Promoting a better public health quality with Urban green space in an informal settlement

Bogota, Colombia

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Promoting a better public health quality with urban green space in an informal settlement, Bogota, Colombia
Förbättra folkhälsan med urbana grönområden i en informell bosättning, Bogota, Colombia

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Preface

Hello and welcome to my master thesis. This is the final piece of academic work that I will use to complete my final two years in Landscape architecture Masters at SLU, Alnarp.

The concept for this thesis began in Hong Kong, where I spent the summer doing an exchange with the Hong Kong University of Science and Technology. I took urban air pollution classes, which sparked my interest in the subject as well as the relationship between man, the urban environment and the natural environment. Going around Hong Kong collecting air pollution data made me more aware of the impact of air pollution and potential solutions that can benefit both human well-being and the natural environment. The lessons I learned during the exchange motivated me to continue my studies into the relationship between humans, nature, and the urban environment. As a result, studying landscape architecture has taught me the benefits of nature-based solutions and how to apply them to our environmental issues in order to ensure a sustainable future for all.

The ability to design public spaces and urban environments as an educated landscape architect is also the ability to make a significant change to the human world as we know it. The structure of certain vegetation and environmental elements has a significant impact on the current and future climate.
This knowledge astounded me so much that I decided to devote my entire thesis to the creation of a public space that could make a difference in mitigating climate change and envrionmental adversities as poor air qualiy and providing a better environment for everyone regardless of socioeconomic disparity.

The masters program has focused on the unique relationship that exists between man and the environment. My studies have focused on natural solutions and other co-benefit situations for humans and the environment.

A MFS stipend was used to obtain data for this thesis, allowing me to further investigate the relationship between humans and the natural environment in Colombia. The advantages of coexisting with one another and providing co-benefits solution for environmental problems and societal challenges.
This thesis has given me the opportunity to work independently as well as collaboratively with experts from around the globe. It was definitely eye-opening and led to some interesting discoveries Therefore, this thesis discusses environmental justice, climate change, socioeconomic inequality, and the benefits of good urban planning using nature based solutions.

I've eventually learned that nature-based solutions have a lot to offer, and this is just a small step in the right direction. An appropriately designed urban park can go a long way toward not only mitigating and adapting to climate change, but also increasing social cohesion and providing recreational opportunities to improve public health.

The motivation and dream of this thesis to to one day inspire the actual creation of the park.

I will like to say a special thank you to my family and friends for encouraging in pursuing this master and inspiring me to take on this journey to Colombia

A special thanks to the assistance I received on the field during the interviews from local students such as Aline Vilela and Camila Pulido for their expertise in field work planning and other important discussions about the results.

A special thanks to all of the locals who took the time to participate in the interviews. My gratitude to Ögren Josefin for inspiring me and answering my technical questions.

I'd like to express my heartfelt gratitude to my supervisors, Åsa Ode Sang in SLU Sweden, in particular for her enthusiasm in encouraging and supporting me in taking on the MFS stipend program, and Jaime Hernandez in Colombia, in particular for his excellent support both on and off the field.

My thesis and time in Colombia would not have gone as smoothly if I had not received this assistance and strong encouragement from both supervisors.

Abstract

Heat waves, rising temperatures, air pollution, and loss of biodiversity are examples of issues that will and are already rising due to climate change. The urban environment is one that continues to steadily grow at the cost of natural vegetation in the city, and this will only worsen with population growth. Urban green infrastructures, specifically urban green spaces, are of utmost importance in combating the consequences of future climate change and urbanization.

This is because they provide immense ecosystem services such as improving the air quality, increasing local biodiversity, providing restoration, managing stormwater in the city, and much more. These services provided in urban green spaces are closely related to residents; physical and mental health, as well as increased social integration and group identity.

The benefits of urban green spaces for public health increase greatly with the use of specific vegetation that can reduce air pollutants. This is why this thesis is about improving public health whilst mitigating and adapting to climate change using sustainable urban green space designs. The study area of the thesis is set in an informal settlement in Bogota.

Green spaces in cities are not always equitably distributed, particularly in developing countries such as Colombia with an intense history of segregation where green space tends to correlate with real estate prices, resulting in urban gentrification, socioeconomic disparities, and green space exclusivity.

This is why in addition to improving the public physical health, and mitigating climate change a strong emphasis on local co-creation methods is highlighted in the thesis. This is because the local perspective is an important aspect of landscape architecture design. Giving a voice to the community.

A local co-creation will foster a stronger connection to the green spaces, allowing for regular maintenance and use. Improving the quality of urban green spaces specifically targeting environmental challenges and protecting the public health of urban dwellers while emphasizing participatory processes will provide a co-benefit approach in urban areas. This will address UN sustainability goals, socioeconomic disparities, and public health.

As a consequence, behavioral research methods such as Gehl's methodology and interviewing are used. Based on the findings and design principles, a design proposal is created.
According to the interviews and observational analysis, the most lacking component for the community, and thus the most important, is safety and recreational opportunities in the park. This opened up the discussion on the importance of adequate communication between citzens and landscape architects in city planning.This had an impact on the design proposal for a sustainable park, as well as the design principles for air pollution management. The proposal resulted in four distinct themes of an urban park with recreational opportunities for people of various ages.

Sammanfattning

Värmeböljor, stigande temperaturer, luftföroreningar och förlust av biologisk mångfald är alla exempel på problem som är vid horisonten och förvärras av klimatförändringarna. Stadsmiljön är en som fortsätter att växa stadigt på bekostnad av stadens naturliga växtlighet, och denna situation kommer bara att förvärras med befolkningsökningen. Grön infrastruktur i städerna, särskilt urbana grönområden, är avgörande för att hantera de framtida konsekvenserna av klimatförändringar och urbanisering. De tillhandahåller faktiskt enorma ekosystemtjänster som att förbättra luftkvaliteten, öka den lokala biologiska mångfalden, återställa, hantera dagvatten i städer och mer. Dessa tjänster som tillhandahålls av grönområden i städerna är närliggande med invånarna, fysisk och psykisk hälsa, samt stärker social integration och gruppidentitet.

Folkhälsofördelarna med urbana grönområden ökar dramatiskt med användningen av specifik vegetation som kan minska luftföroreningarna. Därför fokuserar den här uppsatsen på att förbättra folkhälsan samtidigt som den mildrar och anpassar sig till klimatförändringarna med hjälp av hållbara grönområden i städer.

Uppsatsens forskningsområde är beläget i en informell bosättning i Bogotá, Colombia. Urbana grönområden fördelas inte alltid rättvist, särskilt i utvecklingsländer som Colombia, som har en lång historia av segregation, och grönområden är ofta korrelerade med fastighetspriser, vilket leder till urban gentrifiering, socioekonomisk differentiering och exklusivitet för gröna ytor.

Det är därför, förutom att förbättra folkhälsan och mildra klimatförändringarna, belyser uppsatsen lokala tillvägagångssätt för samskapande. Detta beror på att det lokala perspektivet är en viktig aspekt av landskapsarkitekturdesign.

Lokalt samskapande kommer att främja en starkare koppling till grönområden, vilket möjliggör ständigt underhåll och användning. Förbättra kvaliteten på urbana grönområden genom att specifikt ta itu med miljöutmaningar och skydda stadsbornas folkhälsa, samtidigt som man betonar deltagande processer som kommer att gynna gemensamma intressen i stadsområden. Detta kommer att arbeta mot FN:s hållbarhetsmål, socioekonomiska skillnader och folkhälsa.

Därför används beteendeforskningsmetoder som Gehlmetoden och intervjuer. Skapa designförslag baserade på resultat och designprinciper. Enligt intervjuer och observationsanalys är den mest bristande delen i bosättningen, och därför den viktigaste var säkerhet och rekreationsmöjligheter.
Detta öppnade för diskussionen om vikten av tillräckligt och lämpligt kommunikation mellan medborgare och landskapsarkitekter i stadsplaneringen. Detta har konsekvenser för designalternativ såväl som för designprinciper för hantering av luftföroreningar. Förslaget leder till en park med fyra olika teman som ger rekreationsmöjligheter för människor i alla åldrar.

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Introduction

The introduction chapter begins with the background which includes a literature review of the subject as well as relevant theories in order to understand the significance of the project. It establishes the context and purpose of the research.

The background is followed by the study's aim and objectives, research questions, and limitations. The thesis method is described in detail, as well as the working process and terminology used in the thesis.

Background

Air pollution affects everyone regardless of socioeconomic differences. It is said to be the greatest environmental hazard to human health by Barwise and Kumar (2020). According to the World health organisation WHO (2016), in 2012, it was responsible for one out of every nine deaths each year. It is a global issue that intensifies with the rise in global population, urbanization, and climate change (Barwise and Kumar 2020).

Outdoor air quality in Bogota, Colombia, is an immediate concern; toxic concentrations of PM10 and PM2.5 have been twice as high as WHO reference values in the last decade (Mura et al. 2020). The local government has acknowledged that air pollution and respiratory illnesses are the leading causes of morbidity and mortality in children under the age of five (Hernández-Flórez et al. 2013; Mura et al. 2020, pp 2).

Urban green spaces (UGS), which include gardens, parks, spaces with trees and shrubs, greenways, etc, (Lotfata 2019) are known to provide a variety of environmental services that enhance the quality of life in the urban environment (Hernández, Pallagst, and Zdunek-Wielgołaska 2018, pp 4). They improve the city's air quality, provide abundant biodiversity, and regulate the surface temperature, among other services (Lotfata 2019). These spaces are extremely important as they allow people to improve their physical and mental health while also increasing local social cohesion in the communities (Jennings and Bamkole, 2019).

Furthermore, the immense ecosystem services such as carbon sequestration, stormwater management, heat wave reduction and improved air quality (Janhäll 2015; Velasco et al. 2016; Basto et al. 2014) provided by UGSs, leads to reduced urban heat island effect, reduced carbon emissions, climate change mitigation, water flow regulation, and increased biodiversity (FAO 2016). It provide opportunities for the sustainable development of cities. Therefore, careful planning and design that considers specific vegetation traits that are known to provide a variety of ecosyste services are extremely beneficial to maximise the benefits of urban green spaces.

The benefits of urban green spaces goes beyound the envrionmental. In 1865, Fredrick Olmsted, a central landscape architect, was among the first to draw attention to the psychological benefits of being in natural areas; these comments, which were based more on folklore, support the scientific research done today on the psychological effects of nature exposure (Stack and Shultis 2013).

The attention restoration theory (ART) proposed by Kaplan and Kaplan (1989) and the stress recovery theory (SRT) proposed by Ulrich et al. (1991) both emphasize the importance of natural elements in alleviating mental fatigue caused by urban environments (Wilkie et al. 2020).

It is now well understood that access to nature in urban environments provides significant psychological benefits because for e.g physical activities can be performed, inducing restoration in individuals (Grahn and Stigsdotter 2010). This adds to the mounting evidence of health benefits. The rapid expansion and growth of the urban population have resulted in a steady decline in natural vegetation in cities, which will only worsen as the population continues to grow (Mao et al. 2020). As a result, green space in cities is not always equitably distributed, particularly in developing countries where green space tends to correlate with real estate prices (Wolch et al. 2014), resulting in urban gentrification, socioeconomic disparities, and green space exclusivity (Mao et al. 2020).

Futhermore, not all green space are created equally which Wood et al. (2018) has proven with their studies, the quality of UGS can affect the users psychological restoriation differently. Therefore, the importance of green spaces to health is a public issue.

This issue has quickly been identified as an environmental justice issue. Environmental injustice is frequently manifested as stratified park access that can be based on income, age, gender, and even ethno-racial characteristics (Wolch et al. 2014). Improving the quality of urban green spaces to specifically target environmental challenges and protect the public health of urban dwellers will provide a co-benefit approach in urban areas. A local co-creation of an urban green space will foster a stronger connection to the public space, allowing for regular maintenance and use (Costa 2020).

A green space that is developed in this manner will address UN (united nations) sustainability development goals, socioeconomic disparities, and public health (UN 2018). Therefore, green spaces in urban areas can no longer be perceived as a luxury rather a necessity in terms of their environmental, social, health, and economic benefits, which have a direct link to achieving the UN Sustainability development goals (SDGS) and generally improving quality of life (Cilliers, 2015).

However, obtaining the social, environmental, and economical benefits of urban green spaces necessitates proper urban planning and design that is site specific. Having a participatory design process will have more weight in the development decision-making process and promotes the use and maintenance of the green space on a regular basis (Hou and Rios 2003). Thus, it would be of significant interest to the scientific community in providing a site-specific design proposal of an urban green space that can utilize the benefits of local vegetation in overcoming several environmental challenges such as air pollution.

Therefore, the purpose of this thesis is to provide a design proposal of a park that addresses envrionmental challenges, poor public health and reduced recreational oppotunities using local vegetation and local participation in an informal settlement in Bogota.

Figure 1:
a) A view of Bogota city taken by author. The image shows the metropolitan city of Bogota with its bustling traffic and mountain scape behind.

B) a view taken over the informal settlement district in Bogota. Already the direct contrast between the two neighborhoods are noticeable

Aim & Objectives

The aim of this master's thesis is to develop a sustainable design proposal for a park in Bogota's informal settlement Manitas Barrio.

A sustainable design proposal means it can provide a variety of ecosystem services in dealing with environmental challenges such as air pollution, storm-water management, and a lack of biodiversity but also improve the mental and physical public health of residents with increased recreational possibilities.

The thesis objectives are
• to in a longterm improve the physical and mental health of residents living in Manitas Barrio.

• to involve the residents in the design process and enhance the recreational value and social cohesion of the community.

Two research questions are addressed in the thesis. The questions are designed to spark discussion about how careful planning of urban green spaces can help to address environmental issues such as air pollution, storm-water management, and a lack of biodiversity and improve the public health of residents in informal settlements.

They also address the critical role of local participation in the design process using cocreation methods and the sustainable benefits of urban green space to both the environment and human health.

The result is delivered through design principles and a design proposal based on these principles.

Research Questions

What are the identified plant traits and factors that contributes to reducing air pollutants, managing storm water, and increasing biodiversity in Bogota?

How can urban green space in an informal settlement be designed to promote better air quality and public health with the integration of a local perspective in Manitas Barrio, Bogota?

Case description

The project is based on an informal settlement in the Colombian capital city of Bogota.

The project will consist of a design proposal centred on Villas el Diamante Park in Manitas Barrio, located in the settlement known as Ciudad Bolivar, as well as analyses of relevant areas and surroundings.

It is restricted to design principles that can be applied to urban green spaces and combine ecosystem services, recreation, and local participation, resulting in a design proposal that employs site-specific solutions.

The design concept focuses on a single park within the settlement. The park is currently a concrete basketball court with a sparsely vegetated and scant playground equipments. It is located on a hilltop on the city's outskirts.

Figure 2: A shapefile of Colombia created using ArcGIS (ESRI, 2019), additions made by Pamela Huskin Okinedo (2022)

Figure 3: the study area of the Villas el Diamante park marked in yellow. Satellite imagery from Ezmap (2021), addition made by Pamela Huskin Okinedo (2022)

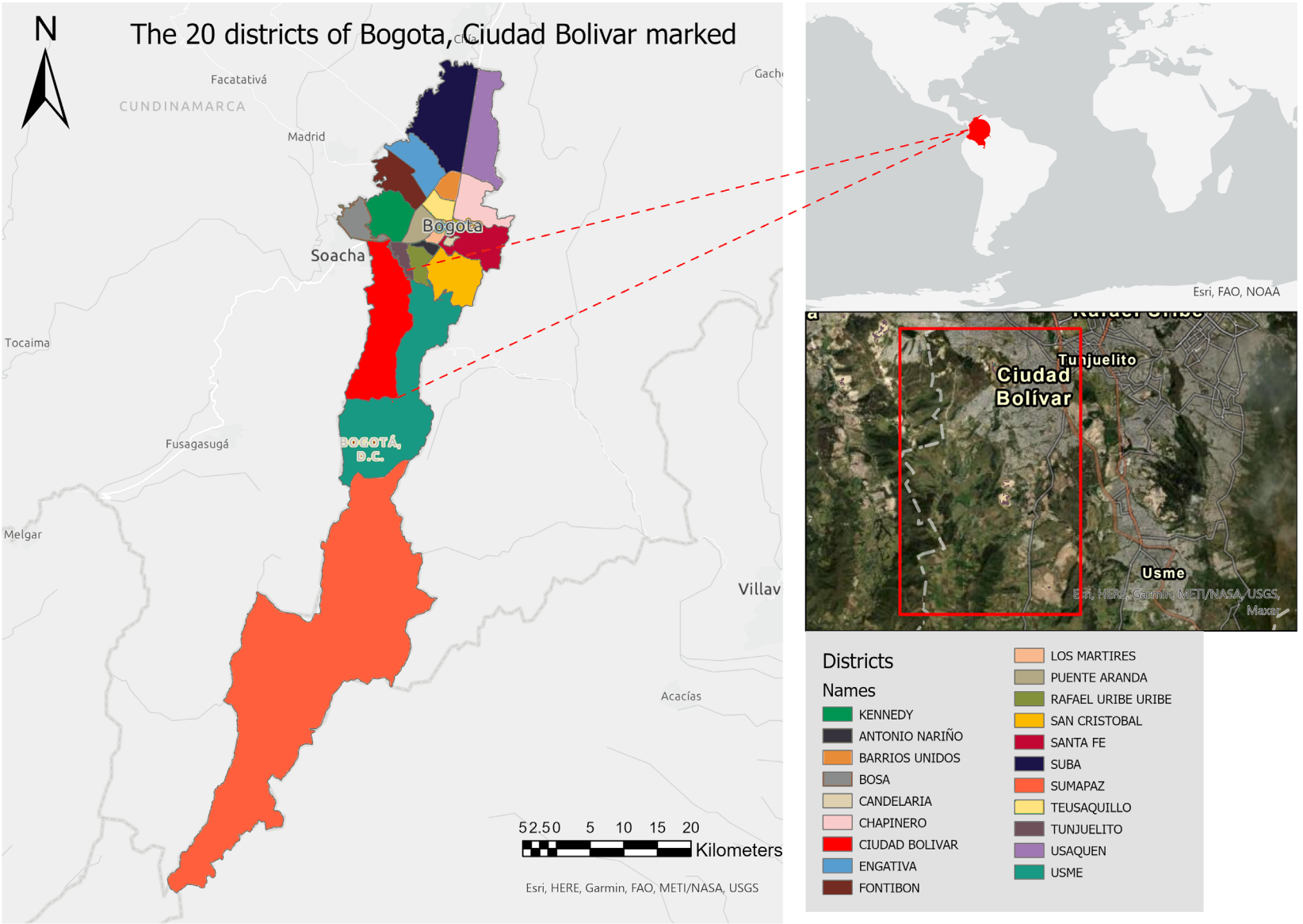


Figure 4: The site of the study is shown on the diagram above. The base map is provided from (Ideca, 2016) and the map has been modified by the author using ArcGIS. The study site is located in Ciudad Bolivar, and the area is called Manitas Barrio. However, the park is located in one of the settlement adjacent to Manitas which is called Villas el Diamante hence the parks name. Villas el Diamante Park.

Context of Informal settlement in Bogota

Latin America is the most urbanized region in the developing world, with cities housing approximately 80 percent of the population (Jose and Amézquita 2022). The effect of such rapid urbanisation in Bogota is largely due to the violent history that has impacted Colombia causing huge displacement of rural residents (Sarmiento et al. 2020). Today, large parts of the population in Latin America live in informal settlements, therefore, a general discontent due to segregation and inequality across the continent is profound (Jose and Amézquita 2022).

This problem has manifested itself in health disparities within cities resulting from the inhabitable conditions that the informal settlements lead to (Sarmiento et al. 2020). Colombia has previously been described as a land of paradox. It has the oldest democracy in Latin America and short period of military dictatorship. The country has been through conflicts on land control, power, and drug trade. It has the longest guerrilla war in Latin America and also the highest displaced people in the world (Walsh 2013).

Bogota – The study site

Bogota, Colombia's capital, has a population of approximately 8 million people. It is the country's most populous city (Moreno-Montoya, Ballesteros, and Idrovo 2022). Bogota is divided into 20 districts (figure 4) with Ciudad Bolivar being the district with the highest poverty (Walsh 2013) and also part of the informal settlement of Bogota. Bogota, like other large Latin American cities, has an intriguing urbanisation history leading to the development of informal settlements. During the 1960s, Bogota immersed six municipalities, resulting in an increase in the rate of urban expansion and dwellings, primarily through informal urbanisations (Walsh 2013; Basto and Bolanos 2015).

Informal settlements

Informal settlements were previously described as the presence of two cities in one. That is, both formal and informal. As Hernandez-Gracia (2013) points out, this viewpoint is problematic for various reasons. As a result, the new perspective in difference to the older recognizes the people who live in these settlements. It is still challenged, but unlike the old perspective, it recognizes that informality can be an opportunity rather than just a problem. It acknowledges informality as a method of producing urban space, and it challenges the binary distinctions of *"formal"* and *"informal,"* or *"legal"* and *"illegal."* These settlements are viewed as a part of the cities, and they eventually start to acknowledge the people behind the houses and streets.

It recognizes it as more than just a collection of run-down houses and streets but also as people interacting with space (Hernandez-Gracia 2013). The definition of informal settlement used in Hernandez-Gracia (2013) book about the barrios of Bogota is also utilised in this thesis. They are according to Kellet (2008, pp 11) *"by definition unfinished projects in which the agency and the creativity of the occupant builders is central, in contrast to architect-produced architecture which emphasises the physical form of the buildings often at the expense of the user"* (Hernandez-Gracia 2013). In Bogota, informal settlements are referred to as Barrio, whereas in Medellin, they are referred to as comunas (Zorro 2016). This research area is known as Manitas Barrio, after the Manitas informal settlement located in Ciudad Bolivar see figure 5.

Informal settlements in Bogota

The brutal history of Colombia led to the hasty movement of groups of people from rural areas into a city that was under the process of development and planning in the 1950s. Therefore, the city had no capacity in integrating the new population (Basto and Bolanos 2015).

These group of people formed their own community by living in habitually dangerous environment and in a much lower quality of life (Walsh 2013; Basto and Bolanos 2015). This self-construction of a society has led to the case of informality since the very first settlements arrived, and the situation still persist today in Ciudad Bolivar, Bogota. The problems of low-quality housing and low living standards (Basto and Bolanos 2015).

Between 1951 and 1964, formal dwelling in Bogota accounted for about 57.9 percent of the total. However, between 1964 and 1973, the percentage of people living in informal settlements increased to about 49.8 percent. Finally, between 1993 and 2005, the informal settlements grew to 44 percent of the dwelling (this number is an approximate). It is nearly equal in size to the "*formal*", articulating the inherent issue on inadequate urban planning (Hernandez-Gracia 2013; Portes 1989; Moreno-Montoya, Ballesteros, and Idrovo 2022; Blanco 2012).

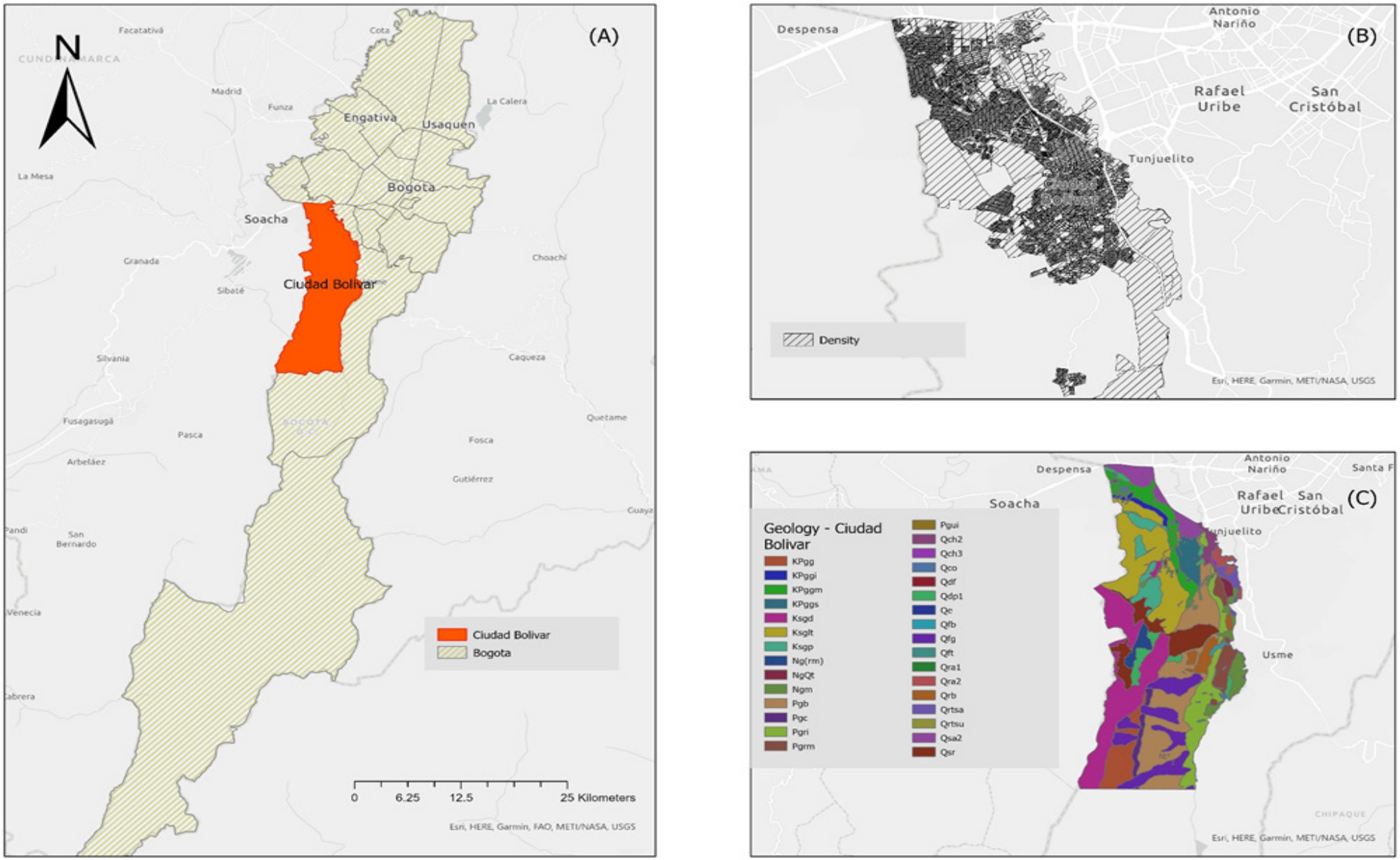


Figure 5: Three maps of Bogota displaying Ciudad Bolivar informal settlement. Map (A) show the layout of Ciudad Bolivar in relation to Bogota city. Map (B) shows the density of Ciudad Bolivar. As displayed, most of the housing are clustered towards the north and central of the settlement. Map (C) displays the urban geological information of Ciudad Bolivar. There are various types of geology and the most occurring is the ksdg formation which implies hard sandstone with minor siltstone inculcation. The basemap is retrieved from Ideca (2016), Colombians government official mapping data site and it has been modified by author using ArcGIS pro.

Ciudad Bolivar

Ciudad Bolivar informal settlement region of Bogota is made up of approximately 95 percent informal buildings, with approximately 58 percent of the population living below the poverty line that is (in dangerously alarming conditions) (Suarez et al. 2015).
Ciudad Bolivar is located in the southwestern part of the city of Bogota see figure 5, it has approximately 326 neighbourhoods and about a million inhabitants with an urban area of 3,391 hectares (ha), (Torrenegra 2019).
It borders the town of Bosa to the north, and to the south Usme and Sumapaz.

The topography is 90 percent mountainous due to its location on the southeastern hills of the savannah (Torrenegra 2019) and about 72 percent of the area is considered to be rural (Basto and Bolanos 2015; Torrenegra 2019).

It is in this region the study site of the thesis is located see figure 6. Las Manitas neighbourhood, in Ciudad Bolivar informal settlement, Bogota Colombia. Villas el Diamante is located in close vicinity with two other Barrios which are Manitas and Nuevo Colombia that makes up Las Manitas.
Ciudad Bolivar's origins can be traced back to the founding of Bogota.

The indigenous tribes of Muisca, Suatagos, Cundais, and Usmes had previously occupied the site (Basto and Bolanos 2015). It was also known as the Usme forest at the time. In 1910, these lands were sold to Gonzalo Zapata Cuenca, and in 1950, they were distributed to Luis Morales, Rosendo Galindo, Mario Suarez, and Eliodoro Criollo, who decided to turn the area into a brick factory and allowed workers settlements in exchange for 1000 bricks manufactured (Leon and de Jesus 2021; Basto and Bolanos 2015).

Figure 6: A basemap over Las Manitas neighbourhood. As can be observed on the image, three neighbourhoods including the study site (Villas el Diamante) make up the Manitas neighbourhood which is located in Ciudad Bolivar the informal settlement of Bogota Colombia. The basemap has been retrieved with capmapper and modified using Sketchup and illustrator by author

The armed forces violence in the 1940s drove many displaced peasants to seek desperate refuge in the lands. With the passage of time, the Manitas neighbourhood in Ciudad Bolivar developed its own urban layout devoid of rules or organization (Leon and de Jesus 2021), resulting in a significant increase in population. Its sociodemographic population and outlying location have resulted in a unique settlement. Its history is littered with poverty, violence, and insecurity. This has a cascading effect on health and equal opportunity, access to resources, and communication with the rest of the city (Leon and de Jesus 2021). Through the power of the constitution, in 1992, the town of Ciudad Bolivar was officially constituted conserving its limits (Zorro 2016).

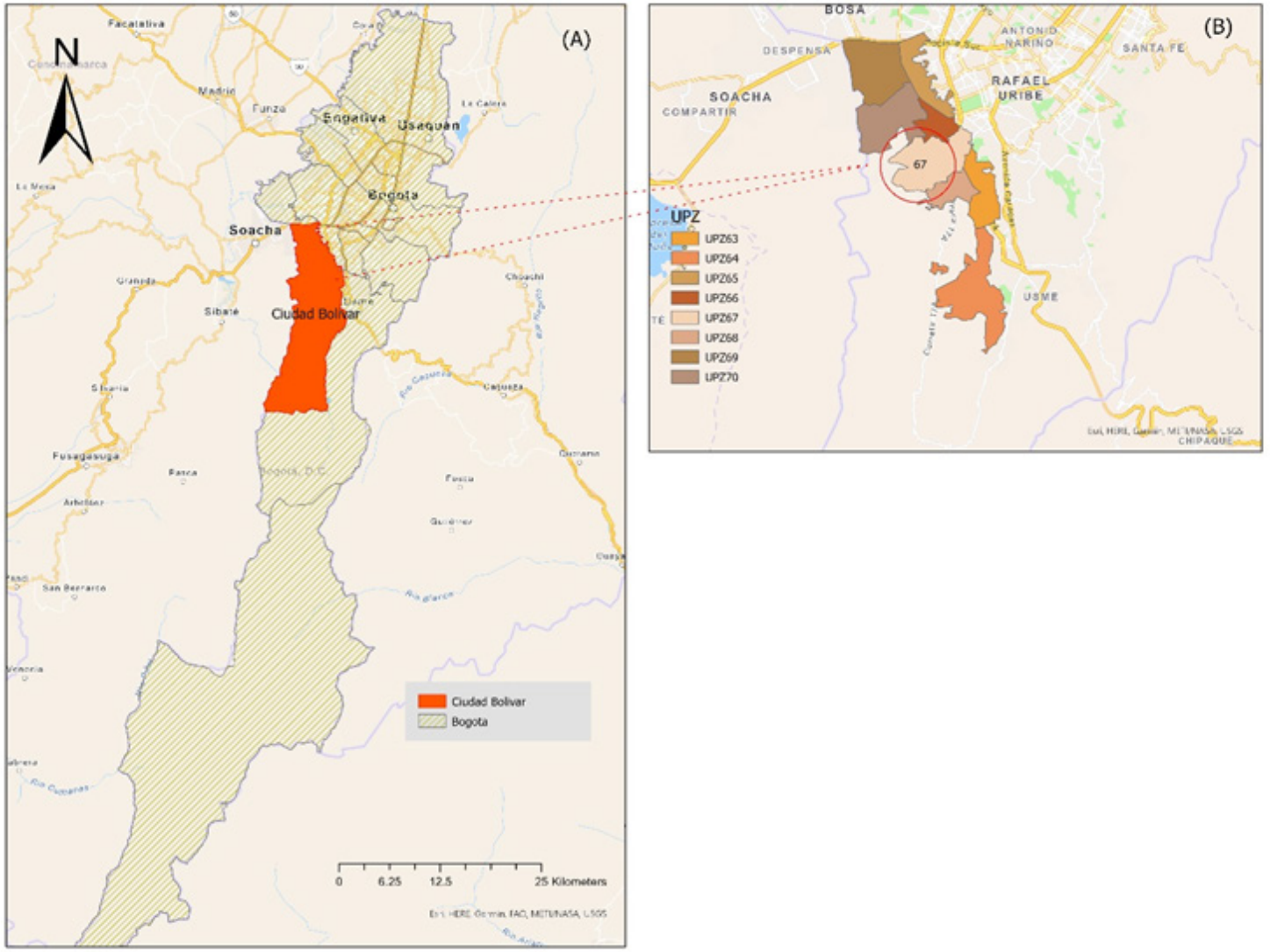


Figure 7: this displays the map of Bogota and Ciudad Bolivar. Figure b shows the different UPZ in Ciudad Bolivar and UPZ67 Lucero is marked. The basemap is retrieved from Ideca (2016), Colombians government official mapping data site and it has been modified by author using ArcGIS pro.

Ciudad Bolivar environment

At 2,625 meters above sea level with an average temperature of 14.5 degrees, Bogota has a subtropical climate (Walsh 2013). Ciudad Bolivar's annual temperature ranges from 9 to 19 degrees, with an average of 14 degrees Celsius. The yearly rainfall ranges from 600 to 1000 mm. The neighborhood is situated at an elevation of 3100 meters above sea level, which is both its highest and lowest point. It has a lot of mountains (Basto and Bolanos 2015). Ciudad Bolivar's geology and soil can be classified into eleven zones; see figure 5.

The soil mainly consist of sandy, silty, and gravels. The area is at risk due to the instability of the land. The sloping soil vary from 20 to 40-degree angles (Basto and Bolanos 2015).
The tree species in the neighbourhood is identified by Nino-Soto (2019) to be comprising of mostly Croton Funckianus (Sangregado), Cedrela montana (Cedro), Myrcianthes leucaxyla (Arrayan), Ficus soatensis (Cuacho Sabanero), Tibouchina lepiota (Sietecueros).

The study site

Ciudad Bolivar is Bogota's informal settlement area. It is the most populous of Bogota's 20 districts. It encompasses the southern part of Bogota and is built on a mountainous terrain (Torrenegra 2019).
Bogota's districts are divided into zones. In Bogota, this is referred to as Zonal Planning Units (UPZ). The UPZ were built to improve the city's territorial planning. As a result, there are 112 zonal planning units among Bogota's 20 districts see figure 7 (OSGIS 2021).

Ciudad Bolivar is divided into eight UPZs numbered from 63 to 70 see figure 7. Five are of the residential type, as in incomplete self-constructed urbanization, one is of the consolidated residential type, one is predominantly endowment type, and one is intended for future locality development (Torrenegra 2019).

This thesis is been conducted at the UPZ 67 Lucero, which is located in the south-eastern part of Ciudad Bolivar see figure 7. Because of serious deficiencies in infrastructure, accessibility, public space, and resources, the government has designated this UPZ unit as a priority for improvement. Poverty, violence, unemployment, illiteracy, and migration are a plenty in this region (Vega 2018). The government classifies it as a human settlement of illegal origin. The municipality has 0.92 m2 of green space per inhabitant (this is significantly less than the WHO recommendation of 9 m2 per person (WHO 2016)), with approximately 1.61 percent of the road network constructed (SDP GOV 2019). Ciudad Bolvar is one of the city's fastest growing areas, owing to migration from rural areas, which adds to settlements and urbanisation, contributing to severe social problems and a lack of basic services (Vega 2018).

Lucero 67 has a total urban area of about 581.61 hectares, and about 200,000 inhabitants, with a population density of about 400 inhabitants per hectare. It also has a total of about 13,597 dwellings, with an average of 1.4 households per dwelling and 4.4 people per household (GOVCO 2017; Torrenegra 2019).

Ciudad Bolivar is further subdivided into three sectors, the first of which was used for material exploitation. Sector B is the land used for quarries, and Sector C is the most populous sector of Ciudad Bolivar with the best infrastructure (Vega 2018).
The study site is in the Manitas neighborhood of locality 67. Manitas is made up of two adjacent neighborhoods, but they are all referred to as Manitas (see figure 4).

As a result, the park's neighborhood is properly known as Villas el Diamante. The Manitas neighborhood is one of the most resource deficient neighborhoods in terms of educational access, recreational facilities, and health opportunities (Vega 2018).

Research Limitations

Limitations due to access of the park

Since the park is located in an informal settlement, there are numerous precautions that must be taken when visiting the park as an outsider. For example, safety is a primary concern, in general the settlement is one of the unsaffest place to be in the city. Therefore, I am advised to go to the park and stay in the area with a companion during daylight. As a result, I limit my observations to whenever my guide is available for a park visit. I try to reschedule some of the planning and limit the visit to two days which is enough to conduct the observational analysis, and night visits are not recommended so I rely on my local guide to describe the night-time.

Limitation due to language barrier

Spanish is the spoken language in Colombia, and it is therefore quite uncommon for Colombians to be fluent in English. As a result, information about the park is difficult to find in English and must be translated using the Google software "Google translate ". Another language barrier is the workshop, which I will be facilitating. This means I'll need to consider hiring someone who speaks fluent Spanish and English to explain the study and the nature of the interview workshop to the residents.
This also mean introducing a new person into the workshop and taking an observational role.

Limitations in map information

As the area is quite isolated, map information is hard to come by such as measurements and other related information that are necessary for visualizing and understanding the landmark of the area, that is the topography of the park and height for the design proposal. As a direct consequence, the study will rely on satellite imagery and measurements taken during my visits to the site, as well as information gathered from local stakeholders who work in the area.

Limitations in ecological choices

As the climate of the country is unfamiliar to me, I have to rely on the literature studies to understand the type of vegetation that are actually suitable in such an area and would complement the landscape. Because the park lacks microclimatic data, I must broaden my search for suitable ecological amenities and even seek expert assistance from the local botanical garden in Bogota, this also mean that I cannot estimate the microclimatic effect of air pollution but have to generalise.

Delimitation

The research focuses on improving public health in a Bogota informal settlement while adapting and mitigating to climate change through the use of nature-based solutions such as using only specific vegetation known to reduce air pollution. The study is limited to a park in an informal settlement and does not include other parks or settlements in the surrounding area of Bogota. It employs the co-creation method, so the redesign will be primarily based on the local perspective of those who live in the park's vicinity. It is restricted to specific design principles that are relevant to the park's goal.

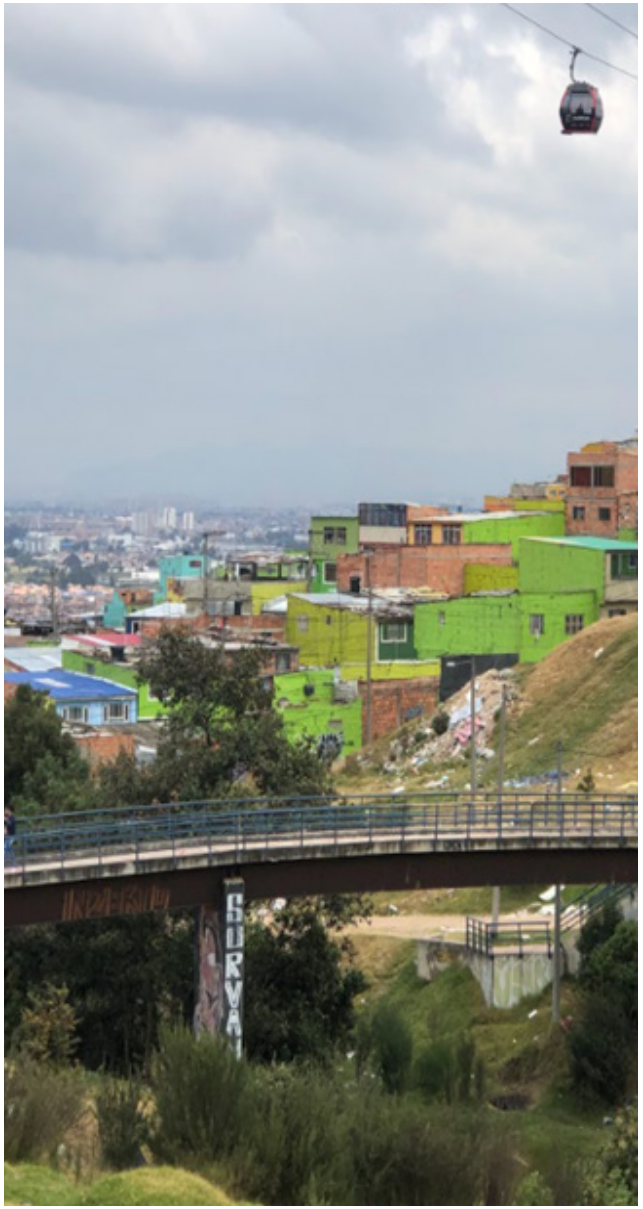


Figure 8: View from Villas el Diamante overlooking the nearby informal settlements. Settlement in direct view is Nueva Colombia. Photograph taken by author.

Method

The final result of this master thesis will be a design proposal for Villas el Diamante Park, using design research as a method. The project is also set out to investigate the site in its current state and to involve the local residents in the design process.
In landscape and urban planning Lenzholzer, Duchhart, and Koh (2013) defines research through designing by breaking down the word research and design.

"When we use the term 'research', we mean curiosity or question driven, rigorous academic research as defined in different disciplines (Creswell, 2009). By 'designing', we mean the process of giving form to objects or space on diverse levels of scale and when we speak about 'design', we mean the results of a design process. The process of 'designing' can include creation of 'designs' i.e., new objects on a 1:1 scale. In landscape architecture however, the designs are usually projected first, either in plans, scale models, computer simulations, or various other media. These are also a result of a design process and thus a 'design'. These designs may be made with the objective to be executed, such as detail designs or with the aim to contribute to changing an environment in a more abstract, visionary way." (Lenzholzer, Duchhart, Koh 2013, pp 121).

In the essay *'Research through designing' in landscape architecture*, the authors discuss methods that employ research through designing. The relations between research and design are categorised in three groups. 'research for design' 'research on design(ing)' and lastly 'research by/through/as design' in which the designing activity is employed as a research method (Lenzholzer, Duchhart, and Koh 2013, pp 121).

This thesis is using the research through designing method. The method is made up of two main parts: theoretical research and the design component. Theoretical research serves as the foundation for strengthening the design principles used in the design proposal.

The literature study in this master thesis is based on; Designing vegetation barriers for urban air pollution abatement: a practical review for appropriate plant species selection written by Yendle Barwise and Prashant Kumar (2020). The source discusses green infrastructure influence on air pollution primarily in open road environments.

All the visual materials such as the sketching, maps, illustrations, photographs, and visualisations will be made using programs as; AutoCAD, Adobe Illustrator, Adobe Photoshop, Adobe InDesign, SketchUp, ArcGIS. The work is written in word using the Harvard reference system, which is then transferred into Adobe InDesign using a template created by the author. The thesis work has been divided into several parts; a literature study, an analysis of the study area, the design principles used and finally the design proposal created from the integrated work between the different methods.

A mixed method approach was used to investigate the study site, ranging from onsite observations using Photography analysis, Gehls methodology, Lynch analysis, Landscape character assessment, literature studies, design principles, and semi-structured interviews with locals.

Literature study 1

The first section of the thesis begins with a review of relevant scientific articles and journals to the project. Google Scholar, Epsilon, and ScienceDirect were primarily used to search for literature. In the procurement of the correct research documents, the following words were used: "socioeconomic disparity" "urban green spaces" "public spaces" "informal settlements" "ecosystem services" "restorative areas" "restorative areas". The literature review focused on the urban environment and future climate challenges that urban green space can help to mitigate. It emphasizes the significance of vegetation in urban green space planning and the envrionmental and human benefits from UGS. The main source used is Balaban, O. (2012). Climate change and cities: a review on the impacts and policy responses.

Analysis

Photography analysis

Analysing photographs taken on site were a part of the methodology.

Observation analysis

In the analysis method, an observation study was chosen to be conducted to get an insight into the use of the designed space (Lipovská and Štěpánková 2013). In this thesis, Gehl's methodology is conducted as the choice of observation method along with field observations of the study site.
Jan Gehl is considered an urban pioneer who observed people's behaviours and public spaces within Copenhagen leading to his pioneering book Life between Buildings: Using Public Space Gehl (1987). These behaviour observations build on the same foundations as Whyte (1980) which led to realisations that by observing what people do other than just listening to

what they say, a designer could decipher what people want from their public spaces (Lipovská and Štěpánková 2013, pp 103). The 12 quality criteria are a method created by Jan Gehl and Lars Gemzøe to assess the quality of public spaces. It is a tool used to assess whether different features of the public space are *protective*, *comfortable, and enjoyable* for people spending time there. Therefore, it is structured into three categories "*protection*" "*comfort*" and "*enjoyment*".

The idea behind each theme is that without basic protection from eg climate, cars, noise people will avoid spending time there. In the second theme, without the elements that make spending time in the place comfortable as walking, standing, sitting, seeing, and conversing will not invite people to spend more time there. And lastly, good public spaces should provide aesthetic and sensory experiences that takes advantage of the site-specific situation and provide human scale elements (Gehlinstitute 2017). The 12 quality criteria are used to analyse the study site on how it is today. How protective, comfortable, and enjoyable is this park for its users? And what can then be improved if it doesn't fulfil the criteria. Simultaneous to this, a general observation of the site as a visitor is also conducted. This observation is inspired by Gehl architect which is mentioned in the book Life between Buildings.

The observation took place in Villas el Diamante Park in Manitas Barrio, Ciudad Bolivar, Bogota, Colombia. The park can be divided into two sections. The first section of the park see figure 10a is a concrete basketball court that also serves as a soccer field. The second section, see figure 10b which overlooks the community, is a small playground designed for small children aged 3 to 9 years old. It is a community park that is popular both during the week and on weekends. My vantage point was a small stone near the basketball court that overlooked the entire park. The observations were made in the late morning between 10 and 12 p.m., and in the afternoon between 13 and 15 p.m. During the time, I talked to the local guide to understand more of how and when the park is utilised and especially by whom.
The activities, gender and age are then recorded during this conversation and the site observation. A walk through the site and surrounding is undertaken during the day. The location of my observation spot can be viewed on the figure (9 and 10) below.

Figure 9: A satellite imagery retrieved from Google maps (2022) displaying the observation site

However, as written above I was walking all over the site and utilising the space as much as I can. The vantage points made it possible to overlook all the structures of the park.

Figure 10: Photographs of observation site taken by author. a) shows the basketball and football court which is a big section of the park. Below in b) a sparse playground which makes up the second part of the park can be seen.

Lynch analysis

Because literature documents are scarce, it is necessary to gain a deeper understanding of the area. A lynch-inspired investigation is carried out. In The image of the city, Kevin Lynch published theories in spatial cognition and behavioral geography in 1960. The book provides insight into how people perceive the city (Filomena, Verstegen, and Manley 2019). Lynch (1960) divides this mental image of how people perceive the city into five main elements in order to increase the imaginability of the urban environment. *Paths, edges, nodes, districts, and landmarks* are examples of these.

This method was developed in a Western context, but it is applicable globally because it constructs the interaction between humans and built environments. The identified elements in the park are according to Lynch (1960).

Paths: this is described by Lynch (1960) as the main lines of movement through the area. In this study the major streets surrounding the park area is highlighted
Edges: are described by Lynch (1960) as boundaries between two kinds of areas. They are linear elements. In the study it is used to differentiate major areas from another
Nodes: this is described by Lynch (1960) as strategic foci and intensive foci that the observer can travel to and from such as major pathways. This is identified in the study.
Districts: Lynch (1960) describes districts as homogenous areas of spatial characteristics. It is also identified in the study.
Landmarks: these are crucial location in the area that are easily identifiable and is allowed to be seen (Lynch 1960). The features that stood out in the area are identified as landmarks

LCA analysis of the built structures
This is an inspired landscape character assessment (LCA) to delve into the study area's various districts. The process of identifying different variations or characteristics of the landscape by describing the landscape character types is known as LCA. As an example, consider different settlement. It seeks to recognize distinct elements or combinations of elements in the landscape that make it unique (Tudor 2014).
It is critical to comprehend the landscape, whether urban, rural, degraded, or in high quality areas (ELC 2000). It is a part of our cultural heritage, and it serves as a bridge between humans and the natural environment (Tudor 2014).
In this thesis, this method is used to describe and understand the study site further. It started with an overview of the site using satellite imagery from Google earth. Features and structures of importance that are distinctive are acknowledged. During the physical site visit this imagery is reflected upon and analysed to compare and adjust if the different districts marked followed the overview assessment.
Photographs of the distinct features are taken and marked on the map.

Green and Blue structure analysis

Since the park proposal is to take on an ecological approach. A green and blue structure analysis is then conducted to investigate the already existing green and blue structures and what areas can be improved in the proposal.
Satellite imagery from Mapas Bogota were used to identify the blue and green structure. During the site visit this image is compared to what exist today

Literature study 2

The second section of the literature study is to provide the vegetation traits that are site specific for Bogota, Colombia in air pollution removal, stormwater management and biodiversity increase. The literature review of scientific articles and journals were sought for using Google Scholar, Jstor, and ScienceDirect.
The literature review focused mainly on vegetation characteristics and traits for air pollution removal. The main source used to design the thesis and also inspired the subject is Yendle Barwise and Prashant Kumar's (2020) in Designing vegetation barriers for urban air pollution abatement: a practical review for appropriate plant species selection.

Interview

On a Saturday, a semi-structured interview is set up with locals living near Villas el Diamante Park. It is presented in Spanish, the local language. Locals are approached at random and asked to participate in the interview anonymously. Questions are asked about the design proposal, their thoughts on the park, and future improvements they would like to see for the park. Around ten locals of various ages and genders could voluntarily participate in the interview. The questions were pre-planned and supplemented with an understanding of the area using literature review. We walked around sitting with the locals, drinking with them, and talking of the park. The structure and questions asked during the interview can be seen in figure 11.
To avoid misunderstandings, the interview questions were reviewed by a local university student, and the language used during the interviews was modified to clarify the given questions. Following the interview, each participant was compensated for their time as was advised by other locals.

The questions started out with getting information on who they personally were, that is their age, gender, and occupation. Then the questions led into their opinions on how the park currently is to understand the importance that the park has in their lives and for their family and friends.
"It is very important for the children mostly- I would like more play opportunities for the children" - an interviewee

Figure 11: a diagram displaying the questions and the categories used during the interview with the locals living in viscinity of Villas el Diamante Park. The interview was carried out in 2022.

The interview is semi-structured therefore, talking off topic was encouraged and happened sometimes when they talk of their children or other family members using the park and what they like to do for recreation around the area and how much they enjoyed living in the area.
The informal setting of sitting with the locals in their shop, homes, or standing on the street gave a lot of room for conversations to be open and inclusive and sometimes inviting neighbours to participate. However, as a facilitator I made sure the interviews were centred on the topic once it dragged on into other irrelevant subjects. The structure of the interview is shown in figure 11.

The questions are classified into four categories. To quickly sort out the target audience, the first category is an introduction to who they are and if they live in the area. The second category delves into their personal impressions of the park and the roles they play when using the park in order to better understand the park's various functions and importance. The third category focuses on their opinions about the park in order to have an idea of what improvements can be made and what can be left alone.
The final category is more of a request for advice than a question. Therefore, it is a bonus question for those who had time or had an idea on what advice to give to me as a foreigner redesigning a park in the area.

Design process
The design process of this thesis follows the method (RTD) Research Through Design. This implies careful integration of research and design for the development of the design proposal. The design process includes thorough observation and analysis of satellite imagery from Google Earth and related platforms, it includes various documentation methods on site such as sketching, lots of photography and taking notes of observations. The sketching process is used to both analysis the place for how it is and to come up with ideas that align with the design proposals

Design proposal
The literature study is the basis of the design principles used in the thesis, along with the conducted analysis and interview with the locals has been for the major core for the design proposal developed for Villas el Diamante Park. The principles for air pollution identifying specific plants for air pollution management, stormwater management, recreation, and local insight are used to guide the design proposal.
For the recreation principles, Bengtsson and Grahn (2014) developed a quality evaluation tool. It is a design guideline for healthy outdoor environments in healthcare settings. It is known as a quality evaluation tool (QET). Due to the increased daily disturbances that are common in the community, this tool provides an additional benefit that is appropriate for a public park in Manitas Barrio. It is a tool based on restoration theories such as Kaplan's attention restoration theory ART and Ulrich's phyco-evolutionary theory that integrates people's well-being and restoration with outdoor environments (Bengtsson and Grahn 2014).
As a result, despite being designed for outdoor use in healthcare settings. It is thought that urban public parks possess restorative potential.

Work process
The working process see figure 12 of the thesis starts off with a literature study which is divided into three parts. It focuses on first the urban environmental issues and climate change, secondly urban green space, and its benefits for the urban environment and lastly the critical role of vegetation in urban green space design.

This is continued with an analysis of the site Villas el Diamante Park to understand the park today and what problems it encounters. This analysis is the basis for the design proposal in which the literature study, analysis, and design principles are used to develop the design proposal.

Terminology

UGS (Urban green space)
Urban green spaces refer to natural, semi-natural, or artificial ecological systems within and around the city (Aronson et al. 2017).

Urbanisation
It is the process through which cities grow with an increase of population (Nationalgeography 2019).

Air pollution
This refers to the release of dangerous pollutants to the air (NRDC 2021).

Informal settlements
This is a broad concept that refers to informal living in dwellings considered illegal or in discord with social norms (Martinez 2019).

Socioeconomic inequality
Inequality in society denotes unequal access to opportunities within or between groups (Markkanen and Kravi 2019, p.829)

Mitigation
Mitigation is the act of removing and reducing the source of climate change, such as limiting greenhouse gases (GHG) in the atmosphere (Ayers and Huq 2008; EU 2021).

Adaptation
daptation is the process of adjusting and preparing for the predicted effects of climate change to reduce vulnerability (Ayers and Huq 2008; EU 2021).

Figure 12: A diagram illustrating the work process of the thesis made by author (2022) using illustrator and base diagrams from Freepik.com.

Literature study

The literature review is divided into three sections. The first section focuses on urban environmental issues and climate change in urban areas. This is about comprehending the challenges of urban cities as a result of climate change.
The second section focuses on urban green spaces and their multifunctional benefits in urban areas, and the importance of participatory process in urban planning.
The final section is about understanding the role of vegetation in urban green spaces and its ability to remove air pollution as well as other ecosystem services it provides.

Urban environmental challenges and climate change

Global warming has increasingly become a familiar topic of discussion. It is defined by the Intergovernmental panel on climate change (IPCC) as *"an increase in combined surface air and sea surface temperatures averaged over the globe and over a 30-year period."* (Allen et al. 2018). This means a drastic change in climate as we know, and implies disastrous consequences for humanity and the environment (Thuiller 2007).

The climate predictions suggest a warming trend over the last few decades. In 2021, the earth was 1.1°C warmer than it was in the 19th century (an important century for the industrial period). This long-term warming is largely the result of human activities (NASA 2021) such as the increased burning of fossil fuels which were intensified during the industrial revolution and destruction of the natural environment by humans (Balaban 2012). So, what are these expected consequences?

To date, global warming has caused significant changes for both humans and the natural environment. Droughts, floods, sea level rise, and biodiversity loss are a few examples (Allen et al. 2018). These not only endanger vulnerable populations, but they also directly threaten everything we know.
Two key principles are important for dealing with climate change. These are mitigation and adaptation (Balaban 2012). Mitigation is the act of removing and reducing the source of climate change, such as limiting greenhouse gases (GHG) in the atmosphere. While adaptation is the process of adjusting and preparing for the predicted effects of climate change to reduce vulnerability (Ayers and Huq 2008; EU 2021). Both of these principles are critical in climate change management.
Cities play a critical role in mitigation and adaptation strategies. According to Balaban (2012), this is due to three primary reasons.

To begin with, cities are significant contributors to green house gas (GHG) emissions, drastic land-use change, and deforestation. Cities are responsible for up to 70 percent of GHG emissions due to the use of fossil fuels (Mollaei, Ibrahim, and Habib 2021). Second, cities are home to half of the world's population and thus have a high concentration of economic activity. Finally, climate change activities will have a significant impact on a large portion of the world's population. It may also open up possibilities for low-cost solutions (Balaban 2012).

The impacts of climate change on urban areas are magnanimous. The main consequences include:

- Rise in sea levels
- Extreme weather events and flooding
- Heat waves and temperature increase
- Air pollution and reduced air quality
- Water shortage and water pollution

(Balaban 2012).

Rise in Sea level
Sea level rise caused by storm surges and high tides will have serious consequences for coastal cities. Coastal risks have increased due to growing population, economic growth, and land subsidence (Muis et al. 2016). Global sea level rise is expected from several sources such as: thermal expansion of the oceans, melting of glaciers and small ice sheets, and changes in accumulation of snow and ice in Antarctica and Greenland (Mclnnes et al. 2003). The estimates of global mean sea level rise (GMSL) in (cm) for 2020 and 2050 according to the IPCC (1996) is shown in the table 1 below.

Table 1: The sea level rise estimated by IPCC in 1996 (cm).

Year	Low	Mid	High
2020	5	10	20
2050	10	20	40

This report was done by IPCC (1996) and was published in (Mclnnes et al. 2003). According to European environmental agency, GMSL for 2020 was 21cm (EEA 2021). This is 1 cm higher than the the high rate predicted by the IPCC in 1996.

Extreme weather events and Flooding
Flood frequency, magnitude, and intensity will increase as a result of extreme weather events caused by climate change (Balaban 2012). The global cost of extreme weather events is already estimated to be around 35 trillion USD. The effects of heavy rainfall, flooding, and extreme heat expose a large portion of the global population to these hazards (Kayaga et al. 2020). Extreme weather events have a significant impact on urban areas. The 2010–2011 La Niña (positive phase of El Niño) event in Colombia is an example of this. This resulted in the destruction of infrastructure and agricultural lands. It had an impact on four million Colombians (Hoyos et al. 2013). Increased storm surges will result from the change in precipitation, which will increase river flows and may eventually cause urban flooding (Balaban 2012). The statistics on these damages may appear large, but they vastly understate the true extent of the damage because there is no formal accounting for the social or environmental costs (Vorosmarty et al. 2013).

Heat Waves and Temperature increase
The urban heat island (UHI) effect is exacerbated in densely populated areas such as cities. The main causes of UHI are the large amounts of heat generated by large concrete structures

and anthropogenic sources. Because urban areas have less vegetation, convective heat removal is reduced (Rizwan, Dennis, and Chunho 2008). Cities are more vulnerable to heat waves, rising temperatures, and droughts (Balaban 2012). The urban environment suffers as a result of this. It increases energy consumption, ozone levels, and mortality rates (Rizwan, Dennis, and Chunho 2008). Megacities such as Bogota are particularly vulnerable to these temperature increases in South America (Ceccherini et al. 2016). This has serious implications for the citizens' health.

Air pollution and Reduced air quality

In 2016, urban areas housed roughly 54.5 percent of the world's population. The UN estimates that by 2030, approximately 60% of the world's population will be living in cities (UN 2016). The congestion of people increases economic activity and energy consumption, both of which are primarily dependent on the combustion of fossil fuels, which emit polluting substances into the atmosphere (Zarate 2007).

According to WHO (2021), approximately 90 percent of people live in areas where the world health organization's air quality standards are not met (Blackman and Hoffmann 2021). Climate change has exacerbated the deterioration of air quality because concentrations of air pollutants are linked to the level of solar radiation, temperatures, and humidity, so during heat waves, the level of air pollution will increase (Balaban 2012). Everyone is affected by and contributes to air pollution. It can harm not only human health but also infrastructure, the environment, and agriculture (Zarate 2007). It causes between 5 to 9 million premature deaths each year along with cases of bronchitis, asthma, and other cardiopulmonary illnesses (Blackman and Hoffmann 2021).

It is predicted that the number of deaths from air pollution will increase to 50 percent in 2050 (Blackman and Hoffmann 2021; Lelieveld et al. 2015).

The main air pollutants in Bogota are ozone O3, PM2.5, and PM10 (Zarate 2007). Vehicles account for 81 percent of combustion emissions in Bogota (Blackman and Hoffmann 2021). Particulate matter is a major pollutant that has serious health consequences for humans. It has an effect on the human respiratory system, and ozone causes increased respiratory illnesses, eye problems, and lung problems (Lozano 2004).

The air quality in Bogota consistently falls short of WHO standards resulting in 1600 premature deaths per year in the city. The air quality in the city's southwest is noticeably worse as seen in figure 13 (Blackman and Hoffmann 2021). Even though air pollution affects everyone, it does not affect everyone equally, and not everyone has equal opportunities to address air pollution concerns. In "Urban Air Pollution in Bogota, Colombia: an Environmental Justice Perspective," Franco (2012) discovered that there is a socioeconomic difference in the level of air pollutant concentrations in Bogota.

Bogota's population is divided into six socioeconomic strata, with strata 1 being the poorest and strata 6 being the richest. About 80 percent of Bogota population live in neighbourhoods classified as strata 2 and 3 while 10 percent resides in strata 4 and 5. The figure 13 is a map of Bogota showing the distribution of PM10 concentrations when compared to figure 4 of the study site, the air pollution rate is at dangerous levels. In figure 13, the southern and west areas if the city has the highest concentration of PM10. This is also the districts with neighbourhoods with low socioeconomic strata. According to Bogota census these are districts classified as strata 1 or 2 (Franco 2012).

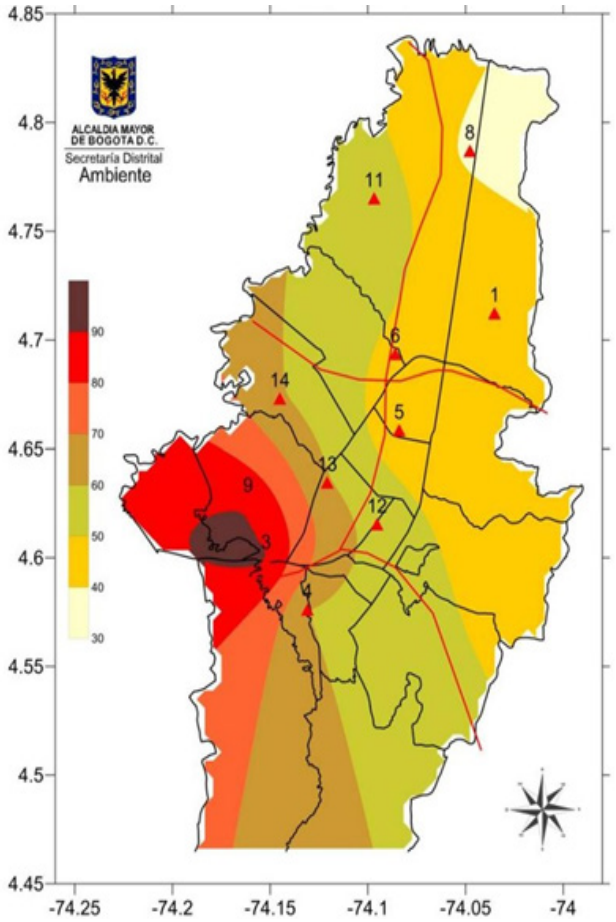


Figure 13: A map of Bogota displaying the ambient PM10 concentration of the city. Retrieved from (Franco 2012:3).

Water shortage and water pollution

Climate change will affect water supplies as cities and their catchment will get less precipitation, which leads to reduced groundwater and river flows. The result of temperature increase and heat wave will increase the demand for water. Higher pressure on water supplies as well as increased potential for water pollution (Balaban 2012).

Urbanisation: an irreversible phenomenon

Urban green spaces refer to natural, semi-natural, or artificial ecological systems within and around the city. This includes gardens, parks, green roofs, and bioswales, among other things (Aronson et al. 2017). As cities become more urbanized, they begin to experience significant environmental stress in the form of poor air quality, noise pollution, and traffic congestion, along with many other things (De Ridder et al. 2004, pp 489). Implementing sound urban planning strategies that take into account the importance of urban green space in reducing the adverse effects of urbanization is becoming increasingly crucial.

Urbanisation

In the literature, urbanization is commonly associated with the equivalent of urban population growth (McGranahan 2016). However, this is not a concise definition of urbanisation because urban population growth does not convey population density, the availability of healthcare, or the quality of infrastructure (Godfrey and Julien 2005).

The definition of what constitutes an urban centre varies greatly by country; for example, in Sweden, a population as low as 200 inhabitants is considered an urbanised centre (Bodo 2019), whereas in Colombia, a population of 50,000 people is considered an urbanised centre (Sanchez-Serra 2016). So, what is actually urbanisation? Well, urbanisation according to Knox (2009), *"involves a complex of economic, demographic, social, cultural, technological, and environmental processes that result in an increase in the proportion of the population of a territory that lives in towns and cities, an increased concentration of population in the larger settlements of the territory, and an increasing density of population within urban settlements"*

Today, about half of the world's population lives in cities, with that figure expected to rise to 70% by 2050 (Pauleit, Sauerwein, and Breuste 2021). Rapid urbanisation as a result of economic development brings with it urban challenges that have an impact on the services that cities can provide (Nordregio 2021).

Consequences of Urbanisation

Urbanization results in the congregation of people in cities, making them vulnerable to communicable diseases, pollution, poor nutrition, and road traffic. The poor are frequently the most vulnerable to these situations (Kiddus, Tynad, McBryd 2020). Urbanization frequently results in a reduction in urban green space due to the densification of urban areas (Haaland and Konijnendijk van den Bosch 2015). As a result, the problems caused by urbanization and a lack of public spaces include physical and mental health issues, poverty, socioeconomic inequality, spread of infectious diseases, and environmental hazards especially in urban slums areas populated by rural migrants as they become unregulated (Kiddus, Tynad, McBryd 2020).

Slums, also known as informal settlements, are distinguished by poor living conditions, unsanitary surroundings, and a lack of basic amenities such as garbage disposal (Agarwal et al. 2007). This has impacts on the public health of the population as major health problems occur due to decreased quality of life. Decreased quality of life can come in unhealthy food choices, reduced outdoor mobility and lack of physical space for recreational activities, and polluted environments. The congested living in unhygienic conditions adds to indoor and outdoor pollution that leads to disease outbreaks (Kuddus, Tynad, McBryd 2020).

On the other hand, urban areas are globally recognized for their economic development because they produce the most GDP in developing countries, have a larger educated labour force, and have better than average health indicators, which can shift the discussion to the overall benefits of urbanisation. However, when we consider the microlevel of urban areas, such as the informal settlements, these benefits of urbanisation are almost non-existent, and the negative impacts are heavily stacked on (Bocquier 2008).

Improving the urban environment

As urbanisation becomes an irreversible phenomenon, addressing the problems and negative consequences of urbanisation is critical. This can be narrowed down to the disparity in socioeconomic situation of the urban poor (Kuddus, Tynad, McBryd 2020). This disparity in socioeconomic conditions permeates the system and has a cascading effect on large segments of the society. It entails, among other things, addressing inequalities in housing, income, transportation, health care, and educational opportunities (Haaland and Konijnendijk van den Bosch 2015; Knox 2009; Pauleit, Sauerwein, and Breuste 2021).

These issues are not easily solved, so an integration strategy to these issues must be in place while residents continue to migrate and establish themselves in urban settings as informal settlements. Waiting for the future to solve these challenges is therefore not a viable strategy, as issues such as these, in addition to climate change, will take a long time to address. Government agencies will need to focus on urbanization adaptation strategies for today while preparing for the future (Kuddus, Tynad, McBryd 2020).

Urban green space design

An adaptation strategy that includes adequate urban space planning that considers the benefits of urban green space integration can address the city's social cohesion, public health, and environmental hazards.

Urban green space can provide important benefits for both the envrionment and urban residents. The multifunctionality of urban green space includes recreation, social interaction, aesthetics, cultural heritage, and ecological functions (Haaland and Konijnendijk van den Bosch 2015, pp 765). These are important functions that are necessary in achieving the UN sustainable development goals (UN 2018). They provide ecosystem services which are the acquired human benefits derived from ecosystem functions. These functions include air purification, climate regulation, stormwater regulation, biodiversity conservation, and carbon storage.

Additionally, the increased human health benefits attained from urban green space which is strengthened by the human to nature interaction. It offers huge opportunities for human recreation and improved social cohesion (Haaland and Konijnendijk van den Bosch 2015). This all lead to improvement in human well-being and the sustainable development of the urban environment.

ART & SRT

Two theories are central to the research on urban green spaces and human well-being. That is the Stress recovery theory (SRT) proposed by Ulrich et al. (1991) and the Attention restoration theory (ART) by Kaplan & Kaplan (1989). SRT according to Ulrich et al. (1991) refers to the recovery from extremely arousing states psychologically and physiologically through natural environments. The theory is derived from a psycho-evolutionary theory, in which restoration is achieved through exposure to nature. The exposure causes a shift towards a positive emotional state that can affect the physiological systems (Ulrich et al. 1991). The rationale behind the theory in Ulrich (1993) is that this positive response is based on the ancestral human need for food, water, and shelter. SRT thereby assumes that modern-day individuals are still biologically wired to exhibit a positive emotional state to natural, vegetation rich environments and can provide restoration from psychophysiological stress (Joye and Dewitte 2018).

ART focuses on directed attention. According to Kaplan & Kaplan (1989), 'directed attention' In cognitive psychology implies the ability to focus on a task that requires effort. It is an ability that is finite and often leads to attention fatigue. Attention fatigue occurs when an individual is forced to concentrate on a task with no motivation while suppressing more interesting but distracting activities. This may lead to poor self-control such as overeating and obesity. ART emphasizes a way for individuals to restore their 'directed attention' by experiencing activities that engage their indirect attention in environments that provide four components for their restorative value: being-away, fascination, extent, and compatibility (Ohly et al. 2016). ART claims that the natural environment provides this restoration of 'directed attention'.

This is because nature offers fascinating stimuli that can effortlessly capture an individual's attention and reduces the demand for one's 'directed attention' (Joye and Dewitte 2018). In an informal settlement as Manitas barrio, restoration is a very important concept that the design proposal aims to emphasize. The intensive research based on these theories has led to the discoveries that even everyday green or small natural spaces play an important role in mental health benefits for urban residents (Thompson 2011).

Urban green space benefits

Extensive research has shown that exposure to green space has tremendous benefits for both mental and physical health. Pollution reduction, restoration opportunities, and social interactions all have an impact on the cardiovascular system. According to Kondo et al. (2018), urban nature has a positive relationship with human attention, mood, and physical activity, but a negative relationship with mortality, short-term cardiovascular markers (heart rate), and violence.

This demonstrates the importance of urban green space to human well-being. Walking is one type of outdoor exercise that can be done in green spaces and is evidenced in promoting better health quality (Lee and Maheswaran 2011). Takano, Nakamura, and Watanabe (2002) even report increased elderly survival with green space availability. Green space has an effect on mental health as well; studies show that having access to green space can significantly reduce stress (Takano, Nakamura, and Watanabe 2002)..

It improves community engagement because it allows for social interaction (Lee and Maheswaran 2011). However, environmental factors such as the accessibility and availability of these green spaces can have a variable impact on human well-being. As a result, it is critical to make urban green space less of a luxury facility and more of a common amenity in society, particularly in developing countries. According to research, the provision of urban green space can influence socioeconomic health inequalities because a lack of park access reduces the use of parks by residents in disadvantaged neighbourhoods, whereas affluent neighbourhoods are more likely to be in close proximity to quality urban green space that provides opportunities for recreation and restoration (Lee and Maheswaran 2011). Creating an unequal soci-

oeconomic gap that has important effects on public health.

Urban green space mental health benefits

Simply being in, near, or within view of green space can improve restorative capacity for recovery of psychosocial stress and even increase optimism as a result of social and physical interactions within green spaces (Astell-Burt and Feng 2019). The type of green space can also have an impact, as Harris et al. (2018) discovered that humans prefer higher density green spaces over open areas similar to grass areas for restoration in Australia (Astell-Burt and Feng 2019). Preferences for green spaces can vary depending on local conditions and cultural context. Many studies on the mental health benefits of urban green space are typically conducted in high-income countries.

In low to middle income countries, there is still a severe lack of green space and mental health associations studies. However, a review by Nawrath et al. (2021) of studies on green space and mental health in low to middle income countries found positive relationships between green space and mental health, including studies from Bogota. The findings indicate that green spaces benefit mental health in low to middle income countries. The benefits of urban green space is clear, however the benefits of UGSs can only be achieved if the inviduals use these places. This implicates the importance of a participatory approach in the design of UGSs.

Environmental Justice and Urban green space

The environmental issues that cities around the world face are monumental, as briefly described in the thesis above. However, not everyone bears the same environmental burdens. The socioeconomic situation of different neighbourhoods is an important factor in the residents' environmental vulnerability (Basto et al. 2019). The term "urban environmental justice" refers to the unequal and disproportionate environmental burdens that less affluent neighbourhoods face as a result of toxic environmental harms due to fewer legal protections than affluent neighbourhoods (Corburn 2017). There is a well-established link between low socioeconomic status and heavily exposed air pollution (O'Niell et al. 2003).

In Bogota, it is still a sad reality that many people living in poor socioeconomic conditions are particularly vulnerable to health hazards such as toxic air pollution (Franco 2012), due to lack of governmental aid and green infrastructures making it an environmental justice issue. Urban green spaces not only have enormous potential for addressing environmental challenges in the city, but also for bridging socioeconomic inequality in society. Environmental justice is a significant benefit that can be obtained from urban green space, which is why it is important in informal settlements like Manitas Barrio.

The importance of vegetation in green space design

Vegetation is the essence of urban green spaces. It is linked to improved air quality because it has the ability to remove pollutants from the atmosphere. This can happen directly through deposition on the tree's surface or indirectly through stomatal uptake of gases. It has a shading effect on the surface, which helps to mitigate extreme heat by changing the microclimatic conditions of the environment (Vieira et al. 2018). It intercept and infiltrate rainwater, to manage stormwater runoff (Radford 2021). As a result, understanding the precise vegetation structure, composition, and management in a particular climate to improve air purification and other ecosystem services is critical for adequate green space design because atmospheric pollutants and air temperature can vary over relatively short distances (Vieira et al. 2018). In this thesis, the air pollution data has not been collected over the park but literature reviews of air pollution in the general area is analysed to understand what vegetation can provide such benefits in promoting better air quality in the region, stormwater management and increased bidoversity.

Vegetation and air pollution

According to Pataki et al. (2011), "*the removal of atmospheric pollutants by vegetation is one of the most commonly cited ecosystem services, yet it is one of the least empirically supported.*" Since then, many scientific studies on vegetation effects on air quality have been conducted. Vegetation has the potential to alter the urban environment by influencing local air temperature through transpiration from its leaves, blocking solar radiation, or altering wind flow. Because many pollutants are temperature dependent, such as ozone, these characteristics have an impact on air quality (Nowak et al. 1998).

Setälä et al. (2013) discovered a difference in air pollution levels between tree covered areas and open areas in a study looking at whether urban vegetation does mitigate air pollution in Finnish parks and open areas. Trees absorb gaseous air pollution via leaf stomata, the plant surface, and/or airborne particle interception. Gases diffuse within the leaf and may react with the leaf structure (Nowak et al. 1998). As a result, vegetation structure is important and should consider the type of climate and topography of the built environment (Barwise and Kumar 2020).

Moreover, urban vegetation can have a negative impact on air quality because VOC volatile organic compounds are emitted, resulting in the formation of ozone and carbon monoxide (Setälä et al. 2013; Nowak et al. 1998) however, since trees reduces air temperatures this can counteract the formation of

VOCs (Nowak et al. 1998). The interaction between individual plants and air quality is critical in influencing the amount of pollution reduced and in avoiding the disadvantageous promotion of air pollution.

Vegetation and Stormwater management
Flood control is a necessity for many cities around the world as impenetrable surfaces increase, making the effects of flooding disastrous. Stormwater management is a twentieth-century effort to provide services to residents in rapidly growing cities that can provide the infrastructure to promote healthy urban environments (Porse 2013).

Urban greening practices is a method used to mitigate the imperviousness of cities (Spahr et al. 2020). Rain garden is an example infrastructure that can mitigate stormwater runoff in different types of climates. They can add biodiversity and provide an aesthetic appeal (Yuan, Dunnett and Stovin 2017).

Participatory approach
Community participation in planning is widely recognized as beneficial in urban planning, but it is still used ineffectively. It is the exception rather than the principle (Dola and Mijan 2006). However, public participation remains critical for sustainable development.

The purposes of participation varies, it can be for one used by decision makers to figure out the needs of the locals. Secondly, improve decision makings, thirdly it increases fairness in the decision making. These purposes are essential to caryy out a just judgment that can consider an open dialouge between decision makers and local citizens (Innes and Booher 2000).

The Rio Declaration emphasizes participation as a means forward for sustainable development; nevertheless, government officials continue to fail to adequately include the public in urban planning processes. Public participation events comes in different formats such as public hearings, reviews, and comment procedures. Public hearings for example are however typically attended by a small number of people who are vehemently opposed or supportive (Innes and Booher 2000). Robert Chambers pioneered for participatory approach, creating a Participatory Rural Appraisal Method (PRA) to engage local communities in identifying local needs in urban development planning (Hataya 2007).

Public participation is essential for decision makers to learn about the public's preferences and perspectives on the project. It seeks to involve the public in the design and decision-making processes. As local knowledge of the area and perspectives are incorporated into the project, it only strengthens the relationship with the government and the locals (Innes and Booher 2000). It is an opportunity to relfects the true lives of the locals both in needs and knowledge which can stregthen any of the developments (Hataya 2007). The participatory approach is an important aspect of the project in this thesis. As a result, an interview and workshop with locals on-site is important.

Research

In this chapter, the result of the literature study to find out the key vegetations suitable for the design proposal is presented.

The identification of suitable plants that will accomplish the design proposal goal in reducing air pollution whist mitigating climate change is addressed below. This is then used as part of the result for the design proposal.

Current air pollution

The air pollution data collected using surface measurements, as well as satellite and modelled data using public monitoring networks (SDA) for Bogota is given over a 24 hour average concentrations for PM10 and PM2.5 in Bogota during February to June 2020 exactly during the COVID-19 Pandemic given by Mendez-Espinosa et al. (2020) in Air quality variations in Northern South America during the COVID-19 lockdown. This is used as a reference in this study to understand the amount of particulate matter over the region. The particulate matter data over Bogota differs greatly before and after lockdown therefore it is important to produce both results.

Particulate Matter Pollution

Atmospheric particulate matter (PM) is a heterogenous material and the main component for anthropogenic air pollution (Grants, Garner and Johnson 2003). It is the most common non-gaseous pollutant in cities, consisting of organic and inorganic particles that remain in the air in either a liquid or solid phase (Vigevani et al. 2022). It is caused by a variety of human and natural activities such as agricultural dust, road dust, mining, traffic activities which leads to a wide range of diseases such as, heart and lung diseases, aggravated asthma and increased respiratory failure leading to premature death (Kim, Kabir, and Kabir 2015).

Particulate matter can be distinguished in different ways such as the diameter, content, and lifetimes (Kim, Kabir and Kabir 2015). The diameters of the particles typically range from 0.0001 to 100 μm. It is however classified as large PM (10-100 μm), coarse PM (2.5 – 10 μm), and fine PM (0.2 – 2.5 μm) (Vigevani et al. 2022).

PM is generally regarded as hazardous because it has a significant impact on human health, visibility, the ecosystem, weather, and climate; however, the effects are dependent on aerosol properties such as its concentration, size, and chemical composition (Zhang et al. 2015). They are regarded as major pollutants all over the world. PM10 particles can penetrate deep into the lungs, causing respiratory problems, and PM2.5 causes health risks (Kumar and Dwivedi 2021). The size of the particles is directly related to an increase in health issues. The smaller the particle, the more dangerous it is because the smaller it is, the deeper it can penetrate and deposit on the respiratory tract at a faster rate (Kim, Kabir and Kabir 2015). The most harmful and long-term effects of PM on biodiversity loss and ecosystem services are observed in the function of managed and natural ecosystems.

The different composition of the particulate matters is identified by Cheung et al. (2011). PM less than 2.5 μm is composed of Sulfate, SO_2 – 4; nitrate, NO– 3; ammonium, NH+ 4; hydrogen ion, H +; elemental carbon, C; organic compounds; PAH; metals, Pb, Cd, V, Ni, Cu, Zn; particle-bound water; and biogenic organics while PM less than 10 μm is composed of Resuspended dust, soil dust, street dust; coal and oil fly ash; metal oxides of Si, Al, Mg, Ti, Fe, $CaCO_3$, NaCl, sea salt; pollen, mold spores, and plant parts (Kim, Kabir and Kabir 2015).

PM sources can be categorised into anthropogenic sources, naturally occurring sources, or conversions from gaseous precursors. Anthropogenic sources range from solid fuel combustion such as coal, oil, and biomass to industrial and agricultural activities and, most notably, traffic through vehicle component wear (Kim, Kabir and Kabir 2015).
The naturally occurring sources include volcanoes, forest fires, sea spray etc (Kim, Kabir and Kabir 2015). The sources of PM 2.5 and PM 10 are listed by Srimuruganandam and Nagendra (2012). PM 2.5 sources ranges from coal, oil and gasoline combustion, the transformation of products of NOx, SO_2, and organics such as terpenes and steel mills. The sources of PM 10 are also through combustion of coal and oil, ocean spray, suspension of disturbed soil (Kim, Kabir and Kabir 2015). The lifetime PM 2.5 vary from days to weeks and PM 10 from minutes to hours (Cheung et al. 2011; Kim, Kabir and Kabir 2015). The travel distance of PM 2.5 is between 100 – 1000 kilometres and PM 10 between 1 to 10 kilometres (Srimuruganandam and Nagendra 2012; Kim, Kabir and Kabir 2015).

PM is a very dangerous material, and the effect of PM is not limited to its concentration, size, and chemical composition (Zhang et al. 2015). In addition to that, PM exposure and effect is influenced by local conditions as weather, seasons, topography, microenvironments, and sources of particles (Kim, Kabir and Kabir 2015).

Several studies have shown that urban vegetation can improve the air quality by absorbing pollutants in the atmosphere. Studies in Beijing, China, the United Kingdom, and the United States (Yang et al. 2003; McDonald et al. 2007; Nowak et al. 2006) have estimated a significant reduction in PM pollutants by trees (Mo et al. 2015).

Plant leaves and barks have been shown to be the most effective plant organs for trapping PM (Vigevani et al. 2022; Mo et al. 2015). Parks, gardens, and different types of urban forests can act as biological filters against PM while also providing co-benefits in terms of other climate change regulations provided by urban vegetation. As a result, it is a definite plus that can benefit both the environment and humans.
All vegetation type can reduce air pollution however the leaves of trees vegetation, have a greater effect on PM trapping due to the size of the leaf area, the crowns, and turbu-

lent air movement that increase PM trapping (Vigevani et al. 2022). Because air turbulence in the tree crowns increases the deposition of PM on the trees, trees collect more pollutants than shorter vegetation (Mo et al. 2015).

Certain characteristics of tree species are more effective than others at collecting air pollution. The retention efficiency is affected by the leaf structures such as the shape, stomata density, trichomes, cuticle ornamentations, and epicuticular waxes. Studies conducted around the world have narrowed down the important characteristics of the trees when it comes to filtering air pollution. The conclusion from a recent study by Vigevani et al. (2022), although done in Europe establishes needle-leaved species as (Pinus nigra and Pinus pinea) and broadleaves with small, hairy, and waxy leaves as (Quercus ilex) should be preferred in air pollution removal. The rougher the surface the greater the retention (Vigevani et al. 2022). These characteristics are sought after, therefore certain species can be narrowed down for the study site to maximise the benefits of urban vegetation. In broadleaved species, the rougher the surface the better it captures PM (Vigevani et al. 2022), therefore, the characteristics sought after are species with trichomes and rough leaf surfaces (Mo et al, 2015; Burkhardt 2010; Hwang, Yook, Ahn 2011; Vigevani et al. 2022)
Needles or scales of Coniferous are more effective than broadleaves as they produce a a thicker epicuticular wax layer (Beckett 1998; Beckett 2000; Vigevani et al. 2022) which promotes trapping and retention. In addition, evergreen species have the ability to remove air pollution all year round, however, they keep their eaves for several years. It is not possible to recycle the accumulated particules annually unliked with deciduous species (Vigevani et al. 2022). However, since the study site is located in Bogota, Colombia a different climate and region and vegetation is expected. Therefore, a review is conducted to investigate vegetation in Bogota closer to figure out which have similar traits that can benefit air quality amelioration.

Table 2: Daily average Concentrations of Particulate matter µg/m3

Station	Pollutant	Before Lockdown	Strict Lockdown
Bogota	PM_{10}	40.2±12.1	24.4±13.2
	$PM_{2.5}$	29.6±10.1	19.4±12.4

A decline of about 16 µg/m3 for PM10 and 10 µg/m3 for PM2.5 was achieved during the strict lockdown. However, as the pandemic is an out of norm situation and the world is slowing coming back to its normal routine. It cannot be considered a regular value. One of the most effective ways to remove PM is through vegetation (Zafra-Mejía, SuárezLópez, Rondón-Quintan 2021). The traits that benefit air pollution removal in trees has been listed above. Therefore, the plants that are specific for Bogota, Colombia are then sought after to understand its capacity on air pollution removal and to maximise these benefits in the park design proposal.

Vegetation key mechanism for air pollution mitigation

The assessment of urban green space mitigation of air pollution is typically done using a variety of methods such as modeling, real-world measurements, and experiments, such as using a wind tunnel (Diener and Mudu 2021).

There are two types of key mechanisms that vegetation employs to reduce air pollution. Both Barwise and Kuman's (2020) and Diener and Mudu's (2021) reviews are used to better understand these key mechanisms.
According to Barwise and Kumar (2020), the mechanisms by which vegetation improves air quality are deposition and dispersion. Deposition refers to the process of depositing pollutants on solid surfaces, lowering atmospheric concentrations whereas dispersion refers to the process of transporting and diluting pollutants from their source (Barwise and Kumar 2020).

Deposition
Deposition is simply the transport of a particle from point a in the air to point b on the plant surface.
Airborne particles can be deposited more easily on plant surfaces when they pass through them because most plants have a rougher surface and a larger surface area per unit volume (Janhäll 2015). Deposition is the result of physiochemical processes on all aboveground plant structures. The physiochemical and biological processes that change the size and properties of the PM determine it. Plant leaves have a high deposition activity because particles can be trapped in the wax layers of the leaves, penetrate the leaf walls, and enter the internal structure of the leaves via stomata (Diener and Mudu 2021).
Deposition differs with particle size. Particles below 0.1 µm are deposited through diffusion, and particles above 10 µm through sedimentation. It is influenced by the leaf area index, the amount of vegetation surface area per m2 of ground area, deposition velocity, pollutant air concentration, and time (Janhäll 2015).

This demonstrates that some plant characteristics are important for increased deposition. Specifically, the surface rough-

ness, trichome, and leaf surface area.
The main plant groups chosen for improved deposition in research are trees, bushes, and grass with trees showing up as better for deposition. Deposition has a significant impact on reducing PM concentrations in a specific area (Diener and Mudu 2021).

Several studies have found a significant reduction in PM through the deposition mechanism. Pugh et al. (2012), for example, discovered a 60% reduction in PM by roadside vegetation with deposition, and Sillars-Powell et al. (2020) discovered a positive correlation between traffic density and deposited PM on the roadside (Diener and Mudu 2021). According to Nowak et al. (2018), increasing vegetation cover from 3.5 percent to 16.5 percent can reduce PM 10 concentration by about 10%.

Dispersion
Dispersion is related to wind systems and their impact on air pollution transport (Janhäll 2015). That is how plants, through their physical structure, alter the velocity of PM. Because of the plant structure and fluid dynamics, this mechanism acts as a barrier or filtering of green space, so dispersion effects reduce PM concentrations (Diener and Mudu 2021).
The configuration of the green space, such as its height, density, depth of plant structures, and proximity to emission areas, has been identified as critical for maximising the green space dispersion mechanism (Diener and Mudu 2021). As a result, the results of the dispersion mechanism will vary greatly depending on the exposure in relation to the green space, so research is varied as it is difficult to compare.

To summarize, plant traits such as leaf physiology and micromorphology, as well as biophysical characteristics, influence deposition, with leaf surface area and leaf properties or functions that contribute to surface resistance being the most important.
Another important consideration is foliage longevity, as evergreen species have longer leaf seasons and can function all year (Barwise and Kumar 2020).
The dispersion mechanism comes down to the barrier's interactions with airflow and turbulence which is affected by wind conditions, topography, climate, the type of vegetation and the local metrological conditions (Barwise and Kumar 2020).

Plants that remove air pollutants in Bogota

The literature review aided in narrowing the list of traits to actively seek when looking for vegetation that can best remove air pollution in Bogota, Colombia.
In an article titled Analysis of Particulate Matter Concentration Intercepted by Trees of a Latin-American Megacity by Zafra-Meija, Suarez-Lopez, and Rondon-Quintana, these vegetation species have been identified and narrowed down to Ligustrum-lucidum and Lafoensia-acuminata as the best existing tree species for Bogota's climate in relation to their intercepted particulate (2021).

The tree species significantly reduced PM concentration by 33.6 percent for every 5 g/m3 increase in PM2.5 concentration. These are the two species with the largest leaf areas, but the study concludes that as wind speed increases, the amount of PM intercepted decreases as the amount of PM2.5 increases, implying that the leaves reach their minimum level of intercepted particulate matter due to a reduction in leaf surface area (Zafra-Meija, Suarez-Lopez, and Rondon-Quintana2021).
An article by Arias et al. (2022) in Arborization strategies to reduce PM 10 in the southwestern polygon of Bogotá, Colombia identifies species specific to the southwestern part of Bogota, Colombia, where the study area is currently located, for the reduction of PM10.

These species were chosen based on their increased ability to reduce PM10 air pollution. Thirty tree species were identified for their excellent PM10 retention, including Red (Calliandra trinervia), Eugenia (Eugenia myrtifolia), Holly Smooth (Cotoneaster pannosa), Wax laurel (Morella pubescens) Sabanero Rubber (ficus soatensis), False Pepper (Schinus molle), Bleeding (croton bogotanus), Hayuelo (dodonaea viscosa) (Arias et al. 2022). These species have been scientifically researched and identified as having the potential to improve air quality and will thus be among the plants chosen for the design proposal.

The characteristics of the species
The two species for PM2.5 reduction are chosen to add into the design proposal and four species of the PM10 redution are included. These are PM2.5 (Ligustrum-lucidum and Lafoensia-acuminata) and PM10 ((Red (Calliandra trinervia), Eugenia (Eugenia myrtifolia), Holly Smooth (Cotoneaster pannosa), Wax laurel (Morella pubescens)).

Lafoensia-acuminata (Guayacan de Manizales)
This plant was chosen to be in the design proposal for the removal of PM2.5 because it meets the design proposal in terms of efficiency in PM2.5 removal and because it is native to South America and is very common in Colombia. The common name is (Guayacan de Manizales) from the Lythaceae family. See table 3. It is native to Colombia, Peru, and Ecuador. It can reach a maximum height of 20 m and a diameter of 60 cm. The leaves are 10 cm long and 4 cm wide, and the flowers are 7 cm in diameter. It performs well at high altitudes and in direct sunlight (Catologoflora n.d).

Calliandra trinervia (El carbonero rojo)

This plant is chosen for the removal of PM10. It is a species from the family of Fabaceae see table 3. It has broadleaves and red flowers. It is found all over South and Central America from Belize, Honduras, to Bolivia and Brazil and does well at altitudes aup to 2700 m.a.s.l. It reaches a height of 7 m with a maximum diameter of 25 cm. The leave is 10 to 20 cm long (OpEpa 2017; Herbariogov 2017; Wikipedia n.d). These specimens are cultivated and seen around Bogota and promotes biodiversity as it attracts hummingbirds and domestic bees (OpEpa 2017; Nogales n.d).

Morella pubescens (Wax Laurel)
This is a small shrub/tree from the family of Morella. It is common in the cloud forests in the high Andes. It is native to Costa Rica, Venezuala and Bolivia. It does well at high altitudes between 1200 to 3900 m. It has an aromatic smell. Its leaves are longer 7 cm, and it is good for eroson control with a fast growth rate (Rarepalmseeds n.d). See table 3
Vegetation for stormwater management
Plants have multifunctional abilities, which implies enlarging and elongating soil pores, reverse soil compaction, and developing macropores which are essential in infiltration rates and the retention for stormwater via evapotranspiration. Stormwater runoff management can depend on the type of vegetation and soil and how well they are able to infiltrate and evaporate the water (Yuan, Dunnett, and Stovin 2017). Green or Eco roofs are a kind of sustainable urban drainage systems. They reduce flood risks, local pollution, and provides a means to rainwater harvesting and many more benefits (Galarza-Molina et al. 2016).

Rainwater runoff is typically used in many communities around Colombia for household needs as toilet, irrigation, or consumption. However, after research into this rainwater. It was discovered that it is quite unsuitable for any of these uses (Galarza-Molina et al. 2016). Therefore, an eco-green roof design was launched by Forero et al. (2011) in Colombia using inexpensive materials as recycled plastic bottles and can be easily replicated in the aims of improving the quality of life in low-income communities.
Including a green roof in the design proposal can provide the opportunity to protect the infrastructures from rainwater runoff and offer a community activity that can increase local cohesion and promote the sustainable development of the area (Yuan, Dunnett, and Stovin 2017).

Therefore, vegetation situated for Bogota's climate that is edible and can provide reduction in runoff is sought after for the design of the green roof. A review on local vegetation for Bogota, Colombia is undertaken to investigate liable edible species that can maximise stormwater control suitable for a green roof. Using the article by Galarza-Molina et al. (2016) about The benefits of an eco-productive green roof in Bogota, Colombia. Plant species for a sustainable green roof design was discovered. In the article, the design of an eco roof with recycled plastic bottles in described using edible plant species as Batavia lettuce and Green leaf lettuce which could retain up to 65 percent of the runoff and reduce the runoff peak to 85 percent (Galarza-Molina et al. 2016).

Interview with locals
The interview results have been summarized and classified according to the question categories in figure 15.

The first category
The first category of interview questions is summarized using charts. In chart 1, the age of the participants are classified. The oldest is 65 years old and the youngest 12. The most occuring ages are 22 and 30. In chart 2, the amount of years they have lived in the settlement can be seen.

The second category
In the second category, the interviewees' responses can be summarized as the park is regularly visited by children every week, but adults, particularly those over the age of 50, rarely visit the park. This is due to the park's reputation for being deficient and deteriorating, as well as the fact that much of the park's equipment has been stolen, leaving little to entice adults to visit. The children who used the park were mainly there to play soccer on the "field" or to cheer on the soccer game. One of the female interviewees said "It is a dangerous place and nothing much to do" which was also repeated by a teen female during the interviews. This statement is therefore backed up with their personal experiences of using the park. It could be gleaned from the interviews that mostly the male children and male adults engage in the soccer activity using the park. Instead of going to the nearby park, one of the interviewees chose to go to a much farther away park for recreation as because many of the parks in the surrounding area are scarce filed for just soccer games and lack amenities that engage people in recreative activities.

"There are not enough equipments in the park. Everything is gone or damaged"

They believe it was previously very important for both adults and children, but that much of the park's equipment has been damaged or stolen. It is no longer considered valuable and is now primarily used for play by children. The play in this instance refers to activities primarily related to the basketball and soccer fields used by the local children. The field are also seen as inadequate but since soccer is an important part of the culture, it is still used regurlarly and appreciated. As a result, more opportunities for recreational activities will be greatly appreciated, as will previously availably exercise equipment

so that adults can once again participate in the park.

The third category
In the third category, "nothing about the park is good today; most of it is damaged and thus needs to be improved." The only source of attraction is the basketball and soccer field that the children currently use, but it has been discovered to be in poor condition, making it unappealing to continue using it. The main problem with the park is the lack of surveillance because there aren't many people using it, so it feels insecure, and things get stolen, and the area becomes a hotspot for illegal activity at night. This was brought up by more than a few of the interviewees, mostly from the women and the younger men. Security is an issue in the park, the use of illegal substances was found to be a strong discouranging reason to use the park in the evenings and sometimes durng the day. The interviewees strongly believed that the gatherings in the park can easily lead to gun violence and therefore is avoided.

Every aspect of the park can be improved, particularly the recreational areas for children. The park is very important for the children, and there aren't many activities for them to do in the park these days. More recreational activities that will engage parents of children, as well as more options for older people, are needed to attract everyone and create a valuable space for the community.

The fourth category
In the last category, having different types of activities to attract more people will improve the security and surveillance of the park. The security and safety of the people is the most important in this neighbourhood and to oversee that the courts and other equipment's in the park are not damaged. To do this, it is clear that creating a value to the for everyone in the community is important. It will create the type of engagement from the locals that will preserve the park.

Table 3: a summary of the chosen plant species and their characteristics

PM removal	Plant species	Common name	Height	Leaves length
PM 2.5	Lafoensia-acuminata	Guayacan de Manizales	20 m	10 cm
PM 10	Calliandra trinervia	El carbonero rojo	7 m	20 cm
PM 10	Morella pubescens	Wax Laurel	16 m	7 cm

Analysis of Manitas Barrio

This chapter focus on the analysis of the study site. Villas el Diamante Park located in Manitas Barrio neighbourhood of Ciudad Bolivar informal settlement.
It is the result of the research analysis presented using the methods described. The lack of digital information is made up with maps information and physical literature gathered from the local university.
The second part is the interview conducted with the locals and the incorporation of the local's perspective on the re-design of the park which will form an important aspect of the design proposal

Observation analysis

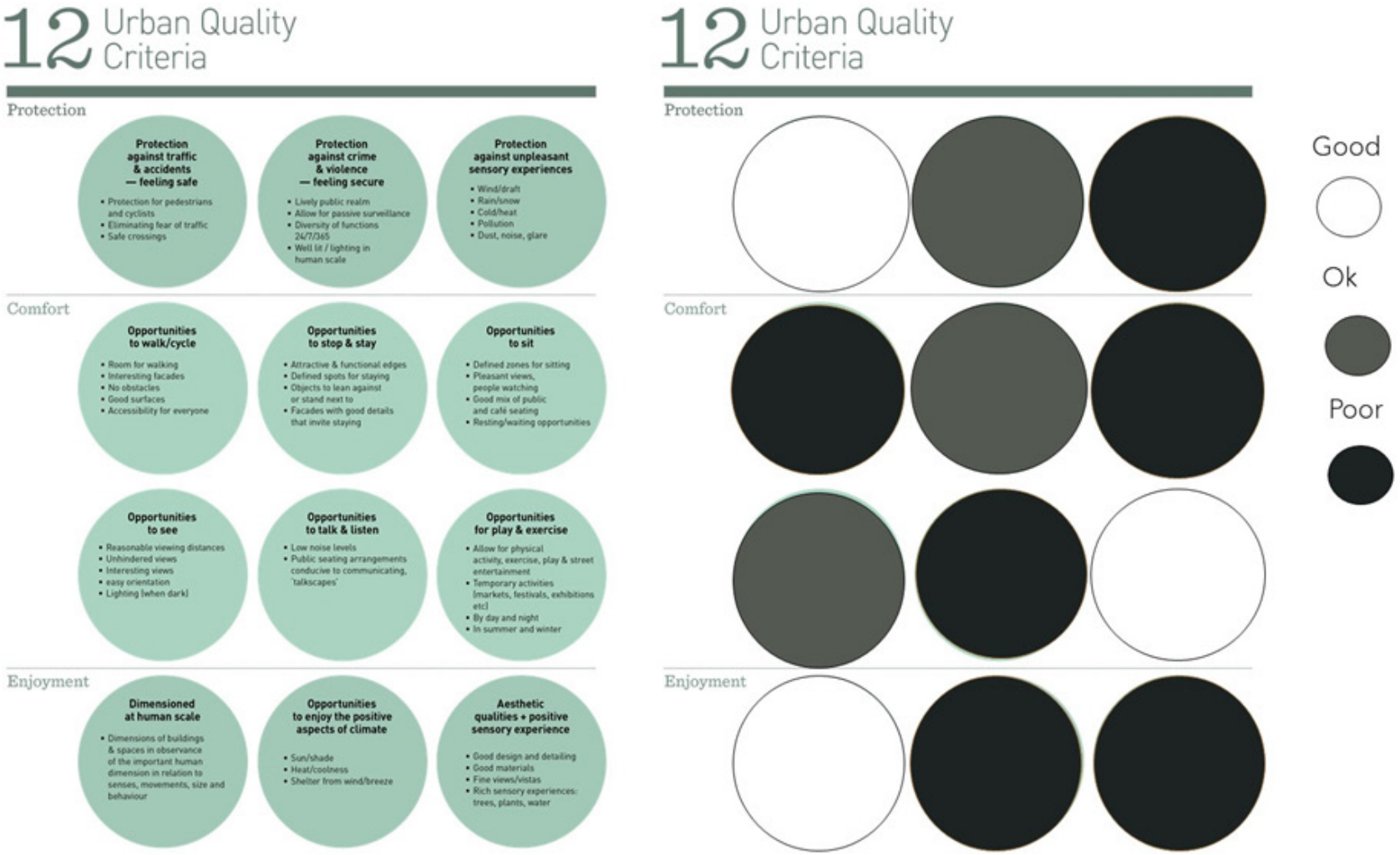


Figure 14:A diagram over the conducted 12 quality criteria by Gehl methodology and the result of said criteria over Villas el Diamante Park

Two observation analyses were performed on the site to better understand how it is today and who uses it. The 12 quality criteria developed by Gehl architect (1987) are used to assess the character of the park in terms of how comfortable, protective, and enjoyable it is for the residents see figure 13. The 12 quality criteria are rated using three values: *"Good," "Ok," and "Poor."*

Observational conclusion

According to the results of the 12 quality criteria, the park is mostly in poor condition, followed by ok and good. The poor condition can be found in any criterion, but it is most noticeable in comfort and enjoyment. The protection has the highest rating due to the park's isolation from traffic and other elements, but after speaking with the local guide, the safety from humans has the lowest rating. Because of its previous history, it is still considered a semi dangerous area as its isolation attracts unwanted attention so people avoid utilising the park at night-time despite adequate lightning.

Lynch inspired analysis

The lynch inspired analysis is conducted to perceive the built structure around the park and to explore the area further. It is a method developed by Kevin Lynch (1960). Lynch divides this mental image of how people perceive the city into five main elements in order to increase the imaginability of the urban environment. Paths, edges, nodes, districts, and landmarks are examples of these. These are chosen to be identified over the study area. They are displayed as images which have been take by the author during site visits and in figure 15.

Barriers

There are two barriers identified in the study. First, there is a natural creek inland that surrounds the study site and serves as an automatic boundary between the settlements. The second identified barrier is the mountain ridge that separates the settlement from each other. See the images below.

A natural creek identified on site

Mountain barrier surrounding the study site

Street Walkways

Paths

There were numerous small walkways throughout the area. However, only two official roadways or paths, as described by Lynch, could be identified at this study site. Smaller walkways were found throughout the study site and were not included in the path identification. The smaller walkaways are depicted in the image above.

Nodes

One node was identified in the study site. This is a major connecting road that leads to the main roads and the transcable transportation.

Landmarks

Several landmarks were identified on the study site. All of these landmarks are places of frequent visits and therefore people are frequently gathered here.

1. Secondary school
2. Primary school
3. Nursery school
4. Religious building
5. Transmicable station

1. Secondary school

3. Nursey school

2. Primary school

4. Religious building

a)

b)

Figure 15: The lynch analysis of Villas el Diamante Park. a) this displays the basemap over the park and the surrounding areas along with the conducted lynch analysis. b) this displays the basemap of the map but with the vehicular flow of the surrounding areas.

Districts

There was only one identifiable district in the study site, and this is because all the housing are built in similar manner and in close vicinity of each other. Therefore, the whole neighborhood can be seen as one district in how small and similar the houses and infrastructures are to each other.

Conclusion from Lynch analysis

The lynch analysis concludes that the area lacks variety in built structures that are not absolutely necessary, such as housing, schools, and transportation. It is occupied with dense brick built mortar with urban voids in between. The major landmarks as seen in figure 14a are the Fanny mickey secondary school, transcable station, and other primary and nursery school. Figure 14b demonstrates that the site area has little traffic because there are only two major roads through which cars can travel. It also demonstrates that it is surrounded by natural barriers, such as streams, hilltops, forests which can make movement difficult but also keep one confined to one district. Some of these areas are turned into dump site that are unsanitary. The city's numerous pathways reveal the residents' involvement in creating their street walkways, resulting in the rough streetscape.

LCA assessment analysis

This is an inspired landscape character assessment (LCA) to delve into the study area's various districts. The process of identifying different variations or characteristics of the landscape by describing the landscape character types is known as LCA. As an example, consider different parts of the settlement such as housing type. It seeks to recognize distinct elements or combinations of elements in the landscape that make it unique (Tudor 2014). The LCA is based on common characteristics and can be divided into three major areas such as the living areas, the commerce areas, and the natural areas. Three type of living areas were identified and when asked about them. The local guide explains that this has to do with the history of the place. Images taken by the author during site visits are used to display the observations

1. The Government painted areas

These are the houses that the city's local government insisted on painting, not the people who live in these areas. Therefore, they are made for people like me who live in the main centre of the city. The goal is to conceal the "truth" of the area while making it appear pretty and bright from the main city centers. The residents of the Barrio are thus hidden in plain sight. Along with the degrading, some of the local artists' work on the area was painted over, and in some cases by artists from the main city centre.

2. The old façade as they were

The government has not intervened to paint over these areas. As a result, these are living areas that are exactly as they were. The history of these areas, as well as the manual labor involved in their construction, have been preserved.

3. Areas that has been painted over by the locals themselves.

The difference is stark. More passion and time have been put into these as explained by the local guide. As explain by the local guide, the ones painted by the government are less quality as they are not painted for the people who reside in these areas.

4. The commerce area

The commercial area is not large in this settlement and is mainly made of a main street in which people can get their basic needs.

5.The natural area (creek)

The creek plays a critical role for the settlement. Its history is what brought people together to take care of it. It has been a major source of water for the community and hence where members of the community gather in harmony to socialise, tell stories, do laundry, and get water .

6. The mountain

The mountain surrounding the area is an important border between the different settlements but also puts the settlements in full view for the residents in the main city centre as these areas can be viewed all over the city.

Green and blue structure

I didn't expect to see so much greenery, but the creek is fully overgrown with flowers and native plantations. There was even small community garden that are started by the youth in the community. A small water still flowing through the creek that apparently runs through the area.

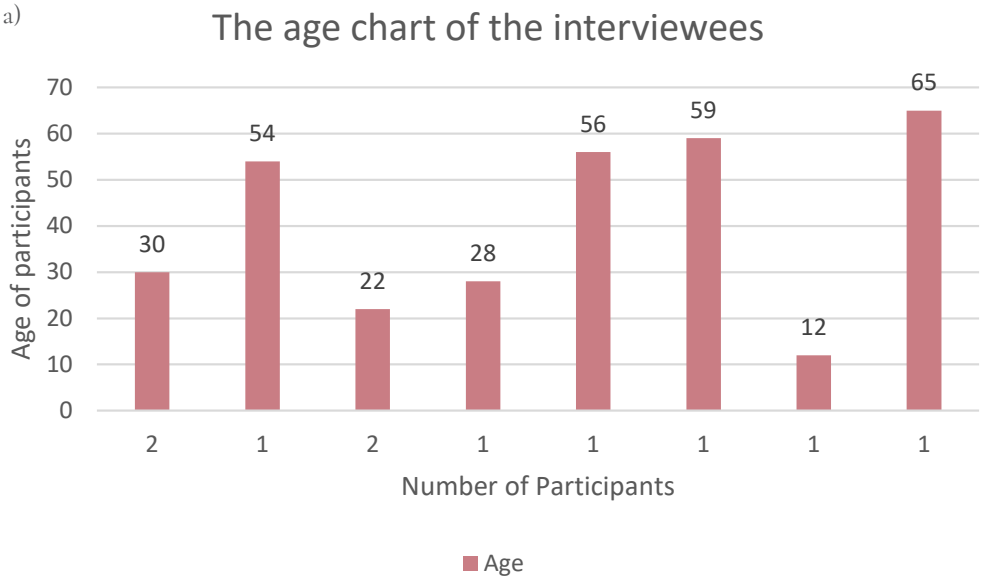
Conclusion from LCA assessment

There are variety in the landscape surrounding the park such as the type of living areas, the commerce areas, and the natural formation. These all together form a unique landscape for the barrio. It is a small but vibrant settlement that has different sections to it and its history still preserved can be identified from the different types of settlements

Conclusion of Green and blue structure

There are two main green and blue areas in the settlement. The main is the mountain with wild vegetation growing up and around. And secondly, the creek with its vegetation growing in and out.

a)



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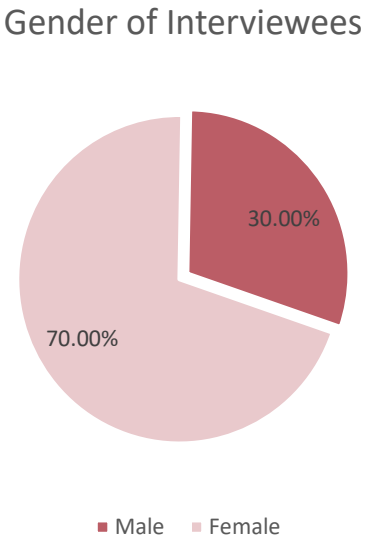

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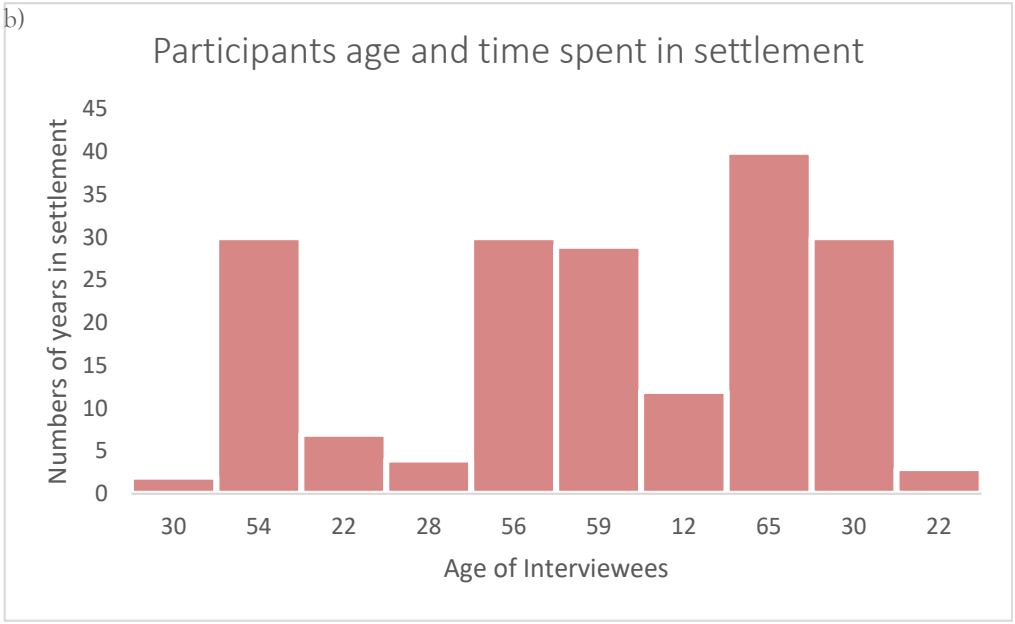

Chart 1:The first category of the interview can be categorised using different charts types made with Excel. a) displays the age of the interviewees participating in the interview/workshop of Villas el Diamante Park. Of the ten participants, the oldest is 65 years old and the youngest 12. The most occuring age is 22 and 30 years old. b) this displays the amount of years the partipants have spent living in the settlement. The highest being 40 years and the lowest being 3 years. c) the gender of the interviewees are displayed. The amount of males are 30 percent and females 70 percent.

The occupation of the interviewees ranged from pensioneer, shop owner, school teacher, unemployed, and student.

Design

In this chapter, the design proposal is finally presented after using the conducted method RTD. The first part introduces the design process of the park proposal and that has led to its final redesign.

The second part is the design principles that will form the guidelines used in the design of proposal for the park. The design principles contain aspect on recreation, air pollution, and other forms of climate change mitigation as stormwater management and biodiversity increase.

The last part presents the sustainable design proposal of the Villas el Diamante Park with integrated local perspectives

Design process

The development of a design proposal based on research through designing that incorporates local cocreation are defined based on the literature studies. Vegetation for air pollution management Arias et al. (2022) in which suitable vegetation for air pollution removal can be applied, climate change mitigation using the design of sustainable green roofs Galarza-Molina et al. (2016). Principles on recreation are followed and the integration of local perspective to produce the final design proposal.

1. The quality evaluation tool

QET tool is used as a guideline for the recreational aspects of the design proposal. Even if the tool is meant for outdoor environments in a healthcare setting, the concepts used to build the tool has an important benefit for small parks in an urban context. The tool has several environmental qualities which are divided into two sections. In total, it has 19 qualities (Bengtsson and Grahn 2014). The aim of the tool is to provide a recreational space for multiple types of users. Therefore, some of these qualities that are applicable in an urban context has been considered in the design proposal.

Section A
These qualities refer to being comfortable in the outdoors and according to the QET. These are:
1. Closeness and easy access
2. Enclosure and entrance
3. Safety and security
4. Familiarity
5. Orientation and way finding
6. Different options in different kinds of weather

Section B
In Section B, this refers to supporting the persons access to nature and the surrounding life. It consists of thirteen qualities

1. Joyful and meaningful activities
2. Contact with surrounding life
3. Social opportunities
4. Culture and connection to past times
5. Symbolism/reflection
6. Prospect
7. Space
8. Rich in species
9. Sensual pleasures of nature
10. Seasons changing in nature
11. Serene
12. Wild nature
13. Refuge

1.1 Section A

Enclosure and entrance
The park has multiple entrances, and the playground SE is surrounded with hedges to provide protection to the children playing and distinguish the different sections. It has enough enclosure between the different sections that it does not feel confined but protected.

Safety and Security
This is a huge part of the design proposal strategy in which having multiple social activities can increase the presence of the locals and perhaps tourists in the park. Providing a join network of security. This is also accompanied by using hedges and rails to physically protect the children and elderly using the park. The natural playground provides a safe environment to play without causing physical harms.

Different options in different kinds of weather
The park offers day and night-time activities to ensure continued safety but also variety in the park activities. There are sitting areas that provide adequate shades as protection from strong sunlight and the vendor area has a roof for unexpected weather so they can keep selling. The park is enclosed by the hilltops and therefore provides wind protection.

1.2 Section B

Joyful and meaningful activities
There are various activities that corresponds to the types of activities favoured by Colombians. Varying activities from physical to social to community related activities. Such as football and basketball, street food, community garden, exercise area, playground and a mirador.

Contact with surrounding life
The mirador offers the view into the community and therefore provides the first contact to the daily life of the locals. The vendor stalls encourage people to buy and sell therefore performing a trade and increasing communication amongst the locals. The green roof offers contact with plant life and the big trees provide shades and contact with nature.

Social opportunities
There are multiple social opportunities. There are places where you can view other people but also places to engage in physical interacting activities.

Culture and connection to past times
Street art is an important part of Manitas barrio therefore having a graffiti wall can offer connection to the local culture in the area and also a way of reflecting on the park

Prospect
There are inviting open spaces to view and to be viewed with the urban layout in display but also lush vegetations with variety of smells and colours

Space
There are different sections of the park that offers a feel of being in different places and therefore increases one's mental space

Rich in Species
The park contains varieties of species that offers interaction with different plant life

Sensual pleasure of nature
The variety in species and the parks layout provides opportunities to smell, hear, and feel nature. Different flowers with different colours which attract varying insects and animals.

Seasons change in nature
There are opportunities to observe the seasonal changes in the plant life however the activities due to the local climate can be done in all seasons and therefore not many activities variations

Refuge
There is a section of the park that provides sitting areas for groups or alone and faces away from the activities which provides refuge

1.3 Integrating the locals' suggestions

A big part of the thesis is a local cocreation, where the locals can input their ideas on the design proposal. This was done through interviewing and reviewing suggestions. The summary of the interview can be read under the section research. It has influenced the ideas behind the design proposal. The important components from the interview have been included into the design proposal. These are

• Safety and surveillance in the park so equipment's will not be stolen or damaged and people can feel secure being in the park
• More recreational activities for both children and adults, emphasis on children
• More activities to attract all kinds of people in the community. Not only recreational but social activities

These suggestions go along with the concept and aim of the park. None of the suggestions were impossible to imagine as features of the park. The focal point will be on heightening the recreational experiences of the park as much equipment's in missing from park along with the focus on improving public health of the residents.
The requested changes are
Playground area
Remodelling of the soccer and basketball field
All of the suggestions are very well integrated in the design proposal. From the increase of equipment's to the remodelling of the soccer and basketball fields and the added strategy to increase communal security and social cohesion.

Design proposal

The park's design is divided into four sections; thus, the park will have four different types of characters and themes that distinguish it from each other. The areas are well connected to one another and are divided as follows: (North, south, east and west). The directions are NE, NW, SE, and SW. The design principles are an essential part of the design proposal and it forms the design proposal of the project. Several principles have been employed in the proposal see figure 16.

The northeast area
This will be transformed into something called a "Mirador," which means a viewing point facing the settlements. It provides a place for visitors to sit and observe the park and its activities without actively engaging in the activities. It will have adequate and cosy lightning for the evening and a telescope to check out the different areas of the park. The benches are separated for different groups and are made of wood for comfortable siting. The surface area is currently a red brick and since the transmicable is built onto it. It will continue being a red brick, however, it also symbolises the material that is very common to find around the city of Bogota. This section is meant as a relaxation and onservation point

The northwest area
This area will form a small vendor point where sellers will be able to sell local snacks while staying in a small wagon with a roof covering. It is meant to have chairs and tables that faces the vendors and therefore have a concrete material for the floor. The roof of the vendor stalls are utilised to provide a small green roof. This will be used to plant local cabbages and can be accessed and taken care of by everyone. For the planting, small Colombian rose bush and Geraniums which provides delightful smells and colours will surround this little area.

The southeast area
This is the playground and physical exercise area. The idea for the playground is to become a "natural playground" (ludic playground) which will have dead woods designed for play on wood chips material that are safer for falling onto. It will include a 360-degree bench and a tree in the middle, which is suitable for parent observation, but also a chance to turn away from the mirador and look at the park activities. It will have a surrounding hedge separating it from the vendor stalls

so as it will be a safe environment for children play. It has a small adult exercise area to encourage physical activity, this will contain small exercise equipment's.

The southwest area

This section of the park is the largest, and it includes the park's already existing basketball and football courts, which will be remodelled to fix the broken sides but will be mostly kept as it is today to familiarise the park for the residents. It will have benches built into the stones for viewing the games with lightning in between the benches for night-time play. On the wall of the park, it will have a provided space for street art as this is a common artwork in the area and to encourage creativity. It will contain the rosebushes and Geraniums.

The principles of design are the first step in the design process. Climate change mitigation (reduced air pollution, stormwater management, and increased biodiversity) is at the heart of the principles, as are recreational opportunities and strengthened local cohesion. Recurring words during the interview are lack of safety, lack of recreational activities, and lack of integration of different ages. In the design proposal, these form the principles of the design. It aims of developing an environmentally sustainable park to assure improved public health in terms of better air quality and the sustainable development of cities for climate mitigation.

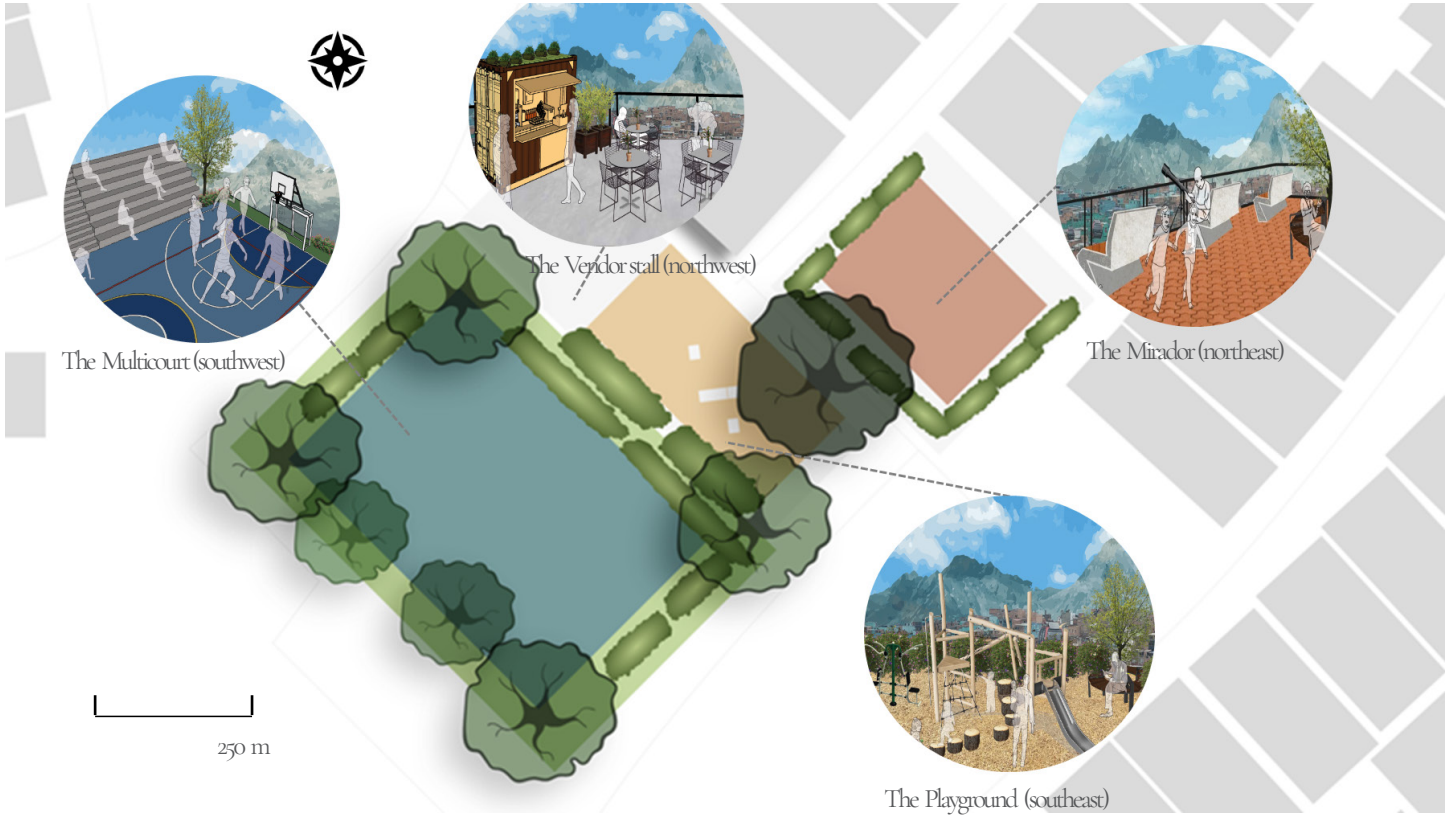

Figure 16: a map over the different themes of the parks design proposal for Villas el Diamante park. Base map retrieved from Capmapper and modified with illustrator and photoshop

How has the design principles has been incorporated in the design proposals?

The northeast area

The open space provided and separate sitting areas in which people can observe the scenes of the park at a distance and stare at the settlement provides an opportunity for self-restoration in accordance with recreation principles. It's a place of refuge, social opportunity, space, and prospect according to the quality evaluation tool see figure 18. It also attracts people of all ages because it can be relaxing for older folks or a hangout for younger generations. It is a versatile space with multiple uses. In this location, trees for air pollution removal are planted, providing a refreshing air and potentially improving public health.

The northwest area

This space is open to people of all ages. The space with the vendor stalls encourages people to gather around and sell or eat, encouraging communal protection as several people pass through, increasing the number of visitors to the area. see figure 20 According to the quality evaluation tool, it provides contact with the surrounding life, social opportunities, and refuge. It increases safety by allowing more people to interact with the park. It also provides activities for people of all ages, such as a small roof garden that is maintained by the community as a whole. This has the potential for climate change mitigation, increasing social cohesion and biodiversity.

The southeast area

The playground and exercise area provide more opportunities for recreation and restoration for people of all ages. The ludic design of the playground encourages creativity outside of the norm figure 19. As children are an important part of the settlement. This allows children of various ages to socialize in a safe and stimulating environment. According to the quality evaluation tool, the surrounding vegetation is rich in species, sensual pleasure of nature, joyful and meaningful activities, safety and security, and contact with surrounding life and provides air pollution removal. It increases the amount of recreational activities, not only for small children, but also for parents who are watching over their children.

The southwest area

Two active recreational activities are available on the multicourt. Basketball and football can be played, but there is also a graffiti wall. This area has benches to encourage people to relax and watch the games, but it also serves as a hangout after dark. The surrounding area is densely forested, which reduces air pollution, increasing biodiversity, improving public health, and encouraging climate change mitigation and adaptation. The open space not only provides safety and surveillance, but also recreation opportunities see figure 21. It provides safety and security, joyful and meaningful activities, social opportunities, culture, and a connection to pasttimes and seasonal changes in nature, according to the quality evaluation tool.

In conclusion, the different aspects of the parks covers all parts of the design principles and most importantly reflects on the aim of the thesis. Which is to provide a design proposal of a park that improves public health, encourages recreational opportunities, increase social cohesion whilst mitigating and adapting to climate change. The aim of the design is to provide a sustainable urban park.

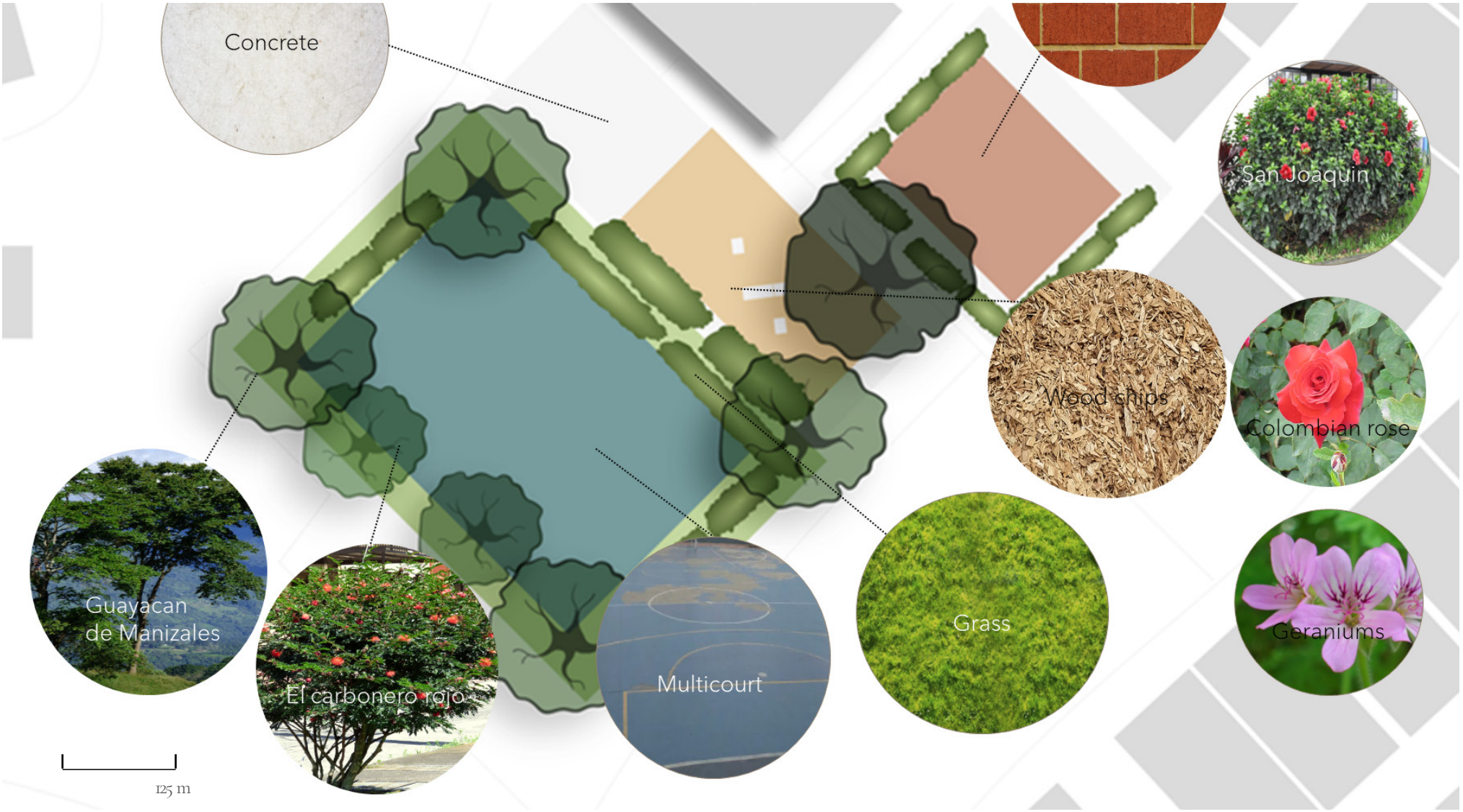

Figure 17: A diagram over the park basemap is created by the author using sketchup and photoshop to better visualise the different sections of the park and the intended materials that will be used for the different sections in the park. There are four sections of the park as described above, the mirador, the vendor stalls (includes the green roof), the natural playground, and the soccer and basketball court.

El Mirador - The view point

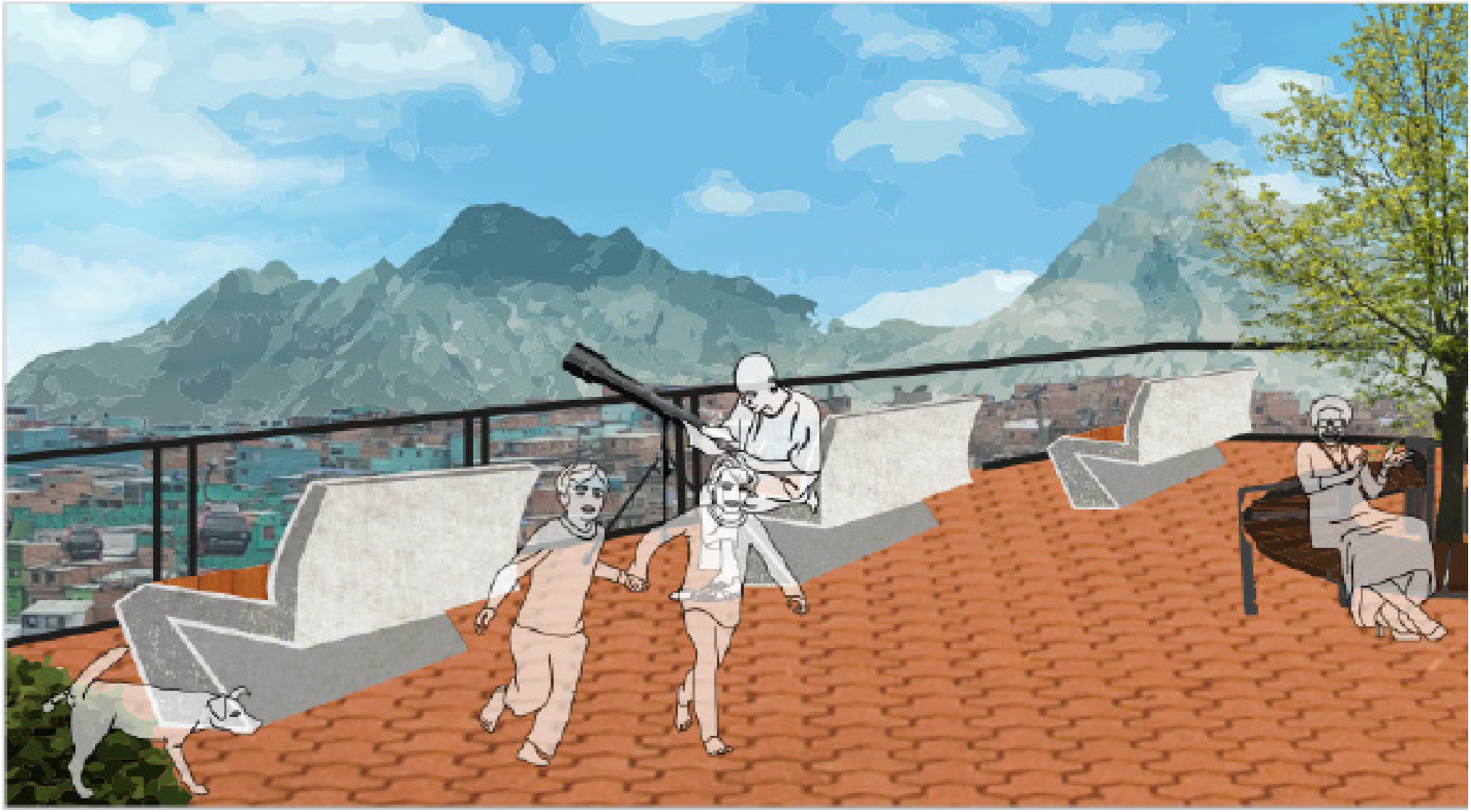

Figure 18: An illustration of the parks northeast area known as the Mirador. It is made using illustrator by the author. The northeast area of the park is transformed into a view point overlooking the settlement, it is a place to relax and observe the park activities without fully engaging in the park itself.

The Playground and Outdoor gym

Figure 19: An illustration of the parks southeast area known as the Ludic playground and outdoor gym. It is made using illustrator by the author. The southeast area of the park is the continuation from the northeast, in which viewers in the El mirador can choose to eithier observe the playground whilst the children are playing. The vegetation provides shelter and protection for the children as they play with natural elements. There is a small option for outdoor excercise to engage adults in the playground.

The Vendor stalls and sitting point

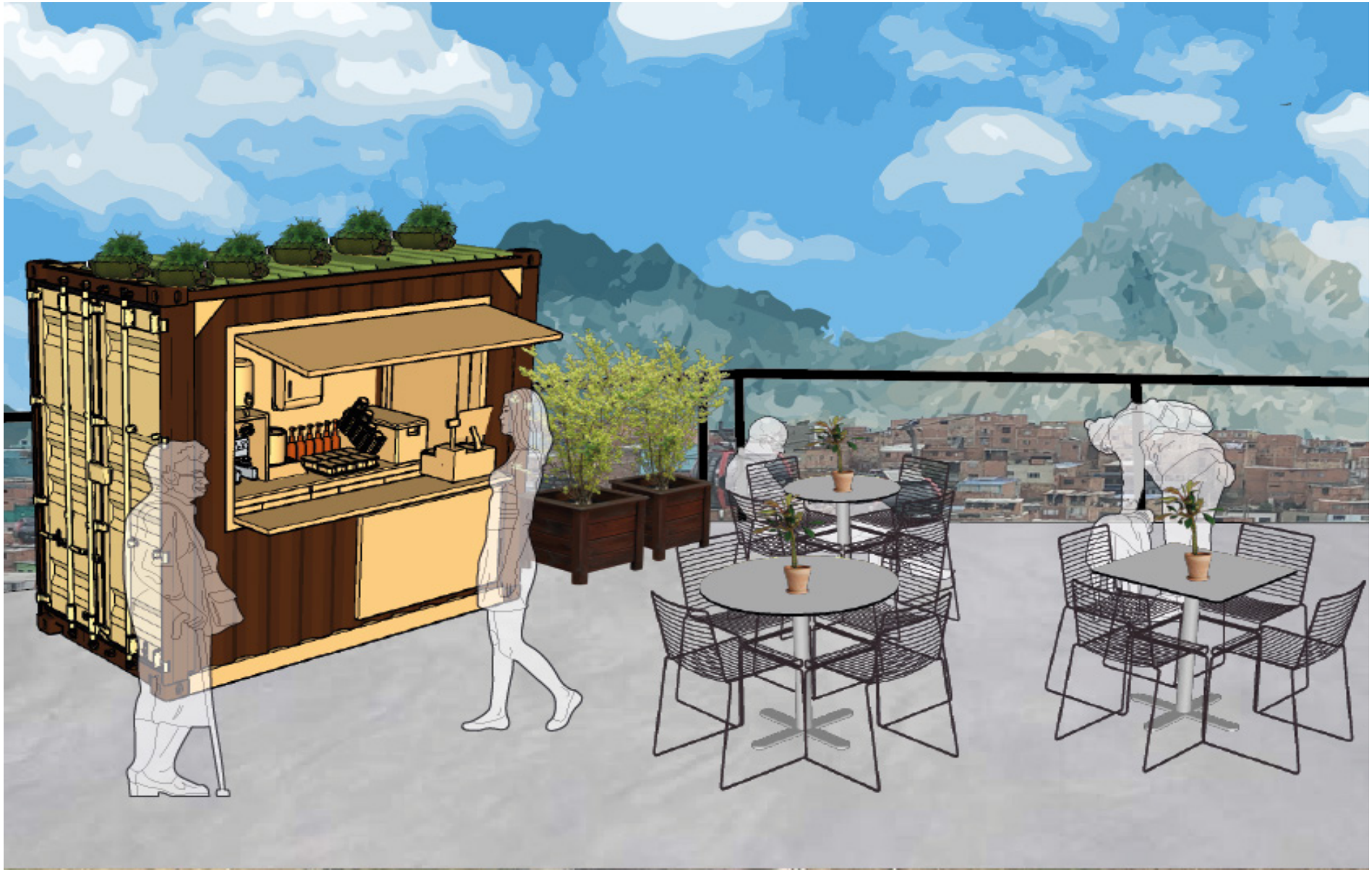

Figure 20: An illustration of the parks northwest area known as the vendor stalls section. It is made using illustrator by the author. The northwest area of the park is the continuation from the southeast in which an area where people can buy small snacks but also sit to eat or chat whilst observing the settlement and also the park activities.

The Muticourt area

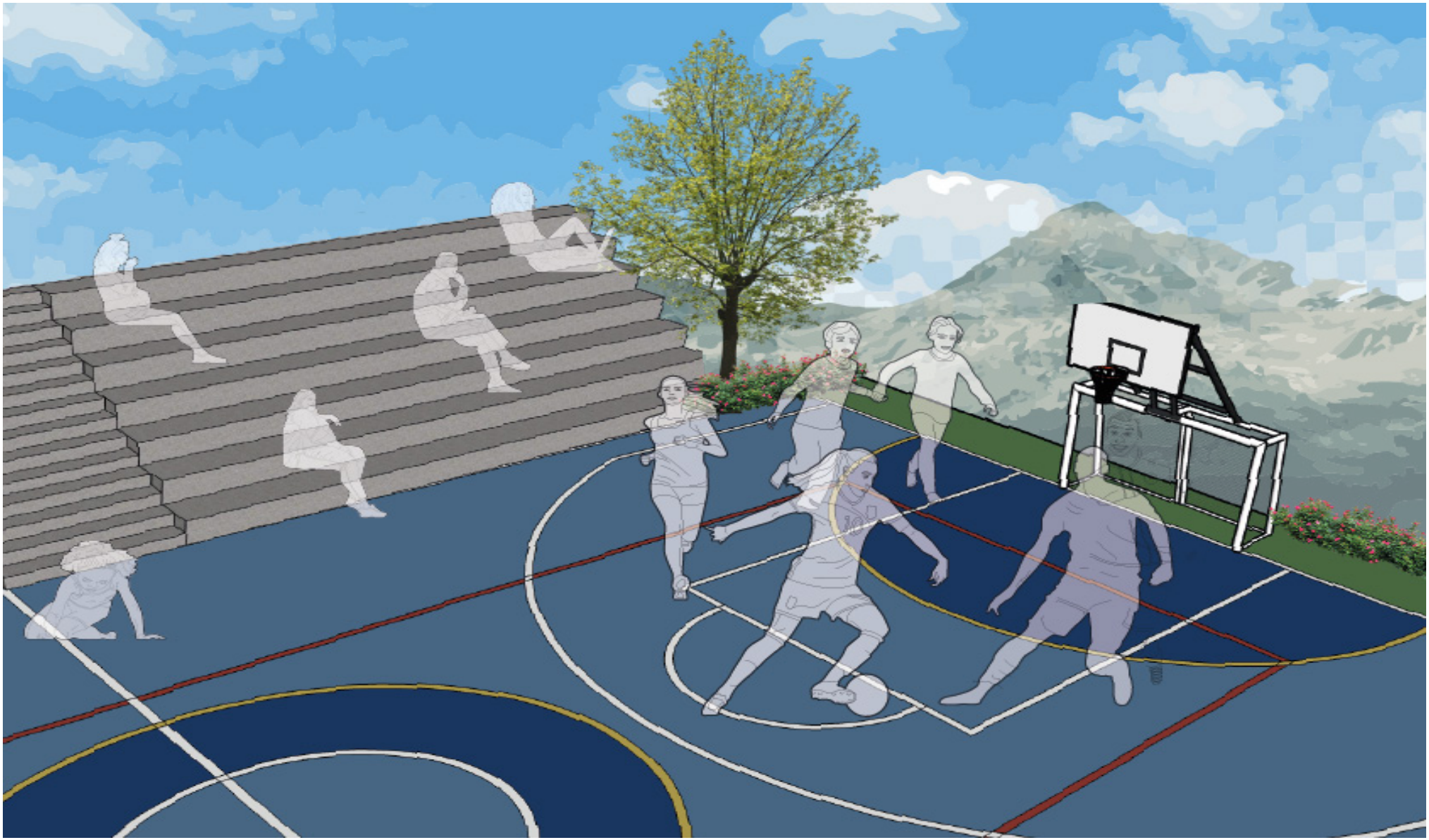

Figure 21: An illustration of the parks southwest area known as the multicourt area. It is made using illustrator by the author. The southwest area is the re modeled multicourt making it possible for park visitors to engage in both basketball or football games. There is a provided sitting area so other visitors can observe the ongoing games and the walls surrounding the court are avaliable for graffiti.

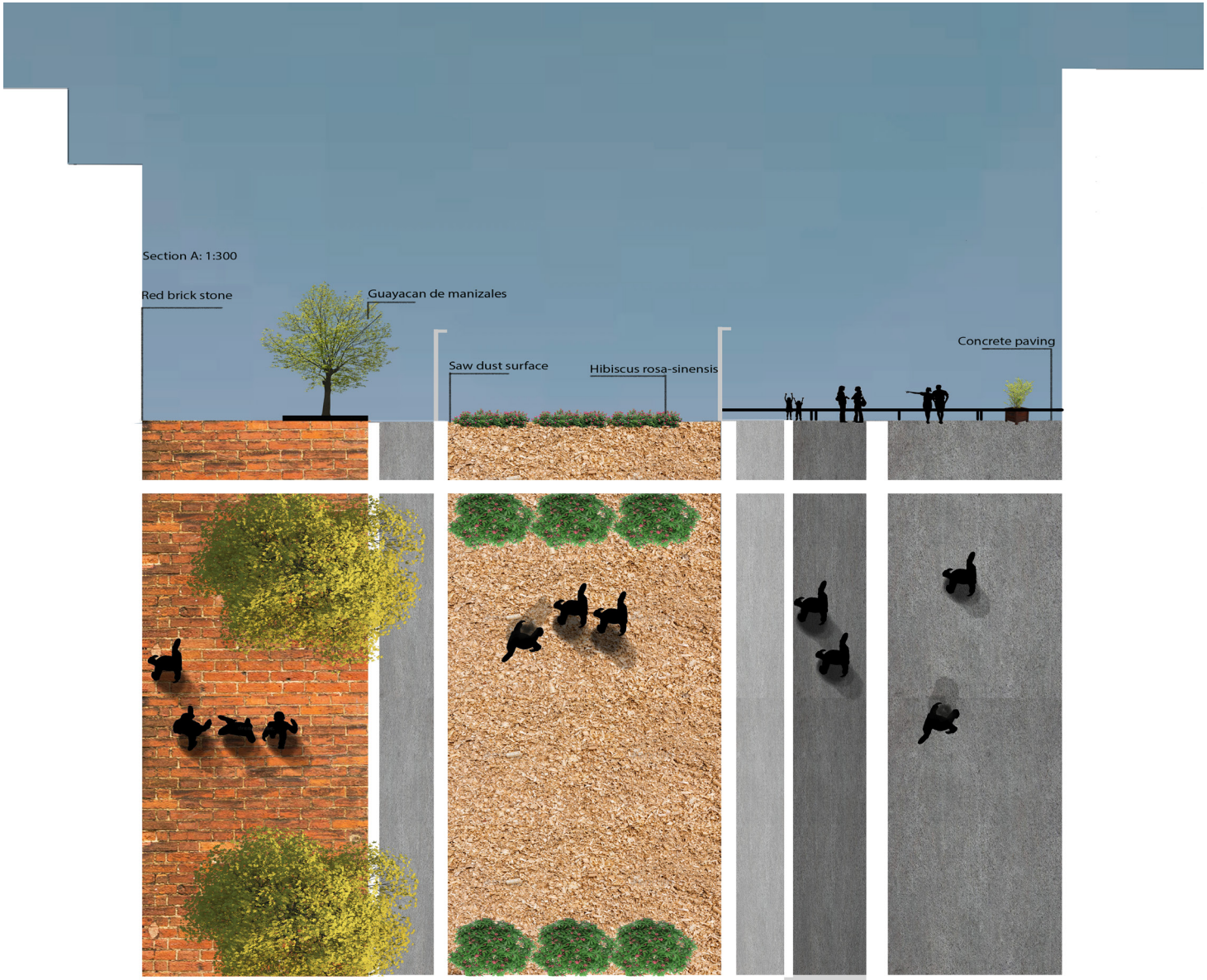

Figure 22: A section and overhead view of the park made using illustrator by the author (2022). The figure shows different sections of the park simultanously facing the north side of the park. In the figure, three sections can be seen divided with the white lines. The overhead view is displayed seperated by white lines. The Viewing point, the playground, and the vendor stalls. The section is accompanied by an overhead view displaying these different sections.

Materials

1. Flowers, shrubs and trees

The hedge that surrounds the playground provides the children with both protection and exclusivity from the outside world. The species was chosen not only for its flowers, but also because it is well cultivated in the city. San Joaquin, also known as Hibiscus rosa-sinensis, is native to East Africa and of the Malvaceae family. However, it is widely cultivated in Colombia. It is a perennial with a year-round flowering period (Nazarudin 2012; Catalogoflora n.d).

The height ranges between 2 and 5 meters, and the flower diameter between 10 - 15 cm. Its flowers are large and can range in size from 6 to 12 cm in length, with a variety of colors ranging from pink to orange to scarlet (Ecuadorinaturalist 2022). Colombian rose and Geraniums are the chosen species of flowers for the park see figure. These flowers, particularly the Colombian rose, are extremely important to the country. It has become a significant part of the country's export and is thus widely grown in Bogota (Farias-Arias et al. 2006).

The various combinations of Colombian roses, which are famous around the world and grow locally in the area surrounding Bogota, will add color, biodiversity, and scent to the park. Rose species include 'Charlotte,' 'Black Magic,' 'Classy,' 'Gabriele,' and 'Leonidas' (Nell and Leonard 2003).
Pelargonium spp. is another name for geranium flowers. Originating in South Africa, and now grown in Colombia. The geranium family contains over 250 species of perennials; however, this thesis chooses the common geranium. They are evergreen perennials with a long flowering period and multiple types of colours (Infoagro n.d). Their height ranges from 15 – 30 cm and a width of about 60 cm (BHG n.d).

The trees chosen for the design of park has been listed above in the research. Two trees are mainly used for the reduction of air pollution and are chosen based on its size and what the park has the capacity for. The trees are Guayacan de Manizales and El Carbonero rojo. Non-native species have been deliberately included to increase diversity, as they are an important part of biodiversity (Schlaepfer 2018), and have been carefully chosen to avoid the negative consequences often associated with their use.

2. Surface materials

In figure 17 several surface materials have been pointed out for the different parts of the park. These materials are explained below:

Red bricks
The red bricks are placed in the mirador area, this is because, it currently has red bricks installed in the area and since the transmicable is connected to that part. This will not be easily moved. Therefore, to avoid further damages the red bricks will stay as it is.

Concrete
The concrete is used for the vendor stalls as it is already made of concrete and makes movement easier for the residents but also inexpensive for renovations.

Grass
The grass is used to surround the multicourt as almost all the surfaces are currently concrete. The multicourt is kept as a concrete as it allows the possibility for both basketball and football play which is identified as a huge importance for the locals. Therefore, to allow plantations grass is used on the pathways to transition into the other parts of the park

Wood chips
The wood chips are placed on the playground to offer a safer environment for play. As the playground is of the natural kind, it provides both aesthetic, safe, and sustainable option for children play.

Green roof
The green roof is made from standard zinc by metal structure (2.80 m x 0.90 m) with a 5% slope. A metal gutter and a plastic container to collect the runoff. The green roof can be equipped with about 20 (3-dm3) plastic bottles distributed around the roof in 4x5 array. Three holes are made in the bottles to facilitate soil and crop placement. 7 x 10 cm are created with 0.5 cm perforations are made 5 cm below the bottles mouth. The soil depth is about 8 cm: containing 60 % black dirt and 40 % rice husk. For maintenance the crop plants (Batavia and Green leaf lettuce) are irrigated in early morning and in the evening using about 15 dm3 of water and in the dry periods the collected runoff water is used (Cortes and Castillo 2012 and Galarza-Molina et al. 2016)

3. Benches and furniture

Wide benches are used in the mirador and multicourt areas of the park. The benches in the mirador are made of wood material for comfortable seating, but they are installed permanently and embedded into the surfaces, so they are not easily moved. The suggested material is hardwood such as oak, which will last a long time through wear. The bench in this area is designed for two people to sit on, so it is approximately 127 cm long, and the wooden material provides an aesthetic experience.

The multicourt, wooden benches were chosen for their view of the games as well as the comfort they provide when sitting. However, these benches are arranged in a stadium-style layout, allowing people to sit in long rows in three steps. Because

there is already a concrete stair, the wood is overlaid on top for more comfortable seating while also making it more secure from theft.
There will be individual chairs and tables for sitting and socializing in the vendor stalls that can be moved around. As a result, plastic materials will be used for the chairs and table, allowing them to be stored in the evenings and require less maintenance, allowing them to be used for more regular purposes.

4. Playground Equipment's

Play is an essential component of a child's development. Interesting results found on the different affordances provided by the traditional and more natural playground themes have shown to impact childrens play and therefore development differently. Traditional playgrounds provide a variety of playground elements that can increase physical activity in children and improve their motor skills (Luchs and Fikus 2013).
However, several scientists Shim, Herwig, and Shelley (2001); Campbell and Frost (1985) have observed that outdoor natural playground that is less structured and constructed leads to dramatic and creative play. The lack of structure encouraged the children to interact more socially with their peers. Other scientific articles, however, found no significant differences in play between these two types of playgrounds (Luchs and Fikus 2013).

Postma and Forest (2016) conducted a case study in the Netherlands, selecting two natural playgrounds in an urban setting to observe children's nature experiences in these playgrounds. The results shows that useful nature, challenging nature, and active nature were the most experience present while utilising the playground. The study however is performed outside of Colombia but is used to inspire the design of the natural playground for Villas el Diamante Park. The playground will have a natural ludic theme which means using natural material to create play elements. Therefore, the playground will be built using dead wood trees and ropes, along with tree stumps for jumping and boulders. These are inexpensive materials that would not stand out for thievery but also be in line with the aim of the thesis for the design proposal.

Discussion

The design process and the result of the thesis in relation to its aim and research questions, are discussed in this session. It also incorporates relevant theories that have influenced the research. It goes over the literature study that was used, the method that was used, and the future improvements to the study.

The method, result, and a landscape architect role

The aim of this master's thesis is to develop a sustainable design proposal for a park in Bogota's informal settlement Manitas Barrio.

A sustainable design proposal means it can provide a variety of ecosystem services in dealing with environmental challenges such as air pollution, storm-water management, and a lack of biodiversity but also improve the mental and physical public health of residents with increased recreational possibilities.

Two research questions are addressed in the thesis. The questions are designed to spark discussion about how careful planning of urban green spaces can help to address environmental issues such as air pollution, storm-water management, and a lack of biodiversity and better the public health of residents in informal settlements.

What are the identified plant traits and factors that contributes to reducing air pollutants, managing storm water, and increasing biodiversity in Bogota?

How can urban green space in an informal settlement be designed to maximise the functionality of vegetation in targeting specific environmental challenges to promote better air quality and public health with the integration of a local perspective in Manitas Barrio, Bogota?

Local cocreation, climate change mitigation, and improving public health are the center of this research investigation which was carried out physically in an informal settlement in Bogota Colombia. Different methods have been applied in order to answer the research questions and to accomplish the aim stated in the thesis. The method was divided into three stages. The literature study, the analysis, and finally the design process.

The methodology

Literature review and Analysis

The literature review has been divided into three major sections, each with a different theme focusing on the thesis's goal. It provides a solid foundation for understanding the problem and potential solutions for the research topic. The topics covered included urban environmental challenges as well as the role of urban green space in improving public health and mitigating climate change. In this section, we recognize that the urban environmental challenges are massive and will most likely have an even more negative impact on a neighborhood like Manitas Barrio, given the city's socioeconomic disparities.

Following the literature review, the field component referred to as analysis in the thesis was an important part of the design process. This stage of fieldwork was divided into two parts: first, I went to conduct observations as an outsider, and second, I interviewed locals to get their perspective on the park today and what they hope it can become.

During the observation, I performed several analyses such as Lynch, LCA, and Gehl's methodology but also green-blue analysis.

The ability to be on the field allowed me to have different experiences and take a different approach than if I had only been on distance.

The value of this on-site observational analysis for the design process cannot be overstated. The design process, according to Entwistle and Knighton (2013), begins on the work site. My observations of the landscape provided me with an awareness of the place and space that I would not have had otherwise.

This awareness aided me in sketching my ideas for the initial processes and comprehending the proposal's details. The decision to use behavioral research, such as Lynch and Gehl's methodology, is based on the fact that environmental-behavioral research has been shown to be a direct and clear way to understand how people experience the environment (a very important process in this project), as well as a time-effective method (Lipovska and Stepankova 2013). Being in a completely new culture this was critical.

The urbanist William H Whyte inspired the use of photography as a method in a project on the effectiveness of city Plazas. The team devised various methods for observing and mapping people's lives and behaviors. The use of lapse photography and film is one of these methods (Whyte 2007). This method allowed for the collection of intuitive data and information that would otherwise be invisible to the unobservant (Lipovska and Stepankova 2013).

As a stranger and foreigner to the country, city, and settlement. The use of photography allowed me to reflect on all of the new things I saw and observed. I could go back and review the photos, making it easier to gather my thoughts on my experience, and could carry my observations both in and out of the field. This provided me with more time to explore and more allowance to be intrusive.

Lynch's analysis and LCA were helpful in reviewing the community and understanding the environment from a broader perspective. Gehl's methodology, long developed by Danish architect Jan Gehl, is a simple way of observing the community. Despite its simplicity, the method allows for careful observation of how and by whom the spaces are used (Lipovska and Stepankova 2013). According to Whyte (1980), designers can better understand what people want from their cities and public spaces by observing what they do rather than just listening (Lipovska and Stepankova 2013).

This is not to say that listening to people has no or little impact; it is also an important aspect of the design process.

Interviewing

Interviewing was a useful method for this study because it provided quality information about human behavior (Alshenqeeti 2014). The interview was semiformal, which allowed the interviewees to express themselves freely and deeply. Interviews are valuable because they allow interviewees to "speak in their own voice and express their own thoughts and feelings," according to Berg and Lune (2017, p. 96). (Alshenqeeti 2014).

The interview method was highly valuable and led to a critical contribution to the design proposal.

The open format of the interviews used in this study encouraged interviewees to bring up and speak passionately about specific topics. Going around and knocking on doors, as well as joining the interviewees in their daily tasks, created a relaxed atmosphere that made speaking with strangers easier.

The benefit of having local students present to speak in the local language made the interviews go more smoothly than they would have otherwise. It provided a more natural way of gathering data, which interviewing should be used for (Alshenqeeti 2014).

It was critical in this case, or subject, to understand the needs of the locals in a natural way. Having locals with me, however, and taking the time to explain the project and listen while they go about their day, ensuring that the interview became less of a data collection task and more of natural interaction between us and the residents.

In this manner, difficult-to-obtain data was accessed, and emotions could be read from the interviewees.

My job as a facilitator ensured that the interviews did not become deflected and that the locals were still engaged in the topic at hand. It was a fascinating role to play because it kept me from actively influencing with my own opinions while yet keeping me aware of the perspectives of interviewees and, notably, the emotions that are crucial, as I was not participating in the discussion but rather listening and leading them.

The Result

The design concept resulted in many scenarios that were formed by the perspective of the locals and based on literal design principles. This proposal resulted in a park design that includes a variety of recreational opportunities for people of all ages, making it inclusive to all types of people in the community. It also includes a focus on community safety and actively building social cohesion, which was a new aspect to consider for me as a landscape architecture student from Sweden. It entails the use of appropriate plants for air pollution control, but due to space constraints and community demand. The vegetation received less attention than expected. However, the plant decision was crucial in achieving the thesis objectives. As a result, the plants were carefully chosen for their ability to reduce air pollution, manage stormwater, and increase biodiversity.

The design proposals in this thesis are intended to demonstrate that landscape architecture may go beyond deluxe and luxurious design to design for necessity. “Landscape architects can show that urbanity means much more than a stylish promenade in Hamburg or Singapore. Necessity is the mother of invention, not affluence.” writes Rekittke (2009). But most importantly, to meet the requirements of the locals.

Design proposal

This proposal is communicated using illustrations and can hopefully reflect the role Landscape architecture takes in an informal settlement. The proposals entail different sections that can provide the needs of the community that have both been expressed during the interviews but also witnessed during the field moments.

The problems communicated were the lack of recreational activities for children, but also older adults, the lack of community meetups and the lack of safety in the public spaces.

Therefore, the proposal resulted in (see figures 18-21), firstly, a viewing section with benches to relax and also observe the settlements, a playground suitable for children of varying ages and a small exercise area for adults, a vendor stalls to sell and buy food and drinks, and lastly a mutlciourt area for basketball and football games along with graffiti walls.

To address the lack of safety in public spaces, an idea of a community safety net was developed. In which activities designed for several people at a time can be ongoing in the community and in that sense provide a safety network as neighbors watch over each other, it also provides a lively atmosphere that can attract visitors to spend more time throughout the day as there are activities provided for all times and in all "seasons".

To address lack of recreation, a ludic playground that can adhere to various ages of children needs is proposed for the park, along with an exercise area for adults so multiple activities can be done simultaneously.
The multicourt also goes under the recreational section, however, with the multicourt a large area for sitting and watching the games is provided therefore, the community can gather together and also engage in different social interactions. The vendor stalls can ensure that people can use the place actively and provide a lively atmosphere to attract visitors.

Research (Hartig 2004; Ulrich et al. 1991), has shown that the negative emotions experienced through stress can be reduced or abolished through restoration. The sustainable design proposed should ofcourse be restorative.

The different aspects of the proposal provide an amount of restoration from the increased recreational possibilities and the network of safety. This goes in accordance with the aim of the research, however, when considering SRT and ART theories. Restoration is only proposed to be perceived from natural environments. It suggests that the natural world provides reflection, and restorative opportunities (Ohly et al. 2016).

However, the design of the park has less natural features and more built elements that goes along with the needs of the residents. Does this imply the park set in an urban environment lacks restorative capabilities?

Relevant theories
Canter's Theory of Place (1996) emphasizes that the significance of a place is the product of the relations between physical features, conceptions, and behaviors (Scopelliti & Giuliani 2004). This implies that the values individuals associate with a place or the interactions related to such locations plays a crucial role in their restorative experiences. With this in mind, many studies have shown interest in people's experiences in locations and their significance for restoration.

An example of such a study is one done by Kaplan et al. (1993), in which participants were analyzed for their level of restorativeness achieved in a museum to test ART theory. In general, the respondents felt like they had a restorative experience.

This experience was futher reinforced or strengthened by participants who already visited a museum regularly during leisure time compared to participants who did not visit museums regularly (Kaplan et al. 1993). This suggests that a place even a museum in a built environment linked to personal experience, particularly positive memories, gives people restoration more than a place without any attachment to.

This is not in line with the theory of SRT, because SRT notes that it is specifically important to be surrounded by natural elements to generate positive emotions that could alleviate stress, but this hypothesis was primarily carried out to understand our physiological reactions in hospital settings. In addition, multiple studies have shown that stress reduction varies depending on the type of activities conducted in the natural environment (Hansmann et al. 2007), thus an activity associated with personal attachment and positive outcomes can play an important role in determining the stress reduction capacity.

That is not to say solely urban environments are more desirable than natural environments. The importance of natural elements has been stressed on by Ulrich et al. (1991). In addition, studies analyzing urban environments have shown that, in contrast to urban environments without natural scenes, the integration of natural elements in urban environments is rated higher in restoration (Hernandez and Hidalgo 2005).

Therefore, integrating restorative urban locations with natural elements that could possibly be rated higher for urban dwellers in restoration than natural scenery would seem beneficial.

A landscape architect role

The proposal was broken into four components, each of which provided recreational value to people of all ages and genders.

However, my concentration as a trained landscape architect in Scandinavia had been nature biased prior to the interview with the locals and the field observation, which can be attributed to the history of landscape architecture education in Scandinavia. Landscape architecture is a relatively new field

in Sweden, having formerly been classified under garden design and horticulture. Books like Gehl's "Life between Buildings" (1987) and Ian McHarg's "Design with Nature" (1969) were frequently used in the curriculum to promote common values rather than individualistic ambitions (Andersson 2015).

Thus, interest in public space design and realizations of the benefits of greenery in the city exploded during the 1970s, which coincided with the arrival of the landscape architecture major in Sweden. As a result, landscape architecture has taken a stand in environmental debates (Andersson 2015).

The disparity between what my studies prepared me for and becoming a landscape architect in a developing country was a startling revelation when working on the field. During my fieldwork and the design process, I've realized that the field of landscape architecture is seen as a luxurious commodity that is not so common. Explaining the project to a settlement that sometimes needed clean water to drink and couldn't always earn enough to feed the family felt almost disrespectful.

This made me realize that landscape architecture is a luxury that cannot be afforded by everyone unless it is tailored to the local context. It struck me then that I couldn't use the same lenses which I had acquired as a landscape architect in Sweden.

However, some questions were nagging when adjusting the view of my project. Is the field too opulent to be used in a non-developed nation? No, that is not the case.

Landscape architecture has a prominent presence and is an absolute necessity in the informal settlements. I'm not implying that it's a luxury that can't be used; rather, I'm attempting to convey that it's perceived as a luxury because it's frequently used and applied primarily in developed countries. In this setting, circumstances similar to those found in informal settlements are not addressed and that has to change. As of 2030, it is predicted by UNFPA that there will be 7 billion people in the developing world and only 1 billion in the developed world (Shetty 2012).

The field is a necessity all around the world, and particularly in developing communities where life is largely spent outside. As a result, the project's outcomes have been tailored to the demands of the people, their living conditions, and the environment. This emphasis the importance of local perspectives and cocreation methods within the field.

One third of the global population live in informal settlement (Rekittke 2009), and about one fourth of the population live in informal settlement in Latin America (Goytia 2021). Therefore, it is a common phenomenon. It made me question, what the landscape architecture discipline actually means for developing countries and especially in informal settlements?

Final reflections

When conducting field research and a literature review, it became clear that there are numerous barriers that exist for neighborhoods such as Manitas Barrio in achieving a green space design that will benefit the environment and their public health goes beyond adequate urban planning and design proposals. These impediments can be categorized as environmental injustice.

In complex urban environments, environmental injustice is a serious issue. The benefits of public spaces are intertwined with social and political processes that allow certain people in society to benefit more from urban ecosystem services due to socioenvironmental inequities that the society has created (Amaral et al. 2021; Erntson 2013). According to Erntson (2013), environmental justice is a concept that refers to the equitable distribution of environmental goods and ills among people.

It focuses not only on the socioeconomic but also on the healthy use of natural resources that can provide a sustainable future for all (Amaral et al. 2021).

Manitas Barrio's circumstances have been classified as economic strata 1 and 2, with 1 being the poorest (Guevara and Shields 2019). This existing urban hierarchy in the city of Bogota is deeply embedded in the city, affecting housing and local businesses while simultaneously oppressing and depriving a large portion of the citizens of equal opportunity to develop (Guevara and Shields 2019).

Segregation is a major issue in Colombia, particularly in a large city like Bogota and a neighborhood like Manitas Barrio, where the government has established it as an informal settlement. Urban green infrastructures, therefore, becomes a luxury that cannot be afforded and less of a neccessity.

This, of course, has a knock-on effect on the residents public health and the environment.

Therefore, the importance of adequate urban planning that is both inexpensive and effective is neccessary. This is why this

thesis proposes a design from the local perspective, and can maximise certain vegetation traits. T

In developing countries, there is a critical need for ongoing landscape architecture work. There are numerous issues to address, including segregation, climate change, the need for green infrastructure, and basic sanitary infrastructure. The field experiences I've had in Manitas Barrio highlight the fact that there is much more to be done in developing green infrastructures with a local perspective and local vegetation that can continue to meet UN Sustainable Development Goals. In developing countries, there is a general lack of focus in landscape education, which leaves a lot of room for improvement. The same theories that have been used in developed countries must be applied and adjusted to situations such as informality. It is an opportunity to impact peoples lives and the future climate.

The study concludes that the importance of a local perspective cannot be overstated. The influence of the locals on the design proposal contrasts with what Swedish residents would consider restorative. This is why landscape architects must be sensitive to local necessities and perspectives.

The work on air pollution constantly changes due to the amount of pollutants released, therefore, more can be done in getting accurate data which this thesis did not have the resource to gather more specific pollutant data and in developing models that can accurately estimate the amount of vegetation necessary in the reduction of air pollution for a given area. These are future improvements areas that can be continued on.

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Figure Reefrences

Cover picture : illustration over El Mirador, a section of the Villas el Diamante park. Pamela Huskin Okinedo (2022).

Figure 1: Okinedo, P.H (2022). Images *over Bogota City, city centre and the informal settlement of Ciudad Bolivar.* (Photograpgh).

Figure 2: ESRI (2019) *Bogota. MAGNA-SIRGAS.* Topographic base Map. (Map) (2022-02-15). Additions made by Pamela Huskin Okinedo in ArcGIS.

Figure 3: Ezmap (2021) *Bogota. MAGNA-SIRGAS.* Satellite imagery. (Map) (2022-02-15). Additions made by Pamela Huskin Okinedo in Illustrator.

Figure 4: Ideca (2016) *Bogota. MAGNA-SIRGAS.* Base and Satellite Map. (Map) https://www.ideca.gov.co/recursos/mapas/sistema-distrital-de-parques-y-escenarios-publicos-deportivos (2022-02-21).Additions made by Pamela Huskin Okinedo in ArcGIS.

Figure 5: Ideca (2016) *Bogota. MAGNA-SIRGAS.* Base and Satellite Map. (Map) https://www.ideca.gov.co/recursos/mapas/sistema-distrital-de-parques-y-escenarios-publicos-deportivos (2022-02-21). Additions made by Pamela Huskin Okinedo in ArcGIS.

Figure 6: Capmapper (2020) *Bogota. MAGNA-SIRGAS.* Base Map. (Map) https://cadmapper.com/ (2022-02-24). Additions made by Pamela Huskin Okinedo in Sketchup, Illustrator and Photoshop.

Figure 6: Okinedo, P.H (2022). Image *over Bogota Villas el Diamante park of the informal settlement of Ciudad Bolivar.* (Photograpgh).

Figure 7: ESRI (2019) *Bogota. MAGNA-SIRGAS.* Topographic base Map. (Map) (2022-02-17). Additions made by Pamela Huskin Okinedo in ArcGIS.

Figure 8: Okinedo, P.H (2022). Image *over the informal settlement of Ciudad Bolivar.* (Photograpgh).

Figure 9: Googlemaps (2022) *Bogota. MAGNA-SIRGAS.* Satellite imagery. (Map) (2022-04-15).

Figure 10: Okinedo, P.H (2022). Images *over Bogota Villas el Diamante park of the informal settlement of Ciudad Bolivar.* (Photograpgh).

Figure 12: Freepik (2022). Diagram modified by Pamela Huskin Okinedo using illustrator. https://www.freepik.com/free-vector/infographic-element-collection_4003154.htm#query=diagrams&position=24&from_view=search (2022-05-05).

Figure 13: Franco, J. F. (2012). Air pollution map (Map). In: Urban Air Pollution in Bogota, Colombia: an Environmental Justice Perspective. *In 105th Air and Waste Management Association Annual Conference and Exhibition.*

Figure 14: The figure shows the result of the 12 quality criteria using the Gehls methodology modified by Pamela Huskin Okinedo

Figure 15: Capmapper (2020) *Bogota. MAGNA-SIRGAS.* Base Map. (Map) https://cadmapper.com/ (2022-02-24). Additions made by Pamela Huskin Okinedo in Sketchup, Illustrator, Powerpoint, and Photoshop.

Figure 16: Capmapper (2020) *Bogota. MAGNA-SIRGAS.* Base Map. (Map) https://cadmapper.com/ (2022-02-24). Additions made by Pamela Huskin Okinedo in Illustrator and Photoshop.

Figure 17: Capmapper (2020) *Bogota. MAGNA-SIRGAS.* Base Map. (Map) https://cadmapper.com/ (2022-02-24). Additions made by Pamela Huskin Okinedo in Illustrator and Photoshop.

Figure 18: Illustration of ElMirador made by author (2022).

Figure 19: Illustration of the playground made by author (2022).

Figure 20: Illustration of vendor stalls made by author (2022).

Figure 21: Illustration of Multicourt made by author (2022).

Figure 22: A section of the park made by author (2022).