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The Multifaceted Benefits of Trees for Livable and Sustainable Communities

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Abstract
We live in an era influenced by humans to the point that the Earth's systems are now altered. In addition, a majority of the world's population live in cities. This paper serves as a critical review of the benefits of trees. Trees promote health and social well-being by removing air pollution, reducing stress, encouraging physical activity, and promoting social ties and community. This paper highlights the vital role of trees in addressing key challenges of the Anthropocene, especially in rapidly growing urban areas. It provides a concise review of scientific evidence on how trees contribute to human well-being, improved cognitive development, stronger economies, climate change mitigation, and sustainable green infrastructure. Trees enhance air quality, support mental and physical health, improve academic performance, generate economic value, reduce urban heat, store carbon, enhance biodiversity, and aid in storm water management. Overall, the paper emphasizes that integrating trees into urban planning is a cost-effective and impactful strategy for building healthier, resilient, and sustainable cities.

Keywords: Earth, Climate, Trees, Temperature, Biodiversity

1. Introduction

This current era, the Anthropocene, is driven by human influence and it has ushered in a growing number of direct and indirect challenges that can greatly impact the health and prosperity of people and the planet (Ellis, 2015) [9]. Climate change is driving an unprecedented number of extreme climatic events and causing ocean levels to rise. The human population continues to increase and metropolitan regions are growing and expanding. By 2050, most of the world's population (70%) will live in cities (FAO, 2016) [12]. These concentrated populations have a wide variety of challenges, ranging from people not having access to clean water to pollution- related health issues.

Climate change is expected to be one of the main future causes of biodiversity loss worldwide (Sala et al. 2000) [41], and there is compelling evidence that climate change will result in the extinction of species from many taxa. Trees (and therefore forest ecosystems) are particularly sensitive to climate change as they are relatively long-lived compared to other organisms and have limited adaptive capacity to respond to rapid environmental change (Lindenmayer et al. 2012) [24]. Furthermore, their longevity may paradoxically prevent managers and society from detecting changes before important changes have already occurred. The potential impacts of climate change on natural forests and their capacity to provide numerous ecosystem services has been the subject of intensive research. There is evidence that links biodiversity conservation to the improved provision of ecosystem services across a range of ecosystem types (Balvanera et al. 2006) [1], however the lack of data from forest systems has hindered the adoption of these concepts by forest policy makers. People and cities need efficient and effective solutions to address the challenges of this current era.

This paper provides a critical and succinct review on how the benefits of trees can increase the well-being of a majority of the world's population. The authors classify the benefits of trees into five categories: (a) health and social well-being; (b) cognitive development and education; (c) economy and resources; (d) climate change mitigation and habitat; and (e) green infrastructure.

2. The Scientific Benefit of Trees

2.1. Health and Social Well-Being

One of the most important benefits for human health that urban forests can provide is the interception and reduction of air pollution (McDonald et al., 2016; Nowak et al., 2018) [30, 38]. Air pollution (e.g. particulate matter (PM), ozone, carbon monoxide, polycyclic aromatic hydrocarbons, nitrogen dioxide, sulfur dioxide, etc.) is linked to bronchitic symptoms, intraocular pressure (leads to glaucoma), myocardial infarction (i.e. heart attacks), changes in autonomic and micro-vascular function, autism, blood pressure, cognitive development problems in children (slower processing speeds, behavioral problems, attention deficit/hyperactivity disorder symptoms), blood mitochondrial abundance, heart failure, and mortality in humans (Berhane et al., 2016; Di et al., 2017) [2, 6]. Trees remove a tremendous amount of air pollution.

There is a link between trees, green spaces and mortality, and it is documented in the literature (Nowak et al., 2018) [38]. In one particular study, the authors associated the increase in cardiovascular and respiratory deaths with the infestation and death of ash trees (genus Fraxinus). Having more trees, especially the right mature species planted in the right locations, can reduce particulate matter and other forms of air pollution, which could reduce mortality and morbidity in our urban centers. Beyond pollution removal, the presence of trees provides additional direct and indirect benefits to human health and wellness (Donovan, 2017) [7]. Regardless of why trees provide so many benefits (see Biophilia hypothesis and Attention Restoration Theory), the presence of trees and green space promotes well-being. Trees and greener environments are strongly linked to reduced negative thoughts, reduced symptoms of depression,

better reported moods, and increased life satisfaction (Li et al., 2018) [22]. A view of trees can help patients recover in a hospital and reduce diastolic blood pressure and stress in research participants (Hartig et al., 2003; Jiang et al., 2015) [14, 16].

Residents of tree-lined communities feel healthier and have fewer cardio-metabolic conditions than their counterparts. The presence of trees can even improve the condition of people with a neurodegenerative disease (Mooney & Nicell, 1992) [34].

2.2. Cognitive development and education

To increase literacy and numeracy, children need to have access to nature, and at the very least, green and natural views of trees (Lin et al., 2014) [23]. As reviewed in Kuo et al., (2018) [18], stress levels, concentration, and intrinsic motivation are likely strong factors in a child's success as a student. Students who are focused, attentive, and engaged are more likely to succeed in school and receive a quality education. Attention Deficit Disorder (ADD) and Attention Deficit Hyperactivity Disorder (ADHD) can impact a student's success in school. Green environments, such as open spaces with big trees, are related to reduced symptoms of ADD and ADHD (Faber Taylor & Kuo, 2009) [10].

Tree cover is strongly linked to student academic performance (Kuo et al., 2018) [18]. In one study, views of trees and shrubs at schools, as opposed to grass, were strongly related to future education plans and graduation rates (Matsuoka, 2010) [29]. Li and Sullivan, (2016) [21] found that students who had views of trees and green environment

from their classrooms, as compared to being in a room without windows or a room with a view of a brick wall, scored substantially higher on tests measuring attention, and they had a faster recovery from a stressful event. Students who learn in the presence of trees and nature have improved classroom engagement (Kuo et al., 2018) [18]. Trees can promote a quality education, which has innumerable advantages for society.

2.3. Economy and resources

Trees provide many ecosystem services that can benefit a city environment, ranging from reducing energy use and removing pollution (Nowak & Greenfield, 2018) [37] to increasing property values, developing the local economy, and supporting tourism (Nesbitt et al., 2017) [36]. Allocating resources in tree planting and maintenance can be a fiscally sound decision based on the benefits and ecosystem services that trees provide. This high return on investment can be multiples of invested capital over time (McPherson et al., 2016) [32]. Many benefits are not fully captured in this return on investment. In addition, the presence of shade trees can reduce the rate of ageing of road and pavement surfaces (McPherson & Muchnick, 2005) [31], influence shoppers to visit a shopping area, and increase the selling price of a home (Donovan & Butry, 2010) [8]. As long as trees do not block the view of an office building, quality landscaping with properly maintained trees can increase rental rates (Laverne & Winson-Geideman, 2003) [20]. A properly planted tree can also reduce energy use, which can reduce the cost of energy bills. While urban trees can provide economic benefits, they can also provide resources, such as food, to a community. The idea that trees can provide food security and promote well-being is not new.

Hundreds of tree species are used for agroforestry to promote food sustainability and nutritional security (Dawson et al., 2013) [5]. Urban orchards, or urban food forestry, can be an efficient way to consistently provide free or low-cost nutrient-dense food to the people that need it. Urban street trees can provide many resources to the inhabitants of cities. The “Incredible Edible” movement is an example of how underutilized plots in urban environments can be used to grow food, as a means to reduce food deserts and build community (Morley et al., 2017) [35]. Planting urban orchards in available spaces could prove an important tool to reduce hunger and increase social ties. Urban foraging may not be practiced in areas of higher opportunity (Larondelle & Strohbach, 2016) [19], and so it may not receive the attention it deserves as a solution for food security.

Forests also provide the habitat for non-timber forest products (NTFP) that can provide valuable resources to a local community (Turner, 2015) [43]. Some examples of NTFP include American ginseng (Panax quinquefolius L.), maple syrup (derived from Acer spp.) and nuts (from trees like the European Chestnut, Castanea sativa Mill.). Traditionally NTFP are associated with a rural environment, yet urban NTFP can provide additional financial, food, and medicinal security to people living in cities (Kaoma & Shackleton,

2015) [17].

Finally, wood is an important source of material and energy for much of the world. Trees that are cut down in cities or communities can be used for timber (Sherrill, 2003) [42]. This could be used for fuel or for producing goods. Innovative programs can promote sustainability and creative usage of urban wood. An example of this is the "Working for Water" program which trains people in South Africa to remove woody invasive species, and then the cleared wood can be used for a variety of secondary industries. While this program works with invasive species, it serves as an example of creative solutions involving the community with urban issues involving trees. Urban forests can also help supply affordable energy to people that need it. It is important to note, however, that burning wood is a large contributor to air pollution in urban environments (Favez et al., 2009) [11]. Therefore, if wood is used for fuel, it should be burned in such a way that the benefits outweigh the harm to human health. Trees are a valuable resource, even after they are cut down. Trees can help countries meet the goals by providing food, resources and economic advantages to countries. These goals include:

- End poverty in all its forms everywhere;
- End hunger, achieve food security and improved nutrition, and promote sustainable agriculture;
- Ensure access to affordable, reliable, sustainable, and modern energy for all;
- Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;
- Reduce inequality within and among countries; and
- Ensure sustainable consumption and production patterns.

2.4. Climate change mitigation and habitat

Climate change directly impacts where people live. One of the most pressing risks for human health associated with a changing climate are the increases in heat-related deaths, diseases, and infectious diseases (Patz et al., 2005) [39]. The increase in heat and heat-related health problems is especially prevalent in cities, where the Urban Heat Island Effect increases the impact of heat waves (Ward et al., 2016) [44]. Properly placed trees can mitigate temperatures in built environments. Not only do trees provide shade through intercepting and absorbing light, but through evapotranspiration trees actively cool the air of cities (Hirons & Thomas, 2018) [15].

Trees incorporated into the built environment can reduce a city's temperature by 9°C. This reduction of temperature in major cities (Loughner et al., 2012; McDonald et al., 2016) [26, 30] can ultimately help ameliorate the impact of climate change on human health. One of the key ways to limit the impacts of climate change is to reduce the amount of carbon released into the atmosphere. Trees are beneficial to storing carbon, which is a major contributor to climate change.

The more mature a tree is, the more carbon it stores in its woody biomass. Although trees are not the single answer, healthy and mature trees have the potential to make significant carbon mitigation returns. Finally, trees, specifically mature ones, perform a keystone role in terrestrial ecosystems (Manning et al., 2006) [28]. Trees are critically important, especially in urban areas, as they provide food and habitat for birds, invertebrates, mammals, and plants. Improving and maintaining biodiversity is necessary for a sustainable city.

2.5. Green infrastructure

Trees are considered "decentralized green infrastructure" and can be important tools for managing water, especially in an urban ecosystem (Berland et al., 2017) [3]. Water runoff is a serious issue in the city environment, as runoff can increase the exposure to pollution and cause property damage. Trees can help reduce and intercept storm water and improve the quality of runoff water (Berland et al., 2017; Bolund & Hunhammar, 1999; Livesley et al., 2016) [3, 4, 25]. With less contact on impervious surfaces, stormwater is cooler and has fewer pollutants when it enters local waterways and water-related ecosystems.

Trees can also be valuable in phytoremediation, where they can remove heavy metals and other contaminants from the environment (French et al., 2006) [13]. While gray infrastructure depreciates over time, trees appreciate in value as they mature. Therefore, an investment in trees can make economic sense. Green infrastructure protects life below water and life on land, while promoting sustainability. The ability of trees to reduce the pollution in the waterways is beneficial to human health and well-being.

A notable example of sustainable plantation efforts in India is the bamboo-based green infrastructure initiative led by Chairman, Khadi and Village Industries Commission (KVIC) presently Leftinent Governor of Delhi Shree Vinai Kumar Saxena and Former State Director, KVIC - Shree Badri Lal Meena under Project BOLD (Bamboo Oasis on Lands in Drought). This was later recognized by UN agency- UNCCD. As shared by author Badri Lal Meena, ex-State Director, KVIC, a total of 5,000 bamboo saplings of Bambusa tulda and Bambusa polymorpha were planted across 25 hectares of arid gram panchayat land in Nichla Mandwa, Udaipur, to restore degraded landscapes and enhance climate resilience. The project includes the installation of borewells and solar pumps, along with the plantation of papaya, pomegranate, and Moringa trees to boost beekeeping and livelihood opportunities (UNCCD, 2025).

3. Conclusion

Trees are far more than aesthetic elements of the environment—they are essential to sustaining healthy, resilient, and thriving societies. The scientific evidence reviewed in this paper clearly demonstrates that trees significantly enhance human health, cognitive development, economic prosperity, climate stability, and ecological sustainability. Their role in improving air quality, regulating temperature, supporting biodiversity, strengthening social well-being, and providing food and resources positions them as a key nature-based solution for the challenges of the Anthropocene.

Investing in trees will result in sustainable cities with happier and healthier people. We reviewed the substantial evidence to better understand the tangible and real benefits that trees provide. While there are considerations, planting and protecting trees is a real solution to many of society's challenges, offering high potential with relatively small input and energy. The results can be profound in the long term. In particular, the five categories of benefits outlined in this article (health and social well-being, cognitive development and education, economy and resources, climate change mitigation and habitat, and green infrastructure) are of particular importance, especially as there is a great global

migration into cities.

For people to receive the benefits, the urban forest needs to be healthy and diverse to create the most sustainable and livable communities possible. We have entered a new era in which humans are the dominant species and the main influencer of the planet. The built environment as it currently exists is not conducive to most trees (Watson & Himelick, 2013). In order to receive the benefits that trees provide, we need people who have the skills required to care for trees. Horticulture experts and plant scientists are of vital importance to the world, and they need to be future-focused in their work, actively seeking positive outcomes for society's challenges (Raven, 2019). This new era of the Anthropocene requires a new era of horticulture. Experts need to understand how to address society's needs and the realities of the urban environment, while taking trees and adapting them to where people live. This requires skills in arboriculture, sourcing, cultivation, production, and care in a way that is calculated and encompasses urban planning. We also need broad engagement across all sectors to strategically plan and manage the urban forest to gain the most benefits (Miller et al., 2015).

If we want to have the benefits of urban trees in the future, we must think of our urban forests as an investment. Like any investment, if trees are not cared for, they depreciate in value and can become a liability. Through planting and care, however, urban forests can have compounding benefits, trickling through every layer of society, leading to a better world. As the proverb says, “The best time to plant a tree is twenty years ago, the second-best time is now.” We must act now for a better world.

4. References

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