Urban planting for mitigating adverse urbanization impacts

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Abstract. Urbanization is a worldwide phenomenon which poses both opportunity and problem for urban areas. Potential for development becomes more significant as the population grows, especially in developing countries. Various perspectives see the phenomenon differently. Economists might see that this development is preferable, while environmentalists and medical people see it is more problematic than beneficial. This paper presents research-based documents and literature regarding urban development with its implication on the urban environment and humans’ health. It also suggested efforts to mitigate the impact of the inevitable urbanization, i.e., urban planting. Abundant scientific evidence confirms the benefits of urban planting to humans’ health and well-being. The virtues of urban vegetation resulted in the rise of concept for urban development that accommodates the existence of greeneries with all its attributes. Among the two most popular are the green networks and ecological network

1. Introduction
As the number of people living in the world is increasing, the need for a better place to live becomes more important. Human need places not only for settling but also for procuring a better life. Over half of the world population settle in urban areas, and the proportion increases over time [1], projected to reach nearly 5 billion in 2030 [2]. Some pulling factors of cities are believed to be the reason for more people coming to urban areas, including completeness of facilities and infrastructure, education and broader job fields [3–5].

The process of urban development (known as urbanization) is a global occurrence today [6]. In more-developed countries, urbanization is occurring less rapidly than in less-developed countries, which tend to be uncontrolled. People flock to the urban centers to find work, and as a result, the cities become ‘over urbanized.’ It leads to enormous social and environmental problems. The latter mainly associated with pollution and inadequate sanitation [7]. However, both will lead to health disturbances suffered by the citizens. Social problems will cause stress and depression (mental disturbances), whereas environmental disruption results in physical disturbances.

The main contents of this paper are description and presentation of scientific results regarding the factual development of urban areas. It also discusses consequences to the urban atmosphere and environment as well as the effect it has on humans as the primary inhabitant of urban areas. Indeed, this paper also provides prescribed recommendation with sound scientific evidence by presenting scientifically confirmed benefits of urban planting in any forms such as green spaces, green corridors, and other forms of greeneries within an urban setting.
2. Urbanization

Several factors are influencing to dynamic changes in the urban environment, which includes economy, society, culture, and technology. The dynamic changes are strongly related to anthropological factors [1].

Urbanization refers to city growth with all its associating factors. Some people consider urbanization mainly relates to population number living in cities and not with the growth of the city in terms of facilities, infrastructures, and other built structures [3]. However, some cities could prove that population growth is not the single cause of urbanization. In some countries, even where the population grows slowly, the effect of urbanization is still significant. It is due to the densification of built areas that expand toward urban fringe to even rural areas. Accordingly, Foreman [8] agreed that some demands following modernization could result in urban growth even without significant population change. However, developing countries experience much faster urbanization than in developed countries [9].

3. Threatening urban development impacts

3.1. Environment related factors

3.1.1. Pollution. Urbanization is the main driver for climate change and pollution [10]. How humankind utilize their environment in modern society have arisen consequences in terms of pollutions. The term pollution itself closely associates with particulates, which cover many different types and species of pollutant, some of which are most concern regarding human health [11].

| No | Environmental aspects | Description | References |
|----|-----------------------|-------------|------------|
| 1  | Water quality;        | the level of urbanization determined surface water quality, and it is the dominant form of land-use change that has impacts on water quality. | [12,13] |
| 2  | Micro-climate;        | Local climatic condition is profoundly affected by urbanization | [10] |
| 3  | Soil surface;         | urbanization and intense industrialization which occurs especially in many developing countries are responsible for heavy metal pollution in soil | [14,15] |
| 4  | Atmospheric greenhouse gases; | increased emissions of methane, CO2 in some developing countries due to high consumption of energy as part of urbanization. | [16,17] |
| 5  | Noise pollution;      | Motorized vehicles which are a consistent part of urbanized areas contribute significantly to noise pollution through honking and engine noise | [18] |
| 6  | Plant diversity       | Urbanization related to many built artificial greenspaces which resulted in less native plants available, thus plant diversity tends to be lower | [19] |
| 7  | Other wildlife        | Sample of fish collected from urban areas has the most microplastics ingested compared to that of less urbanized areas. | [20] |

Two kinds of pollution become concerns in urban areas and mainly have implications on human health; water and atmospheric pollutions. Water pollution defines as a chemical or physical change in water detrimental to the living organism. Water bodies are the primary recipient on an extensive array of wastes produced by man. These may be discharged directly into watercourses by sewers or pipes from factories [21]. An excessive amount of water pollutant in water bodies, which are the primary urban water sources in many developing countries is a severe threat to human health. Atmospheric pollution is a more common type of pollution in urban areas. The main sources of this kind of
pollution are manufactures in industrial areas, smog from vehicles, and gas-form chemical wastes from daily human activities.

A study in China confirmed the need for developing pollution prevention and strategies for reducing heavy metal pollution for areas undergoing urbanization and fast industrialization [22].

3.1.2. Effects of pollution on human health. Pollutants are considered hazardous to human health if their concentration is exceeding the value stated in the Air Quality Standard. In order to prevent more detrimental effect, some countries impose standards for air quality. Table 1 presents the European Air Quality Standards for major pollutants as an example.

**Table 2. European Air Quality Standards**

| Pollutant       | Type of value          | Period                      | Value (µg.m⁻³) |
|-----------------|------------------------|-----------------------------|----------------|
| Ozone           | health protection      | 8-hour mean                 | 110            |
|                 | vegetation protection  | 1-hour mean                 | 200            |
|                 | vegetation protection  | 24-hour mean                | 65             |
|                 | population information | 1-hour mean                 | 180            |
|                 | population warning     | 1-hour mean                 | 360            |
| Sulfur dioxide  | Limit                  | 98% of annual daily means   | 350            |
|                 | Guide                  | 50% of annual daily means   | 120            |
|                 | Guide                  | 24-hour mean                | 100-150        |
|                 |                       | annual mean                 | 40-60          |
| Nitrogen dioxide| Limit                  | 98% of annual hourly means  | 200            |
|                 | Guide                  | 98% of annual hourly means  | 135            |
|                 | Guide                  | 50% of annual hourly means  | 50             |
| Smoke           | Limit                  | annual mean                 | 80             |
|                 | Guide                  | annual mean                 | 40             |
| Lead compounds  | Limit                  | annual mean                 | 2              |

Source: [23]

When concentrations of pollutants mentioned above exceed the standard value, they potentially lead to some health disturbances. In most common urbanized place i.e. cities, especially in the developing world, air pollution found to be worst, thus type of pollution is known to be the leading cause of morbidity and mortality [5].

The excessive ozone in the air would result in a reduction in lung function. Sulphate and Sulphur Dioxide could induce branchial-constriction in asthmatic patients. Oxides of Nitrogen and Nitrate also have implications on lung function. Ammonia and Ammonium are less threatening in atmospheric concentrations, yet they poison water. Carbon Monoxides, which is produced during combustion by the incomplete oxidation of fuel, is responsible for the reduction in the oxygen-carrying capacity of the blood. Generally, particulate pollution is a serious health problem throughout the world, exacerbating a wide range of respiratory and vascular illness in urban areas [23]. Additionally, according to the International Agency for Research on Cancer (IARC), when forming organic compounds, particulates are carcinogenic to humans [24].

Possibly health-threatening factor from water pollution does not always come from consuming polluted water. It might also indirectly affect human as top-level terrestrial predators when consuming products from contaminated water (Jackson, 1996). The prevalence of asthma was higher in more urbanized areas [25]. Additionally, as urbanization results in more people living within more limited an area, some diseases that transmit through respiratory and fecal-oral routes are found to be more common in crowded conditions, for example, tuberculosis [26].

3.1.3. Stratospheric Ozone Depletion. Human activity in urban areas has been responsible for an increase in the flux in the stratosphere. Stratospheric ozone absorbs ultraviolet light that is roughly
coincident with the biologists UV-B. Increased levels of UV-B are expected to harm human health. The incidence of relatively trivial complaints such as sunburn, snow blindness, and enhanced aging of the skin is expected to rise. Similarly, a range of more severe afflictions will become more common, including cataracts and eye and skin cancers. Furthermore, the skin's immune system is adversely affected by UV-B; diseases that involve the skin are expected to become more problematic. These include measles, chickenpox, malaria, and leprosy. Enhanced UV-B levels may well decrease the effectiveness of vaccination against these diseases [21].

Extensive fossil fuel burning and other emission-production activities by urban settlers have resulted in increasing sun burning UV radiation. There are eminent correlations between ozone depletion and climate change due to the increased emission of greenhouse gases [27], which are significantly anthropogenic.

3.2. Social related factors – life pressures
The fast growth of cities has demanded people to lead a competitive life that gradually leads to mental problems. Life pressures with the requirement to keep abreast equally with others in terms of economy, result in stress, depression, and other mental disturbances and instability.

Pressures of living in an area where privacy is getting more limited are proven to contribute to mental illness, the rates of intentional injuries, both suicide, and homicide [28]. An urban area with some of its attributes such as overcrowded environment, polluted environment, as well as decreased social contact and support has a higher prevalence of mental disorders by 80.6% as opposed to 48.9% in rural areas [29]. These could be seen by the enormous range of disorders such as severe mental disorder, depression, substance abuse alcoholism, crime, delinquency, family alienation and disintegration [30,31].

4. Contribution of planting in urbanized areas
A significant number of researches have been conducted in order to assess the benefit of urban planting as an effort to present greeneries within the urban setting. Contribution of vegetation through tree planting is eminent and has become the justification for regulation issues by urban authorities. Among the prominent concepts that have been introduced by developed areas are concepts for ecological improvement, which targeted at the improvement of urban spaces considering many interests [32]. The following are some of the contributions

4.1. Indirect contribution of trees planting
Trees’ planting in urban areas is related to urban forestry establishment. The term urban forestry is increasingly used to refer to the planting and management of all woodlands and trees in urban areas. Government and other agencies are promoting urban forestry as a means of improving the amenity value and appearance of the urban environment.

On the other hand, it has more critical value in terms of retaining the negative implications of Pollution:

4.1.1. Trees as sinks for air pollutants. There have been many researches concluded that trees and woodland could act as sinks for several pollutants. Trees in urban areas are actively involved in particulates deposition. Some pollutants uptake rates by several species of trees are presented in table 3.
| Type of Pollutant: Ozone                  | Species                  | Cx (ppb) | Flux (Ng m⁻¹ S⁻¹) | vₑ (cm s⁻¹) |
|----------------------------------------|--------------------------|----------|-------------------|-------------|
| Acer platanoides                       | 250                      | 0.10     | 0.019             |
| Sorbus aria                            | 250                      | 0.13     | 0.024             |
| Betula pendula                         | 250                      | 0.16     | 0.030             |
| Pseudotsuga menziesii                  | 250                      | 0.28     | 0.053             |
| Picea abies                            | 250                      | 0.20     | 0.038             |
| Picea abies                            | 300                      | 0.72     | 0.112             |
| Picea abies                            | 250                      | 0.53     | 0.099             |
| Picea abies                            | 300                      | 0.35     | 0.055             |
| Picea abies                            | 80                       | 0.312    | 0.182             |
| Picea abies                            | 100                      | 0.576    | 0.269             |
| Pinus sylvestris                       | 400                      | 0.30     | 0.035             |
| Pinus nigra                            | 250                      | 0.171    | 0.032             |
| Phaseolus (bean)                       | 600                      | 2.7      | 0.21              |
| Phaseolus (bean)                       | 380                      | 1.67     | 0.21              |
| Lycopersicum (tomato)                  | 160                      | 2.5      | 0.73              |
| Alfalfa                                | 50                       | 3.8      | 0.36              |
| Petunia                                | 250                      | 0.5      | 0.093             |
| Helianthus (sunflower)                 | 710                      | 4.29     | 0.28              |
| Type of Pollutant: sulphur dioxide     | Betula pendula           | 55       | 0.9                |
| Betula pendula                         | 400                      | 0.29     | 0.025             |
| Betula pendula                         | 1000                     | 2.39     | 0.084             |
| Ligustrum vulgare                      | 1000                     | 1.89     | 0.066             |
| Fraxinus americana                     | 1000                     | 1.28     | 0.045             |
| Sorbus aria                            | 400                      | 0.25     | 0.022             |
| Pinus sylvestris                       | 70                       | 0.56     | 0.28              |
| Acer rubrum                            | 1000                     | 2.4      | 0.084             |
| Acer platanoides                       | 400                      | 0.148    | 0.013             |
| Pinus nigra                            | 400                      | 0.290    | 0.025             |
| Pinus nigra                            | 770                      | (0.11)   | 0.05              |
| Pseudotsuga menziesii                  | 400                      | 0.238    | 0.021             |
| Picea abies                            | 400                      | 0.362    | 0.032             |
| Quercus palustris                      | 770                      | (0.53)   | 0.024             |
| Ulmus americana                        | 770                      | (2.42)   | 0.11              |
| Type of Pollutant: Nitrogen dioxide    | Picea abies              | 50       | 0.072             |
| Picea abies                            | 400                      | 0.185    | 0.023             |
| Betula pendula                         | 400                      | 0.164    | 0.020             |
| Betula pendula                         | 270                      | 1.70     | 0.307             |
| Acer platanoides                       | 400                      | 0.103    | 0.013             |
| Sorbus aria                            | 400                      | 0.181    | 0.022             |
| Pinus sylvestris (field)               | 97                       | 0.13     | 0.65              |
| Pinus sylvestris (lab)                 | 240                      | 0.09     | 0.18              |
| Quercus myrsinaefolia                  | 300                      | 0.67     | 0.109             |
| Pinus taeda                            | 770                      | 0.252    |                  |
| Quercus alba                           | 590                      | 0.060    |                  |
| Populus nigra                          | 300                      | 2.0      | 0.325             |
| Pseudotsuga menziesii                  | 400                      | 0.171    | 0.021             |
| Pinus nigra                            | 400                      | 0.246    | 0.030             |
Other studies have revealed similar conclusions. The Department of Forestry at Australian National Universities presented a case study in Canberra, Australia, about extensive tree plantings since 1911 that had delivered several benefits including aesthetic values and the amelioration of climatic extremes. Recently, the benefits might extend to pollution mitigation and the sequestration of carbon.[33]

Research by USDA Forest Service has concluded that increasing urban tree cover from 20% to 40% led to an average decrease in hourly ozone concentrations in urban areas during daylight hours of 2.4%.[34]

In addition, another previous research held by Lawrence Berkeley National Laboratory resulted in a conclusion that the net effect of increased urban vegetation is a decrease in ozone concentrations.[35]

4.1.2. Air quality improvement. With its capability in pollutants deposition, the urban forest has led to an improvement of air quality in urban areas. Based on a study conducted by Heat Island Group of Lawrence Berkeley National Library, urban shade trees offer significant benefits in reducing building air-conditioning demand and improving urban air quality by reducing smog.[36] Areas perform contribution to air quality improvement are those with dominant trees. These planted areas become efficient scavengers for particulate matters, which result in higher rates of dry deposition, compared to other land use types.[37]

4.1.3. Mitigating greenhouse gases. Some human activities in urban areas such as inefficient burning of fossil fuels, excessive use of vehicles, running environmental-unfriendly factories and use of products that produce CFC have increased the amount of greenhouse gases in the atmosphere. As trees absorb CO₂—one of the greenhouse gases—and release O₂ which is vital for human, they could at least retain a factor of ozone layer depletion. However, other further actions are essential for full retention. Expansion of trees and forests area in the United States could be a case study. Investigation proved that they could have an impact upon the annual uptake of atmospheric CO₂[24], also with trees in an urban setting.[38]

4.1.4. Water conservation. Clean and healthy water shortages are a common problem in many urban areas. To help cope with increased urban water demands and low water supplies, the introducing of native and non-native landscape plants revealed as an alternative conservation method.[39]

4.2. Direct contribution

4.2.1. Turfgrasses utilization. Research by Texas A&M University portrays huge benefits of turf grasses planting for human life quality. Turfgrasses have been utilized for more than ten centuries for environmental improvement, possess some benefits which are functional, recreational, and aesthetic. Specific functional benefits include pollution control, groundwater protection, noise reduction, as well as reduction of glare and other visual pollution. The recreational benefits such as low-cost surface for outdoor leisure and sporting activities, which affect the improved physical health of participants. The aesthetic benefits include enhancement of attractiveness through beautiful soothing green color and
creation of beautiful composition of turf-flower-shrubs-tree in the landscape. These all provide a therapeutic effect for both ordinary people and those with mental health disturbance. Activity in the wide turf-covered area enhances social interaction, stability, and harmony. Overall, its existence could improve life quality, especially in urban areas where the population are dense [39,40].

4.2.2. Plants for medical treatment. As the use of herbs for therapy purposes becomes more popular, medicinal plants are familiar in both rural and urban areas. A study conducted in Brazil is presented to show that the employment of medicinal plants related to traditional practices. Their use in official public health care, however, requires more than traditional knowledge. Recent laws require that scientific evidence be brought to support the widespread use, that possible toxicity, especially when chronic use is contemplated [41].

4.2.3. Indoor air quality improvement. People in the cities spend 80 to 90 percent of their time indoors. They breathe mostly indoor air, however, until recent years, most health studies did not take this fact into account [42]. Although most air pollution derived from outdoor, it is not doubtful that indoor air quality is also significantly affected. A research in Australia has shown that selected indoor plants in test chambers can reduce concentrations of volatile indoor pollutants such as formaldehyde or benzene by up to 90 %. This study has enormous potential world-wide cross the full range of indoor environments, in which the population of modern cities spends most of their time. These include commercial, public utility (e.g., schools, hospitals), and private dwelling environments [43].

4.2.4. Other value. Still related to mental health enhancement, planting of trees in urban areas would give a feeling and experience of peacefulness, quietness, and relaxation within a hectic environment. Benefits of urban planting can also be valuing their ecosystem services. According to Brack [33], with their services in energy reduction, pollution mitigation, and carbon sequestration, planted trees in a study location in the US, are estimated to have a value of US$20–67 million during the period 2008–2012

| Benefits                                                                 | References       |
|-------------------------------------------------------------------------|-----------------|
| Improvement of urban climate                                            | [44,45]         |
| Mitigation of urban heat islands                                        | [46,47]         |
| Store and sequester carbon                                              | [48]            |
| Reduce noise pollution                                                  | [49]            |
| Improve air quality                                                     | [50–52]         |
| Improve water quality                                                   | [53]            |
| Lower temperatures of parked cars                                       | [54]            |
| Reduce volatilization of bitumen                                        | [55]            |
| Reduce the consumption of electricity for heating and cooling           | [36]            |
| Reduce the need to invest in new power utilities                        | [50,56]         |
| Aesthetic contribution, scenic beauty, visual amenity                    | [57,58]         |
| Architectural enhancement of buildings                                  | [33]            |
| Improve property values                                                 | [59,60]         |
| Increase privacy, barrier against unpleasant/stressful scenes           | [33]            |
| Control urban glare and reflection                                      | [39,40]         |
| Improve general livability and quality of urban life                    | [61,62]         |
| Increase tourism                                                        | [63]            |
| Provide opportunities for outdoor recreation and enjoyment               | [39,40]         |
| Attract birds and other wildlife                                        | [64,65]         |

There are too many benefits of urban planting in any form of applications. Whether they are green spaces, urban forests, urban parks, neighbourhood garden, green corridors, or even simple green spots
around houses, they are potential agents for improving the environmental quality of urban areas. Table 4 provides some more scientific evidence of tree planting in the form of urban forest as retrieved from Brack [33] and has been supported by supporting references. While figure 1 shows an Illustration of the benefits of trees at different levels.

![Figure 1. Illustration of benefits of trees at different level (Source: [66])](image)

5. Conclusion
As an inevitable phenomenon in both developed and developing contexts, urbanization poses problems related to changes in demography, environment, and social structures. The changes potentially lead to disturbances for humans’ health and the quality of the environment. This simple paper provided several benefits of urban planting to overcome some of the urbanization-related factors in cities and urbanized regions. It is expected that the information will be used as a trigger to plant more trees within the urban setting and promote ideas of more green development.
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