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Unique plants and grouping strategies promoting Cairo streets air quality

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design

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18/OCT/2020

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Disclaimer

This dissertation is submitted to Ain Shams University, Faculty of Engineering and University of Stuttgart, Faculty of Architecture and Urban Planning for the degree of Integrated Urbanism and Sustainable Design.
The work included in this thesis was carried out by the author in the Year 2020

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

18/OCTOBER/2020

Ahmed Youssef

Signature

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Last, but not least, it is my pleasure to thank all my tutors in the IUSD family and my classmates both abroad and in Egypt. The IUSD experience gave tools, opportunities to explore, and helped me to become a man-of-action to help in finding better solutions.

Abstract

2. Abstract

The main umbrella of this research is towards healthier air quality. In simple words, the objective of this research is to study which plantations are capable to trap particulate matters from the air and can withstand Cairo's hot climate. It is a growing environmental concern Egypt has to comply with to achieve SDG's. Furthermore, various researches are presented in the literature review chapter to understand further how the use of vegetation affected not only the air quality of the environment but also its health impact on the users themselves. These researchers concluded that there is a strong impact on the outdoor and indoor air quality from the absence of vegetation. Different attempts in these researchers were trying to understand which plantation is more successful than others in cleaning the air and what part of the air (Gassesous and Particulate Matters).

In the further chapter, as a primary source of data Alazhar planting book was used as the main reference for filtering which plantation is more successful to trap particulate matters in the air. Six main criteria were set in total to assess the plants and each criterion is rewarded for one point. These criteria were set from points of realization from different literature reviews to prepare such a list for Cairo.

After setting the planting list, the Basilic garden in Cairo has been chosen as a case study and new points of realization appeared in the design process. The mapping of the area was done mainly by secondary data such as (On-site and phone calls interviews, handmade drawings, and sketches). These points mainly were concerning the management system of the Authority of Cleaning and Beautification of Cairo. These points made me realize that there must be clearer guidelines of how gardening activities held by the government should be implemented, and how these green spaces may be used for future benefits (economically, socially, and environmentally).

Keywords: Air quality, pollution, Particulate matters, vegetation, water, Cairo.

List of Abbreviations

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Chapter 1: Introduction

7. Chapter 1: Introduction

7.1. Research Motivation for topic selection

I have been working in close contact with vegetation since my bachelor's level. Working on Landscape design projects, gave me an edge of appreciating the natural environment. Two years ago, exactly in 2018, I had to do a surgery to fix my breathing issues, in my nasal cavities. At that time, I was unaware of how much “Cairo” is air polluted until my surgical Dr. advised me to spend my recovery time away from the city for cleaner air!

After this point during my recovery period, I started asking my self-questions on how did we reach this level of pollution and how we can compensate for this problem in natural ways. This is when I stumbled upon different researches collaborating on the importance of vegetation with air pollution mitigation and understood how Cairo faces great crises in air quality.

Cairo is the main capital of Egypt, and unfortunately, it stands on top of the most air-polluted cities in the world, according to statistics from WHO. Therefore, when the thesis time has come, I knew exactly my research topic.

7.2. Problem statement

According to the air quality report done by World Health Organization, Cairo stands on the top of the list (Whittaker-Wood, 2018). The World Health Organization ranks Cairo as one of the most air-polluted cities in the world. WHO guideline states that the safe level values 20 µg/m3 for PM10, and 10 µg/m3 for PM2.5, and Cairo exceeded double of this limit.

Furthermore, according to the 2018 WHO updated report (WHO, 2018), Cairo, stands on the second highest country of PM 10 level after Delhi scoring 284 µg/m3 PM 10 and 117 µg/m3 pm 2.5 which is On average, is about 14.2 times the average for PM10 and 11.7 times safe levels (WHO, 2014). These numbers are

conducted from the latest Annual report on air quality in Egypt, provided by the Cairo government in 2014. Even though Cairo is going under major work towards sustainability after setting SDGs goals back in 2015 creating a vision for 2030, Cairo has a long way to go!

There is no doubt, air quality is a fundamental aspect of life and it touches all living creatures on planet Earth. Levels of Particulate Matters stand on the peak of the most fundamental reasons for respiratory infections. According to the United States Environmental Protection Agency, PM 2.5 is "the worst kind of pollution" (EPA, 2017). It is stated, that these fine particles which are less than one hair thickness, can get deep into your lungs, and some may even get into your bloodstream.

7.3. Research Gap

There is a research gap on how to compensate for air pollution using natural ways. For years, various researches have been undertaken; how trees can help in mitigation air pollution for gasses emissions and trapping PM, especially in urban areas, where contamination levels are at the highest.

However, there is minimal research in Egypt about understanding and defining the characteristics of vegetation for cleansing air. Therefore, this research shall try to demonstrate, few recommendations in choosing plantations are suitable for Cairo's climate. Hoping, to give a small contribution to this academic field, in the end.

7.4. Research questions

These questions listed below are to highlight the main research track.

- What is Air consisted of and what are the levels accepted levels of Air pollution both in Cairo and worldwide?
- Why air pollution in Cairo is an important topic and whom it affects?
- What are the top-rated vegetation for cleansing air and specifically for trapping dust particles for Cairo, Egypt?
- How vegetation can help in reducing air contamination?
- What are the vegetation characteristics for collection for trapping dust particles?
- What is the preferable way of vegetation's grouping strategies, to maximize trapping of Particulate matters in the air?
- What might be the futuristic goals for setting up vegetation as the main lead to air purifications in urban streets of Cairo?

7.5. Aims and objectives

The thesis research's main aim is to understand what sort of vegetation is best suitable to trap PM in the vibrant streets of Cairo. Thus, create suitable design guidelines and a list of plantations for designing outdoor green pockets at Cairo's vibrant streets.

To do this, the research will present different studies that proving the importance of vegetation existing both in the indoor and outdoor environments. Furtherly, after understanding the positive role of vegetation in decreasing air pollution a list of vegetation specimens will be developed for mitigating AQ.

7.6. Research Methodology

Deciding which plant to use and how to group it with other vegetation, has various deciding factors. After searching and understanding that there are important factors that can affect the rate of trapping particulate matters in air and thus decreases air pollution; this research will recommend specific plantations to be used. These factors are such as: (hardy species, hairy leaves, leaves with large surface area, dense twigs) to maximize sink effect. Besides, a grouping strategy shall be presented to maximize trapping PM. These data are combined from a secondary source provided by Anne in her research (Sprin, 1986).

Secondly, 2 main water criteria will be set such as: (water intake level and drought tolerance) to help to choose the best specimens to withstand higher PM levels in a hot climate. These criteria came after realizing the important factors that can affect the survival of plants, especially in Cairo's hot climate.

However, a planting database should be used to apply on these filtration criteria, and "Al Azhar planting book" has been used as the main secondary source of data. This book documents the most common plants used in Cairo with consistent data about each and furtherly will be filtered to obtain a newly selected plantation list, to help to mitigate Cairo's air quality. Moreover, the filtered plantation will be categorized into three main categories such as (trees, palms, shrubs, and groundcovers).

Thirdly, after the filtration vegetation process is done, a case study is chosen and taken for evaluation and further study. The definition of a vibrant street in this research has 3 main criteria.

1. Firstly, a street that has both accessible routes of vehicles (4 lanes) and pedestrian lanes.
2. Secondly, a street that is looking at mixed commercial and residential buildings.

3. Thirdly a street that has a minimum green space of 500m2; this could be a small park, outdoor public plaza, or planting beds in between streets or at sidewalks.

According to these criteria, various streets may fall into the category such as Makram Eibad street in Nasr city, 90 St. street in 5th settlement new Cairo, el Orouba road, Abdelaziz Fahmy and El Hegaz street in Heliopolis district. Hoovering through google maps is used for gathering this observed information. Nevertheless, Google maps are counted as a secondary source of data.

However, during the Corona pandemic, and curfew enforced at the time of writing the thesis. It seemed useless to make such screening over Cairo's vibrant street as the mobility outside residency is very limited. Therefore, the Basilic garden has been choosing due to its proximity to my house which will save time taken to study the area due to the curfew. Fortunately, this garden also falls in the vibrant streets criteria's and the investigation started to take action for redesigning this area to act as a natural filter to the surrounding streets and residence.

Fourthly, comes the case-study and proposal development stage of the targeted location. Therefore, Firstly, site visits have been undertaken divided into 3 days to map the existing number and types of vegetation. This has been developed after screening this area through google maps to determine the total area of the space. Eventually, a full sketch is developed of the area locating various kinds of vegetation, which are divided into 3 main categories (palms, trees, shrubs, and groundcovers).

However, during the second site visits, new aspects have been realized that may affect the existence of the garden in the future. These factors have been concluded after studying the context site and conducting various interviews with potential stakeholders related to the topic. These personas are such as: such as garden worker, former authority member who is part of the governmental organization responsible for gardening and beautification of Cairo's streets, a Ph.D. researcher on the topic of authority management for gardening of Cairo and lastly

Landscape architects who are taking a leading part in designing and executing landscape designs in the private sectors.

Consequently, a new design proposal is set to maximize the potentiality of this garden as a dust-sink and minimize water requirement. In the first proposal, the main aim is to maximize air quality using vegetation that is more suitable to Cairo's warm climate. However, for better evaluation, this proposal is taken under on site for evaluation with main personas using and working at the garden. After meeting them again for second interviews with flyers of the first proposal, new aspects of design appeared from the perspective of each persona.

Finally, according to these personas advice on how to make this garden a better place to use. A second proposal is made after taking into consideration their thoughts into account. Closing the discussion, with a simple conclusion that any garden design meant to be used by the people must be discussed with people. Designing a public green place can not be done with one-way of communication from higher management. The design has to be communicated with the main users of the place especially if it’s an already existing place with existing activities taken in it.

7.7. Thesis limitations

Few points could be done better if the research time is more and the pandemic regulations are different. Firstly, the planting database is limited to only one book; and another plantation database could be taken into consideration such as the (Al Orman) planting booklet.
Due to the thesis limited time, the Al-Azhar booklet has been chosen as the only main database for filtering vegetation. However, if there was more time, more secondary sources of data would be taken into consideration to maximize the output opportunity.

Secondly, to have an on-site case study, a site must be chosen for further analysis and experiment. The importance of determining where to intervene is crucial, as it will maximize the selective opportunities for future interventions. There are various streets in Cairo's urban life to choose from. The more vibrant the street the higher the pollution, therefore, a vibrant street in Cairo has 3 main characteristics defined in this research to ease the filtration process.

However, due to the Corona pandemic and curfew enforcement during the preparation of this thesis. It seemed useless to make such screening over Cairo's vibrant streets as the mobility outside residency is very limited. In the end, Basilic garden has been choosing due to its proximity to my place of residency, and after assessing it also went-down into the criteria set for vibrant streets.

If there was more time and free-movability, the screening process would be wider and thus, a list of places would be given for future interventions. The importance of this list lies in documenting the future perspective hotspots for further action.

7.8. Research structure

Chapter one: Introduction: This chapter discusses the motivation behind writing this topic, problem statement, research gap, research questions, aims and objectives, methodology and research structure, and conceptual framework.

Chapter two: Literature review: This chapter mainly presents and discusses the important role of plants in promoting air quality. It is broken down as follows:

- Background of ambient air pollution.
- The main problem of air pollution on an international scale and then specifically in the case of Cairo Egypt.
- Plants and mitigation for air pollution from different researches point of views such as 1st: Wolverton Nasa research, Kamal, 2nd Kamal Meattle in case of

pahapur building Inia, 3rd: Hied research in case of Roros Rehabilitation center Norway city, 4th APTI in case of Ahmedabad city, India, and lastly, 5th: variable influences affecting Sink effect by, Anne Sprin.

- Lastly, a conclusive chapter summarizing the important facts of all for further use in this research.

Chapter three: Study Design and Methodology: This chapter mainly focuses on how the Plantation criteria are set, the filtration process for obtaining optimum vegetation for Cairo's weather. Finally, having a case-study, to design 2 proposals for setting future recommendations as an example.

- Firstly, it explains how the weighting criteria are formed from the realization and conclusions of previous literature.
- Secondly, it divides these criteria into the main 3 groups having different criteria set for each (Trees, palms, and lastly shrubs and groundcovers).
- Thirdly, choosing a vibrant area as a case-study and concluding the case of Basilic garden for zones A and B.
- Fourthly, mapping, and preparing the needed information for setting a new recommendation for this area and designing Basilic garden aiming for maximum mitigation of air pollution.
- Fifthly, Revisiting the Basilic Garden with the first proposal, to main 3 personas and realizing new points of design requirements for preparation of the second proposal.
- Lastly realizing the important factor of the surrounding context and main personas requirements on garden design.

Chapter four: Discussion and conclusion: this chapter presents general design recommendation resolutions and the role of emerging context factors that play a huge role in the success of such design for future use these aspects are broken down into two 3 main parts.

- Firstly, realizing the context-specific factor of the Basilic garden.
- Secondly, watering and irrigation systems are used.
- Thirdly, management and planning level for Basilic garden and the role of responsible governmental authority in charge.

Chapter 2: Literature review

8. Chapter 2: Literature review

8.1. Background of Ambient air pollution

Air pollution is a global crisis and in Cairo nowadays under the regime of the president "Abdelfattah El Sissi" new and more approaches have been undertaken to control and limit it. Egypt has started taking big foot-steps towards enhancing renewable energy usage to limit pollution. In 2018 the Ministry of Electricity and Renewable Energy has initiated a project to build the largest wind farm in the Middle East's in the Suez Bay, at a cost of 5 billion LE. (Tawfeek, 2018). Furthermore, just recently on October 1, 2020, the world bank approves a 200 million dollar loan, helping to reduce Cairo's Egypt air pollution (A.Moneim, 2020).

Further note, the ministry of Electricity and renewable energy had announced back in the new year of 2018 the building of the Benben solar ark project near Aswan; which will be the world's largest solar park.

According to the Egyptian government official export website, Egypt intends to supply 20 percent of its generated electricity through renewable energy sources by 2022. In figure 1, shows the staggering increase of renewable energy

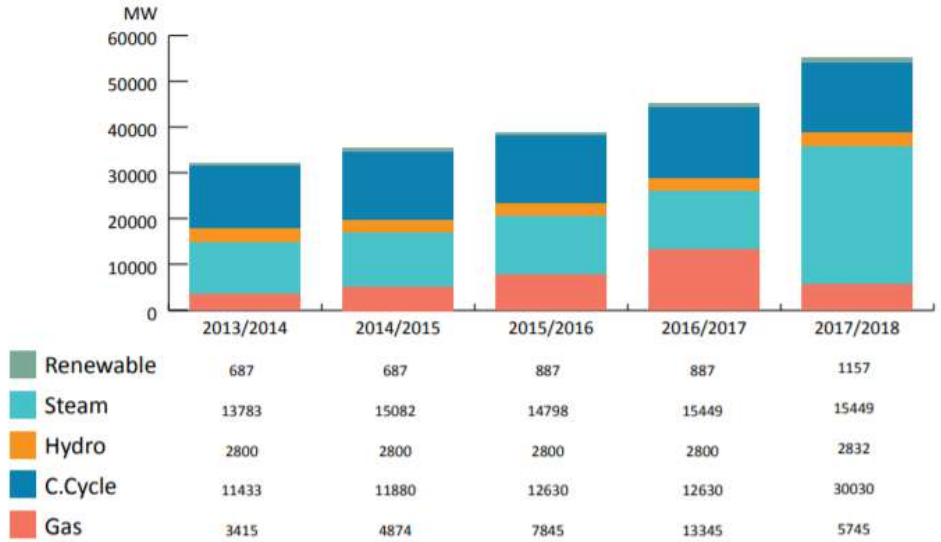


Figure 1: Increase of energy production divided by 5 main categories from 2013 until 2018. Source: (company, 2018).

production, with 12 % from wind energy, 5.8 % from hydro-power, and 2.2 % from solar energy. (Tawfeek, 2018).

Regardless, from another point of view, the government looks unlikely to meet its 2022 target of 20 % renewables energy production, says BMI research. This research says that despite the rapid growth in the renewable energy production sector, it is still “an unrealistic target, especially given the hefty investment registered in gas-fired thermal power projects.” (Anon., 2020).

However, there is still hope as renewable energy production is increasing gradually year by year. According to the ministry of electricity and renewable energy latest report, the average growth rate of the installed capacities is 14.5% per year during the period 2013 /2014 till 2017 / 2018. Renewables include wind farms capacity of 967 MW, solar/thermal Kuriemat P.P. capacity of 140 MW of which the solar component amounts to 20 MW, and 50 MW solar PV in the Benban region. In addition to isolated and reserve units with a total installed capacity of 226 MW (Anon., 2020).

Fortunately, Egypt is having good conditions to become a strong candidate in renewable energy-dependent since it has an abundance of land, sunny weather, and high wind speeds. There are many approaches to sustainable developments that are already done and yet under construction.

However, the aim of this research is not to speak about the country’s aim of producing more renewable energy. There is a specific problem that this paper will try to express and discuss and this issue is related to air quality in Cairo. This important issue is already a hot topic that has been already discussed hundreds of times and this paper will try to reveal a promising side to this story.

Outdoor air pollution or so-called ambient air pollution is a major cause of death and global diseases. It causes negative effects on various levels of health, ranging

from increased hospital admissions and emergency room visits to increased risk of premature death. About 4.2 million premature deaths worldwide are linked to outdoor air pollution. Mainly causing (heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children as shown in table 1. (WHO, 2020)

Percentage	Problem
29%	of all deaths and disease from lung cancer
17%	of all deaths and disease from an acute lower respiratory infection
24%	of all deaths from stroke
25%	of all deaths and disease from ischemic heart disease
43%	of all deaths and disease from chronic obstructive pulmonary disease

Table 1: Air pollution accounts for health-impacts. Source: (WHO, 2020)

Enhancing AQ was and will always be a mandatory field of attraction to everyone as it is one of the fundamental survival needs. According to a WHO report, 5 to 10 million asthma emergency room visits happen every year which is approximate to (4 to 9 percent of total global asthma ER visits) were linked to fine particulate matter.

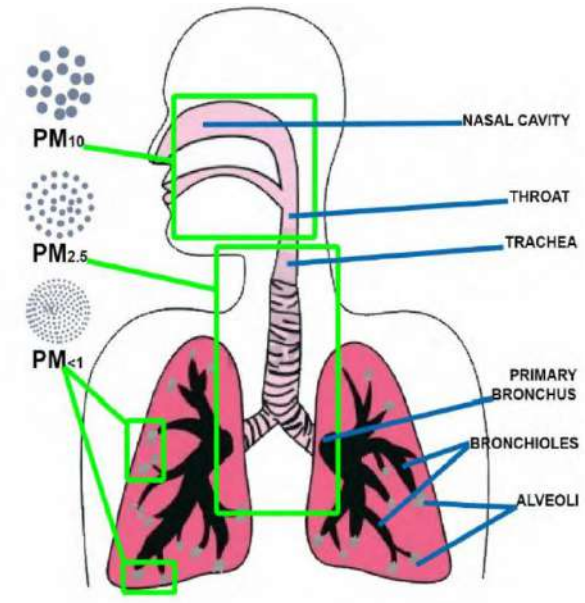


Figure 2:The size of particles is directly linked to their potential for causing respiratory health problems. Source: (Guerrero, 2014).

Particulate matters vary in sizes and affect the respiratory system differently as shown in Figure 2. PM 2.5 is the most dangerous ones, they are small in size and can lodge deep in the lung's airway tubes.

Unfortunately, approximately 95 % of the world's population lives in places with unsafe air. Never the less, a global burden of disease study focused on quantifying the impacts of air pollution on heart disease, chronic respiratory disease, lung cancer, and lower respiratory infections. Resulting in 4.1 million and 230,000 premature deaths in 2016. (Susan C. Anenberg, 2018).

Furthermore, Asthma has become the most common chronic disease in children living in cities and has exponentially increased ER visits across the world. In addition to this, Susan also mentioned that in places like houses where you spend 80% of your time, potential pollutants are contained and tend to build up more than they do in open spaces (Susan C. Anenberg, 2018).

From a national point of view; according to the Egyptian Department of "Agriculture, Water and Environment" PM 2.5 is generally described as "fine particles" (Anon., 2007). In literature, these particles vary in names such as (dust, particulate matter, inhalable particles, smoke, mist). They can affect AQ and visibility. Once they are in the air, PM generally takes a long time to settle. They may be washed from the air by rain or snow, when they settle on land they may settle permanently or be re-entrained.

In 2007, the World Bank ranked Cairo's air, the worst in the world for pollution by particulates, the tiny fragments of soot or dust that are most damaging to human lungs (Swanson, 2007). Furthermore, high emissions contribute to the problem, but Cairo's topography and climate make the pollution even worse. The city lies in a valley surrounded by hills, which hold the poisoned air like water in a bowl.

However, PM is different than black clouds or so-called smog. The black cloud is different, it appears only once a year, in September or October in Cairo. Besides, it is much more intense than PM, darkening the sky into a foreboding smog, Says Heba Marey in her research (Heba S. Marey, 2010).

Heba Marey also mentioned that the black cloud brings pollution levels up to ten times the limits set by the World Health Organization and can persist for days or weeks at a time. It sends people to the hospital with exacerbated lung infections and asthma attacks at unusually high-rates and contributes to cancer and other long-term health problems

8.2. Main problem

It can't be denied, because of the anthropogenic activities caused by humans along the years on planet Earth, many drastic changes happened to the environment. One of these important changes to earth is its climate and air quality. The crisis is, that air acts as a vital support-line for, the survival of living creatures!

In 2019 WHO reported there are over4.2 million deaths every year as a result of exposure to ambient (outdoor) air pollution and 91 percent of the world's population lives in places where air quality exceeds WHO guideline limits (WHO, 2019). Unfortunately, Cairo the capital city of Egypt, ranked as number two contaminated city all over the world; stating that according to, the WHO ambient (outdoor) air quality database Summary results in 2018 (WHO, 2018). Furthermore, Cairo is suffering greatly, its safe level is approximately 10 times the amount considered to be safe as showing in figure 3.

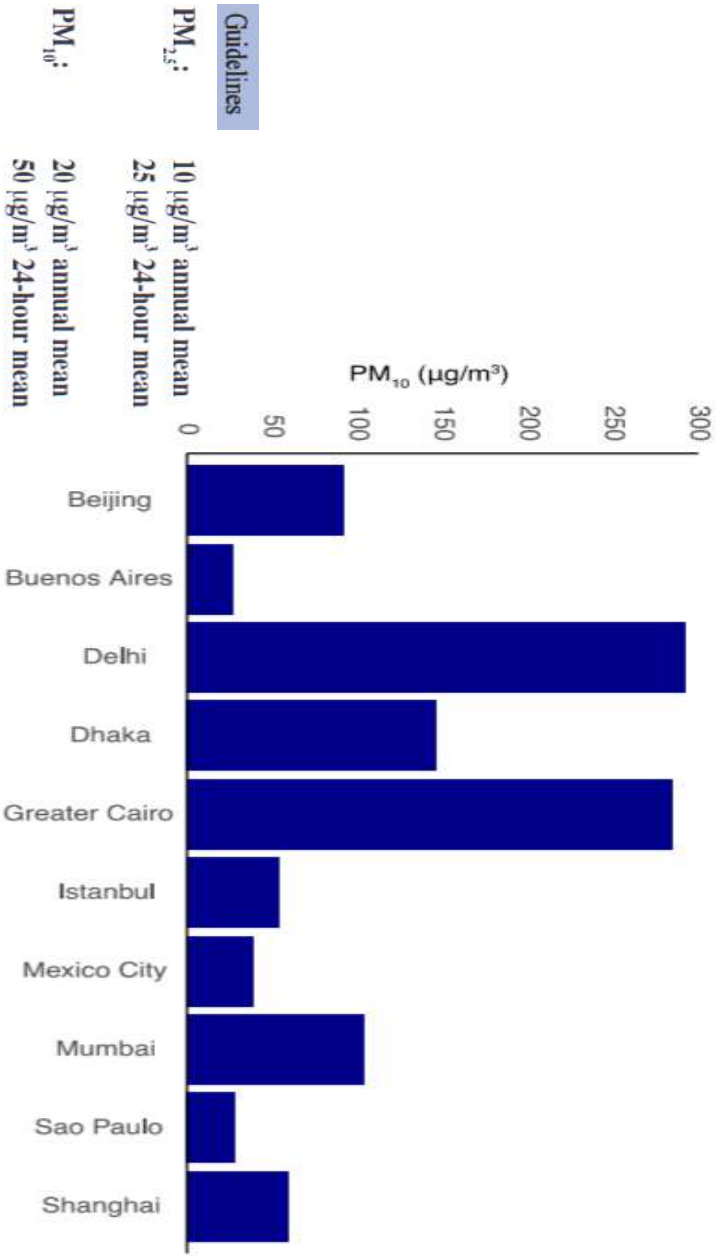


Figure 3: shows PM10: Particulate matter of 10 microns or less: Afr: Africa; Amr: Americas; Emr: Eastern Mediterranean; Eur: Europe; Sear: South-East Asia; WP: Western Pacific; LMIC: low and middle-income countries; HIC: high-income countries. Source: (WHO, 2014)

Of course, there are different ways to measure air pollution, and each country has its way of identifying its measures of assessments about the national AQ standards. Canada, for example, has an "Air quality standards" assessment, Malaysia has an "Air pollution index" and Singapore has "pollutant standards index".

Furtherly, Egypt also has its way to assess its air quality. Egyptian Environmental Affairs Agency is entitled to do so and it is under command of the Ministry of Environment. According to EEAA, Decree No. (5) of Law No. 4 of 8994 and amended by Law No. 9 of the year 2009 (EEAA, June 2018) that the maximum pm 10 level is 150 µg / m3 on 24-hr mean. AS such, from the government's point of view, Cairo Egypt has moderately good air quality.

This is the point of collision between the Who results and EEAA data, because according to WHO guidelines it is only accepted by 50 µg / m3 on a 24-hr mean. This means, that the government assessment exceeds 3 times the WHO mean assessment (Anon., 2005).

However, the problem here is not about the government recognizing the acceptable international air quality guidelines. It is about the fact, that Cairo "the main capital" urgently needs strong means to save its polluted air. Causes of air pollution are various and it is utterly complex to route the main reasons. However, According to a NASA report, says that the absence of trees can lead to measuring failures in air quality (Wolverton, 1989).

Figure 4: The land cover maps of Cairo in 1972 and 2020 showing Urban expansion and loss of green-lands. Source: Google maps timeline and compiled by researcher.

Thinking about it logically, vegetation is the natural filter of air, and therefore decreasing in them will lead to a decrease in air quality. It is clearly shown in figure 4 through the past 30 from 1972 to 2020 years. Cairo has been losing massive green spaces to urban settlements. Resulting in a domino effect, a massive decrease in the AQ.

To conclude the problem, air quality degradation has several factors such as un-updated quality rules by the ministry of environments, a decrease of vegetative lands, and urban sprawling that is directly connected to the increase in population. Furtherly, the intertwined sources of air pollution, such as excessive combustion of fossil fuel and limited use of renewable energy, are all factors added up to give us the same result as illustrated in figure 5.

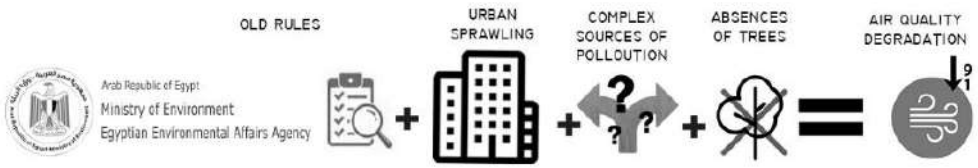


Figure 5: illustration showing the added values resulting in the Air quality degradation for the current situation. Source: By researcher.

8.3. Plants mitigation for AQ

8.3.1. Perspectives of researches

Several pieces of research have proven that the use of vegetation strongly decreases air pollution. Vegetation comes in different forms (Palms, trees, shrubs, ground covers, etc.), and whatever the category is; all plants produce oxygen and absorb Carbon dioxide. This is more or less what people learned since primary schools and we have been taught that cutting trees are bad for the environment.

However, various researchers presented an advanced understanding of the idea that plants just absorb CO_2 and give out O_2. Moreover, the location of pollution whether the problem is indoor or outdoor doesn't affect the fact that the problem still exists. In the end, the outdoor environment is directly connected to the indoor environment, therefore if the outdoor environment is highly polluted there is still a high risk that this contamination will move into any indoor space; unless we all decided to live our lives in capsules from now on.

This research perspective about air pollution mitigation is simple. It does not differentiate from indoor to the outdoor environment. However, it tries to search for answers on how air can be cured in the most sustainable way using vegetation "Natural ways"? To understand this few researchers will be presented to give a wider example.

8.3.2. Air specific absorbents

First It all started with a myth; when Nasa tried to simulate indoor environments for astronauts on their way traveling to the moon. In 1989 Dr. Wolveron led the study on which plants can be used in a closed environment to help in mitigation of air quality. This study revealed a new understanding of the relation of plants to air quality. They revealed that there is a different variation of pollutant absorption compared to one plant specimen to another as shown in figure 6.

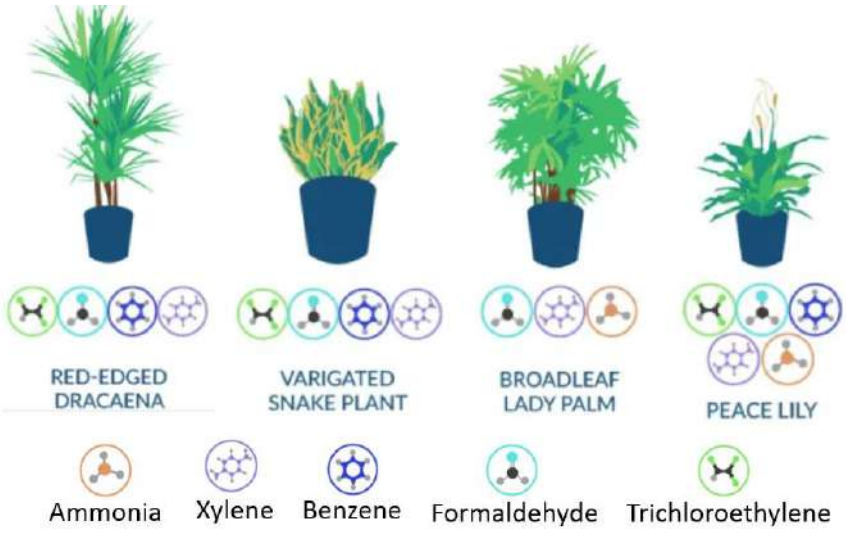


Figure 6: list of indoor plants and the pollutant absorption to few examples of Nasa list of indoor air purifiers compiled by researcher. Source (EEAA, June 2018).

Based on this research, some scientists say house plants are effective natural air purifiers, and the bigger and leafier the plant, the better as this means more Photosynthesis reaction to the plant which means more oxygen production and CO_2 absorption. "The amount of leaf surface area influences the rate of air

purification," says Bill Wolverton, a former NASA research scientist who conducted that 1989 plant study (Wolverton, 1989).

Wolverton says that it's impossible to guess how many plants might be needed to clean a room of its contaminants. But he usually recommends at least two "good-sized" plants per 100 square feet of interior space. He did not specify what is "good-sized "! It could be ranging by pot size, plant height, or spread. "The (Nephrolepis exaltata) and also known as (Boston fern) is one of the most effective plants for removing airborne pollutants, but it is often difficult to grow indoors," he says. "I usually recommend (Epipremnum aureum) also well known as (Golden pothos) as my first choice, since it is a popular plant and easy to grow." (Wolverton, 1989).

8.3.3. Fresh air promotes physical & psychological health

Away from Nasa and space, another researcher tried to investigate the ability of plants to clean indoor air quality. Kamal Meattle, an Indian environmental activist started to think about how to increase the fresh air quality in the business center "Paharpur". In 2009 he held a talk at TED 2009 in the title of "How to Grow Fresh Air". This talk was short due to the time given to him for presentation, however, he discussed that they developed a certain ratio per person to sustain a person inside a closed environment. Given the right ratio of chosen plants to create a natural air cycle. He also referred that the size of the plant adds a huge role in the air purification process, stating that is not only a matter of plant specimen.

Unfortunately, the research itself was not surely discussed leaving many questions behind. Questions Such as which list of plants? What are the ratios for every plant listed in comparison with other plants?

In the end, the concept of using vegetation for providing fresh air inside an indoor environment that he was implying was applicable as his business center

was noted to be the healthiest building in New Delhi India. In 2008 According to the Central Pollution Control Board, tests have been carried out through a period of two years showing remarkable results new of its own. The results showed that there were 52 percent fewer cases of eye irritation, 24 percent fewer cases of headaches.

Furtherly, about a 30 % decrease in the occurrence of respiratory problems among employees in the building compared to other Delhi residents as illustrated in figure 7. After working on enhancing the indoor air quality to meet the standards set by the American Society for Housing, Refrigeration, and Air-conditioning Engineers; Paharpur building received its recognition in 1996. At that time, it was an amazing accomplishment as it was the only building in India to get such a certification. Even the government of India tagged Paharpur as the "healthiest building in Delhi" in 2008. (Munjal, 2015).

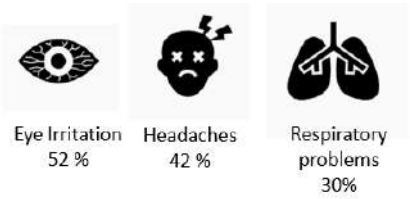


Figure 7: Results shown after enhancing the air quality inside Paahapur building using vegetation. Source: done by researcher.

However, another complimentary research to mention in this similar field for using indoor plants to maximize health benefits. Min-sun Lee and other researchers in 2015 published another research in a similar field. This research proved that using plants inside indoor environments helps in decreasing stress.

Their results suggested that active interaction with indoor plants can reduce physiological and psychological stress compared with mental work. The term “Active Interaction” may seem confusing. However, in general, active interaction means getting more in touch and action with plant and these actions covers general activities. These activities are such as gardening activities (pouring water, adding minerals to the soil, and trimming). All these activities help in the suppression of sympathetic nervous system activity, promotion of comfortable, and natural feel as also as decreasing blood pressure. (Min-sun Lee, 2015).

Another research published in the journal Hort-Science was a collaborative effort by investigators from the Norwegian University of Life Sciences and Sweden's Uppsala University. The investigation took place at Roros Rehabilitation Center, a clinic in Norway city by RK Raanaas (Grete Grindal Patil, et al., Mar 2010). The investigators focused their work on a large sample group of 436 cardiac and pulmonary patients at the clinic.

The test was in a consistent order, half of the patients went through a four-week series of visits and treatments, while the waiting room was left in pretty much the condition in which the researchers found it in the original conditions — which is to say pleasantly furnished, lit and with only a few scraggly looking plants scattered about.

On the other hand, the other group went through the same treatment protocol. However, during their visits, the waiting area was changed. It was filled with 28 leafy, healthy, altogether happy-looking plants. All of the patients completed questionnaires about their general sense of well-being during their first visit and again at two and four weeks after.

When the investigators went through the patients' questionnaires and medical records at the end of the study period, they noticed some striking differences and similarities. All of the volunteers had improved on a range of objectively measurable scales such as blood pressure, heart rate, and respiration — and that wasn't a surprise. After all, getting healthier was the main reason they came to the clinic — helped by the prescribed protocols written by the doctors.

However, that wasn't the case when it came to the subjective assessments of well-being. When these results were tabulated, striking results appeared.

Fortunately, the second group that had spent time in a waiting room softened by greenery just felt happier and healthier than those who'd been in a plant-poor environment (Heid, 2017). The results, clearly show that having full fledge green plants helps the patients to feel happier.

Maybe it's only the matter of plants colored green, which is another point of view. A question may appear as; why green indoor plants make people feel happy? Paul Brunto a British author of spiritual books said that "Green, which is Nature's color, is restful, soothing, cheerful, and health-giving" (Brunton, 1989).

Furtherly he says that this is purely a psychological expression, and could be debatable over and over as colors could be interpreted by others differently. In the end, green represents nature and it is one of the most common colors used in interior designs. The reason is its soothing effect on the eyes. Green gives a relaxes the body and alleviates stress. Researchers have proven that the green color improves visions says Chapman in his report (Chapman, 2010).

8.3.4. Air pollution tolerance Index

The urban air quality is continuously affected by emissions from the combustion of fossil fuels that comes from both stationary and mobile sources. Mobile sources of combustions account for the major urban air pollutants. These pollutants may include Carbon monoxide (CO), Sulphur oxides (Sox), nitrogen oxides (NOx), particulate matter (PM), lead (Pb), photochemical oxidants such as ozone (O3), and ozone precursors like hydrocarbons and volatile organic compounds (Costa, 2001).

Air pollution affects directly plants through air medium affecting leave pores, or indirectly settling at soil acidification (Steubing, 1989). In testing and measuring of pollutant realms. Absorption of pollutants from the air can be analyzed using Air Pollution Tolerance Index "APTI".

The air pollution tolerance index (APTI) is based on four parameters to identify the tolerance levels of plant species (Rao, 1983). This index is used mostly by landscapers to select plant species in relevance to its tolerance to air pollution.

In Ahmedabad city, a study of the Air Pollution Tolerance Index (APTI) was calculated for various plant species growing at the different seven cross-roads. leaf samples were collected from 5 common present tree species located at the cross-roads to determine their APTI. The APTI two parameters were physiological and biochemical as shown in figure 8.

S. No.	Tree Species	Total Chlorophyll mg/ml	Ascorbic acid mg/g	pH	Relative water content %	Air Pollution Tolerance Index (APTI)
1.	*Ficus religiosa*	3.77	16.1	6.2	59.33	21
2.	*Ficus benghalensis*	4.4	14.9	6.5	70.5	23
3.	*Ficus glomerata*	3.1	13.6	6	68.52	19
4.	*Azadirachta indica*	1.92	9.9	6.1	80	15
5.	*Polyalthia longifolia*	2.56	10.4	5.9	80.63	16

Figure 8: APTI scores for the 5 targeted trees in Ahmedabad city. source: (D. K. CHANDAWAT, 2011)

It included (leaf relative water content (RWC), Ascorbic acid content (AA), total leaf chlorophyll (TChl), and leaf extract pH) in the equation as shown in figure 9. The results have fluctuated. However, the APTI value of *Ficus benghalensis* exhibited the highest value at all the sites followed by *Ficus religiosa*, *Ficus glomerata* followed by *Azadiracta indica* and in the 5th place *Polyalthia longifolia* (D. K. CHANDAWAT, 2011).

APTI given as:

$$APTI = \frac{[AA\ (T + P) + R]}{10}$$

Figure 9:APTI calculation method. Where (AA is the ascorbic acid in mg/g, T is the total chlorophyll in mg/g, P is pH of leaf sample and R is the relative water content in mg/g). source: (D. K. CHANDAWAT, 2011)

8.3.5. Plants Vs Particulate Matters

Similarly, another interesting attempt to understand how plants can be used to trap Particulate matters. Anna Whiston specified certain characteristics of plantations to maximize trapping particulate matters such as dust. In her book

(Air quality at street Level: Strategies for Urban Design) she specified 4 main characteristics "sink effect" such as the following ash shown in figure 10.

Looking at each point to understand why it's important. Firstly: When the plant specimen has a more rough texture on its trunk or branch increases the probability of the plant to trap air particles.

Secondly: referring to the leaves to be hairy makes the leaves literally to act as an air broom to trap air particles in it.

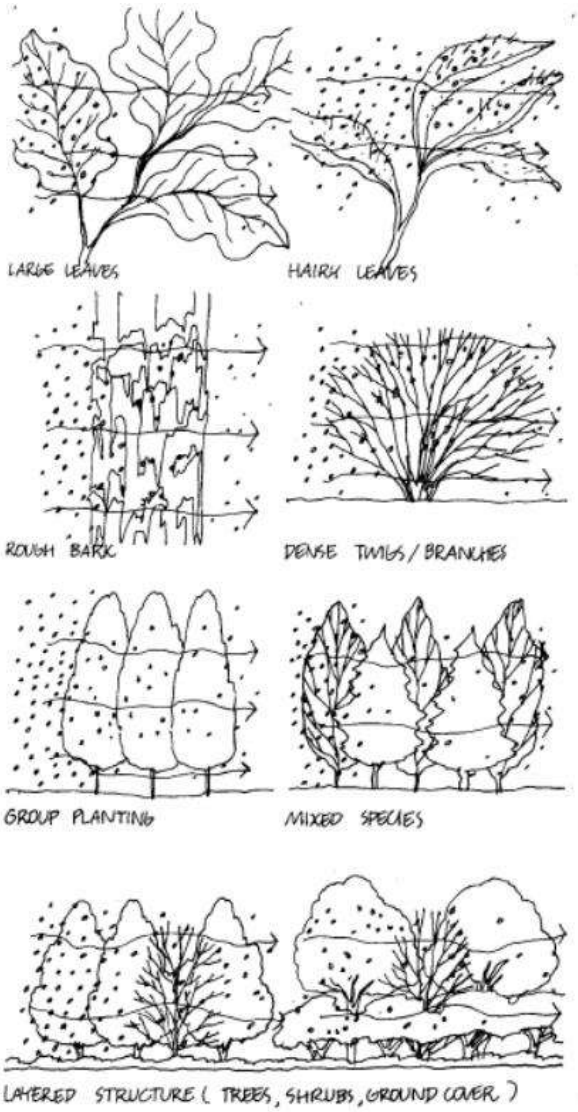


Figure 10: variable influences plants effectiveness as sinks for particulates. Source: (Sprin, 1986)

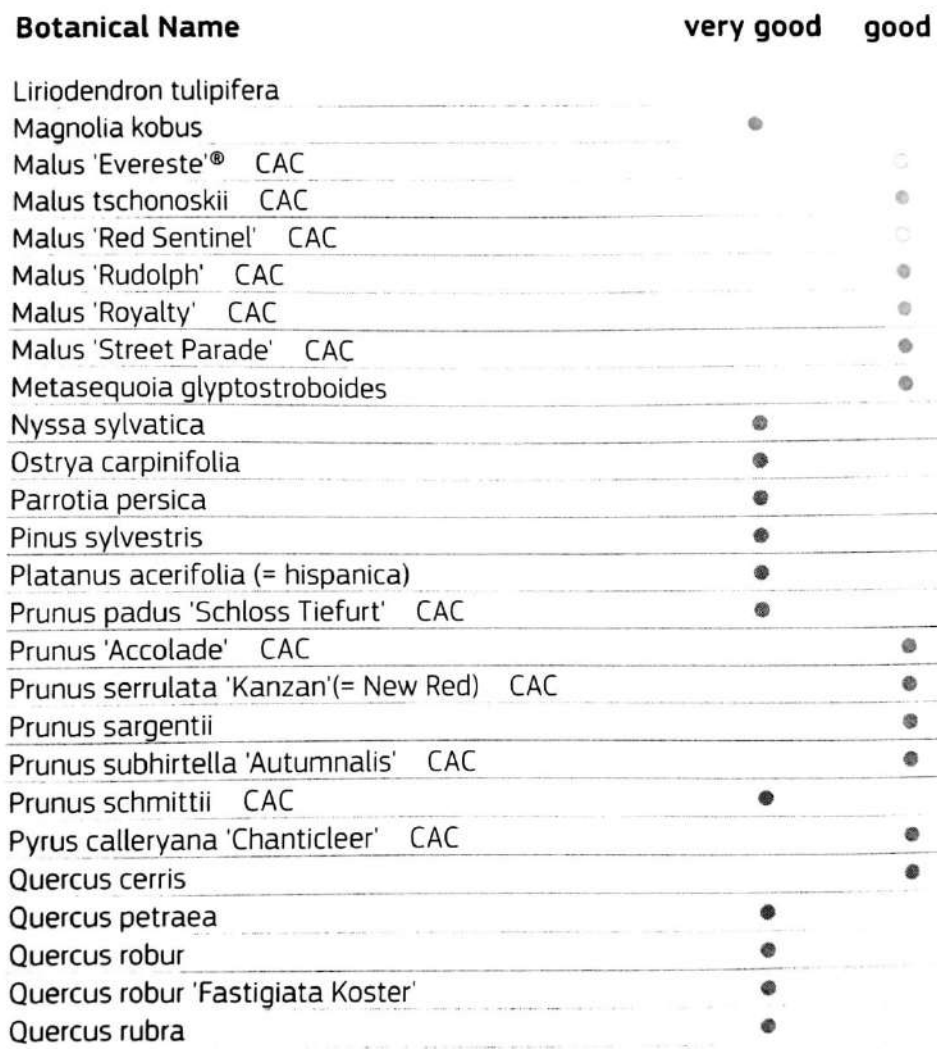
Thirdly, leaves with a large surface area mean more stomatal openings which mean more trapping of PM. Fourthly, Dense twigs: again, it increases the probability of trapping air particles more than a plant a few twigs growing habits having a branch or two.

The sink effect in her book was described as the ability referred to the plants to trap particulate pollutants. In addition to this she further explained that the combination of various tree types of plantation such as evergreen with deciduous trees helps in maximizing this effect; as the variety of species will lead to trapping a wider range of pollutants from the air.

Furthermore, she also referred in her book about the patterns of accumulation of PM, she said that “The more enclosed space is by buildings, walls, embankments, or canopies adjacent to or over the roadway, the fewer opportunity pollutants within that space have to disperse, and the more likely that they will build up” (Sprin, 1986).

In addition to these characteristics mentioned another entity tried to classify plants according to their best use called Lorberg. Lorberg is a German company founded in 1843 and started to grow and expand from Berlin to different cities such as Baden-Baden. In their last book edition 85th in 2019, they had different lists of plantations for different purposes. What is unique about them that they have managed to create a list of plants according to their applicability to grow in harsh conditions as shown in figure11.

The vegetation collection mentioned is only made up of trees. Concerning the trees collection, They said “A well-considered selection of plants creates sustainable greenery that is better able to cope with radiation, heat, limited root space, storm or prolonged wet weather” (H.Lorberg, 2019).



Botanical Name	very good	good
Liriodendron tulipifera		
Magnolia kobus	●	
Malus 'Evereste'® CAC		○
Malus tschonoskii CAC		●
Malus 'Red Sentinel' CAC		○
Malus 'Rudolph' CAC		●
Malus 'Royalty' CAC		●
Malus 'Street Parade' CAC		●
Metasequoia glyptostroboides		●
Nyssa sylvatica	●	
Ostrya carpinifolia	●	
Parrotia persica	●	
Pinus sylvestris	●	
Platanus acerifolia (= hispanica)	●	
Prunus padus 'Schloss Tiefurt' CAC	●	
Prunus 'Accolade' CAC		●
Prunus serrulata 'Kanzan'(= New Red) CAC		●
Prunus sargentii		●
Prunus subhirtella 'Autumnalis' CAC		●
Prunus schmittii CAC	●	
Pyrus calleryana 'Chanticleer' CAC		●
Quercus cerris		●
Quercus petraea	●	
Quercus robur	●	
Quercus robur 'Fastigiata Koster'	●	
Quercus rubra	●	

Figure 11: A list of trees best suitable to withstand harsh stress test. Source: (H.Lorberg, 2019).

8.4. Literature conclusion

All the researches presented in the literature have one thing in common. They all have shown how important plants in the environment. The first part which talked about NASA's research showed which showed how each plant acts differently to air. The list of plant air purifiers showed that there are different tendencies to each plant absorbing a certain pollutant from air.

This brings us to a fundamental conclusion that there is no one perfect plant to clean air and this is related to different aspects. Firstly, because air, consists of various gasses and particles and each vegetation reacts with surrounding air differently. Secondly, is because each plant has preferable conditions of growth and different nutrition requirement.

Therefore, sitting a preferable list of vegetation to be used at any location without understanding the environmental context will lead to failure. Thus understanding the plant requirements for growth in terms, of (growing habits, medium soil, water, and drought tolerance) is a crucial point that will help the landscaper to have a higher success rate of grouping strategies to cleanse the air

The second part of the literature mainly talked about how the existence of plants in our working and living (Indoor environment) is important for the user's health. The researches done by Kamal Meattle and Health showed that using plants in an indoor environment can decrease stress, headaches, eye irritation and brings happiness, increase hemoglobin rate in the blood which makes the person healthier.

These researches proved that using plants indoors is crucial to living a healthier life. They absorb toxins from the air, increase oxygen, and just by looking at them the sensation of relaxation increases.

The third part of the literature, generally shows how the researchers presented different ways to assess the ability of plants to clean the air. The first method was

by calculating the APTI value of the tree; this value helps the landscape designers to choose plants targeting high levels of air pollutions by a simple equation.

The research done in India done by Chandwat proved that this concept of using plantation for cleansing air and trapping PM is valid. In fact, after further testing in Ahmedabad city, they found high tendencies for specific trees that excelled more than others in trapping PM and the results were consistent on five different locations having *Ficus benghalensis* in the first place followed by *Ficus religiosa* in the second place.

Furthermore, talking about how Lorberg "German landscape company" took into perspective a new classification or listing of trees. This list of trees came after doing stress tests in collaboration with Humboldt University in berlin. Resulting in creating a list of trees rating them into two very good and good.

This shows how this company in its practical field of design goes a considers the environmental aspects in choosing trees specimens in their design. This is quite important, as it presents how this practical entity in the design and construction field is aware of the environmental concerns in their design.

Lastly, the research was done by Anna that showed four main characteristics (Hardy species, Hairy leaves, leaves with large surface area, Dense twigs) which upon it trees are chosen for best trapping of PM. This book enforced again, how trees are different in their reaction with absorption and dispersal of air. The characteristics she mentioned in her book highlighted the apparent physical perspective in vegetation for trapping PM.

After understanding how crucial importance of vegetation with its various forms in our lives. I have decided to create a list of vegetation that applies to Cairo's climate to minimize Cairo deadliest air pollutants "Particulate Matters". To do this, the physical criteria created by Anna Sprin for trapping PM will be taken into consideration for building new criteria working best for Cairo's climate. This will be explained furtherly, in the next chapter with examples.

Chapter 3: Study Design and Methodology

9. Chapter 3: Study Design and Methodology

As mentioned before, Cairo stands in a crucial crisis in the field of air quality and it needs all the sustainable mitigation options to have a sustainable solution as it aims to perform well with the SDGs goals for 2030 which has AQ clear goals in its agenda. This research contribution is to sort out a few vegetation that is suitable for Cairo weather and have high value to trap particulate matter.

The first purpose importance (apply PM sink effect), lies in choosing vegetation's that are effective for PM sink effect to help in reducing the main problem in air pollution in as declared by WHO results.

The second aspect (withstand Cairo's hot climate) is important as it considers the drought tolerance and the water requirement of the plant to suites Cairo's desert-like scape. This means that the second aspect will act as a filtration method of what could be suitable to survive, and this point is obligatory.

In other words, if the vegetation specimen has a high score for trapping PM but a low score for withstanding drought and has a high need for water intake for growth, then this specimen will be disqualified from the list.

So the question now, how we shall create such a list? How can we give a reasonable rating system to determine if this planting specimen is suitable or not according to the main points discussed? This can be understood in a simple structure as shown in figure 12. Furthermore, the actual list will be discussed in detail in the next chapter, divided into 3 main categories (Trees, Palms, shrubs, and groundcovers).

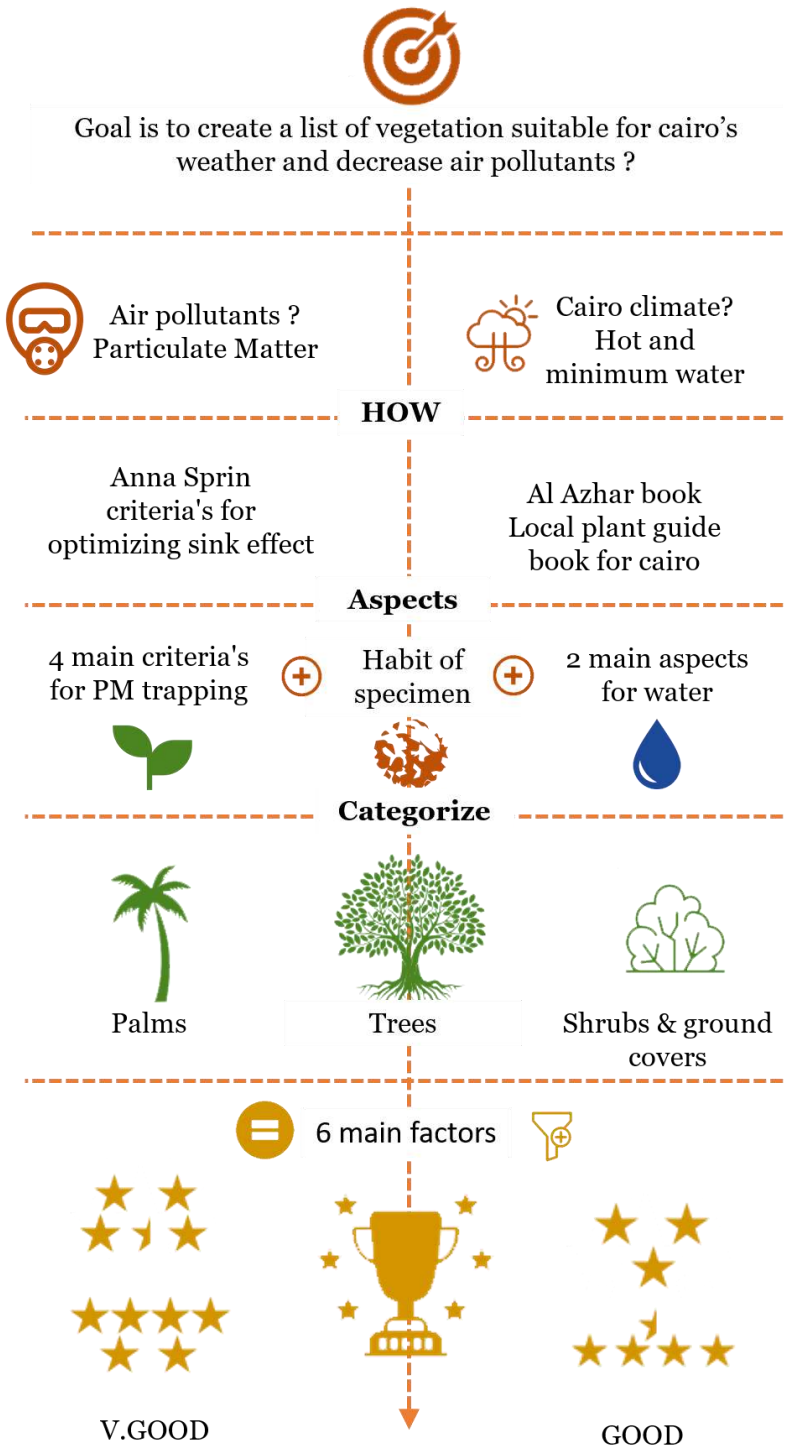


Figure 12: Breakdown structure of how the criteria's are set to reach the suitable list of vegetation's to Cairo. Source: done by researcher.

9.1. Table criteria's

Firstly, planting guidebook must be chosen. One of the best guidebooks used by landscapers in Cairo is called (A Plant Guidebook for Al-Azhar Park) published by Sites international. This book has consistent data on plants that are commonly used in Cairo. The book has already divided vegetation's into different categories such as (palms, trees, etc.) This book is crucial to the research as it documents the available planting specimens used in Cairo, Egypt. It contains 383 planting specimens, which will be filtered out according to upcoming criteria in the next chapter.

Secondly, comes setting the rating and assessment criteria. In the beginning, there are main 3 categories that divide plantations from each other. Firstly, Trees, secondly Palms and finally shrubs and ground covers. Each category will have the same filtration criteria for rating the specimens with a slight change in the description to fit each independent category.

Thirdly comes the weighting scoring aspect, which will differ if the plant is considered very good or good. Generally, there are 6 independent aspects.

The green aspects are 4, each aspect holds one full point. The other 2 points are related to water and each point is divided into 3. Which gives us the smallest fraction equals to 0.33.

Doing simple math scoring 3 is an average score of a total of 6 points. Therefore, scoring more than 3 will be considered above average, in other words good. The other 3 points are also divided into 2 to get 1.5. Therefore, the maximum score allowed for the good category is 4.5 and it can not be reached as the smallest fraction is one-third of a point.

By adding the smallest fraction to the equation it is only applicable to score 4 full points and one-third of a point having 4.33 in total. Above this limit is scoring two-thirds of a point; scoring 4.67. Thus, scoring from 4.67 is considered the

bottom margin for a very good category, and its maximum limit is scoring full 6 points. Thus, all specimens, are ordered in descending order. Rating the top specimens scoring (4.67 to 6) very good in the first category and good specimens in the second category (3-4.33) as shown in figure 13.

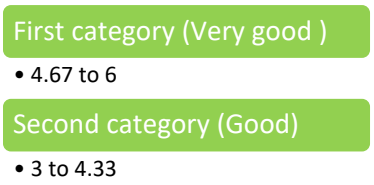


Figure 13: rating and categorization of scores. Source: done by researcher.

9.2. Trees criteria's

9.2.1. Table breakdown

Talking about Trees category, as shown in table 2. Firstly, comes the Botanical name of the specimen followed by the main criteria for selection that can be seen divided into three coded colors: Green, Brown, and Blue.

Firstly, in green, comes the PM trapping characteristics that is divided into 4 aspects. In blue comes the criterions related to water, divided into 2 main aspects. Thirdly, in brown, plant habit for shedding its leaves.

However, talking about the PM criteria's in detail. The PM criteria colored in green, have different aspects that will be furtherly explained in the following.

- Criteria 1: specifies the size of the leaves to be longer than 15cm.
- criteria 2: specifies the leaf's texture to be (Hairy / throned/ toothed /waxy/ rough leaves).
- Criteria 3: specifies the density of branches to be heavy.
- Criteria 4: specifies the tree trunk to have rough bark

All these aspects are obtained from previous research presented by Anne Sprin in her book (Strategies for Urban Design).

Secondly, in blue, comes the water aspects which are represented in two points water intake level and drought tolerance. Each aspect has 3 options either: High, medium, or low.

Thirdly, in brown comes the shedding habit of the tree leaves, which comes only in two options stating if the tree is deciduous or evergreen. Having no score for any.

The total of all points is a maximum of 6, each criterion is rewarded one full point except the water intake and drought tolerance. Each criteria of water description are divided into 3 options: High = H, Medium = M, Low = L. It can be scored one full point in certain conditions, for example: if the tree needs low water intake this means it will score one point. If it needs medium water then, it will score 0.67 respectively if it needs high water intake this means it scores 0.33.

Furthermore, if the tree is rated to withstand drought tolerance it will score High = 1, or 0.67 for medium or tolerate low drought scoring a minimum of 0.33. This gives us at the end of the full 6 points. Back to the main list, we can divide it into 2 categories Very good and good.

9.2.2. Filtration results

In the very good category Sesbania *Sesban* scores full 6 points which means that it has full potential to trap PM, can withstand drought, and requires low water intake. Moreover, from number 2 *Castanea Sativa Miller* till Terminalia Satappa in number 11, all trees scores 5.67 which are similarly strong as shown in table 4.

However, in total from number 1 to 49 tree specimens are highly suggested as very good specimens to be used. The others from number 50 *Conocarpus Erectus* to number 62 *Acacia Smallii* is the other group rating good specimens.

In summary, out of 62 trees, 49 specimens are rated as very good and the 12 others are rated as good as shown in table 2.

No. 1-49 = 49 V.Good specimens
No 50-62 = 12 Good specimens
Total = 62 specimens

Table 2: A summary table for Trees ratings. Source: done by researcher.

Number	Name of specimen (Botanical Name)	Large/ Long Leaves 15cm >	Hairy/ Throned/ Toothed/ Waxy/ Rough leaves	Desnse twigs	Rough Bark	Form (Decidious / Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									Max. 6
1	Sesbania Sesban	1	1	1	1	Decidious	1.00	1.00	6
2	Castanea Sativa Miller	1	1	1	1	Decidious	1.00	0.67	5.67
3	Citrus Limon	1	1	1	1	Evergreen	1.00	0.67	5.67
4	Citrus Medica	1	1	1	1	Evergreen	1.00	0.67	5.67
5	Cordi myxa	1	1	1	1	Evergreen	1.00	0.67	5.67
6	Ficus Bebghalensis	1	1	1	1	Evergreen	1.00	0.67	5.67
7	Ficus Lyrata	1	1	1	1	Evergreen	1.00	0.67	5.67
8	Ficus macrophylla	1	1	1	1	Evergreen	1.00	0.67	5.67
9	Gleditsia triacanthos	1	1	1	1	Decidious	1.00	0.67	5.67
10	Melia azdarach	1	1	1	1	Decidious	1.00	0.67	5.67
11	Terminalia catappa	1	1	1	1	Decidious	1.00	0.67	5.67
12	Morus Alba	1	1	1	1	Decidious	0.67	0.67	5.34
13	Balanites aegyptiaca	0	1	1	1	Evergreen	1.00	1.00	5
14	Ficus Auriculata	1	1	1	1	Evergreen	0.33	0.67	5
15	Olea Europaea	0	1	1	1	Evergreen	1.00	1.00	5
16	Plumeria Alba	1	1	1	0	Decidious	1.00	1.00	5
17	Tamarix aphylla	0	1	1	1	Evergreen	1.00	1.00	5
18	Aberia Caffra	0	1	1	1	Evergreen	1.00	1.00	5
19	Aphanamixis polystachya	1	0	1	1	Evergreen	1.00	0.67	4.67
20	Callistemon Viminalis	1	0	1	1	Evergreen	1.00	0.67	4.67
21	Casimiroa edulis	1	0	1	1	Evergreen	1.00	0.67	4.67
22	Cassia Fistula	1	0	1	1	Evergreen	1.00	0.67	4.67
23	Cassia Nodosa	1	0	1	1	Decidious	1.00	0.67	4.67
24	Cassia spectabilis	1	0	1	1	Evergreen	1.00	0.67	4.67
25	Casuarina Cunninghamiana	1	0	1	1	Evergreen	1.00	0.67	4.67
26	Ceratonia Siliqua	1	0	1	1	Evergreen	1.00	0.67	4.67
27	Citrus Paradisi	1	0	1	1	Evergreen	1.00	0.67	4.67
28	Cupressus macrocarpa	1	0	1	1	Evergreen	1.00	0.67	4.67
29	Cupressus sempervirens	1	0	1	1	Evergreen	1.00	0.67	4.67
30	Delonix Regia	1	0	1	1	Decidious	1.00	0.67	4.67
31	Enterolbium cyclocarpum	1	0	1	1	Decidious	1.00	0.67	4.67
32	Eriobtyra japonica	1	1	1	0	Evergreen	1.00	0.67	4.67
33	Erythrina Caffra	1	0	1	1	Evergreen	1.00	0.67	4.67
34	Ficus benghalensis	1	0	1	1	Evergreen	1.00	0.67	4.67
35	Cupressus macrocarpa	1	0	1	1	Evergreen	1.00	0.67	4.67
36	Ficus Decora	1	1	1	0	Evergreen	1.00	0.67	4.67
37	Ficus Maclellandii	1	0	1	1	Evergreen	1.00	0.67	4.67
38	Ficus religiosa	1	1	1	0	Decidious	1.00	0.67	4.67
39	Jacranda ovalifolia	1	1	1	0	Decidious	1.00	0.67	4.67
40	Magnolia grandiflora	1	1	1	0	Evergreen	1.00	0.67	4.67

Number	Name of specimen (Botanical Name)	Large/ Long Leaves 15cm >	Hairy/ Throned/ Toothed/ Waxy/ Rough leaves	Desnse twigs	Rough Bark	Form (Decidious / Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									Max. 6
41	Melaleuca Leucadendroa	1	1	1	0	Evergreen	1.00	0.67	4.67
42	Parkinsonia Aculeata	0	1	1	1	Decidious	1.00	0.67	4.67
43	Peltoporum africacum	0	1	1	1	Decidious	1.00	0.67	4.67
44	Populus Alba	0	1	1	1	Decidious	1.00	0.67	4.67
45	Salix Babylonica	0	1	1	1	Decidious	1.00	0.67	4.67
46	Sophora Seucundiflora	1	1	1	0	Evergreen	1.00	0.67	4.67
47	Spathodea Campunalata	1	1	1	0	Decidious	1.00	0.67	4.67
48	Tabebuia argentea	1	1	1	0	Decidious	1.00	0.67	4.67
49	Tecoma Stans	1	1	1	0	Evergreen	1.00	0.67	4.67
50	Conocarpus Erectus	0	0	1	1	Evergreen	1.00	1.00	4
51	Annona Muricata	1	0	1	0	Evergreen	1.00	0.67	3.67
52	Artocarpus Heterophyllus	0	0	1	1	Evergreen	1.00	0.67	3.67
53	Dalbergia Sissoo	1	0	1	0	Evergreen	1.00	0.67	3.67
54	Certonia Siliqua	1	0	1	0	Evergreen	1.00	0.67	3.67
55	Ficus Benjamina	0	1	1	0	Evergreen	1.00	0.67	3.67
56	Ficus infectoria	0	1	1	0	Decidious	1.00	0.67	3.67
57	Ficus Microcarpa	0	1	1	0	Evergreen	1.00	0.67	3.67
58	Araucaria Heterophylla	0	0	1	1	Evergreen	0.67	0.67	3.34
59	Carica Papaya	1	0	1	0	Evergreen	0.67	0.67	3.34
60	Diospros Kaki	1	0	1	0	Decidious	0.67	0.67	3.34
61	Acacia Nilotica	0	0	1	0	Evergreen	1.00	1.00	3
62	Acacia Smallii	0	0	1	0	Evergreen	1.00	1.00	3

Table 3: List of trees specimens ordered from the highest rating to the lowest. Source: done by researcher.

9.3. Palms criteria's

9.3.1. Table breakdown

Talking about the Palms category, as shown in table 4. Firstly, comes the Botanical name of the specimen followed by the main criteria for selection that can be seen divided into three coded colors: Green, Brown, and Blue.

Number	Name of specimen (Botanical Name)	Large/Long leaflets 2 m >	Hairy / throned/ toothed /waxy/ rough leaflets	Leaflets compactnes	Rough trunk	Form (Decidious/ Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									max. 6
1	Pheonix Cnariensis	1	1	1	1	Evergreen	1.00	0.67	5.67
2	Washingtonia Robusta	1	1	1	1	Evergreen	1.00	0.67	5.67
3	Pheonix Dactylifera	1	1	1	1	Evergreen	1.00	0.67	5.67
4	Livistona Australis	1	1	1	1	Evergreen	0.33	0.67	5
5	Pitchardia Pacifia	1	0	1	1	Evergreen	1.00	0.67	4.67
6	Washingtonia Flifera	1	0	1	1	Evergreen	1.00	0.67	4.67
7	Chamaeropes Humilis	1	0	0	1	Evergreen	1.00	1	4
8	Hyphhaene Thebaica	1	0	0	1	Evergreen	1.00	1	4
9	Licuala Grandis	1	0	1	1	Evergreen	0.33	0.67	4
10	Chrysalidocarpus Lutescens	1	0	1	0	Evergreen	0.67	0.67	3.34
11	Cycus Revoluta	1	0	0	1	Evergreen	0.67	0.67	3.34

Table 4: List of Palms specimens ordered from the highest rating to the lowest. Source: done by researcher.

Firstly, the PM trapping characteristics which is coded in green are divided into 4 elements. Each criterion has its different description and will be furtherly explained as follows:

- Criteria 1: specifies the size of the leaflets to be longer than 2 m.
- Criteria 2: specifies the leaflet's texture to be (Hairy / throned/ toothed /waxy/ rough leaves).
- Criteria 3: specifies the leaflets are compacted and dense.
- Criteria 4: specifies the Palm trunk must have rough bark.

Secondly, in blue, comes the water aspects which are represented in two points water intake level and drought tolerance. Each aspect has 3 options either: High, medium, or low.

Thirdly, in brown comes the shedding habit of the shrub, coming only in two options stating if the palm is deciduous or evergreen. Having no score for any.

The total of all points is a maximum of 6, each criterion is rewarded one full point except the water intake and drought tolerance. Each criteria of water description are divided into 3 options: High = H, Medium = M, Low = L.

It can be scored one full point in certain conditions, for example: if the palm needs low water intake this means it will score one point. Respectively, if it needs medium water then it will score 0.67 and so on.

Respectively, the grades from each aspect will add up reaching a maximum of 6 full points.

9.3.2. Filtration results

In the very good category, 3 palms stand on the top scoring 5.67 points and they are *Pheonix Cnariensis, Washingtonia Robusta, Pheonix Dactylifera*. Meaning that they have the full potential to trap PM, can highly withstand drought, and requires medium water intake. Moreover, in number 4 *Livistona Australis* scores full 5 points setting a very good example to trap PM, but it can't withstand drought and needs a medium level of water quantity.

In number 5 and 6 (*Pitchardia Pacifia, Washingtonia Flifera*) scores 4.67 endings in the Very good category. They both scores the same 3 points in trapping PM, excellent specimens to withstand drought however they need a medium level of water to survive.

From Number 7 *Chamaeropes Humilis* till number 11 *Cycus Revoluta* Stands in the Good category. Number 7 *Chamaeropes Humilis* and number 8 Hyphhaene Thebaica both scores 4 points. They are both excellent specimens to withstand drought and require low water intake, but they only score 2 points in trapping PM.

From the rest going down the points earned varies reaching a minimum of 3.34 points having *Chrysalidocarpus Lutescens and Cycus Revoluta* in the last place.

In the end, out of 11 palms in total, 6 specimens are rated as very good and the other 5 are rated as good as shown in table 5.

No.1-6 = 6 V.Good specimens
No. 7-11 = 5 Good specimens
Total = 11 specimens

Table 5: A summary table for Palms ratings. Source: done by researcher.

9.4. Shrubs and groundcovers criteria's

9.4.1. Table breakdown

Finally, talking about last category shrubs and groundcovers as shown in table 6. Firstly, comes the Botanical name of the specimen followed by the main 3 criteria for selection that is divided separately into 3 main colors green, brown, and blue.

Firstly, the PM trapping characteristics are coded in green and divided into 4 elements. Each criterion has its different description as following:

- Criteria 1: specifies the size of the leaflets to be longer than 10 cm.
- criteria 2: specifies the leaflet's texture to be (Hairy / throned/ toothed /waxy/ rough leaves).
- Criteria 3: specifies the leaflets are compacted and dense.
- Criteria 4: specifies the bark must have rough.

Secondly, in blue, comes the water aspects which are represented in two points water intake level and drought tolerance. Each aspect has 3 options either (High, medium, or low).

Thirdly, in between the green and blue segment lies a brown segment representing the habit of the shrub or ground cover in shedding its leaves. It comes only in two options stating if they are deciduous or evergreen.

Number	Name of specimen (Botanical Nam)	Large/ Long Leaves 10cm >	Hairy / Throned/ Toothed / Waxy/ Rough leaves	Desnse twigs	Rough bark	Form (Decidious/ Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									Max. 6
1	Acokanthera Spectabilis	1	1	1	1	Evergreen	1.00	1.00	6
2	Myoporum laetum	1	1	1	1	Evergreen	1.00	1.00	6
3	Nerium Oleander	1	1	1	1	Evergreen	1.00	1.00	6
4	Pittosporum tobira	1	1	1	1	Evergreen	1.00	1.00	6
5	Rhaphiolepis Indica	1	1	1	1	Evergreen	1.00	1.00	6
6	Dasylirions quadrangulatum	1	1	1	1	Evergreen	1.00	1.00	6
7	Euphorbua lactea	1	1	1	1	Evergreen	1.00	1.00	6
8	Euphorbia milii	1	1	1	1	Evergreen	1.00	1.00	6
9	Pachypodium lamerei	1	1	1	1	Decidious	1.00	1.00	6
10	Yucca aloifolia	1	1	1	1	Evergreen	1.00	1.00	6
11	Yucca elephantipes	1	1	1	1	Evergreen	1.00	1.00	6
12	Yucca filametosa	1	1	1	1	Evergreen	1.00	1.00	6
13	Verbena Hubrida	1	1	1	1	Evergreen	1.00	0.67	5.67
14	Acalypha Margianta	1	1	1	1	Evergreen	1.00	0.67	5.67
15	Aralia Japonica	1	1	1	1	Evergreen	1.00	0.67	5.67
16	Caesalpinia pulcherrima	1	1	1	1	Decidious	1.00	0.67	5.67
17	Cassia tomentosa	1	1	1	1	Decidious	1.00	0.67	5.67
18	Euphorbia	1	1	1	1	Decidious	1.00	0.67	5.67
19	Euphorbia pulcherrima	1	1	1	1	Decidious	1.00	0.67	5.67
20	Ficus Carica	1	1	1	1	Decidious	1.00	0.67	5.67
21	Hibscus rosa-sinensis	1	1	1	1	Evergreen	1.00	0.67	5.67
22	Murraya exotica	1	1	1	1	Evergreen	1.00	0.67	5.67
23	Bouganivillea stans	1	1	1	1	Evergreen	1.00	0.67	5.67
24	Carissa grandiflora	0	1	1	1	Decidious	1.00	1.00	5
25	Dodonea Viscosa	0	1	1	1	Evergreen	1.00	1.00	5
26	Leucophyllum frutescens	0	1	1	1	Evergreen	1.00	1.00	5
27	Rosa hybrida	1	1	1	1	Evergreen	0.33	0.67	5
28	Santolina chamaecypaissus	0	1	1	1	Evergreen	1.00	1.00	5
29	Calotropis procera	1	1	1	0	Evergreen	1.00	1.00	5

Number	Name of specimen (Botanical Nam)	Large/ Long Leaves 10cm >	Hairy / Throned/ Toothed / Waxy/ Rough leaves	Desnse twigs	Rough bark	Form (Decidious/ Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									Max. 6
30	Carpobrotus edulis	1	1	1	0	Evergreen	1.00	1.00	5
31	Calliandra Haematocephala	1	1	1	0	Evergreen	1.00	0.67	4.67
32	Callistemon rigidus	0	1	1	1	Evergreen	1.00	0.67	4.67
33	Cassia Alata	1	1	1	0	Decidious	1.00	0.67	4.67
34	Crotalaria madurensis	0	1	1	1	Evergreen	1.00	0.67	4.67
35	Eranthemum pulchellum	1	1	1	0	Evergreen	1.00	0.67	4.67
36	Justicia adhatoda	1	1	1	0	Evergreen	1.00	0.67	4.67
37	Lawsonia Alba	0	1	1	1	Evergreen	1.00	0.67	4.67
38	Myrtus commuis	1	1	1	0	Evergreen	1.00	0.67	4.67
39	lantana montevidensis	0	1	1	1	Decidious	1.00	0.67	4.67
40	Senecio cineraria	1	1	1	0	Evergreen	1.00	0.67	4.67
41	Monestera Deliciosa	1	1	1	0	Evergreen	0.33	0.67	4
42	Agava americana	1	1	0	0	Evergreen	1.00	1.00	4
43	Agave angustifolia	1	1	0	0	Evergreen	1.00	1.00	4
44	Agave atrovirens	1	1	0	0	Evergreen	1.00	1.00	4
45	Agave attenuata	1	1	0	0	Evergreen	1.00	1.00	4
46	Agave Desmettiana	1	1	0	0	Evergreen	1.00	1.00	4
47	Agave ferox	1	1	0	0	Evergreen	1.00	1.00	4
48	Aloe striata	1	1	0	0	Evergreen	1.00	1.00	4
49	Aloe vera	1	1	0	0	Evergreen	1.00	1.00	4
50	Cereus peruvianus	0	1	1	0	Evergreen	1.00	1.00	4
51	Opuntia ficus indica	1	1	0	0	Evergreen	1.00	1.00	4
52	Sansevieria trifasciata	1	1	0	0	Evergreen	1.00	1.00	4
53	Annona Muricata	1	0	1	0	Evergreen	1.00	0.67	3.67
54	Annona Muricata	0	1	1	0	Evergreen	1.00	0.67	3.67
55	Cestrum Aaurantiacum	1	0	1	0	Evergreen	1.00	0.67	3.67
56	Lavandula angusifolia	0	1	1	0	Evergreen	1.00	0.67	3.67
57	Catharanthus roseus	0	1	1	0	Evergreen	1.00	0.67	3.67
58	Anisacanthus thuberi	0	1	1	0	Evergreen	0.67	0.67	3.34
59	Plumbago capensis	0	1	1	0	Evergreen	0.67	0.67	3.34
60	Aglaonema species	1	1	0	0	Evergreen	0.33	0.67	3
61	Anthurium species	1	1	0	0	Evergreen	0.33	0.67	3
62	Echinocacus grusonii	0	1	0	0	Evergreen	1.00	1.00	3

Table 6: List of Shrubs and groundcovers specimens ordered from the highest rating to the lowest. Source: done by researcher

The total of all points is a maximum of 6, each criterion is rewarded one full point except the water intake and drought tolerance. Each criteria of water description are divided into 3: High = H, Medium = M, Low = L.

It can be scored one full point in certain conditions, for example: if the shrub or groundcover needs low water intake this means it will score one point. Respectively, if it needs medium water then it will score 0.67 and if it needs high water intake this means it scores 0.33.

Furthermore, if the plant is can withstand drought it will score high = 1, or 0.67 to tolerate medium level or score 0.33 to tolerate low drought.

9.4.2. Filtration results

In the very good category, 12 specimens stand on top scoring full 6 points and they are: (*Acokanthera Spectabilis, Myoporum laetum, Nerium Oleander, Pittosporum tobira, Rhaphiolepis Indica, Dasylirions quadrangulatum, Euphorbua lacteal, Euphorbia milii, Pachypodium lamerei, Yucca aloifolia, Yucca elephantipes, Yucca filametosa*). This means that they have the full potential to trap PM, can highly withstand drought, and requires low water intake.

Moreover, from number 13 "*Verbena Hubrida* "until number 23 "Bougainvillea *stans"* which are similarly strong 11 specimens that score 5.67. They all score 4 full points for trapping PM and full points for highly withstanding drought. However, they only miss one-third of a point for requiring a medium level of watering. scoring 0.67.

Furthermore, as we go down in this first category, we find in number 24 *Carissa grandiflora* until number 30 *Carpobrotus edulis* scoring full 5 points with various ratings for PM. and water requirements.

Finally, to close this category, from no. 31 *Calliandra Haematocephala* until *Senecio cineraria* specimens score 4.67. These ten specimens score full points for

having a high level of drought and requiring a medium-level intake of water. Not to mention, they all scores different ratings for PM criteria.

However, for the second category ‘’Good specimens”, we have 22 specimens in total. Starting with *Monstera Deliciosa* in no. 41 until no. 61 *sansevieria trifasciata* with a total of full 4 points. They all share full points for withstanding high levels of drought and requires minimum water intake for survival. In addition to this, they score different points for the 4 main criteria of trapping PM. Apart from, *Monestera Deliciosa* which is very weak for withstanding drought and requires a medium level of water intake for survival.

Furthermore, from number 53 *Annona Muricata* until number 57 *Catharanthus Roseus* all 5 specimens score 3.67. They all score one full point for the high level of drought tolerance, variable points for PM trapping, and requiring a medium level of water intake for survival.

Going down we find number 58 *Anisacanthus thuberi* and number 59 *Plumbago capensis* both scores 3.34. They both have medium drought tolerance and medium watering level, apart from having different points for PM trapping.

Lastly, Aglaonema, Anthurium, Echinocacus grusonii the last 3 specimens in number 60, 61, and 62 score solid 3 points. All 3 specimens score different points in all aspects either PM. trapping and water requirements.

In the end, 62 specimens of total shrubs and groundcovers, 40 specimens are rated as very good and 21 more rated as good as shown in table 7.

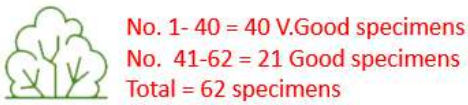


Table 7 :A summary table for shrubs and groundcovers ratings. Source: done by researcher.

9.5. Investigating a location

After listing down planting specimens commonly used in Cairo into two categories A and B, with its 3 main variations (palms, trees, shrubs, and groundcovers), a vibrant street will be located to start the experiment.

The goal of this experiment firstly, is to understand the current structure of the outdoor green pocket in terms of what sort of vegetation is used, what watering system is used, how often this area gets maintained, and how they take care of it seasonally?

After understanding the existing fabric, we shall give few recommendations to optimize this green pocket to serve as a green lung to the area and maximize its ability to trap PM with recommended groupings and planting specimens to be able to set a recommendation to optimize this green space.

There are various streets in Cairo's urban life to choose from, that follow under the criteria of the vibrant street. However, a vibrant street in Cairo has 3 main characteristics defined in this research.

Firstly, a street that has both accessible routes of vehicles (4 lanes) and pedestrian lanes. Secondly, a street that is looking at the mixed commercial and residential building. thirdly a street that has a minimum green space of 500m2; this could be a small park, outdoor public plaza, or planting beds in between streets or at sidewalks. According to these criteria's, various streets may fall into the category such as:

Makram Eibad street in Nasr City, 90 st street in 5th settlement new Cairo, el Orouba road, Abdelaziz Fahmy, and El Hegaz street in Heliopolis district. There are so many others to list down, but this is not the objective here.

9.5.1. COVID 19 curfew

Unfortunately, during the writing of this thesis, a strong virus has spread all over the world affecting mobility at both the national and international levels to limit its spread as much as possible. This virus across the world is called “COVID 19” and has been acknowledged as a pandemic in Egypt as part of the worldwide pandemic disease 2019. It is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

The virus was confirmed to have reached Egypt on 14 February 2020 (Ahram, 2020). Coronaviruses belong to a group of viruses that infect animals, from peacocks to whales. They’re named for the bulb-tipped spikes that project from the virus’s surface and give the appearance of a corona surrounding it.

According to Benjamin Neuman a Professor of Biology, Texas A&M University “A coronavirus infection usually plays out one of two ways: as an infection in the lungs that includes some cases of what people would call the common cold, or as an infection in the gut that causes diarrhea”. “COVID-19 starts in the lungs like the common cold coronaviruses, but then causes havoc with the immune system that can lead to long-term lung damage or death,” says Neuman. (Neuman, 2020).

The pandemic situation took a major role in setting decisions for this thesis and because of the long lockdown, I start to think about other means.

9.5.2. Locating Basilic Garden

Fortunately, just across my balcony on the 4th floor where my grandmother lives; lies one of the most important hotspots in Masr Elgdeda district. Yes, it is the Basilic church! This church that lies down in the heart of Heliopolis city since 1911.

It is easily seen; how dominant a figure it was from an old photograph of the city in 1920 as shown in figure 14. Heliopolis city is one of the most important old districts in Cairo governorate, it was established in 1905 by the Heliopolis Oasis Company headed by the Belgian industrialist Édouard Empain and by Boghos Nubar, son of the Egyptian Prime Minister Nubar Pasha. In front of this masterpiece of architecture lies 2 plots of open green pockets between 2 main streets (Othman Ibn Affan St. and Al Ahram st.) as shown in plan figure 16.

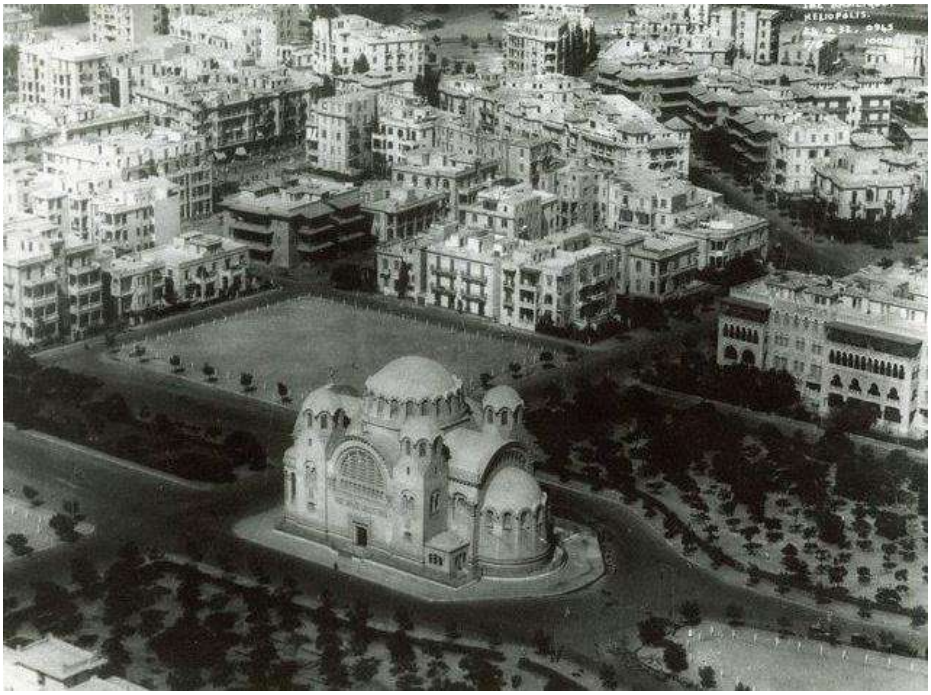


Figure 14: An aerial view of the Basilique church. Captured in the 1920s. Retrieved from Facebook page Heliopolis. Source: (ZAINELDINE, 2020).

There is a place where it seemed to be applicable to study during this lockdown. The main positive point from this site, that it is within 5 minutes' walking distance and, it is easily observed from top-level from where I live. Therefore, better to map. The 2 areas are about 1500 m2 and equipped with vegetation and a water source. However, to simplify the area location process to study a

conclusive structure is presented to simplify the process easier as shown in figure 15.

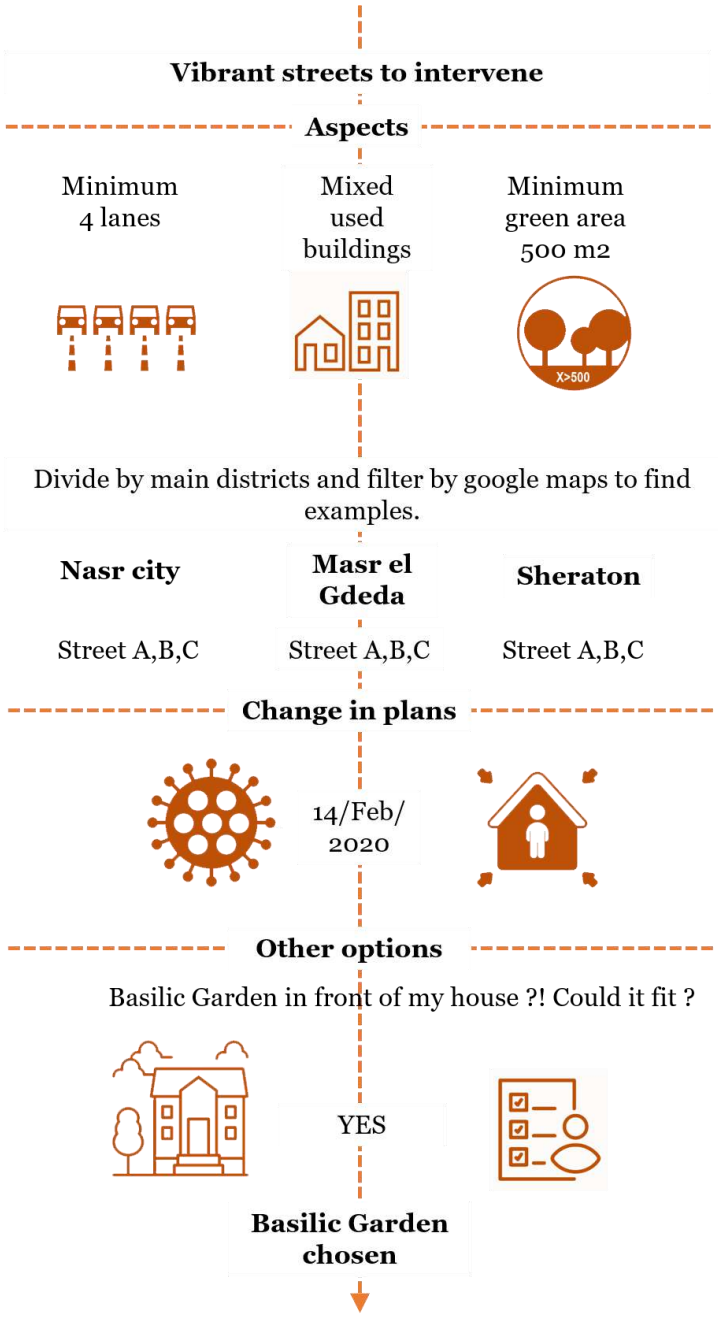


Figure 15: showing an infographic of how the Basilic garden is chosen for a case study. Source: done by researcher.

Figure 16: Targeted surrounding area of Study location (Hafiza el Alfy garden). Source: done by researcher

9.5.3. Mapping existing fabric

The importance of this stage mapping is that it identifies the quantity, variation, and location of vegetation in the existing field. To do this stage I had to visit the site personally, to map and sketch the plant groupings from a closer look; looking from the balcony was not enough!

Firstly, on the first site visit on, the 15 of May 2020, I was able to map both areas for zone A and B. I started to identify the quantity and variation of species used to grow in this garden in tables divided by the main four categories (trees, palms, shrubs, and groundcovers) as shown in table 8 for example, and figure 17 shows the symbols for each specimen.

Table 8: Table listing the main categories and specimens under each zone. Source: done by researcher.

	Trees/no.	Palms/no.	Shrubs/Area m2	Ground Covers/Area m2
Zone A (880 m2)	Ficus benjamina (6)	Washgntonia flifera (3)	Dodonica viscosa (87)	Grass (758)
	Delonix regia (3)		Lantana (23)	
			Acalypha (12)	
Zone B (1480 m2)	Ficus benjamina (14)	Washgntonia flifera (2)	Dodonica viscosa (54)	Grass (1363)
	Ficus hawai (3)	Wodyetia bifurcata (2)	Lantana (13)	
		Pheonix dactyliefra (1)	Acalypha (26.5)	
			Neruieum oleander (24)	

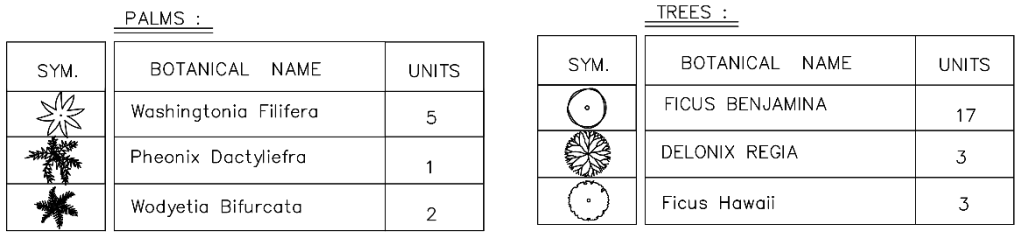


Figure 17: Planting legend and quantities for the main existing vegetation for zone A and B. Source: done by researcher.

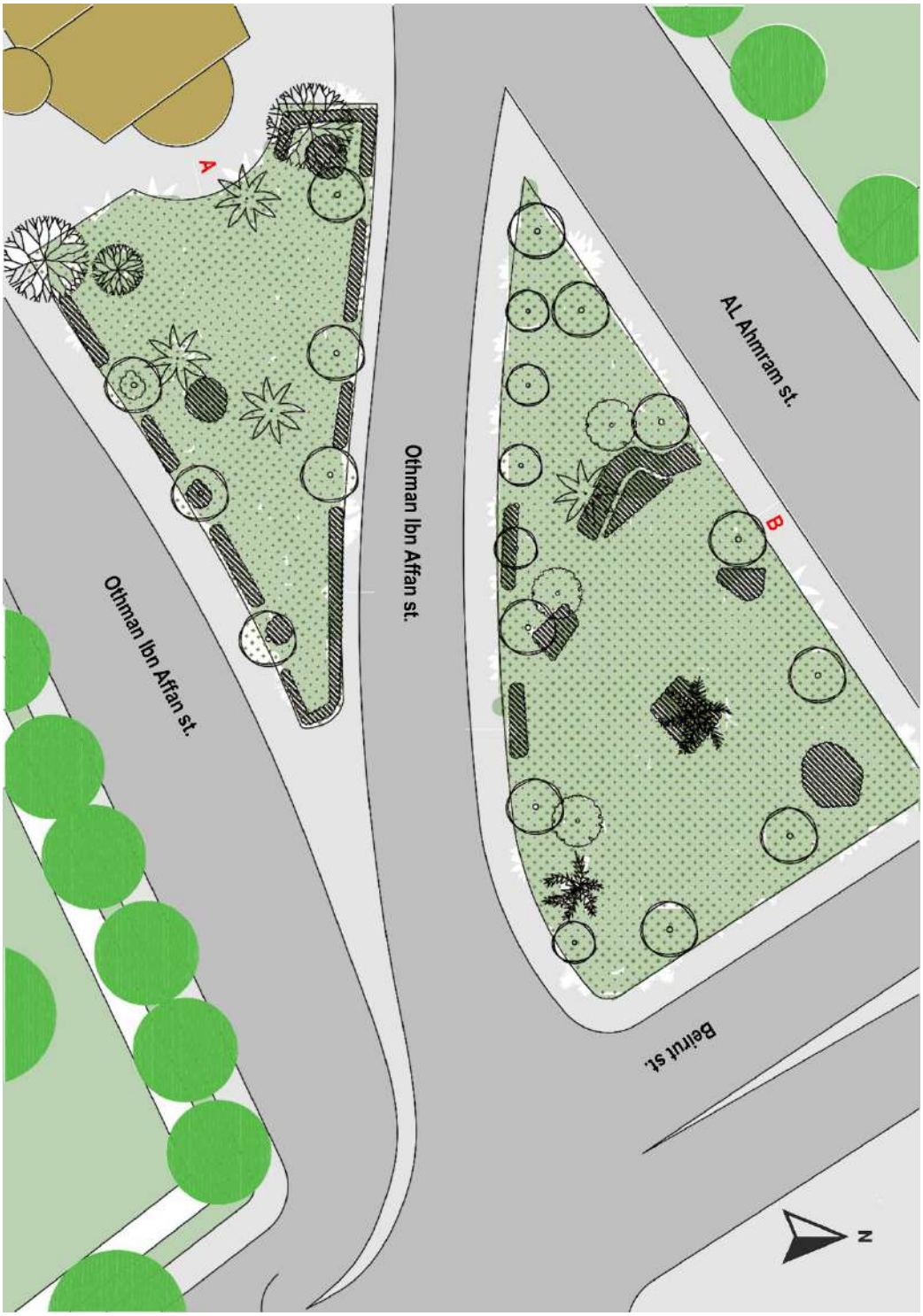


Figure 18: Main existing plan for zone A and B scale1/400. Source: done by researcher.

Secondly, to locate the vegetation's on a plan, and calculate their areas, Google Earth maps were of great help. After taking a satellite screenshot of the area the drawing procedure became much easier, using AutoCAD. This step helped me to save at least 1 month of waiting to get actual drawings from the main authorities. Furthermore, due to the Corona pandemic, it was not sure if any person would be available to provide any documents as all governmental agencies were closed. Therefore, this seemed to be the best option at this time.

After drawing the main plan on an Autocad scale of 1/400 as shown in figure 18, locating the trees and palms on the main plan became much easier. However, the plantation's specimens were still unknown, and the plant groupings were still unclear. Thus, on a small paper, sketching seemed to be efficient to position the plant groupings more precisely. Furtherly, to map the plantation and record them

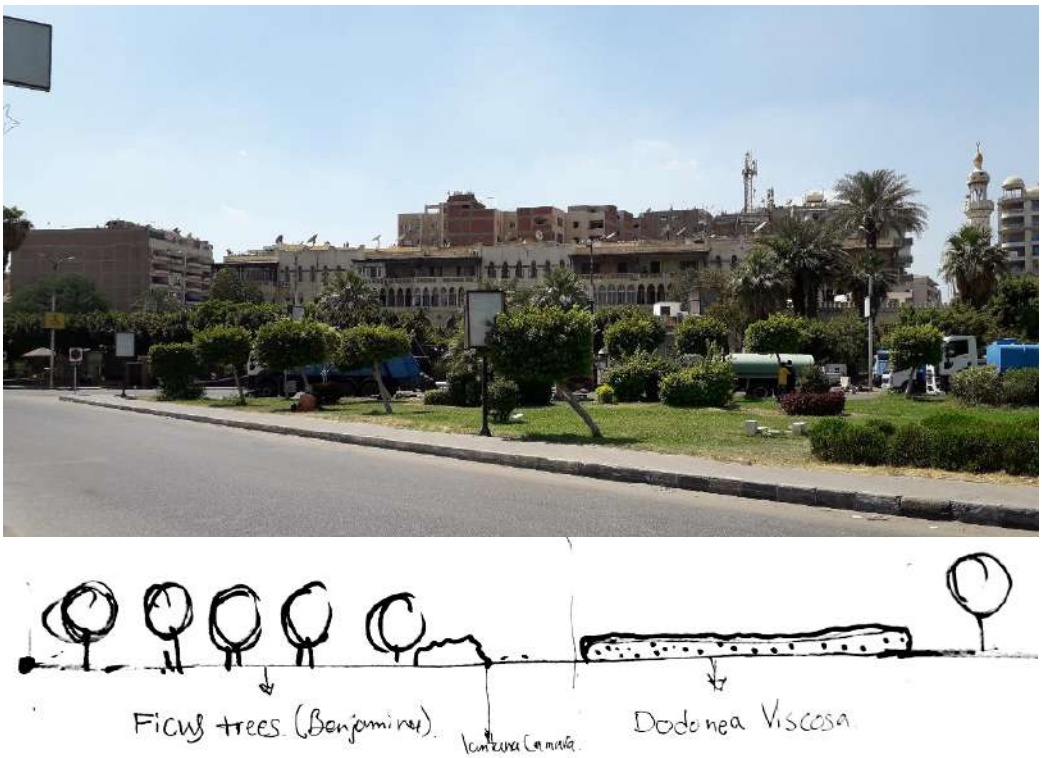


Figure 19: compiled image. on top show one side of the zone B garden looking from Othman Ibn Affan st. underneath shows manual sketch done mapping the plantation with plantations names. Source: done by researcher.

in their existing state, pictures had to be taken as a reference guide for the future as shown in figure 19.

Consequently, to avoid any confusion between various planting specimens, plants Latin names have been added to the sketch. I consider myself very lucky as I already knew all the names of all specimens from my previous work in landscape design. Most of these specimens are commonly used in Cairo, Egypt.

Like a domino effect, a full sketch is made mapping all shrubs, palms trees highlighted in their approximate locations. This was the foundation, to build a full vector drawing for both zones A and B.

To conclude, a pictogram is presented to structure how all these steps are taken into consideration together in a simpler way as shown in figure 20.

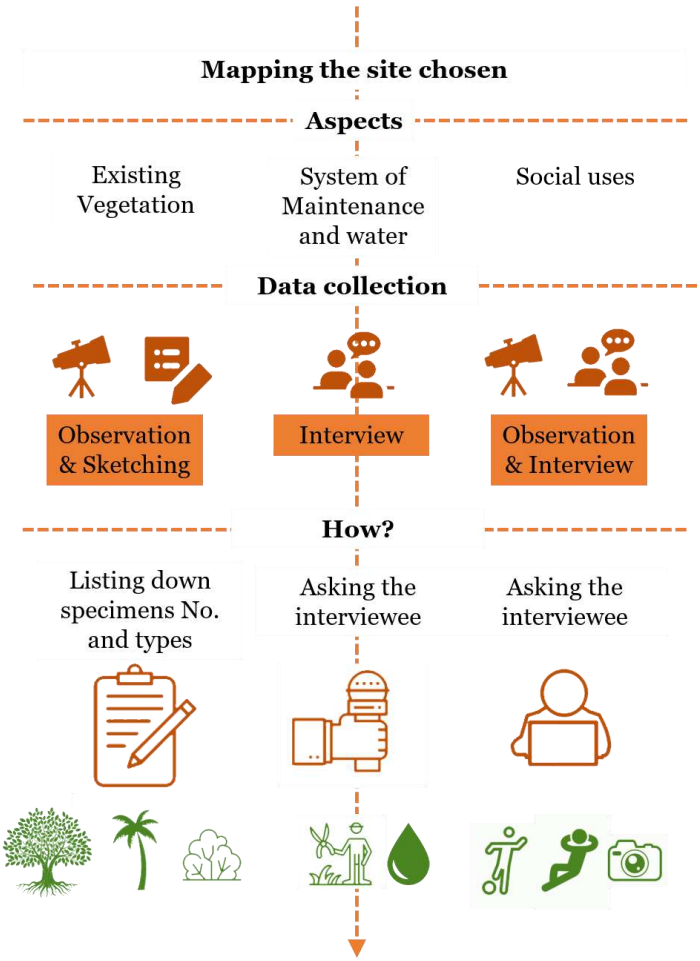


Figure 20:showing an infographic of how the mapping and data collection taken place for the targeted site. Source: done by researcher.

9.5.4. Planning a new design

While mapping the area, I have noticed that various people use this place as a chill-out place in the day time. Most of these people appear around 1 pm are workers from the garbage and cleaning authority (الهيئه العامه لنظافه وتجميل القاهره فرع مصر الجديده) which is right in front of the garden as shown in map illustrated number 22. Workers usually come to the garden to have a break under the shade of trees lying on the grass. As shown in figure 21.

Figure 21: picture showing workers from around places having a break under the shade of trees. Source: shot taken by researcher.

Away from the worker's category, you can also find youth in this garden, day and night. Usually, they, come around 4 pm when the sun breaks-down. They come to have a nice chat over a few drinks chilling on the grass. Furtherly, the nearest kiosk they buy from is at the end of Al-Ahram street. This is where they buy their snacks.

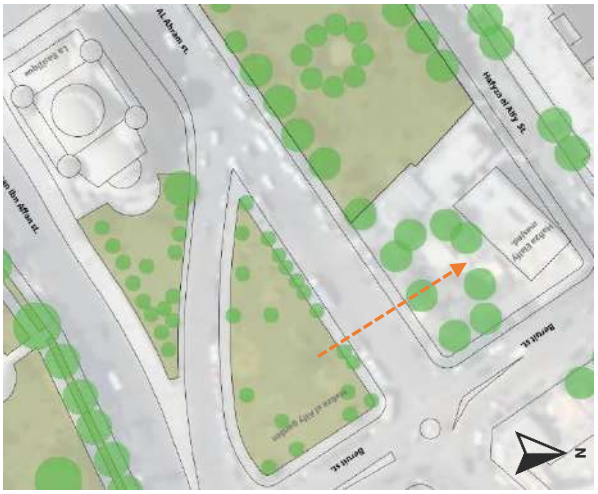


Figure 22: zoom in map showing the public authority in front of the targeted garden. Source: done by researcher

They use the trees as a canopy to protect them from the sun and they use the grass as a playing field. Few of them find it fortunate to have an open free space with few blooming flowers where they can come and take a few pictures with them in the background as shown in figure 23.

After understanding to a certain extent how people use this place, the pieces of the puzzle started coming together to form a new proposal.

The aim of redesigning this garden is sole to provide better alternatives to vegetation and grouping methods that will mitigate in reducing the PM in the air. However, there are existing patterns of activities, that need also to be taken into consideration.

Walking through the garden, time-by-time, inspired me to create a few sketches of how plantations could be regrouped and reinforced with new ones. The importance of these sketches is it showed what could be do dealt with from the existing green fabric as shown in compiled sketches in figures 24 and 25.

Figure 23: shows youth having a snack under the shades of trees at the site. Source: shot taken by researcher.

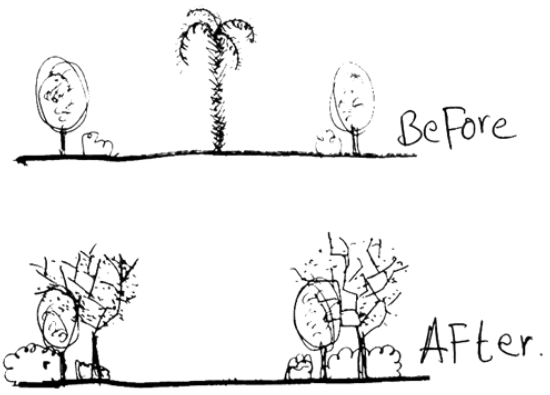


Figure 24: sketch showing before and after grouping modification to the existing Ficus trees on the border lines. Source: done by researcher.

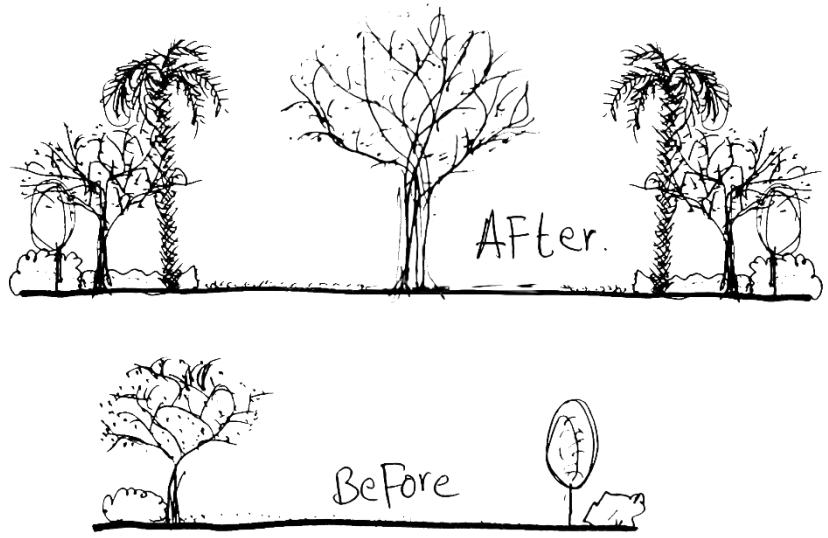


Figure 25: sketch showing before and after grouping modification to the existing Ficus trees to formulate a entrance for zone A garden and creating a focal point tree with large shading area. Source: done by researcher.

From the look on the plan after mapping all vegetation together, it is seen that the result is chaotic! The only order that can be seen in both zones A and B is planting *Ficus benjamina* tree around the borders along with having *Dodonea Viscosa* as the main shrub to complete the borderline. Unfortunately, the garden was not in a good condition. There were missing plants various empty spots in the garden without trees or even shrubs. However, why the garden ended up in this condition is not the question now and is an important question that will be discussed later in another section of the researcher.

9.6. Forming the design proposal

The first principle in this redesign is to plant vegetation that can support each other, throughout the whole year. In other words, it is highly recommended to choose specimens that are both deciduous and evergreen. One of the reasons why this is important, that if one type of tree got infected by a disease, it would not

spread to others very fast, as this is more likely to happen between the vegetation of the same type. Especially *Ficus* trees, as there are commonly used in Egypt and generally they get maintained by clipping its leaves and branches. Likewise, the other benefit of having deciduous trees is that it collects dust particles, more frequently, because of its last longing leaves.

The second principle is regarding water needs and drought tolerance. Unfortunately, due to the warm-hot climate in Cairo, it is highly suggested to plant more vegetation that requires a minimal amount of water. The availability of water for the next upcoming years is highly concerned. One of these main concerns is the upcoming water dam built by the Ethiopian government on the Nile river illegally. Which makes huge concerns about Egypt's share of water, as the Nile river counts as a main source of water to the country.

Lastly, the social aspect; which counts for keeping enough space for visitors to maintain their activities as discussed above. However, all these aspects were taken into consideration and the main plan has been drawn as shown in figure 26. The plan shows zones A and B drawn to scale 1/400 showing main entrances proposed and new plant groupings built upon the existing greeneries. Each zone will be explained in detail in the next chapter.

However, to have an overall understanding of the design approach. Furtherly, after the mapping stage, a structured plan is made to compile the design aspects in one diagram as shown in figure 27 to ease summarizing the steps together.

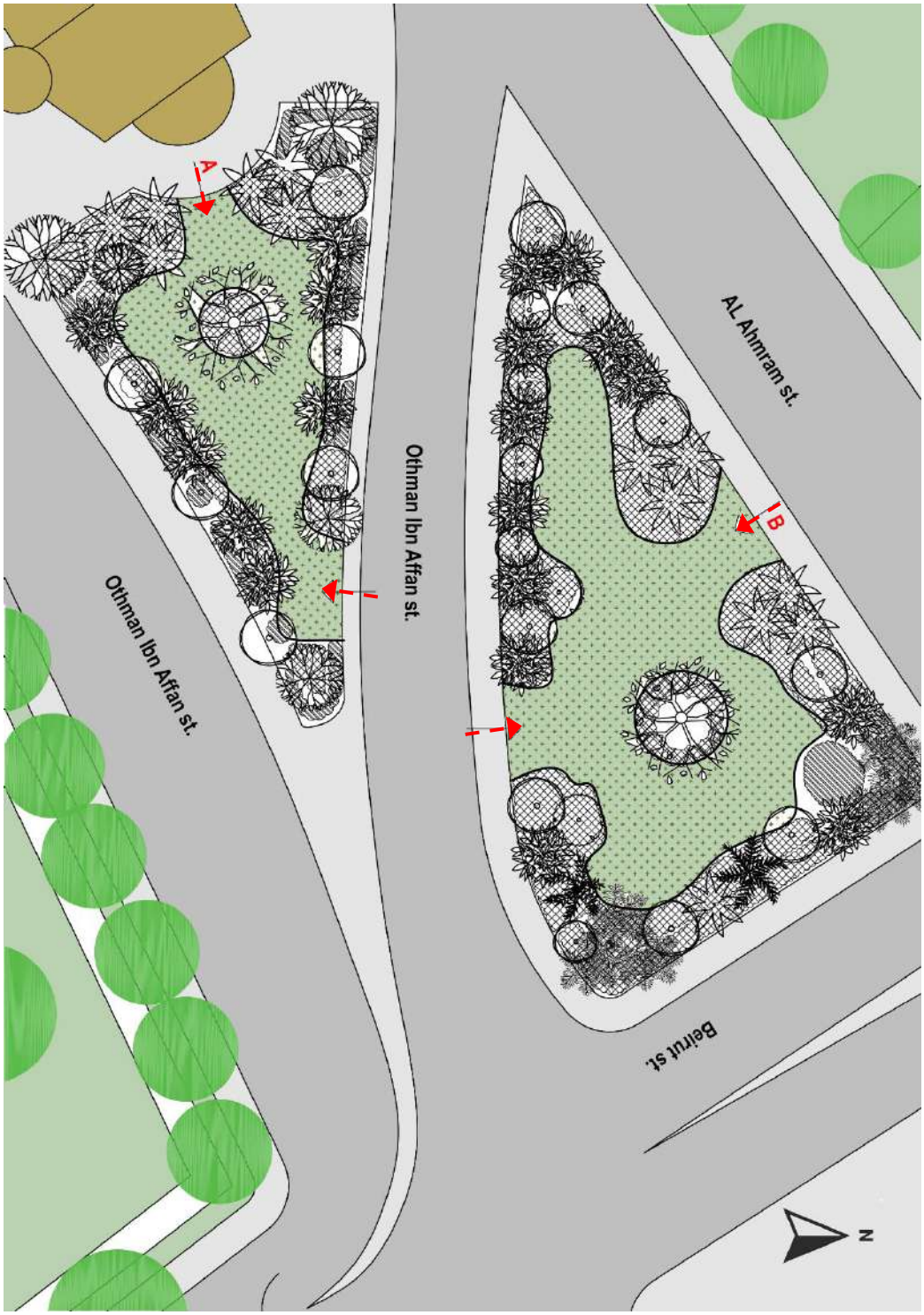


Figure 26: Main Plan scale 1/400 showing the new proposal for zone A and B. Source: done by researcher.

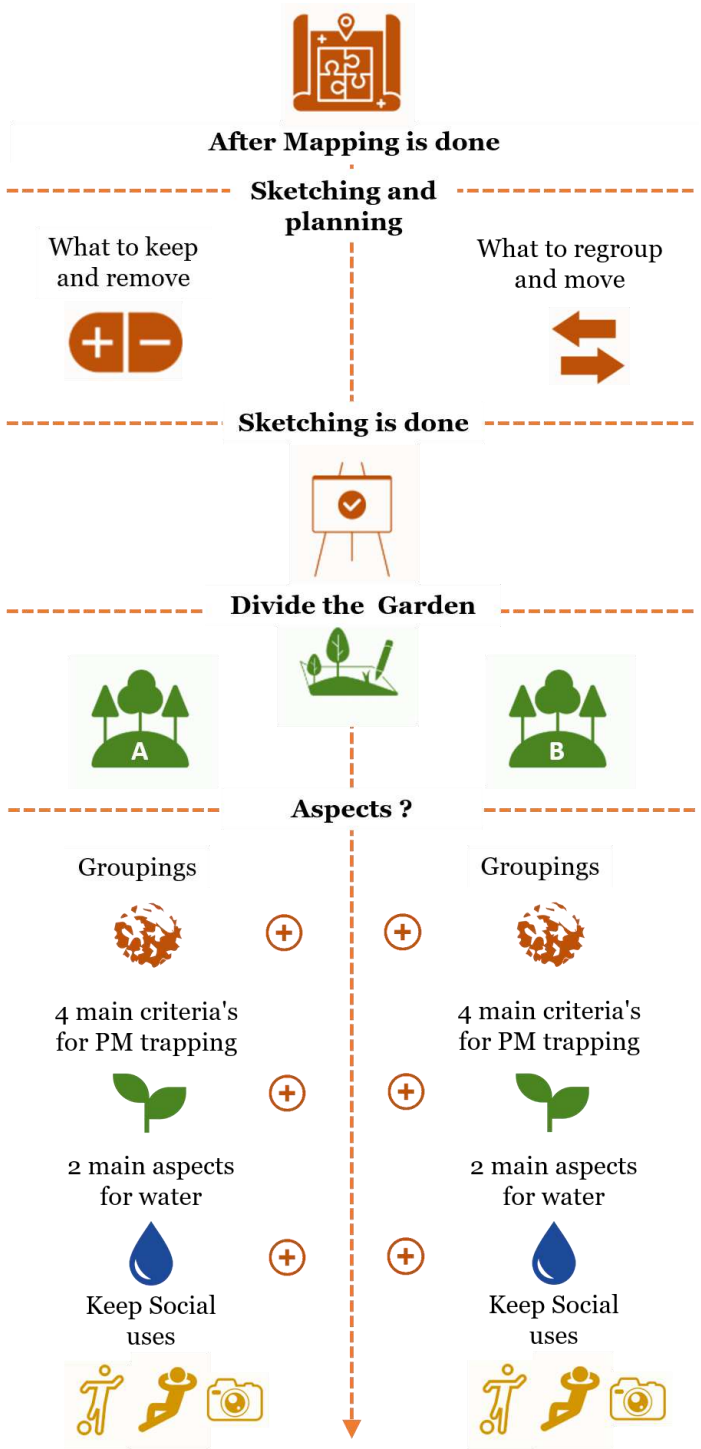


Figure 27: structure showing the planning for design targeted garden. Source: done by researcher.

9.6.1. Zone A

Starting with zone A, the scattered palms in the middle of the zone will have regrouped to form a cheerful entrance from the church side. Additionally, Washgntonia Palm is added to the existing *Delonix Regia* on both sides. This will help to provide a cheerful entrance to the area as shown in figure 28.

Figure 28: Render shot for zone A main entrance from the church side. Source: done by researcher.

Secondly, all *Ficus* trees on the outline will be kept and regrouped with new deciduous trees. From the list of vegetation obtained in the previous chapter of this research, top plants will be used in this proposal such as *Sesbania Sesban*. This tree, for example, is deciduous, scores full 6 points for both PM trapping and water minimum requirements.

Moreover, a few *Delonix regai*, will be added to the other entrance to the same zone to form an entrance like figure; looking forward to Othman Ibn Affan street. Furthermore, one *Ficus Bebghalensis* will be added in the heart of the garden to act as a focal point, where visitors can come around and have a nice shade underneath as shown in figure 29.

Figure 29: Render 3d shot for zone A proposal. Source: done by researcher.

Thirdly talking about shrubs and groundcovers. Unfortunately, the whole area is covered with grass, which consumes a huge amount of water every day. By approximate figure one m2 of grass consumes 4.5 liters of water each day. This means that for zone A only, the grass consumes around (758*4.5= 3411 litters of water every day).

In the new proposal for zone A; the grass area is decreased to be around 393 m2, which is about 50 percent of the existing fabric. The other 50 percent is used by vegetation that will be chosen to form the obtained top vegetation list from the previous chapter. These specimens should, consumes a minimum amount of water and best trapping of PM, such as 6 points specimens from the list such as: (Nerium Oleander, Euphorbia milii, Acokanthera Spectabilis, Cassia Tomentosa, and Hibiscus rosa, etc.). All these shrubs are ever-green with different flower colors and even leaves colors. However, if we would like to add deciduous shrubs we can add something like (Pachypodium lamerei) as shown in figure 30.

Figure 30: Rendered shot for zone A showing layering of shrubs having Nerium Oleander as main backdrop along with Acokanthera Spectabilis in pink and white ,Euphorbia milii and Hibscus rosain in red for the second layer along with cassia tomentosa in yellow. Source: done by researcher

All these specimens require around 2.5 liters of water each day; which means by using these specimens we will be saving around another 50 percent of existing water consumption done by grass. In total, we will be saving 1705 litters a day. Nevertheless, talking about the PM value, these specimens ranks on the top more than *Dodonia* shrubs and of course grass which was scattered everywhere in the garden. In the end, the result is clear, the garden is vibrant, the green open spaces increased having maximum shade for visitors to use, and minimum water consumption for plants.

9.6.2. Zone B

In Zone B, vegetation's generally will be regrouped and moved from the middle zone to the outline of the garden. The scattered shrubs such as Didonia, Lantana Cammara in the middle will also be is removed. This will give more open green space in the middle, giving more opportunity for a wider specimen to give shade, as shown in a general view in figure 31.

Figure 31: Render 3d shot for zone B proposal. Source: done by researcher.

Secondly, the Ficus trees on all edges will be kept as it is, however as they are all evergreen trees, they must be regrouped with deciduous trees. According to the list of trees provided previously in the research, we can choose 2 main deciduous specimens that score full 6 points. These are (Sesbania Sesban and Castanea Sativa Miller). These 2 trees, full score points for trapping PM, and excellent in withstanding drought.

Moreover, 3 Washfntoni palms, will be added to each side of the entrance the with the only existing palm on each side of the entrances; looking forward to AL-Ahram street.

Figure 32: render 3d shot showing entrance from Alahram st. decorated with Washgntonia palm on both sides. Source: done by researcher.

In addition to this, another Ficus Bebghalensis can be added in the heart of the garden to act as a focal point, where visitors can come and gather around. The visitors can enjoy some nice shade and nice pictures with the fleshy greens in the background as shown in figure 32.

Thirdly, talking about shrubs and groundcovers. Unfortunately, the whole area is covered with grass, which consumes a huge amount of water every day. This means, that for only zone B the grass consumes around (1363*4.5= 6113 litters of water every day). In the new proposal for zone B; the grass area is decreased to be around 708 m2, which is around 50 percent of the existing fabric.

On other hand, the other 50 percent is covered by other vegetation which consumes a minimum amount of water and has a high rate of trapping PM, such as: (Nerium Oleander in pink and white color working as a Skelton, *Euphorbia milii* and *Hibscus rosa* as a decorative element with their red flowers and finally in yellow *Cassia Tomentosa)*. Furthermore, all these shrubs are evergreen. If we would like to add Deciduous shrubs we can add something like (Pachypodium lamerei and Euphorbia cotinifolia).

All these shrubs specimens require around 2.5 liters of water for every 1 m2 each day. In other words, we have decreased the grass area by 50 percent and planted more efficient specimens for water and PM value instead. Thus as a result we save around 25 of the grass existing consumption. Which is about 340 liters per day.

As a general result, the full image of both gardens will look similar, with a bit of difference with the preliminary existing vegetation in it. All, green grass floor has been minimized from the borders and rearranged to provide wider space in the heart of each side.

Secondly, all existing trees have been kept and furtherly supported by new trees such as *Ficus* trees on the borders, that have been regrouped with *Sesbania Sesban* trees to form a stronger hedge for trapping PM. Furthermore, the scattered palms in the middle of both zones that again were regrouped and added with a few more of them to form a more delightful entrance.

Thirdly, using the existing shrubs on the borderline such as Dodonia shrub. These shrubs were increased in the proposal as a back hedge and then reinforced again other shrubs such as: (Nerium Oleander as the main backdrop along with *Acokanthera Spectabilis* in pink and white, *Euphorbia milii* and *Hibscus rosain* in red for the second layer along with *cassia tomentosa* in yellow) as shown in figure 33.

In the end, a full image is presented to show the complete final look for both zones as shown in figure 34.

Figure 33: render 3d shot showing layers of shrubs starting with Dodonia in green color and ending with cassia tomentosa in yellow. Source: done by researcher.

Figure 34: render shot showing both zones A and B with its surrounding complex. Source: done by researcher.

9.7. Further vital personas realization points

After setting the first proposal design, new questions appeared to put this design proposal into reality. This is very important as these questions reveal a new side of the story and it opens another level of discussion, that may open new ways to do more research about upcoming studies.

Walking through this area was a natural thing to do since I was 16 years old. However, for the first time, I looked at the garden and the surrounding area from a different perspective. I was seeing it, to understand how it works, and why it ended up looking like this after it was full of fleshy greeneries, who is responsible for this, and what system do they have to keep maintain it?
There must be some answers to these questions, someone to explain what is happening! Therefore, the next step was to find some clues and connections to explain what is happening.

Fortunately, after other site visits with potential stakeholders and searching in the authority organizational chart who is responsible; the main personas has been identified. These People have been identified and meet either physically on the site or through a phone call interview. However, these points of realization are furtherly explained and categorized by main personas and it will be furtherly explained and discussed in the next chapter.

9.7.1. Mr. Ramadan gardening routine

The first person I have met was Mr. Mohamed Ramdan. Ramadan has been working in this area for more than 3 years. He clarified important points regarding the maintenance routine and watering system. He said that in regards to the maintenance routine, he works 5 days a week, he starts in the morning around 6.30 am until around 10 am. He only works in this area around this time as he is also entitled to taking care of other nearby green plots.

Furthermore, he highlighted that the (هيئه النظافه وتجميل القاهره) the government authority who is responsible for taking care of theses plots does 2 main nurturing sessions to all outdoor green pockets. One main maintenance in the summer season and the other is at the beginning of the winter season. This maintenance includes adding compost, and other minerals to the soil to keep it nurtured for growth. Also, the pruning sessions are done on yearly basics, it is done manually, and all green scraps are furtherly collected for creating new compost.

Figure 35: Watering truck used to transport water for watering vegetation with no point source of water. Source: shot taken by researcher.

It is also important to mention that the watering system in this area gets done manually every day in the morning. Fortunately, the Heliopolis area has various open sources of water and doesn't need water to be transported by a truck as shown in figure 35. Unfortunately, according to Mr. Ramadan, some places he says do not have a direct source-point of water and they have to transport water by a truck every day to keep the plants alive.

Mr. Ramdan hides a 40 m long hose of water in one of the underground swearers' rooms, as it is too heavy to carry every day to the garden and he does not any sort of storage room to keep his tools in as shown in figure 36.

Figure 36: compiled images from a site visit at the Basilic garden. on the left shows the sewer room, in the middle shows an open source of water and on the right picture shows Mr. Ramadan the gardener. Source: shots taken by researcher.

He simply opens the main access of water and starts watering the land by himself after collecting the rubbish on the grass. He mentioned also, sometimes, he keeps the main hose open while he collects the rubbish from the ground or until he trims some of the shrubs to save time. He does this, by creating the main canal in the soil connecting all trees, and then opens a stream of water. This method just reminded me of how our ancestors used to water the green fields in old Egyptian times!

Furthermore, in regards to planting regulations in the garden Mr. Ramadan was of a great assistant. During the interview, he explained what may happen if the plants got sick or died. Unfortunately, the reality is that if any vegetation got sick and died it is really rare that the mangers from a governmental authority (الهيئه العامه للنظافه و التجميل) will add any. He clarified that this area used to have many other plants and trees, but they usually die because of a lack of resources. Even though the source of water in the garden uses greywater, Mr. Ramadan said, “it is not enough to keep the plants healthy”.

Furthermore, I asked him" What do you think could be done to make your job easier maintaining this garden?". He replied with a simple thing to have to make his daily routine much easier on him. Things to have such as: (new scissors as the gear he has got dull from sharpening it with rocks and a locker have where he can keep his tools in safely.

9.7.2. Fortunate gardens

Furtherly, in regards to the facts about gardening maintenance done by governmental authority "الهيئه العامه للنظافه والتجميل " another interviewee "Eng. Rehab Ali" gave some valuable information. Eng. Rehab is a landscape manager working at one of the leading landscape companies in Cairo Egypt. With more than 10 years of experience, she said "usually, each green plot gets treated differently according to the district manager of that area and according to an opportunity suggested by a private investor to the governmental managing entity such as (جهاز المدينه). For example 5th settlement new Cairo, in 90th main street, we can find the main square is named after a residential compound called Mountain View.

Figure 37: Mountain view square at 5th settlement. Source: Instagram account of mountain view. (Anon., 2020)

The compound representative's area responsible cultivate it and maintain it generally after taking permission from district authority (جهاز المدينه) New Cairo, 5th settlement branch. After visiting this square personally, it was clearly shown that there is a huge difference in garden design and maintenance level compared to the Basilic garden in Heliopolis.

The level of execution, maintenance, and landscape design is much higher than what is done at the Basilic garden. This area had regular maintenance, uses a sprinkling system for watering, has lighting elements, and other decorative physical elements as shown in figure 37. Eng. Rehab said: because this plot is for private benefit, it will always have more flexible means to get better every year in fields of design and execution; as a result, people enjoy it more.

9.7.3. Unfortunate gardens

In light of the public controlled management, two main people were of great insight into this topic. The first person is a Ph.D. Student Merham Keleg who had previous research work with different authority members from (The Authority of Cleaning and Beautification of Cairo). Moreover, the second person is Eng. Fayza Mohamed. She left her title as a manger from (الهيئه العامه للنظافه والتجميل, اداره الجهود الذاتيه) on2/May/2018.

The phone call interviews with both of them were highly informative about the current system. However, the discussion with Merham Keleg, was generally about how government authorities plan and execute gardens and recent projects were mentioned to give examples. She mentioned one of the recent urban traffic solutions also in Heliopolis city but a different area. Specifically, around January 2020, the Cairo governorate decided to build not less than 9 bridges in what so-called the "Masr El-Gadida or Heliopolis development plan".

The project development aim is to solve heavy congestions at Heliopolis roads. The strategy included widening the streets in the district, turning some of those streets into highways locating it in the heart of residential areas. However, the result of the residence around the area is catastrophic! Before and after images explains the whole situation as shown in figure 38. The project is implemented by the army's Engineering department which is racing to finish the project as soon as possible.

Figure 38: Before and after images showing the new traffic road after removal of the garden at AL Nozha street. Source: (Zeinobia, 2020).

However, with less consideration to the existing old trees in the area, the plan was to wipe entirely all greens and build concrete roads, just to save time as the time, the plan was to make this happen in around 100 days! According to the citizens of Heliopolis, not less than 90 Feddans of green spaces were wiped out completely in that plan. The citizens documented all those green spaces gone in the wind by number and location and it is more than shocking.

Figure 39: one of the old trees removed for planning new roads for Heliopolis traffic congestion. Source: (Zeinobia, 2020).

They documented all those green spaces on Google earth (Anon., n.d.) We are speaking about nearly 375,000 square meters of green spaces. Adding up to this, according to the citizens of Heliopolis' estimations and Heliopolis Heritage Initiative, 2561 trees were cut in the district since August 2019.

Unfortunately, some of those trees are 90 years old!! As shown in figure 39 (Zeinobia, 2020). Then sadly, the woods of those trees are sold to factories mainly producing Shisha or Hookah's Charcoal which is a very big market for production.

It's quite sad to witness such a massacre, at the same time when the current minister of environment Yasmine Fouad decided to designate the month of January in Egypt as the month of afforestation. Happily, the environment ministry launched a nationwide campaign for afforestation called "Be ready for the green" or "Live Green" or as in Arabic "اتحضر للاخضر". But the current actions make no sense; the cost is heavy on the environment.

This scenario makes you question so many things, such as: who is taking these actions, and on what basis the authorities can take such drastic measures towards the massive green areas? Is there no collaboration between authorities to find a better solution which serves the environment and solve traffic issues?

During the phone call interview with Ph.D. Student Merham about her opinion towards this, simply said "this is quite a normal action from the authority of "Cleaning and Beautification of Cairo "as its main manager has no environmental background. After all, he is a retired military General! Mr. Adel Mohamed, the general manager, is indeed a great man serving the military. His academic achievements are Holder of Bachelor of Arts in Military Sciences 1981 and Master of Military Sciences from the College of Leaders and Staff. He also obtained, a fellowship of the High War College from Nasser Higher Military Academy. Furtherly Graduate Diploma holder in Human Resources Management 2009/2010 (Anon., 2020).

Furthermore, Engineer Fayza and former manager of department “Self-efforts” in Cleaning and Beautification of Cairo” clarified that all designs and orders only come in a one-way direction. Meaning that, after discussion within the top authority, orders are sent to the next minor department allocated to each district to carry out strict orders. Which puts an imaginative picture of how a general is dealing with their soldiers.

In the end, the aim here is not to blame any specific entity, but rather clarify just a small side of the story. A story of the missing chain between project research preparation and project management execution; adding up to the fact of having a very tight schedule. Another point to highlight, that there is clearly, lack of specialty placement for leadership and management; after-all when it comes to dealing with nature and landscape, there must be environmentalists, researchers, or even landscape architects and engineers to help in decision making.

There must be more awareness in dealing with a green environment along with studying the surrounding context to get optimum solutions. All these points of realization are gathered in one chart to simplify and conclude the main points of discussion showed in the next figure 40.

Figure 40: Pictogram showing the summary of points of realization categorized by main Personas. Source: done by researcher.

9.8. Further aspects of Design

In the past section, the design approach for both zones A and B is initially and primarily to redo this area for the sake of compensating for air pollution using natural vegetation. However, after reaching the design goals, I wanted to check if this proposal yet fits what happens with the existing fabric and main users. Therefore, I created small flyers from the rendered shots produced to cheek the garden user's opinions and acceptance? Surprisingly, other aspects of design appeared after evaluating the design rendered proposal to the visitors on-site for future evaluation.

Basically, in simple words. I took some small printed flyers with some extra shots in colors and started asking the garden users on-site about their opinion about the first proposal produced as shown in figure 41.

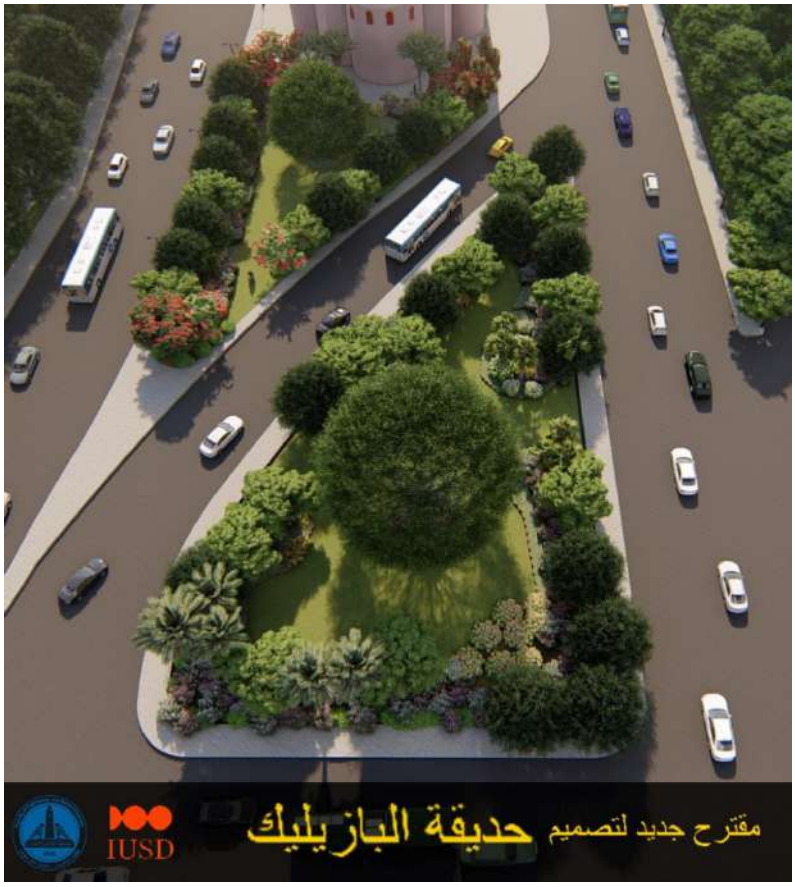


Figure 41: Flyer proposal for Basilic Garden. Source: done by researcher.

However, it was not just random, I knew before already that there are main 3 personas to focus on as they are the most frequent users of these gardens. These 3 personas could be simply summarized as the gardener and maintenance workers, the youth who comes to mingle and chill at the garden around the mid-day, and garbage collection workers who come to the garden to have some rest in the early morning.

The site interviews presented new visions of what the garden design may include benefiting each persona from their perspective. These aspects will be furtherly demonstrated and discussed in the following section. Therefore, in this section, the aim is to demonstrate another proposal serving these new points of realizations, adding a new layer upon the green proposal shown previously.

9.8.1. Mr. Ramadan "Gardner"

Talking about Gardner again "Mr. Ramadan", who I had the privilege to interview him before. Generally, I asked him about what he thinks of the garden proposal presented on the flyer and the discussion started opening different topics.

Firstly, he referred to the flyer images as heaven! He told me "that coming to such a place every day for work and seeing these beautiful greeneries and seating under the shades of trees would make his day joyful ". However, he raised the storage issue he informed me about before and said ''I would love to have just a small box with a lock to keep my stuff without worrying about it from thieves".

This showed that the garden is not always a leisure place for all, there are workers (Gardner's) who are also a part of the equation and their opinions must be considered. Therefore, setting this storage box was a mandatory request for him.

One more thing he highlighted, is that during his break time he usually gets some food from a close-by street vendor to enjoy it under tree shades and he thought it would be a nice idea to have that small vendor within the garden. However, surprisingly, he canceled the idea from his head.

He said, “I will stay all day and night cleaning up after the people if it did happen, especially the garbage collection workers on the opposite street”. He said “they make the place worse and they end up cleaning their miss in front of their entrance after eating from Mohamed (a street vendor who sells Egyptian street food). This added another insight about the availability of outdoor trash bins for visitors to use, which is not existing in the garden anyway!

9.8.2. Ali and Asma “Youth students”

Ali and Asma are the second Personas, they represent most of the youth who comes to have a break in the outdoor air; their sole purpose in the garden is for leisure. After showing them the design proposal for the garden their reaction was quite positive as it gives the place a new look. However, it missed some aspects according to them. They said, that this place looks like “Bat house at the night” so when they come to the garden at night they usually stay at the end of the garden, next to Beirut street as there are existing light pools which make them feel a bit safe.

This particular comment made me wonder, how is a garden in the middle of a highly congested neighborhood stands without lightings? This issue defiantly added another point to the garden requirements; which is lightings.

Additionally, they talked about the possibility of adding small kiosks to the garden to keep it more alive. They said that the surrounding streets have various street vendors and coffee shops as shown in figure 42 and it would complement the surrounding street vibe to have kiosk also inside.

Figure 42: 2 pictures showing various street vendors, coffee shops and cinema around Basilic garden. Source: photos taken by researcher.

However, this brings up the discussion again if the garden will be considered as a garden when buying and selling activities are set 24/7. Therefore, what seems to be practical and convenient for the second proposal, is it to plan these kiosks occasionally and not permanently. Thus the main purpose of the garden would be for relaxation and breaking out of the vibrant streets around.

9.8.3. Mr. Mahmoud "Garbage collection worker"

Thirdly talking about the third persona, Mr. Mahmoud, the third persona, who opened a new discussion to the design proposal. It seemed to Mr. Mahmoud that this place is just as a resting place, a place where he comes have something to eat, drink, and wash after a long working day in garbage collection.

The beautiful colorful images as flyers did not make a strong impact on him. He simply said, "nice images, it would be nice to see it in reality". The conversation about how the garden may be better was not of interest to him as long as the design proposal keeps some green flooring. This would be the most crucial thing to him as it is his place for relaxation after a long tiring day in garbage collection.

9.8.4. Design proposal conclusion

At this moment all the pieces started to come together to make a full image presenting the second proposal. This proposal is shown in figure 43 and will be discussed in points furtherly.

Firstly, in regards to lighting elements, the existing lighting pools presented in black colored dots as shown in figure 43. They are mostly located away from the garden outline making it looks dark at night. Therefore, adding new lightings as presented in orange dots from figure 43 will be of great benefit within the garden and on the outline. This will bring more users to the garden at night. Furtherly, cross signs area added as shown in yellow strips on the surrounding 2 main streets. This may help to increase safety for users to pass from and beyond the garden.

The second point is related to adding temporal activities to the garden such as having kiosks. However, this would add the risk of increasing trash and of course, the fact that the garden will become more of a heightened, crowded, and noisy place. Therefore, the proposal now is to have temporary kiosks that can be set into seasonal occasions as a recommendation and install garbage bins within the garden. In this way, the garden will be always inconsistent change, clean and will bring new vibes to the people as well as some extra income, that can be used for garden maintenance and upgrade.

The third point is the fact that the garden is not equipped with any seating elements and sooner or later with people coming over walking on grass, the grass will disappear. Therefore, adding pavements with the respect of keeping a few grass areas as well adding few seating elements shall be considered.

In the end, this proposal is simply more reactive to the existing users and surroundings.

In the end, these modifications shall add a new perspective on how gardens should be designed. The fact is that the surrounding context and main stakeholders have a strong impact on how this garden is formed and how it will

exist for future use is shocking! This brings us to a conclusion; that any project design meant for the people has to be communicated with the people. This will ensure maximum benefit and use to both sides; the designer committee and the user.

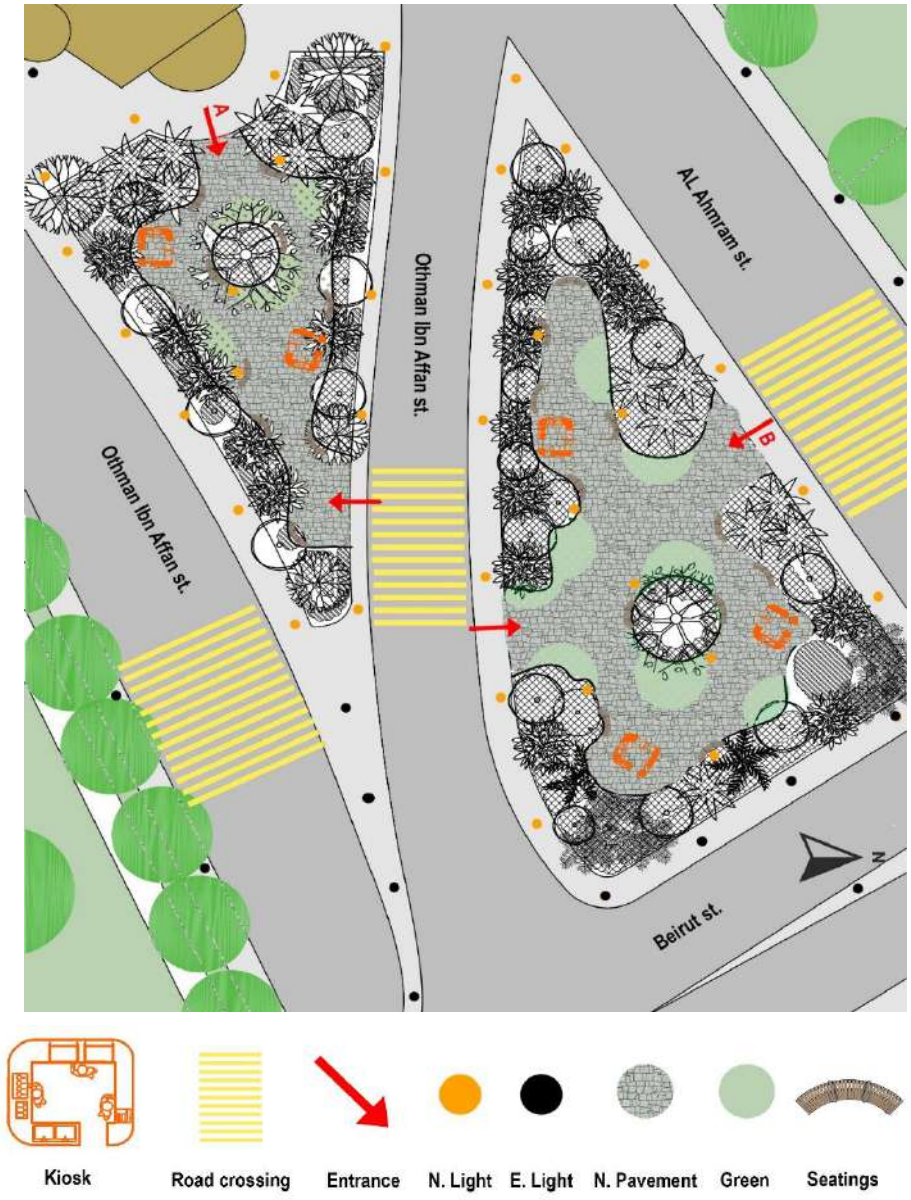


Figure 43:Main Plan scale 1/400 showing second proposal for zone A and B. Source: done by researcher.

Chapter4: Discussion and conclusion

10. Chapter4: Discussion and conclusion

10.1. Design proposal for zone A and B

Unfortunately, the state of both gardens was in sort of neglection and miss planning and organization. We can say that there is a level of unawareness of what this garden might provide for the community and the environment. This sad story has a strong connection to the main organizational authority.

Both zones were almost identical with the same vegetation used for plantation. They all had Ficus benjamina trees as main border trees, Dodonia Viscosa as the main shrub, and grass as the main groundcover. After the discussion with Mr. Ramdan, who is responsible for this area he said: “The flowering trees such as Delonix Regia are becoming less and less each year in the garden”.

Furthermore, the idea behind having planting recommendations is to set suitable lists for planning green areas. Fortunately, the goal has been achieved, and a list has been produced with various deciduous and evergreen options of vegetation; grouped in 3 main categories. In the end, this allowed preparing a design recommendation for Basilic garden; aiming primarily to increase air quality.

However, after setting the list of vegetation and preparing the first design proposal new aspects of design appeared after revisiting the site's main 3 users. At this point, the point of creating a design proposal aiming to increase air quality became just the foundation layer to design the garden for the people.

Each group of people “stakeholders” had a point of view to add to the design. The (youth students) cared about having more leisure activities and safety. Therefore, adding lighting elements, crossroads signs, and street vendors made perfect sense to them. On the other hand, (Gardner) wanted to feel relaxed and job security. Therefore, adding lockers where he can keep his tools in and garbage bins to the garden was of great help to him. Then comes (Garbage collection

workers), who cared more or less about having grass flooring for resting after a long day of work. Therefore, the garden flooring kept few spots in green, in respect of paving the rest of the grass area to gain more solid ground for other activities. In the end, as a result, a pictogram is presented to show how each persona help in adding design aspects to the garden as shown in figure 44.

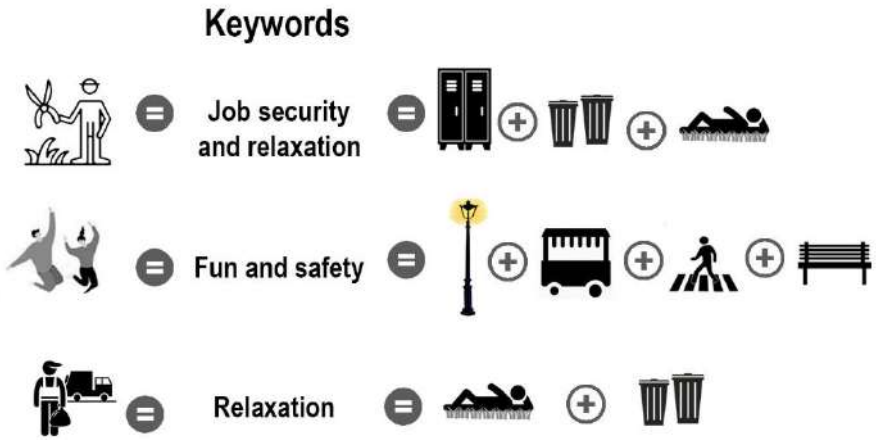


Figure 44: 3 main personas main request presented in keywords and their design aspect recommendations to Basilic garden. Source: done by researcher.

The main conclusive point here is that after presenting the first proposal to the people, each stakeholder had an added point to the design proposal. Which means, that the process of design, from one side point of view! Therefore, the garden design must correspond to the surrounding context and users. Thus, any design proposal for the people must be discussed with the people, to ensure maximum benefit for both hands. The designers on one hand and the user on the other.

10.2. Watering system

Unfortunately, it seems using grass as a main groundcover is the easiest way to plan any green open spaces in Cairo. Regardless of the cost, even though Egypt as a whole, faces water supply issues. Furthermore, grass needs regular pruning throughout the whole year, requires frequent compost and minerals.

Setting plantation groups, that are water-sensitive is highly recommended for garden design in hot climates. However, having a controlled watering method will increase the effectiveness of vegetation survival and usage of water. This also will provide help to the gardener, as it will save time, so he can do other tasks of maintenance such as the pruning of trees and shrubs. There is various irrigation system nowadays, and the automatic drip irrigation is used widely for private sectors in Cairo Egypt

Even though the drip irrigation system is an old idea system that existed before 1950, it was revolutionized by Israeli water engineer “Simcha Blass” in the 1960sand the slowly it spread across the globe until nowadays. (Leichman, 2019).

It is time to open this topic, because Egypt now, faces the threat of water scarcity. Egypt uses Nile river water as the main source of water for irrigation and public use. Furthermore, at the center of the dispute lies the Ethiopian dam, which will control the flow of water coming to Egypt.

However, hydroelectric power stations do not consume water, but the speed with which Ethiopia fills up the dam's reservoir will affect the flow downstream. Moreover, the mega-dam has caused a row between Egypt and Ethiopia, and Sudan is caught in between, which some fear could lead to war, and the US is now helping to mediate (Mutahi, 2020).

10.3. Management and planning level

Numerous governmental bodies are mandated with green spaces in Cairo. However, each body works on a different level and has its agenda and perspective on the issue of green spaces, says Eng. Merham Keleg in her research as illustrated in Figure 45.

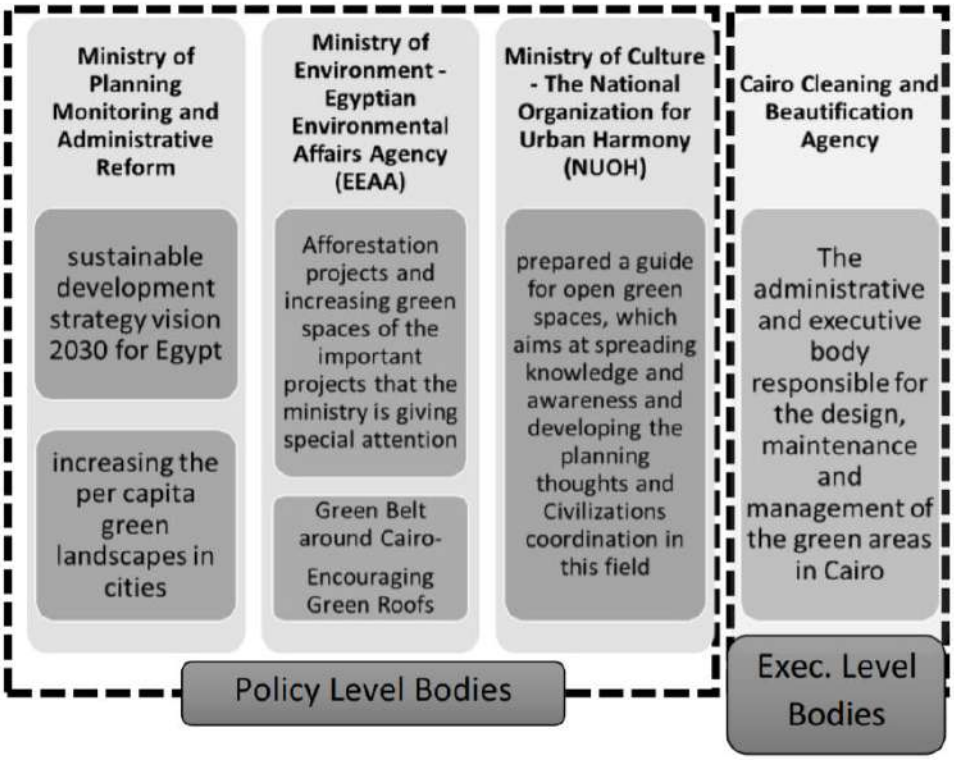


Figure 45: illustrated the main bodies in Cairo mandated with green spaces provision or monitoring. Source: (Keleg, 2018).

The investigation about authority management with Ph.D. student Merham and Former authority manager Eng. Fayza gave a clear understanding of what is going on in taking decisions.

What became clear after having interviews with them. First, the general management lack expert in landscape engineers. Furthermore, the main design aim is for beauty (looking green). Which causes, concerns about what are the standards of beauty? and who should set these standards? More or less, most of the plants chosen for the design comes upon availability from the mega

greenhouse which is situated in the Shoubra district or the sub-district greenhouses.

Another important aspect is concerning the flow of decision making to have a design plan and execution. Unfortunately, the existing structure is built upon one way of information between public and governmental authority. Moreover, the Case of Heliopolis city and the trees massacre is presented to support this claim. The project happened against the public residents well, only, for the sole purpose of winding the roads trying to solve traffic congestion in the area. Furthermore, the authorities neglected completely the importance of greenery which was estimated at 375,000 square meters.

10.4. Conclusion

There is no doubt that plantations have great tendencies to minimize air pollution both indoor and outdoor. Researches have proven that there are positive biological and physiological effects of having more greeneries in the surrounding environment. These effects may vary from increasing your hemoglobin rate in your blood, to decreasing headaches and making you feel happier.

Therefore, finding suitable specimens to work best according to your environment is an important goal. Fortunately, in this research a planting list has been produced, recommending the top specimen according to specific criteria. These criteria have been set for 2 main purposes. The first is to mitigate air pollution and specifically trapping dust particles and 4 aspects have been placed for rating them. The second is, water criteria, and 2 main aspects are placed for rating them. In total 6 points helped to achieve the main list grouped in 2 categories Very good and good specimens.

Eventually, the list could grow and become bigger, however, the Al Azhar planting book has been the only source of species used for filtration due to the availability of time.

Ending this section with a list was perfect, opening a new page to study a case and make a design proposal. This design proposal mainly focused on mitigating air quality using vegetation and did not take into consideration the surrounding user aspect in the design.

However, after setting the design proposal and meeting with potential users at the Basilic garden, new aspects and concerns of the garden users appeared. These aspects were related to the people around this area and how they use it.

These aspects widened the perspective of garden design and after meeting with potential users in the garden for the second time; the image became clearer and therefore a second proposal is made. This proposal had different elements of design added from the user's recommendation on the first proposal.

Investigating the design proposal with potential stakeholders, presented new approaches to what a garden design may need. Concluding that, there must be more researches attempts to reinforce research-based projects for green-open-spaces design in Cairo, Egypt. In the end, I believe that Cairo has a great opportunity to reconsider planning green spaces for future use. This use could be targeted for different goals, such as environmental, economic, and social goals.

Economically, trees may be used for the production of wood in the future. This will provide a great opportunity for market demands, as Egypt is a heavy importer of wood for manufacturing. Socially, the quality of life will increase. Nowadays, Cairo's green spaces share per capita of green spaces is low. It is low in share, even when compared to more arid cities than Cairo like Dubai says "Nezar Kafafy" an Egyptian scholar at Cairo University. (Nezar Kafafy, 2020).

Furthermore, the Local delivery plan should be properly communicated with local users, landscape specialists, and other emerging stakeholders. The collaborative efforts shall ensure a more sustainable design to benefit all users and enhance the air quality of the environment.

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Annexes

12. Annexes

12.1. Planting tables

12.1.1. Trees list

Number	Name of specimen (Botanical Name)	Large/ Long Leaves 15cm >	Hairy/ Throned/ Toothed/ Waxy/ Rough leaves	Desnse twigs	Rough Bark	Form (Decidious / Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									Max. 6
1	Sesbania Sesban	1	1	1	1	Decidious	1.00	1.00	6
2	Castanea Sativa Miller	1	1	1	1	Decidious	1.00	0.67	5.67
3	Citrus Limon	1	1	1	1	Evergreen	1.00	0.67	5.67
4	Citrus Medica	1	1	1	1	Evergreen	1.00	0.67	5.67
5	Cordi myxa	1	1	1	1	Evergreen	1.00	0.67	5.67
6	Ficus Bebghalensis	1	1	1	1	Evergreen	1.00	0.67	5.67
7	Ficus Lyrata	1	1	1	1	Evergreen	1.00	0.67	5.67
8	Ficus macrophylla	1	1	1	1	Evergreen	1.00	0.67	5.67
9	Gleditsia triacanthos	1	1	1	1	Decidious	1.00	0.67	5.67
10	Melia azdarach	1	1	1	1	Decidious	1.00	0.67	5.67
11	Terminalia catappa	1	1	1	1	Decidious	1.00	0.67	5.67
12	Morus Alba	1	1	1	1	Decidious	0.67	0.67	5.34
13	Balanites aegyptiaca	0	1	1	1	Evergreen	1.00	1.00	5
14	Ficus Auriculata	1	1	1	1	Evergreen	0.33	0.67	5
15	Olea Europaea	0	1	1	1	Evergreen	1.00	1.00	5
16	Plumeria Alba	1	1	1	0	Decidious	1.00	1.00	5
17	Tamarix aphylla	0	1	1	1	Evergreen	1.00	1.00	5
18	Aberia Caffra	0	1	1	1	Evergreen	1.00	1.00	5
19	Aphanamixis polystachya	1	0	1	1	Evergreen	1.00	0.67	4.67

20	**Callistemon Viminalis**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
21	**Casimiroa edulis**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
22	**Cassia Fistula**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
23	**Cassia Nodosa**	1	0	1	1	Decidious	1.00	0.67	**4.67**
24	**Cassia spectabilis**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
25	**Casuarina Cunninghamiana**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
26	**Ceratonia Siliqua**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
27	**Citrus Paradisi**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
28	**Cupressus macrocarpa**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
29	**Cupressus sempervirens**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
30	**Delonix Regia**	1	0	1	1	Decidious	1.00	0.67	**4.67**
31	**Enterolbium cyclocarpum**	1	0	1	1	Decidious	1.00	0.67	**4.67**
32	**Eriobtyra japonica**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
33	**Erythrina Caffra**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
34	**Ficus benghalensis**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
35	**Cupressus macrocarpa**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
36	**Ficus Decora**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
37	**Ficus Maclellandii**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
38	**Ficus religiosa**	1	1	1	0	Decidious	1.00	0.67	**4.67**
39	**Jacranda ovalifolia**	1	1	1	0	Decidious	1.00	0.67	**4.67**
40	**Magnolia grandiflora**	1	1	1	0	Evergreen	1.00	0.67	**4.67**

41	**Melaleuca Leucadendroa**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
42	**Parkinsonia Aculeata**	0	1	1	1	Decidious	1.00	0.67	**4.67**
43	**Peltoporum africacum**	0	1	1	1	Decidious	1.00	0.67	**4.67**
44	**Populus Alba**	0	1	1	1	Decidious	1.00	0.67	**4.67**
45	**Salix Babylonica**	0	1	1	1	Decidious	1.00	0.67	**4.67**
46	**Sophora Seucundiflora**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
47	**Spathodea Campunalata**	1	1	1	0	Decidious	1.00	0.67	**4.67**
48	**Tabebuia argentea**	1	1	1	0	Decidious	1.00	0.67	**4.67**
49	**Tecoma Stans**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
50	**Conocarpus Erectus**	0	0	1	1	Evergreen	1.00	1.00	**4**
51	**Annona Muricata**	1	0	1	0	Evergreen	1.00	0.67	**3.67**
52	**Artocarpus Heterophyllus**	0	0	1	1	Evergreen	1.00	0.67	**3.67**
53	**Dalbergia Sissoo**	1	0	1	0	Evergreen	1.00	0.67	**3.67**
54	**Certonia Siliqua**	1	0	1	0	Evergreen	1.00	0.67	**3.67**
55	**Ficus Benjamina**	0	1	1	0	Evergreen	1.00	0.67	**3.67**
56	**Ficus infectoria**	0	1	1	0	Decidious	1.00	0.67	**3.67**
57	**Ficus Microcarpa**	0	1	1	0	Evergreen	1.00	0.67	**3.67**
58	**Araucaria Heterophylla**	0	0	1	1	Evergreen	0.67	0.67	**3.34**
59	**Carica Papaya**	1	0	1	0	Evergreen	0.67	0.67	**3.34**
60	**Diospros Kaki**	1	0	1	0	Decidious	0.67	0.67	**3.34**
61	**Acacia Nilotica**	0	0	1	0	Evergreen	1.00	1.00	**3**
62	**Acacia Smallii**	0	0	1	0	Evergreen	1.00	1.00	**3**

Number	Name of specimen (Botanical Name)	Large/Long leaflets 2 m >	Hairy / throned/ toothed /waxy/ rough leaflets	Leaflets compactnes	Rough trunk	Form (Decidious/ Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									max. 6
1	**Pheonix Cnariensis**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
2	**Washingtonia Robusta**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
3	**Pheonix Dactylifera**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
4	**Livistona Australis**	1	1	1	1	Evergreen	0.33	0.67	**5**
5	**Pitchardia Pacifia**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
6	**Washingtonia Flifera**	1	0	1	1	Evergreen	1.00	0.67	**4.67**
7	**Chamaeropes Humilis**	1	0	0	1	Evergreen	1.00	1	**4**
8	**Hyphhaene Thebaica**	1	0	0	1	Evergreen	1.00	1	**4**
9	**Licuala Grandis**	1	0	1	1	Evergreen	0.33	0.67	**4**
10	**Chrysalidocarpus Lutescens**	1	0	1	0	Evergreen	0.67	0.67	**3.34**
11	**Cycus Revoluta**	1	0	0	1	Evergreen	0.67	0.67	**3.34**

12.1.3. Shrubs and Groundcovers list

Number	Name of specimen (Botanical Nam)	Large/ Long Leaves 10cm >	Hairy / Throned/ Toothed / Waxy/ Rough leaves	Desnse twigs	Rough bark	Form (Decidious/ Evergreen)	Drought Tolerance (H/M/L)	Water Requirment (H/M/L)	Earned Points
									Max. 6
1	Acokanthera Spectabilis	1	1	1	1	Evergreen	1.00	1.00	6
2	Myoporum laetum	1	1	1	1	Evergreen	1.00	1.00	6
3	Nerium Oleander	1	1	1	1	Evergreen	1.00	1.00	6
4	Pittosporum tobira	1	1	1	1	Evergreen	1.00	1.00	6
5	Rhaphiolepis Indica	1	1	1	1	Evergreen	1.00	1.00	6
6	Dasylirions quadrangulatum	1	1	1	1	Evergreen	1.00	1.00	6
7	Euphorbua lactea	1	1	1	1	Evergreen	1.00	1.00	6
8	Euphorbia milii	1	1	1	1	Evergreen	1.00	1.00	6
9	Pachypodium lamerei	1	1	1	1	Decidious	1.00	1.00	6
10	Yucca aloifolia	1	1	1	1	Evergreen	1.00	1.00	6
11	Yucca elephantipes	1	1	1	1	Evergreen	1.00	1.00	6
12	Yucca filametosa	1	1	1	1	Evergreen	1.00	1.00	6
13	Verbena Hubrida	1	1	1	1	Evergreen	1.00	0.67	5.67

14	**Acalypha Margianta**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
15	**Aralia Japonica**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
16	**Caesalpinia pulcherrima**	1	1	1	1	Decidious	1.00	0.67	**5.67**
17	**Cassia tomentosa**	1	1	1	1	Decidious	1.00	0.67	**5.67**
18	**Euphorbia**	1	1	1	1	Decidious	1.00	0.67	**5.67**
19	**Euphorbia pulcherrima**	1	1	1	1	Decidious	1.00	0.67	**5.67**
20	**Ficus Carica**	1	1	1	1	Decidious	1.00	0.67	**5.67**
21	**Hibscus rosa-sinensis**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
22	**Murraya exotica**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
23	**Bouganivillea stans**	1	1	1	1	Evergreen	1.00	0.67	**5.67**
24	**Carissa grandiflora**	0	1	1	1	Decidious	1.00	1.00	**5**
25	**Dodonea Viscosa**	0	1	1	1	Evergreen	1.00	1.00	**5**
26	**Leucophyllum frutescens**	0	1	1	1	Evergreen	1.00	1.00	**5**
27	**Rosa hybrida**	1	1	1	1	Evergreen	0.33	0.67	**5**
28	**Santolina chamaecypaissus**	0	1	1	1	Evergreen	1.00	1.00	**5**
29	**Calotropis procera**	1	1	1	0	Evergreen	1.00	1.00	**5**
30	**Carpobrotus edulis**	1	1	1	0	Evergreen	1.00	1.00	**5**
31	**Calliandra Haematocephala**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
32	**Callistemon rigidus**	0	1	1	1	Evergreen	1.00	0.67	**4.67**
33	**Cassia Alata**	1	1	1	0	Decidious	1.00	0.67	**4.67**
34	**Crotalaria madurensis**	0	1	1	1	Evergreen	1.00	0.67	**4.67**
35	**Eranthemum pulchellum**	1	1	1	0	Evergreen	1.00	0.67	**4.67**

36	**Justicia adhatoda**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
37	**Lawsonia Alba**	0	1	1	1	Evergreen	1.00	0.67	**4.67**
38	**Myrtus commuis**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
39	**lantana montevidensis**	0	1	1	1	Decidious	1.00	0.67	**4.67**
40	**Senecio cineraria**	1	1	1	0	Evergreen	1.00	0.67	**4.67**
41	**Monestera Deliciosa**	1	1	1	0	Evergreen	0.33	0.67	**4**
42	**Agava americana**	1	1	0	0	Evergreen	1.00	1.00	**4**
43	**Agave angustifolia**	1	1	0	0	Evergreen	1.00	1.00	**4**
44	**Agave atrovirens**	1	1	0	0	Evergreen	1.00	1.00	**4**
45	**Agave attenuata**	1	1	0	0	Evergreen	1.00	1.00	**4**
46	**Agave Desmettiana**	1	1	0	0	Evergreen	1.00	1.00	**4**
47	**Agave ferox**	1	1	0	0	Evergreen	1.00	1.00	**4**
48	**Aloe striata**	1	1	0	0	Evergreen	1.00	1.00	**4**
49	**Aloe vera**	1	1	0	0	Evergreen	1.00	1.00	**4**
50	**Cereus peruvianus**	0	1	1	0	Evergreen	1.00	1.00	**4**
51	**Opuntia ficus indica**	1	1	0	0	Evergreen	1.00	1.00	**4**
52	**Sansevieria trifasciata**	1	1	0	0	Evergreen	1.00	1.00	**4**
53	**Annona Muricata**	1	0	1	0	Evergreen	1.00	0.67	**3.67**
54	**Annona Muricata**	0	1	1	0	Evergreen	1.00	0.67	**3.67**
55	**Cestrum Aaurantiacum**	1	0	1	0	Evergreen	1.00	0.67	**3.67**
56	**Lavandula angusifolia**	0	1	1	0	Evergreen	1.00	0.67	**3.67**
57	**Catharanthus roseus**	0	1	1	0	Evergreen	1.00	0.67	**3.67**
58	**Anisacanthus thuberi**	0	1	1	0	Evergreen	0.67	0.67	**3.34**

59	**Plumbago capensis**	0	1	1	0	Evergreen	0.67	0.67	**3.34**
60	**Aglaonema species**	1	1	0	0	Evergreen	0.33	0.67	**3**
61	**Anthurium species**	1	1	0	0	Evergreen	0.33	0.67	**3**
62	**Echinocacus grusonii**	0	1	0	0	Evergreen	1.00	1.00	**3**

12.2. List of Interviewees and Site Visits

Name	Profession	Entity	Date
Ehaba Mokhtar	Architect, Msc holder	CEO, IDIA	21/Jun/2020
Rehab Ali	Architect, MSc holder	IDIA	21/Jun/2020
Mohamed Ramadan	Gardner	The Authority of Cleaning and Beautification of Cairo	18/Jun/2020 15/SEPT/2020
Merham Keleg	Landscape Architect, Msc holder, Ph.D. student	Ain Shams university	01/July/2020
Fayza Fawzy Mohamed	Engineer, Retired on 02/May/2018 from The Authority of Cleaning and Beautification of Cairo (اداره الجهود الذاتيه)	The Authority of Cleaning and Beautification of Cairo (اداره الجهود الذاتيه)	02/July/2020
Saif and Dalya	students	High school	18-Jun-2020
Ali and Asmaa	students	High school	16/SEPT/2020
Mahmoud	Garbage collector	The Authority of Cleaning and Beautification of Cairo	18-Jun-2020 15/SEPT/2020

Site Visits	Reason	Date
Field visit Basilic Garden Zone A and B (Heliopolis city)	Mapping the existing vegetation and watering system	18-20/Jun/2020
Field Visit Mountain View square (5th settlement, new Cairo).	Checking planting proposal by a private entity	01/July/2020
Field Visit Masr el Gdedah (El montazah street).	Checking the new road transformation after removal of the existing garden.	27/Jun/2020
Field visit Basilic Garden Zone A and B (Heliopolis city)	First design proposal evaluation with potential stakeholders	15-17/sept/2020

12.3. Interview Guide Sheet

Purpose of the interview (explained to the interviewee at the beginning): My name is Ahmed and I am currently a student in the MSc. IUSD Program at Ain Shams University. I am conducting several interviews with experts and practitioners in the field of plantation in Cairo Egypt to find some mitigation methods to compensate for air pollution, as part of my research work for the preparation of the final thesis titled "Unique plants and grouping strategies saving Cairo's air quality." Any information given will be used only for the research. The purpose of the interview is to understand the current management, plantation, and watering system to set new design and planting recommendations. I am very grateful for your kind assistance in answering my questions.

Interviewee	Question
Ehab Mokhtar and Rehab Ali (Architects at IDIA)	• What are the measurements taken in designing outdoor garden places and how different users may affect your design? • What specimens of vegetation used in the landscape design? • Do you have a maximum cap of water in choosing your planting specimens? • What is the watering system do you use in your designs? • How regular is the maintenance for the garden designs that you are in control of? • How can you describe your maintenance procedure for your garden designs? • Briefly, can you explain the hierarchy of orders with job main titles for the maintenance level of the garden execution and who are the people

Mohamed Ramadan (Gardner)	• How many days per week do you work in general? • How often do you do the maintenance for zone A and B? • What is your maintenance routine for this garden? • How do you water this garden? • How often new plants are planted in this garden? • Who gives orders to keep maintenance of this area and where they are based? • What do you think could be done to make your job easier cleaning this garden? • What do u think about this 1st garden design proposal? • What could be added from your point of view and why? •
Ali and Asma (youth student)	• How often you come to this garden? • What activities you do here? • Why do you prefer to come here? • What do you think could be done to make this garden a better place? • What do u think about this 1st garden design proposal? • What could be added from your point of view and why?
Mr. Mahmoud (Garbage collector)	• How often you come to this garden? • What activities you do here? • Why do you prefer to come here? • What do you think could be done to make this garden a better place? • What do u think about this 1st garden design proposal? • What could be added from your point of view and why?
Merham Keleg (Phd. Student Ain shams uni.)	• From your previous interviews with the authority manager in (The Authority of Cleaning and Beautification of Cairo), how can you describe their system? • What are the main departments and generally what each department main job? • How are their designs are connected to the level of public use? • Which department do you think after all these interviews have more potential to make a change in the current circumstances?

Fayza Fawzy Mohamed: Retired manager from The Authority of Cleaning and Beautification of Cairo (ادارة الجهود الذاتيه)	• What was your job role in this entity? • How do you find it beneficial to the public? • What can you tell me about their greenhouse plantations? • How do you find the public response towards your awareness campaigns? • What opportunities do you see working cooperatively with public audiences? • What other departments see this collaboration with the public and your department?

ملخص البحث

المظلة الرئيسية لهذا البحث هي تحسين جودة الهواء. بكلمات بسيطة ، الهدف من هذا البحث هو دراسة الغطاء النباتي القادر على حبس الجسيمات في الهواء ويمكنه تحمل مناخ القاهرة الحار لأنه مصدر قلق بيئي متزايد يتعين على الجهة المعنيه في مصر الامتثال له من أجل تحقيق أهداف التنمية المستدامة.

علاوة على ذلك ، يتم تقديم العديد من الأبحاث في فصل مراجعة الأدبيات لفهم كيفية تأثير استخدام الغطاء النباتي ليس فقط على جودة الهواء في البيئة ولكن أيضًا على تأثيره الصحي على المستخدمين أنفسهم. وخلص هؤلاء الباحثون إلى أن هناك تأثيرًا قويًا على جودة الهواء الداخلي والخارجي من عدم وجود الغطاء النباتي. كانت المحاولات المختلفة في الابحاث تحاول فهم أي انواع النباتاتت أكثر نجاحًا من غيرها في تنظيف الهواء وأي جزء من الهواء (المواد الغازية والجسيمات).

في الفصل التالي ، كمصدر أساسي للبيانات ، تم استخدام مكتبة الازهر للنباتات كمرجع رئيسي لتصفية النباتات الأكثر نجاحًا في حبس الجسيمات في الهواء. تم وضع ستة معايير رئيسية لتقييم النباتات وتتم مكافأة كل معيار بنقطة واحدة. تم وضع هذه المعايير من نقاط الإدراك من مراجعات الأدبيات المختلفة لإعداد مثل هذه القائمة للقاهرة.

بعد تحديد قائمة النباتات، تم اختيار حديقة البازليك في القاهرة كدراسة حالة وظهرت نقاط تحقيق جديدة في عملية التصميم. تم رسم خرائط المنطقة بشكل أساسي من خلال البيانات الثانوية مثل (المقابلات في الموقع والمكالمات الهاتفية والرسومات).

كانت هذه النقاط تتعلق بشكل أساسي بنظام إدارة هيئة نظافة وتجميل القاهرة. جعلتني هذه النقاط أدرك أنه يجب أن تكون هناك إرشادات أوضح حول كيفية تنفيذ أنشطة البستنة التي تقيمها الحكومة ، وكيف يمكن استخدام هذه المساحات الخضراء للمنافع المستقبلية (اقتصاديًا واجتماعيًا وبيئيًا).

الكلمات الرئسية: نوعية الهواء ، التلوث ، الجسيمات ، الغطاء النباتي ، المياه ، القاهرة.

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شتوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام .إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة 2020

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المأخوذة من المراجع العلمية كلٌ في مكانه في مختلف أجزاء الرسالة.

وهذا إقرار مني بذلك،،،

التوقيع:

الباحث :احمد يوسف

التاريخ:

النباتات الفريدة واستراتيجيات التنسيق لتعزيز جودة الهواء في شوارع القاهرة

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

إعداد: احمد يوسف

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لجنة الحكم أ.د
.الممتحن الخارجي

التوقيع

أستاذ.....
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أستاذ.....
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أستاذ.....
جامعة .....

تاريخ المناقشة:.....

الدراسات العليا

ختم الإجازة
موافقةمجلس الكلية .../.../...

أجيزت الرسالة بتاريخ:.....
موافقة مجلس الجامعة .../.../...

جامعة عين شـــــمس

جامعة شتوتجارت


جامعة عين شـــــمس


جامعة شتوتجارت

النباتات الفريدة واستراتيجيات التنسيق لتعزيز جودة الهواء في شوارع القاهرة

رسالة مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

إعداد

(احمد يوسف)

المشرفون

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جامعه عين شمس

18/OCT/202