

# Creating urban health through the promotion of green walls

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**Abstract**— Since the industrial revolution took place, the gap between people and nature has been increasing rapidly. Nature-deficit disorder is the major issue in most cities worldwide. The lack of nature affects our daily lives negatively by threatening our mental and physical health. Many people are experiencing heart disease, high blood pressure, mental illness, and many more due to unhealthy living conditions: air pollution, noise, high temperature and lack of nature.

Plants can improve public health by reducing the negative effects of those factors. Although there are some ways to turn nature back to the cities such as public parks, green roofs or street trees, vertical gardens would be a considerable trend in crowded cities where there is a shortage of land as they can cover large areas, and accessible for those who can not afford going to public parks regularly to enjoy the nature.

**Keywords**— Green wall, Vertical Garden, Public Health, Mental Illness.

## I. INTRODUCTION

Urban development has been causing serious economic, social, environmental and health issues in the built environment. It is estimated that 70% of the world's population will live in cities within thirty years. That would be a major shift from nature to crowded cities where the air pollution, temperature and noise are high, Figure (1). This movement would affect the human health negatively as many people will be experiencing different kind of diseases (Danielle & others, 2015).

Cities used to design for 5 miles/hour, yet it goes to 70 miles/hour due to the change of life styles. Back in the days, city planning was based on the human and animal scale, yet it is based on speed of vehicles and public transportation. This shows how far we get away from interacting with nature.

Changing the urban living conditions such as nature connection, air quality, noise, temperature, traffic and so on would improve the health of the city in some points (Dannenberg & others, 2011), Figure (2).



Fig.1: The gap between people and nature: New York

Source: <https://www.flickr.com>

Living walls, green walls, vertical gardens or bio-walls are plants growing vertically on buildings. They can be found on the external or internal walls. A few years ago the notion of green wall was discussed among specialists. However, recently the demand of connecting with nature have been rising including living walls. Since the invention of the hydroponic system, which plants can grow without soil, the usage of living walls has been increasing and changing the way that our cities look (Tong, 2017). A green wall is one of the green architectural practices aimed to reduce the impacts of global warming and increase public health by reducing indoor temperature, noise, air pollution, urban heat island effect and stormwater. Also, vertical gardens can

improve indoor air quality, building aesthetic, human comfort and biodiversity (Hopkins & Goodwin, 2011).



Fig.2: The possibility of changing the living conditions.

Source: <https://www.archdaily.com>

Green walls can cover large areas, especially in the built environment where high rise buildings are dominated. By doing a math for a tower that has a green wall ratio of one to seven of elevation areas, the plant area would be equal three times the site area. This means we would get more vegetation than what was on the site (Sheweka & Magdy, 2011), Figure (3). Also, “Green walls not only bring nature back into city life, they do so in a way that is accessible to everyone” (Weinmaster, 2009).

## II. HYPOTHESIS

“The more high-tech our lives become, the more nature we need to achieve natural balance” (Louv, 2011). To achieve natural balance in our daily lives, vertical garden would be a new trend for achieving that as large areas would be turned green especially in crowded cities where high rise buildings are dominated.

## III. IMPORTANCE

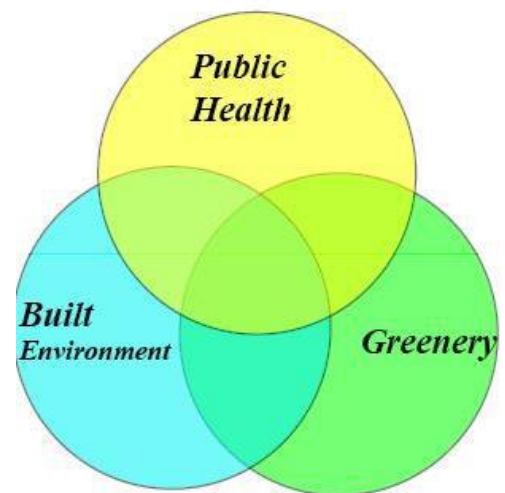
Recently many studies have shown that reconnection to nature is the key to human health. The power of nature has impacts on human sense and intelligence including our physical, psychological and mental health (Louv, 2011). Greenery can improve public health by reducing air

pollution, urban heat island, noise, and mental illness (Danielle & others, 2015).

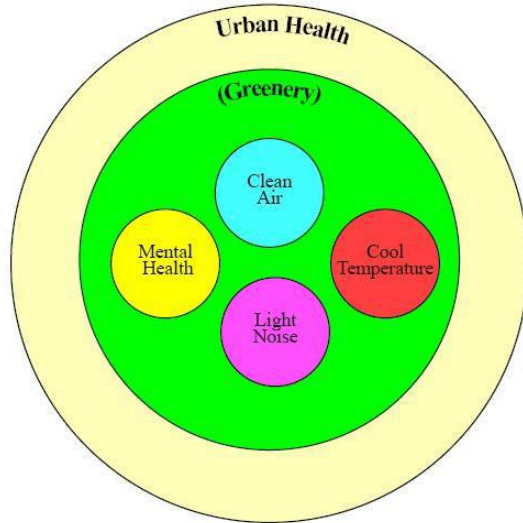


Fig.3: Green walls can restore nature in a larger area of the site.

Source: <https://www.justclick.sg>



Green & Public Health



Relationship between plants &amp; urban health

### A- AIR POLLUTION & GREENERY

Air pollution is a situation where unhealthy substances are present above their average levels. Those ambient materials as a result of traffic vehicles (cars, trucks, motor bikes, etc), waste, wildfire, industrial and residential activities. In 2014, it was estimated that 92% of humans are living under poor air quality that does not meet the air quality standards established by the World Health Organization (WHO). There is an urgent need to improve the air quality since it is an invisible threat that affects our health by causing some common diseases like lung cancer, stroke, respiratory diseases and many more. Although 3.7 million premature deaths globally caused by outdoor poor air quality in 2014, that number was estimated to be approximately 9 million annually within forty years (Appuhamillage, 2018).

**Greenery** (vegetation) enhances the quality of the air through the phenomenon of deposition and dispersion. It depends on the kind of plants, their location related to the source of pollution, level of air pollution and the wind direction. Generally, plants can deposit airborne particles once they get to their surface. Plants have 10 to 30 times faster deposition compared to manufactured surfaces such as glass and cement that exist in the built environment. The airborne particles stay on leaves for a while then turn back to the soil once it rains. For a better deposition plants should be hairy and have large leaves, and penetrate for air movement. While trees have the most effective filtering air compared to shorter plants, they should be close to the

source of pollution like traffic sources since air passing above or down the leaves is not filtered. For example, lower vegetation on streets that close to the human scale and pollution sources, vehicles, would improve the air quality better than large trees in the same street since the latter gives a chance for wind to spread pollution all over (Janhall, 2015).

In addition, plants can increase the oxygen during the day through photosynthesis phenomenon. It is indicated that between 1-3 ton of oxygen per day can be produced in one km<sup>2</sup> of trees. This can improve the air quality during the day in crowded cities where CO<sub>2</sub> is produced heavily by vehicles. A single tree can filter an average car's exhaust by around 2500 miles/year (Muharam, 2015).

Moreover, indoor air pollution could be as much as ten times outdoor air pollution since finishing materials made by combining many different toxicity chemicals that leads to major health problems. According to EPA more than 300 contaminants are inhaled by people who are living and working in buildings of artificial substances. Almost 90 percent of the time people spend indoors surrounded with toxic substances. A recent study of (NASA) shows that plant can improve the indoor air quality by taking off the toxic chemicals through their leaves or roots depends on the kinds of toxic substances. As a result of that a new integrated system between HVAC system and green wall is invented. This works by using fans behind a green wall to draw the air through vegetation to deliver the harmful substances to leaves and roots. Also, indoor air quality is enhanced since plants enrich oxygen which keeps people alert. Then the clean air is circulated through the building (Weinmaster, 2009).

### B- NOISE & GREENERY

Noise is known as undesirable sound, and one of the most harmful environmental factors to urban health. According to World Health Organisation (WHO), noise is the second threat to public health, after air pollution. In cities, traffic, trains and airplanes are the main source of noise. Around 36% of disease due to noise in a poor quality of urban planning. Noise makes the response system activated that leads to high stress and heart disease (Ione Avila & others, 2018).

The average noise level in a quiet neighborhood at night around 40 decibels while in a busy street goes up to 75 decibels. In the design process, around 40 decibels would be the goal for a healthy environment (Hammer & others, 2014).



Studies have shown, in Manhattan, people have to speak loudly even though they are on the eight floor as the noise level is 66 decibels. In the 1970s, it was found that children living in lower and noisy floors had more difficulty learning than those in higher floors. In 2011, a study demonstrate that 10-decibel increase in airport noise can rise the medication use of anxiety by 28%. Another study showed that depression and heart problems would be increased by 25% for people living in a noisy road traffic than those living in a quiet neighborhood (Sheikh, 2018).

**Plants** and trees can be used as noise barriers in the built environment. Green wall would do the same since vegetation absorb and reduce the penetration of the noise. It depends on the kind of plan and the foliage area. An experiment found that 15 decibels can be reduced of the indoor noise by using green wall system. This indicates the significant benefit of vertical gardens as a sound insulation. Also, this experiment aimed to determine the amount of sound that a vertical garden can absorb. A green wall with ,10m<sup>2</sup>, was placed on the building and at frequencies of 100–5 000 Hz. The results showed that 40% of the sound was absorbed by green wall. Although 30 to 70 decibels of noise could be reduced by using other systems like double-glazing, green wall is an environmentally friendly insulation that has other benefits such as filtering air pollution, reducing temperature, improve biodiversity, visual quality and creativity (Azkorra & others, 2015).

### C- TEMPERATURE & GREENERY

Temperatures in cities tend to be up to 10°C higher than in surrounding areas. This effect is known as “urban heat island” that causes health, environmental and economical problems. High temperatures increase mortality, due to cardiovascular and respiratory diseases (Ione Avila & others, 2018).

According to Centers for Disease Control (CDC) extreme heat causes around 688 deaths annually in the US. While heat waves don't always case the death, other health consequences can be dangerous, including sunstroke and organ damage. For example, around 692 killed and 3,300 people sent to hospitals once a heat wave hit Chicago in 1995. A study showed that 28 percent of the patients who had a serious heat stroke died within a year of the incident, and most of the survivors have some health issues (Harmon, 2010).

Furthermore, 98.7 degrees Fahrenheit is the normal temperature for the human body. At that level the human body is designed to reduce the temperature through

sweating. However, once an extreme heat wave happens, a person may not be able to sweat. That causes serious health problem which leads to death in some cases. People, no matter what their age, with inherent diseases such as heart and lung disease, asthma and diabetes are more affected than others. Heat stroke is not only uncomfortable, but it is life-threatening especially once it lasts for a few days (Carlton, 2018).

Urban heat island effect UHIE occurs since high percentage of solar radiation is absorbed by building and street materials then a huge reflection occurs back and forth among building and urban surfaces. As the temperature is increasing, the demand of air conditioning is increasing too that leads to higher energy consumption and negatively affects the rate of ozone consistence.

**Plants** can reduce the temperature due to evaporation, transpiration and shading phenomenon. This reduction in temperature reduces the negative impacts of the UHIE no matter what kind of plants are used. A study in Oregon showed that non-vegetated areas could reach 50°C in summer whereas vegetated areas stayed at 25°C. Also, green can reduce indoor temperature depends on the kind of plants and greenery systems such as green roofs, green walls or street trees. studies have demonstrated that up to 30% of energy consumption for air conditioning can be reduced by using green walls (Weinmaster, 2009).

Green wall can provide shading for facade that reduces the heat flux into buildings. A study showed that depends on the type of plant ,dense foliage, 40% to 80% of sun radiation can be absorbed or reflected by a fully vegetation wall during summer season (HUI & Zheng, 2013). Also, the thermal performance of vertical garden depends on facade thermal properties, orientation and climate. Studies found that in Berlin, Germany green walls decreased up to 11.3 °C of facade temperature while in Chicago temperatures were reduced up to 1.8 °C, 3.0 °C, 11.1 °C, and 12.6 °C for north, south, west, and east consecutively. In addition, vertical garden can reduce indoor temperature up to 7 °C . Other studies reported a reduction of 0.8 °C to 2.1 °C for ambient air temperature in Chicago, and up to 5 °C in China (Yazdanseta, 2017).

### D- MENTAL HEALTH & GREENERY

In 2005, a study found that 10% of worldwide disease due to mental health problems, and this percentage would be increased to 15% in 2020. Mental health issues can increase anxiety, depression, schizophrenia and suicides. Urban life is high of tension that impacts the mental health

negatively. However, it is found that greenery such as plants, trees and vegetations, can reduce the negative effects of stress in cities. People are benefited by seeing greenery (Bajirao, 2015).

According to World Health Organization (WHO) mental illness, depression, would be the greatest source of illness by 2020 as it encourages other unhealthy behaviors such as smoking, overeating and over-drinking which lead to serious health problems like diabetes and cancer.

Studies have shown that nature can improve our mental health and reduce stress levels in different levels of engagements. **First** is watching nature through a window or in a picture. **Second** is doing some activities nearby nature such as walking, biking, seating, playing or readings. **Third** is involved with nature in the agricultural industry such as gardens or farms. An experiment indicated that exposure to nature during the physical activity has positive impacts on mental health. The experiment tested the blood pressure, self-esteem, and mood among five groups that were exercising in different urban and rural conditions (Pretty, 2005).

Another review of more than 20 studies indicated that activities such as walking or running ,exposure to vegetations, have greater energy and less anxiety, stress and anger than non green surrounding (Lahart, 2019). Also, an experiment tested the impacts of plants for indoor activities. Heart rate and blood pressure were measured during computer and plant tasks in a room. The results showed blood pressure and heart rate were higher during the computer task than plant task (Lee & others, 2015).

#### **A question will be asked why people feel more comfortable around plants?**

It was found that around 2,000 shades of green color can be distinguished by the human eye while 100 shades of red color. As a result of that green walls can promote a natural green color that is missing in the concrete cities (Weinmaster, 2009). Also, the relationship between humans and plants is known as Biophilia, natural pleasant that comes from being surrounded by living organisms, that people may not be aware of it. Humans as creatures like to be surrounded by other creatures. For instance, a study found that at Steelcase company 42% of office employees brought plants to their offices. Another study found that plants at workplace reduce anxiety, anger and fatigue by 37%, 44% and 38% respectively, and increase creativity and productivity by +15% (Green Plants for Green Buildings, 2019).

Exposure to green or view images of green spaces can improve patients health. A study in Japan showed that plants can reduce blood pressure, muscle tension, fear, stress, anger and sadness. Another study found that viewing to a green fence has more physiological benefits than concrete fence. Other studies have been conducted that plants can improve the patient's mood, reduce medication use and length of stay in healthcare facilities. On the other hand, a study found negative impacts for patients viewing through windows a sculpture in a garden without any plants. Many studies have recommended investment of gardens in health care facilities, prisons and schools. Plants should be placed in the design of new projects. Increase the awareness of plants benefits for humans. Encourage using any space for placing plants such as window boxes, walls and balconies (Thompson, 2018).

#### **E- GREENERY & GLOBAL WARMING**

Plants are considered one of the climate change fighters. Global warming occurs as a result of high percentage of CO<sub>2</sub>, which is due to human activities, in the atmosphere. Photosynthesis phenomenon, which plants take carbon from the air, and provide more Oxygen, can reduce the emissions. However, plants cannot fight climate change by themselves since a lot of water, spaces, budgets, nitrogen fertilizers and technological improvements are needed. It is impossible to plant enough vegetations to stop climate change. The only way to avoid natural catastrophes is to cut down on sources of carbon dioxide emissions as fast as possible (DeWeerd, 2017).

#### **IV. COST OF VERTICAL GARDENS**

Green wall system is considered one of the most expensive man-made walls. In the US depends on the kind of system the installation cost is \$75 to \$125 per sqft, and the Maintenance Cost is \$7 to \$12 per sqft (8-10% of installation). This is almost more than double the cost of a green roof system which is \$28 to \$47 /sqft (Mathew & Salot, 2014). However, the price varies among countries ;for example, in Turkey green facade cost is \$3–5 and \$4–8 per sqft for a wall with self-winder plants and a wall with wiring mesh system respectively. However, green wall with boxes installed cost \$40 per sqft. Also, \$5 to \$6 per month is the cost of the maintenance per sqft (Meral & others, 2018).

Although it seems that green wall may not be economically sustainable, some studies have shown that green walls can payback the initial cost in the long term regardless of the

environmental benefits. A study of cost-benefit for living wall systems in a hot climate, showed that 18% of cooling energy was reduced compared to bare wall. It was estimated that vertical garden can payback the initial cost in range of 13 to 17 years depends on the local cost of electricity (Haggag & Hassan, 2015).

Another study showed that vertical garden did not create any damage for a plaster over 70 years while the next door building replaced the plaster three times during the same period. This means reduce the cost of the regular maintenance. Also, the vertical garden can push the property value up to 15% compared to building in the same location with no greenery systems (Meral & others, 2018).

## V. POLICIES

Although the lack of data, technical issues, risk and cost are the most factors of preventing green walls for spreading out, some countries like Singapore enforces using greenery system with building permits. It is required to create a greenery system, green roofs or green walls, on the building as much as the area of the land. Singapore government has issued a legislation called LUSH (Landscaping for Urban Spaces and High-rises) for including greenery in buildings. The government is willing to pay up to half the cost of rooftop gardens and green walls. This policy has pushed the movement of green walls rapidly (Velazquez, 2019).

Since the vertical garden system is a new trend in the built environment, it has not yet got governments support or attention as much as green roof systems which spread out in the 1980s. Different policies have been established in different countries based on financial incentives. For example, in Germany 13.5 km<sup>2</sup> per year of green roof systems are funded by the government. In Esslingen, government offers 50% back for owners who installed a green roof system while in the cities like Bonn, Cologne, and Mannheim, owners get a reduction for utilities fee. Also, in Toronto, the government subsidizes 50–70% of the entire roof area when in Basel, the government offers 20% of the cost. In the U.S. some states like Oregon 70% of the roofs will be switched to green roofs. New York City encourages the installation of green roof systems by reducing the tax of \$4.5/sqft once a green roof system covers 50% or more of the entire roof (Muharam, 2015).

## VI. DISADVANTAGES

While vertical gardens have various advantages, such as reducing temperatures, noise, stormwater, energy consumption, and improving air quality, creativity,

biodiversity, aesthetic, mental and physical health, there are some disadvantages such as adding to buildings new loads, costs, damages, high maintenance, allergies and insects. Maintenance is a considerable issue to sustain green wall systems. It is required monthly fertilization and daily or weekly irrigation depending on the climate and plants kind. Another issue might be plant allergies due to their pollen including itchy, sneezing, runny nose and so on. Since some people are sensitive to some kind of plants, designers must study the side effects of plants during the plant selection process (Meral & others, 2018).

## VII. CONCLUSION

Greenery has the potential to be a fundamental factor for improving public health. Cool temperature, clean air, light noise and green connection are creating a healthy environment. Since many cities are crowded, land shortage, and liveless, vertical gardens would be a perfect idea for turning nature back to them. Green walls would increase the chances for people to be surrounded by plants while they are working, walking, driving during a busy day. Low income class would benefit too as they cannot afford going to public parks constantly. Although green wall systems are expensive, their benefits would pay back on human health and the cost of medicine.

Studies are still needed to investigate the cost reduction on public health as a result of using multiple greenery systems for creating a healthy environment.

It is suggested to increase the awareness of using vertical gardens among designers. Also, governments should subsidize greenery systems, and issue new legislation to encourage developers to do so.

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