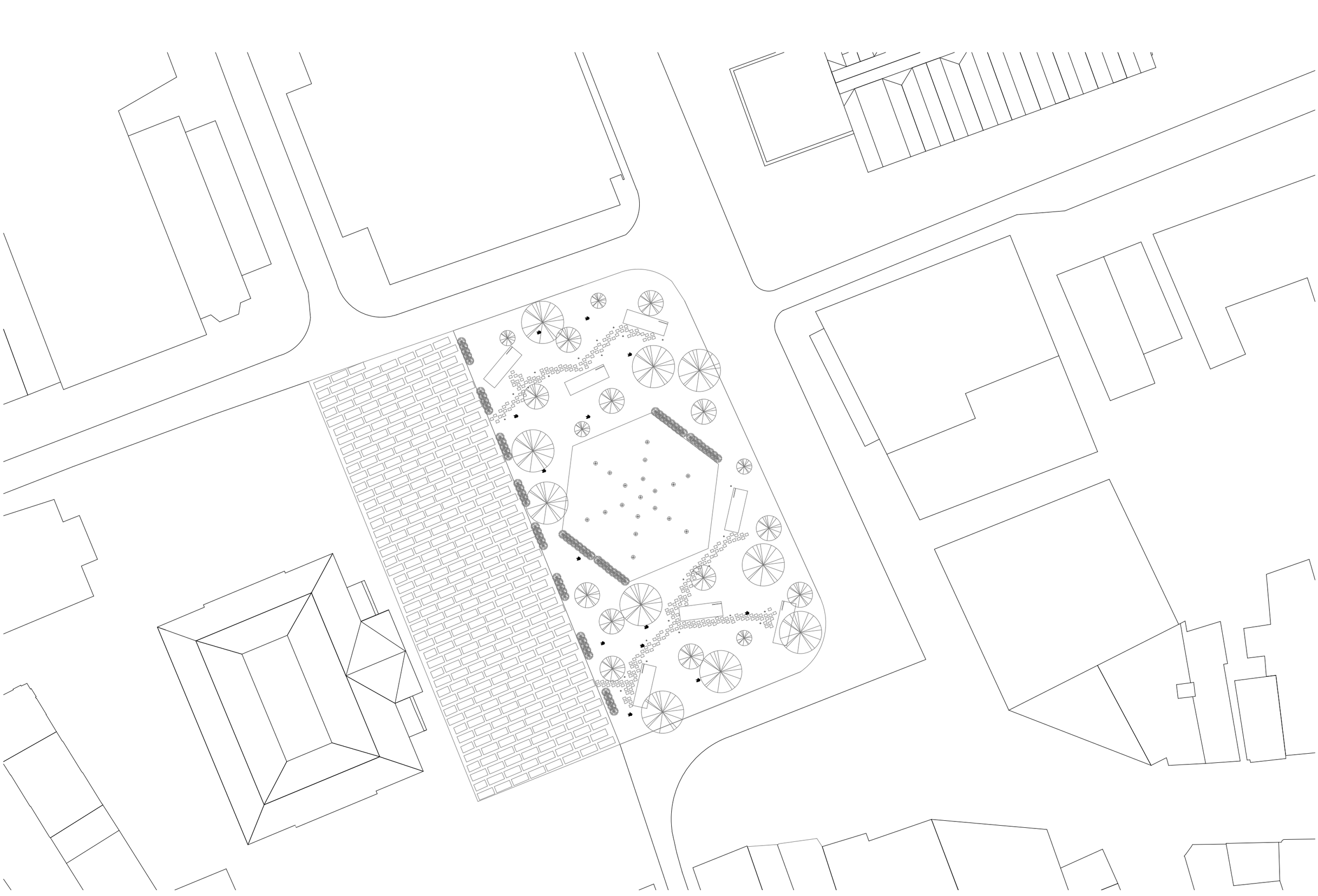
	Mónica Morales LLamas	349422	General Scale: 1/500
	Ricardo Santiago Gómez Bugeda	350412	



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University of Applied Sciences

Appendix_Proposal 2

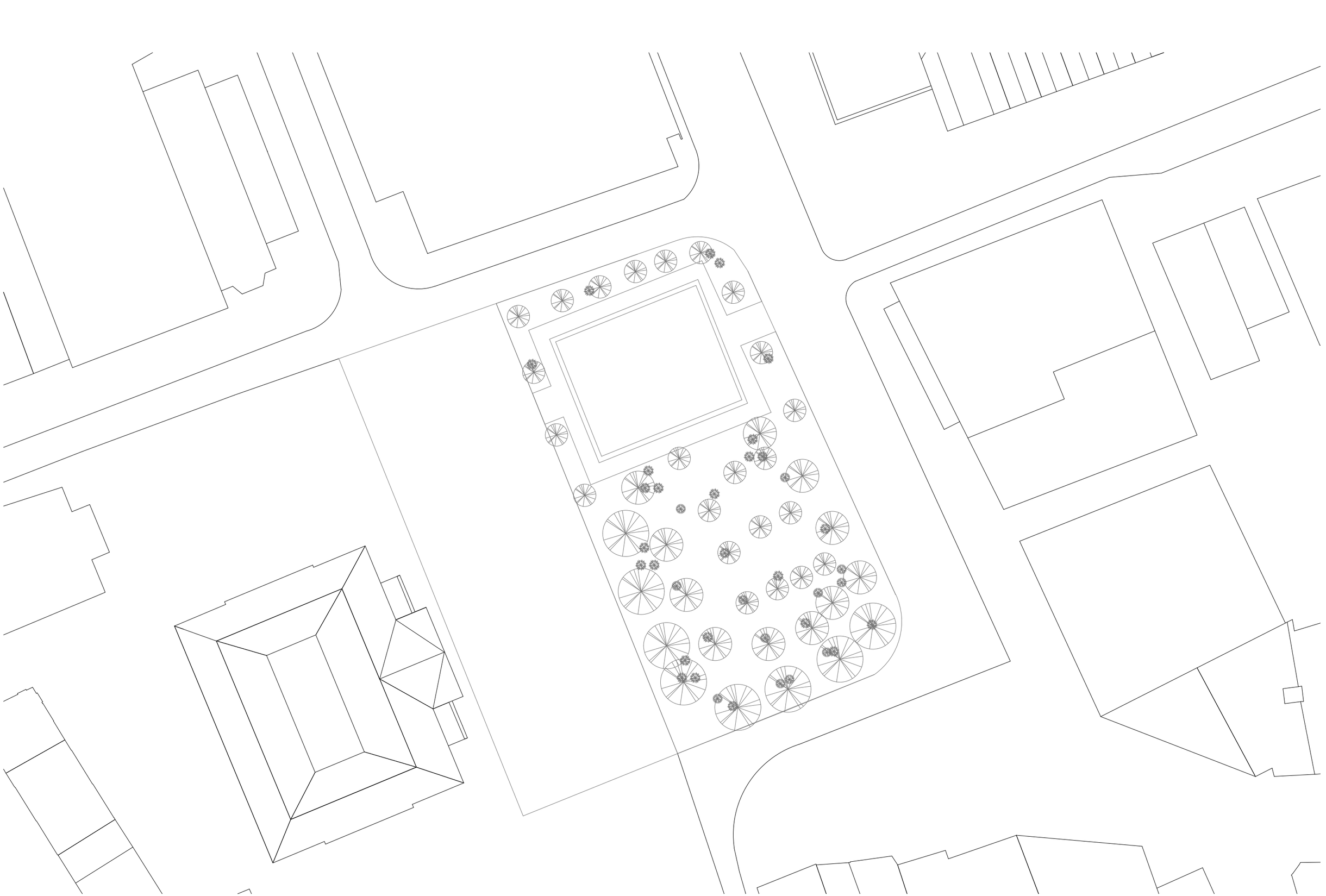
Design

Student: Student number:

Alfredo Riera Pérez 350188
Mónica Morales LLamas 349422
Ricardo Santiago Gómez Bugeda 350412

Group: Spanishteam

General Scale: 1/500



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Hanzehogeschool Groningen
University of Applied Sciences

Appendix_Proposal 3	Student:	Student number:	Group: Spanishteam
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	Ricardo Santiago Gómez Bugeda	350412	