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Entry

Health-Promoting Nature-Based Paradigms in Urban Planning

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Definition: Since the 19th century, urban planning has largely been guided by ambitions to improve the population's wellbeing and living conditions. Parks and green areas have played a significant role in this work. However, the confidence in the function of green areas, and thus the motives for creating urban parks and green open spaces, have shifted over the years, which has affected both the planning and design of green areas. This entry describes three overarching paradigm shifts in urban planning, from the end of the 18th century to today, and the focus is on the major paradigm shift that is underway: how green areas can mitigate climate effects, increase biodiversity and at the same time support people's health and living conditions in a smart city.

Keywords: landscape architecture; biophilic design; restorative environments; smart cities; climate change; attention restoration; stress reduction; calm and connection; perceived sensory dimensions; urban heat islands

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1. Introduction

A paradigm can be defined as a model that people use as a starting point when discussing a phenomenon. Thomas Kuhn adopted this Greek word to define scientific paradigms as universally accepted theories, which for a time provide models and solutions to a community of practitioners. The paradigm sets the framework for how the phenomenon should be described, how observations of the phenomenon should be interpreted and what predictions can be described. Anomalies are seen as facts that contradict the paradigm, the generally accepted theory. When the anomalies become too many in number, a redefinition of the model takes place—this becomes a paradigm shift [1]. The word paradigm is used widely today, with essentially the same meaning defined by Thomas Kuhn.

Major paradigm shifts have taken place in urban planning, and in this entry we intend to focus on the role that parks and green areas have had since the end of the 18th century. At that time, urban planning came to be characterized by an ambition to strengthen the health and living conditions of the inhabitants, and the introduction of parks and green areas was then seen as a good means of achieving this. A couple of important paradigm shifts regarding the view of the design and function of green areas have taken place since then. The shifts have been characterized by anomalies, of which we are now experiencing the latest. In recent years, the increasingly warmer climate has led to more frequent heat waves and floods, which not least hit densely populated areas hard. Research shows that parks and green spaces can mitigate high temperatures [2] and effects of floods [3] significantly. In addition to their coolness and refuges from rainwater, urban green areas can also harbor an important species richness of plants, animals and microbiota of great importance for human health and wellbeing [4]. The research shows, among other things, that major parks with large volumes of trees are needed for climate regulation, that low points in the terrain with loose and pervious soil that can absorb large masses of water and thus slow down and store water volumes are needed, and that nontoxic, natural biotopes in cities are needed to preserve a rich biodiversity [2–4].

However, a number of researchers believe that the view on urban construction must change radically. Today's densely populated cities with green areas characterized by lawns do not work. Comprehensive visions about the design and planning of green areas are missing. In addition to serving as refuges for biodiversity and mitigating climate effects, the overall ideas about the green areas of the future must also include people's preferences and behaviors. This is because there is evidence that exposure to green areas has positive effects on people's mental health and wellbeing. The availability of green areas also affects how much physical activity people engage in. Therefore, these functions should be included in the planning and design of cities [5–11]. Section 2 presents today's situation and anomalies related to today's planning of parks and green areas. Next, we describe the two major paradigm shifts that led to the planning and design of the parks and green areas we have in today's cities. The remaining part of this entry describes the gradual emergence of a new paradigm shift, which includes people's behavior and preferences for green areas, how exposure to or stays in green areas of different qualities can positively affect people's health and wellbeing, and also the function of green areas with regard to climate and biodiversity in smart urban areas.

2. A Changed World Situation That Places New Demands on Urban Green Infrastructure in Urban Planning

During the last hundred years, the climate has become warmer. When cities contain many hard surfaces, they become very hot, causing serious health problems, not least for the elderly and the sick. If urban planning succeeds in developing several larger green areas with high tree canopy cover, this can lead to significant relief from the heat. Green areas can also alleviate extreme weather situations resulting from an increasingly warmer climate, such as frequent downpours and floods. This places new and difficult demands on urban planners and landscape architects [8–10].

In the planning and design of green environments, people's preferences must also be taken into account, as well as the possibilities of green areas to generally be able to support people's health and wellbeing. There is current evidence that urban green areas are of great importance to people, as the world's population has experienced more or less completely locked down societies due to the widespread COVID-19 pandemic. During this time, access to urban green spaces and parks has been found to be important for people's wellbeing and health [11–13]. From the late 18th century until the beginning of the 20th century, urban green areas and parks were created with the ambition to improve people's health, but in those days to reduce the prevalence of infectious diseases [14]. The risk of communicable diseases should of course be respected, and pandemics can pose major threats to the world's population. However, the public diseases from which most people suffer and die today are not contagious. In this entry, we describe that urban parks and green spaces, if planned, maintained and designed according to the new findings presented here, should be able to prevent a significant proportion of these noncommunicable diseases.

Common mental disorders, such as mild/moderate depression, anxiety and burnout, have increased substantially in recent decades and become a serious problem worldwide. Approximately one billion people globally suffer from some mental disorder, and the increase in the number of people suffering from mental illness is happening very fast [15–17]. Mental illness often debuts early in life, and approximately 14% of the world's adolescents (aged 10–19 years) are affected by a mental disorder [18]. The most common mental illnesses are anxiety and depression [19]. US National Center for Health statistics report that on average 13% of the adult population (aged over 18 years) have used antidepressant medications in the past 30 days, double as many for women as for men [20]. However, there are great opportunities to prevent mental illness by changing people's lifestyles. Urban planning focused on health-promoting measures can contribute substantially to supporting people in reducing the risks of ill health [16,17].

Diseases of the heart and blood vessels are the most common cause of death in the world. About 18 million people die from this cause each year, accounting for about a third of all deaths in the world. Added to this is a large percentage who become chronically ill due to problems with the heart and blood vessels every year, for example millions of stroke survivors. Up to 90 percent of all cardiovascular diseases are estimated to be preventable by people adopting a better lifestyle, such as by increasing physical activity, having a better diet and avoiding or preventing stress [21,22].

It is estimated that around half a billion adults between the ages of 20 and 79 worldwide suffer from type 2 diabetes, the fastest growing public disease in the world [23]. That is around 10 percent of the world's population in that age group. In addition, nearly 900 million people have impaired glucose tolerance (IGT), and/or elevated fasting blood sugar or nondiabetic fasting hyperglycemia (IFT). In impaired glucose tolerance and elevated fasting blood sugar, the blood sugar is higher than normal, but below the threshold to be diagnosed as type 2 diabetes. It has become common to use the term "pre-diabetes" to describe conditions that increase the risk of type 2 diabetes and diabetes-related complications [23]. The mortality rate due to type 2 diabetes is unfortunately high. In 2021, it was estimated that nearly 7 million people worldwide between the ages of 20 and 79 died due to type 2 diabetes and diabetes-related complications [24,25]. Type 1 diabetes often begins in childhood but can occur at any age. It cannot be prevented. However, there is evidence that most cases of type 2 diabetes and pre-diabetes can be prevented or delayed. In the United States, it is estimated that about 90 percent of type 2 diabetes cases can be prevented [26,27].

The main factors that increase the risk of cardiovascular disease, type 2 diabetes and common mental disorders are physical inactivity, stress, problems with sleep, tobacco use and unhealthy diet [16,28–30]. Stress can apply both to acute stressful life situations such as a loved one's death or a divorce as well as severe long-term stress at work and/or at home. Long-term stress is a risk factor in several ways: Stress triggers the sympathetic nervous system, which in turn affects the amount of plaque and the elasticity of the blood vessels, increases heart rate and blood pressure and affects insulin release, sleep quality, ability to focus attention, memory capacity, etc. The result is an increased risk of cardiovascular disease, type 2 diabetes and common mental diseases [16,27,31–35].

A large percentage of morbidity in the world can hence be attributed to cardiovascular diseases, type 2 diabetes and stress-related mental illness. This morbidity can be significantly reduced by changing people's lifestyles, which can be facilitated by smart salubrious urban planning. What is proposed by WHO is, among other things, to reshape physical characteristics of different environments to prevent mental disorders, type 2 diabetes and cardiovascular diseases, including homes, schools, workplaces, healthcare services, urban green areas and natural environments [19,36,37]. This entry should show that there are now research results that can support the planning of cities' green infrastructure, where both climate effects and health-promoting support for several public diseases can be taken into account. In this context, we will give an overview of how our urban environments have been influenced for a couple of centuries by ideas about how people's access to parks and green areas can give the inhabitants better living conditions and health.

3. Shaping a Paradigm for Building Green Healthy Cities: 19th-Century Thoughts on Salubrious Landscaping

Since the end of the 18th century, urban planning has been strongly influenced by concern for people's health, which resulted in green areas and parks being incorporated into the urban body. A driving person who can symbolize the development of this paradigm was the landscape architect Frederick Law Olmsted.

During the 18th century, industrialized fast-growing cities began to densify, which resulted in crowded housing, vermin and poor sanitation. Coal combustion flue and lack of wastewater treatment made cities bad-smelling and unhealthy, which led to the rapid spread of infectious diseases. Mortality was high, not least among children. Within the medical profession, the hypothesis was advanced that bad air (miasma) spread the infection, but that humans can breathe health-giving clean air in nature [38].

Ever since ancient times, certain types of natural areas have been considered more health-giving than others, although this belief has been of varying strength and applied in different ways [39]. During the scientific revolution and the age of enlightenment, intellectuals began to describe the importance of nature for human health based on scientific theories which were partly supported by ancient writings. Thoughts were, e.g., taken from Hippocrates' texts, like "Airs, Waters, Places". Environmental factors, such as the quality of air and water, the fertility of the soil and the climate of the site, were according to Hippocrates considered to play a major role in the occurrence of diseases in the locality [40]. Above all, great emphasis was placed on air quality, in which bad air, "miasma", was assumed to be directly linked to outbreaks of infectious diseases [39]. In addition, reference was made to Hippocrates' and Galen's humorism, which described that diseases could arise from an imbalance between the body's four fluids, where the composition depended, among other things, on the person's physical condition and disposition, how active the person was and what diet and nutrition they needed. A good measure to strengthen health was physical activity in nature, because the body fluids mixed best there; Hippocrates said the following: "Walking is the best medicine"; "If you are in a bad mood, go for a walk. If you are still in a bad mood, go for another walk"; "Food and exercise work together to produce health"; "If there is any deficiency in exercise, the body will become liable to disease, defective in growth and age quickly" [39,41].

The spread of diseases and child mortality became an increasingly pressing issue for decision makers in the growing cities. In several countries, such as Germany, England and Austria, demands were made from churches, charities and from people in higher social positions that people in exploited cities should be compensated for the lack of light, clean air and greenery. An influential person who diligently studied the medical literature was landscape architect Frederick Law Olmsted. His idea was that a healthy urban landscape would be constructed by draining the city of stagnant water and building parks where the wind and trees could clean the air. The "salubrious landscape" became a concept which around the world resulted in the building of parks near hospitals, the construction of sanatoriums in rural areas, the establishment of nature reserves and national parks, the creation of green suburbs and, not least, the creation of green parkways and large urban parks [14,38]. After the discovery that bacteria and viruses were responsible for much of the spread of disease in society, many of Hippocrates' and Galen's theories, not least those concerning miasma, came to be mocked. Today, health researchers have begun to reappreciate the salutogenic principles discussed by Hippocrates [42,43].

4. Shaping a Paradigm for Building Green Cities for the General Public: 20th-Century Thoughts on Health-Promoting Modernist Urban Planning

Many parallel lines of development at the end of the 19th century and the beginning of the 20th century paved the way for a new urban planning paradigm: modernism. From the middle of the 19th century, a series of moral/political positions and facts began to spread, which became anomalies within the prevailing paradigm. The germ theory of diseases presented by John Snow and not least Louis Pasteur challenged the miasma theory: it was not bad air that spread diseases, but microorganisms. However, it took a couple of decades into the 20th century before the miasma theory completely lost ground to the germ theory [44]. With the development of new medicines and better hygiene, the belief that being in nature was good for health gradually lost ground. In the middle of the 19th century, social movements also emerged in many countries. There were several different types of social movements, such as the working-class movement, the temperance movement, the free church movement, the women's movement, the popular education movement, the sports movement and trade unions. These organized themselves into associations and political parties, and what they had in common was a quest for better conditions for the public [45–47].

Many architects argued that the profession should take greater social responsibility. The task would primarily be to work to ensure that all people received a good home and a good living environment. The modernist ideas in architecture, landscape architecture and urban planning encompassed a change of the world, from the social system to urban planning, architecture, furniture and everyday objects in the home. The picture of the future was bright and positive, and there was a strong belief in technology, science, development and progress. The ideas were based on the belief that through rational thinking, logical problem solving and the use of new techniques and machines, it would be possible to create better living conditions for people. The dark, cramped, dirty houses and alleys would be replaced by hygienic houses with large window areas that would be nestled in bright clean parks. The vision of the modernist architects was that no one should live in cramped downtown areas or in dirty factory areas. In practice, this led to the city being divided into different areas based on function. In accordance with the pursuit of objectivity and strict expediency, there was no need to decorate the facades of buildings. Likewise, parks and green areas would be characterized by simplicity and cleanness, and the parks would offer large sunlit areas for play, sports and socializing [48,49]. Many specific sports grounds and playgrounds also came to be placed in urban environments. Design was often austere and pared down, with large grassy areas framed by trees and shrubs of a limited number of species. Ornamentation was considered not only unnecessary but also false and sentimental. A modernist ethic emerged where allusions to historic architecture, landscaping and ornamentation were prohibited [48,49].

The breakthrough of modernist architecture can be traced to several pioneers, such as Walter Gropius, Ludwig Mies van der Rohe and Louis Sullivan. However, the person who is usually associated with modernism more than others is Le Corbusier, partly for his long-term work as an architect, partly for his influential writings. Le Corbusier began his career as an architect at the beginning of the 20th century. Some healthier suburbs and garden cities had then been built, but the industrial cities were still crowded, dirty, filled with smoke and unhealthy. During the 1910s, Le Corbusier developed his type of modernist architecture and his ideas about how cities should be built for the future. He was inspired both by the garden city and by the new techniques in construction that were developed. The houses in the inner cities were generally built in a neoclassical or eclectic style with historical roots. Le Corbusier argued that they were too expensive for the common person to live in. In the book *La Maison des Hommes*, de Pierrefeu and Le Corbusier [50] wrote that the homes and cities created up to the 20th century were for "religion, the bourgeoisie, the royal house. They were not for the common person".

Together with other influential architects, he initiated the modernist CIAM 1928 [51]. During his long career, Le Corbusier presented many controversial ideas. The book "Vers une architecture", which he published in 1923, became incredibly influential, was translated into many languages and is still published in new editions [52]. It is even compared to Vitruvius' *De Architectura* as one of the most influential books on architecture in world history [53,54]. The book is strongly polemical and argues that to achieve a bright and green city, architects need to rethink. They need to base their projects on new, innovative construction techniques. In particular, glass, steel and reinforced concrete can open up buildings and let in light. The form of the houses should largely follow function instead of historical conventions. Houses in parks became a winning concept. However, it was after the Second World War, in the years 1950–1980, that the theories had a real impact on construction around the world [54]. One illustrative example is Stockholm: Inspired by Le Corbusier, the architect Holger Blom took modernist ideas to Stockholm. In 1952, he invited architects from the war-torn European continent to an attention-grabbing and appreciated conference in Stockholm, where attractive housing projects in nature near water were presented [55].

5. Arguments for a New Paradigm: Multifunctional Green Spaces in Smart Cities

5.1. Current Leap in Technology Development Is Pushing for a New Paradigm Shift in Architecture

However, the division of a city into different areas for housing, work and recreation has caused increasing problems associated with population growth, e.g., increased car traffic and longer distances to work, shopping centers and schools. This means, among other things, that it has become difficult for families to obtain a work–life balance. Residential areas tend to be empty in the daytime, when people are at work, and children are alone after school and receive poor support. The neighborhood square is now losing many of its former functions as a natural meeting place. Modernist architecture needs to be modernized, with priority for people's social needs. This insight is shared by many researchers, politicians and policy makers. Many of them trust this will be made possible by leveraging major advances in technology, and the concept being highlighted is called smart cities [56,57].

In the 1980s, the term Internet of Things was used for the first time, but it became more widespread around the year 2000. The term refers to the fact that everyday objects such as household appliances, clothing, machines, vehicles and buildings with built-in electronics and Internet connections can be controlled via or exchange data over the Internet. The network allows things to be controlled and share information from different locations, making it easier for the physical world to integrate, and this can result in higher efficiency and greater economic benefits [56]. The Internet of Things can be integrated into cyber–physical systems, where smart houses and smart mobility systems belong. Around the year 2005, the concept of smart cities began to be used. It spread quickly, so that already in 2011 when the Smart City Expo World Congress was held in Barcelona, 6000 visitors came from more than 50 countries [56,58]. At the beginning, the term mainly referred to smart houses and smart mobility systems, but it soon had to be broadened to include economy, management and governance. The concept was still tied to information and communication technologies such as the Internet of Things, but that was also going to change [57,59,60]. Today, many types of smart solutions are included in the concept of smart cities, and the following six main types often appear [56–59].

1. Smart mobility is about expanded public transport that should be better able to meet the demands from the public. It is also about being able to share vehicles to a greater extent, such as driverless cars on demand. This leads to far fewer vehicles in cities.
2. Smart living is about buildings with a high degree of connection to the Internet of Things, including in terms of household appliances, games, social media, entertainment, monitoring and security, energy use, work, healthcare and education. However, it is also about a range of amenities and public goods within a close distance from the home, such as social meeting points, shops, schools, recreation areas, etc.
3. Smart citizens is about education level, work and health, and is about participating in the cocreation of all parts of society and the environment.
4. Smart companies is about staff recruitment, employee care and smart workplaces where staff can work efficiently.
5. Smart environments is about environments providing clean air, clean water and high biodiversity and moderating high temperatures.
6. Smart governance is about using databases to a greater extent and increased transparency and democracy through people's participation.

There are obvious connections to architecture and the green salubrious outdoor environment in all the above parts. For example, smart mobility will probably lead to wide streets, squares and parking lots in cities being partially converted into park lanes and parks. This will in turn affect other parts, such as smart living and smart companies.

Le Corbusier saw the possibilities of technological development in architecture far beyond the technology itself. It has influenced housing, work and communications, as well as aesthetics and recreation. The smart cities concept is still strongly linked to information and communication technologies, but the change has begun. In recent years, landscape architects have worked with the concept of smart cities. Through a smarter use of databases, planning for the conservation of both biodiversity and cultural areas can be facilitated [59]. The smart city is now used more and more in a broad sense, in which the fascination for technical solutions is increasingly replaced by a critical approach, where the new technologies are thought to be used as natural aids in a well-thought-out way. Research is underway on planning for ecosystem conservation, better flood resilience, and mitigation of urban heat islands. However, more needs to be done on human wellbeing and health. There is a gap regarding preserving and developing qualities in green areas that are important for people's health. This applies to stress recovery, physical activity and breaking loneliness. These qualities can be refined with the help of AR, VR and AI, so it is necessary that technology, medicine, aesthetics and the humanities come together in research and development work [60–62].

Smart cities could solve many problems, but it is extremely difficult and costly to change social structures. It took more than thirty years and a world war before Le Corbusier's ideas really spread. Today, however, there is an energy crisis, a climate crisis, a large-scale war in Europe, and we have hardly seen the end of the COVID-19 pandemic at present.

The possibility of meeting over the Internet had been discussed for many years, and the technology was available, but habits are hard to break. In connection with the COVID-19 pandemic, however, authorities, companies and individuals have learned to work from home. Traveling is time-consuming and working from home obviously saves time. People have learned that they can communicate and collaborate well remotely over the Internet and are becoming more and more used to creating, developing and producing remotely. Many people have also discovered the wellbeing that results from being able to devote more time to a walk in the green quarter, but also a new solution to their balance between work and private life: they have time for work, family and leisure as the time for commuting is reduced [13]. The modernist division of the city into different functions, with areas for work, living and central functions, has over time led to sprawled cities with long distances and a large amount of commuting. It is unnecessary to travel every day if there are opportunities to work from home from time to time. Additional positive effects are reduced traffic congestion, reduced exhaust emissions and a greater awareness among people to value and take care of common green areas [11]. This should open up a changed approach in urban planning and construction.

This change may be perceived as positive for some branches of businesses, but is a more difficult issue for others. However, the changed conditions require decision makers and property owners to listen more carefully to users' needs and expectations. Demands will be made that neighborhoods need to be revitalized, so that the feeling of safety is improved and that the physical environment is able to support people's health and wellbeing.

5.2. Strong Evidence That Outdoor Activities Can Support People's Health and Wellbeing

Research has reported many confirmed connections between spending time outdoors, not least in green areas, and people's health and wellbeing. Living near urban green areas is strongly correlated to a higher quality of life, more healthy years and increased longevity, as several extensive research studies show [63–65]. The cost of society's healthcare should therefore be significantly reduced if people in cities can spend more time in green areas [66–68]. The risks of suffering from several common serious diseases, such as cardiovascular diseases [69], type 2 diabetes [70] and mental illness [71,72] are significantly reduced if people have greater opportunities to be exposed to urban green areas. How often and how long people should stay in, or be exposed to, green areas for health effects to manifest is not completely clear. However, proximity to green areas, which correlates with frequency of visits, plays a major role [65,73]. Regarding how long people should stay in green areas per week, a minimum of 120 min is suggested [74]. Effects are most noticeable in studies in metropolitan areas [68,71], and on people with low socioeconomic status [75,76].

Humans have evolved over millions of years to function optimally in natural environments, which could explain why spending time outdoors in urban green spaces leads to many health benefits. Outdoor air is usually healthier than indoor air in Western cities. Indoor air often contains dangerous amounts of dust particles, solvents, mold, asbestos and bacteria [77]. Exposure to daylight releases endorphins, our body's own morphine, which relieves pain, is generally mood-elevating, and affects our desire to eat, drink and sleep. Daylight also affects our biological clock, which regulates the hormones melatonin, which makes us sleep well, and cortisol, which makes us alert in the morning. When the biological clock works as it should, people become more alert, the body's immune system works better and the risk of depression and cardiovascular diseases decreases [78].

When the sun shines on the skin, vitamin D is also formed, which the body needs to build and repair tissues in the body. Designing nearby places, such as homes, workplaces, schools and nursing homes, from which people are attracted to going outside for a while every day and enjoying natural daylight, getting sunlight on their bodies and being able to breathe fresh air, should therefore bring great health benefits, such as better sleep and a reduced risk of many diseases, such as depression and cardiovascular diseases [77,78]. However, it is not only exposure to daylight, sunlight and fresh air that affect the positive health resulting from staying in green areas. Several systematic reviews indicate that green areas themselves—exposure to and time spent in them—contribute positively to people's health and wellbeing [72,79,80].

5.3. The Importance of an Enriched Green Urban Environment

Large systematic reviews show that exposure to certain green spaces stimulates psychological recovery from stress [81] and mental fatigue [82]. That is, not all green environments work. If people are mentally tired and have difficulty concentrating, a stay in certain natural areas can provide effective help. In these natural areas, people can take quiet walks where they can go on autopilot to achieve mindfulness. In such areas, people do not need to sort information, plan or make decisions. These areas should preferably be larger and uniform, without too much diversity, as in a beech or pine forest, where people can move for a long time without having to make a decision [83,84]. For a stressed person, exposure to certain natural environments can quickly lower stress levels. These areas should ideally be bright and open, contain elements of water and be not too noisy but calm. A good place to rest for stressed people should provide opportunities for a view and contain escape routes so that people do not risk feeling trapped [84,85]. Urban green areas and parks are also of great importance for creating social interaction and breaking loneliness, which is an important part of public health [86]. For both young and old, it is important that such green areas are close to their homes, and have access to certain facilities such as playgrounds, open areas for ball games or picnics, flower arrangements, cafeterias or other social meeting points and restrooms [84,87,88].

Studies show that most urban green areas in the world consist of grass areas bordered by shrubbery, a legacy of the ideals of modernism [89]. But the above shows that urban districts' green areas must be able to meet different types of needs and support them. It is in the relationship between the environment and the visitor that opportunities for support can arise, which can be described as affordances. An urban environment that can provide a range of green areas with different opportunities can be defined as an enriched environment [90]. Different types of green areas are therefore needed.

In the relationship between the visitor and the environment, the human mind and body interact with the opportunities afforded by the setting. Humans have a large number of senses that help us perceive our surroundings, of which sight, hearing, smell, taste, soft touch, pressure, balance, proprioception, temperature sense, gravity and pain are the most described [91]. These senses collect a wealth of information, about 11 million bits of information per second, and communicate this information to the central and peripheral nervous systems in a variety of ways. The conscious brain can process about 40 bits of information per second [92]. The capacity of our consciousness is thus not without importance, but we must not overlook the capacity of the unconscious. Much of the processing of what happens in our environment, and the decisions that are made, takes place completely unconsciously [92,93].

Attractive environments where people feel calm and safe can lead to increased activation of an ancient psychophysiological system that makes people feel calm, trust, belonging and hope: our calm and connection system—the oxytocinergic system—which, among other things, activates the hormone oxytocin [94]. It leads to reduced stress, increased healing ability, increased joy and interest in social activities as well as increased cognitive ability and ability to manage life situations (coping). Memories and considerations are also found in the environmentally enriched subliminal, and affect us in both the short and long terms. All our senses, with the enormous amount of information they deliver, activate both lightning-fast action and rational thought, but also a parallel consideration, which operates relatively quickly and unconsciously in contrast to the slow, conscious rational thought. This subliminal reasoning, which we can call intuition, is an important part of how we act and make considered decisions, and can help us get through life crises and improve our life management [93,94].

The environment can also support physical development and ability. When people are indoors, for example working in an office, they use only a couple of senses, and only a fraction of their neuromotor capacity, in which muscles, nerve pathways, bone structure and sense impressions communicate in lightning-fast processes with the sympathetic and parasympathetic nervous systems as well as with the brain. Humans are physically and psychologically prepared to move and develop in a multisensory enriched natural environment. To maintain health, people need to use, train and develop this capacity. Natural environments offer complex interactions with the inherited functions of our bodies, which influence and change the structure and function of the body and brain over a person's lifetime. Physical activity has a positive effect on the whole body, including stimulating growth in the brain, or so-called neurogenesis. However, in order for the new cells to remain and function, they need to be used as soon as possible, ideally in a multisensory enriched environment [95–97].

For example, if a person is running on a forest path, this requires hyper-fast communication between the person's eye, brain and muscles so that the person has time to lift their feet high enough, for example to both detect and avoid a stone on the path. The eye perceives the stone and primes (i.e., prepares and instructs) muscles in the legs and feet as to how the runner should face the obstacle. This occurs in rapid processes of which the person is unaware; they are subconscious or subliminal [98–101]. Such subliminal priming processes in nature can stimulate and facilitate healing processes in the body and accelerate neurogenesis in the brain. Even a very old human brain can develop via neurogenesis through stays in diversely enriched environments [102–104].

5.4. A Spectrum of Perceived Sensory Dimensions Satisfies the Need for an Enriched, Health-Promoting City

Hypotheses about stress-reducing environments have been based on preference studies about environments where people reflexively feel safe, for example in open savanna-like environments [105], or where visitors can see and monitor their surroundings without being seen [106]. Other studies suggested that people prefer environments with good opportunities for wayfinding, and where there are opportunities for discovery, a stimulus for curiosity [107,108]. Recent experimental studies have investigated these factors and found that preferences for different environments depend on subtle relationships between these factors [109,110]. Current research also shows that stressed people are sensitive to exposure to the outside world. Forest areas and trees provide significant health-promoting effects, unlike open grassy areas [67,72].

In order to be able to plan and design environmentally enriched and health-promoting green areas, it is important to be able to distinguish different qualities and understand what significance they have in different contexts. They must be described holistically, based on sensory information obtained via sight and hearing, the size of the area and connotations related to, e.g., activities, safety and symbolism. The qualities must not be too many and must be understood intuitively, one by one, and in relation to other qualities. Over the past couple of decades, research has led to the development of the perceived sensory dimensions (PSDs) [84,111,112]. Table 1 describes the eight PSDs in an overview.

Table 1. Brief descriptions of the eight PSDs [90].

PSD	The Environment Affords. . .
Natural	- Fascination with the natural world, its distinctive shapes and colors, its inherent force and power. A sense of the wild and untouched, of the passage of time.
Cultural	- A sense of fascination with human culture, creativity, labor and history. The cultivated, crafted and human-made, as opposed to the "self-made" or natural.
Cohesive	- A sense of spatial cohesion and spaciousness, an experience of a "world in itself", an extended, uninterrupted whole that is possible to explore.
Diverse	- A sense of diversity and variation in the environment. A large variety of different species of plants and animals. Multilayered and diverse vegetation, often in combination with water features.
Sheltered	- A sense of shelter, safety and protection. An enclosed space, a refuge, a hideaway. The possibility to "be seen without being seen".
Open	- A sense of openness and freedom. Overviews, prospects, vistas and stays. Open space for physical activities, room to roam freely, to see far into the distance.
Serene	- A sense of serenity, peace, quiet and stillness. Freedom from noise and disturbances. Peaceful sounds of nature. Absence of other people, signs, signals, threatening or intrusive stimuli.
Social	- A sense of bustling activity, people and movement. A dense and lively place, with social activities and interactions. Often especially strong in dense urban settings, around, e.g., cafés, shopping streets and squares.

The PSDs have been shown to work in different cultural contexts, such as Denmark, Iran, Serbia, China, Malaysia, Russia and Japan [113–119]. Whether the studies take place in Iran, Malaysia or Sweden, they show that the environments that best support people to be able to recover attention and reduce high stress levels are areas characterized by nature: homogenous coherent spaces, areas which can offer silence and spaces where one can be shielded from exposure to the eyes of the outside world [112,115,120]. This applies to four of the eight PSDs: Cohesive, Serene, Natural and Sheltered. However, many studies show that a spectrum of different environments is needed for people to feel good. This is partly because different PSDs support different activities [121], but also provide different types of psychological support. Research shows that people affected by life crises seek large, natural areas, but when the crises begin to subside, they seek social contexts [122]. In addition, studies show that when rehabilitating people affected by stress-related mental illness, participants initially need supportive environments that are calm, secluded and characterized by nature, while later in rehabilitation they need more stimulating and social environments [90]. When people are affected by stress, fatigue, worries and troubles, they have a great need for support from a restorative environment. As they become more alert and recovered, they need less and less support from a restorative environment. This can be described as a pyramid; see Figure 1.

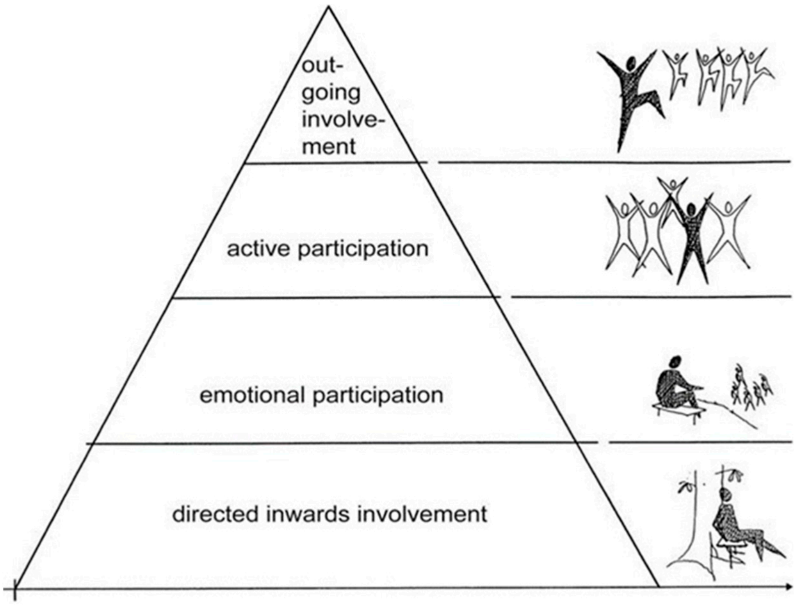

Figure 1. The model of supportive environments: This explains the relationship between the individual's mental strength, the need for supportive environments and PSDs. The *X*-axis shows the degree of need for supportive environments while the *Y*-axis shows the individual's mental strength. This figure shows the situation for people affected by stress-related mental illness, where the need for directed-inwards involvement is great, while the need for social involvement is slight. Reprinted from Ref. [123].

The supporting function of the different PSDs is clearly felt when it comes to crisis victims and the sick, but they fulfill the same function for the common person. This is noticeable in epidemiological studies, where it turns out that the more PSDs there are in a neighborhood's green areas, the greater the physical activity, neighborhood satisfaction and general health [124,125]. Moreover, in various experiments and studies, all eight PSDs are found to have supportive functions, but while some PSDs are clearly restorative, such as Serene and Shelter, others are more stimulating, such as Social and Cultural [122,123,126]. See Figure 2.

5.5. Using Developed Knowledge Regarding Health-Promoting Green Qualities in Practical Planning and Design

All over the world, more and more studies are being conducted in which the eight PSDs are used, not least regarding health-promoting environments, in cities [120,127], in forests [128] and on university campuses [117], for example. They are also used experimentally through manipulated images [123] or in VR environments [118]. In addition, they are, e.g., used in case studies on noise impact [129] and in town planning as criteria for achieving social, ecological and economic sustainability goals [130].

In 2021, a study was published that summarizes several decades of qualitative and quantitative studies regarding PSDs, including several factor analyses with oblique rotation. These show that some factors have opposite attributes while others are closer together. In summary, the eight PSDs are illustrated as shown in Figure 3: The eight PSDs lie along four axes. Each axis has two opposing qualities that need to be balanced against each other as they are often associated with opposite attributes [84]. There is thus a gradient along these four axes, from the extreme outer edges to more moderate expressions. Adjacent PSDs in the model are synergistic and support each other. It is suggested that support for three such adjacent PSDs can contribute to places with high aesthetic function and low conflict between different experiential values [84]. Through this synthesis of the eight PSDs, a model of experiential values has now been created that has a high development potential for being used in the planning and design of health-promoting urban green areas (Figure 3).

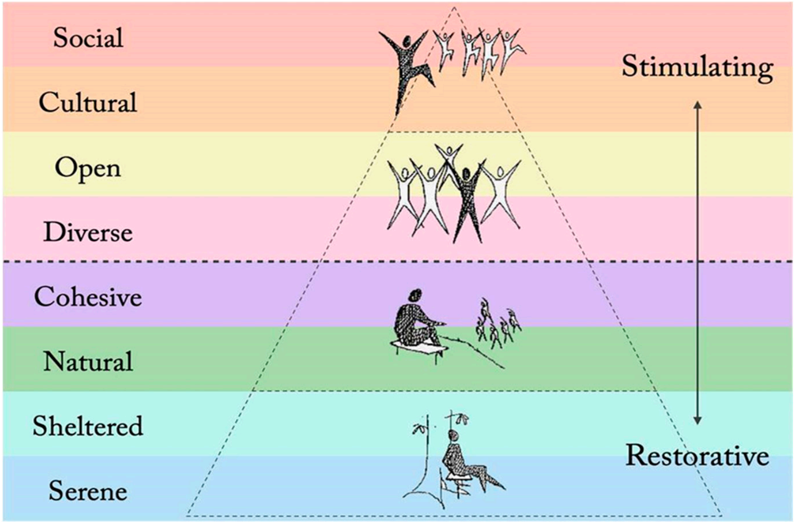

Figure 2. The model of supportive environments integrated with perceived sensory dimensions. The eight PSDs are placed on a scale from the most stimulating to the most restorative.

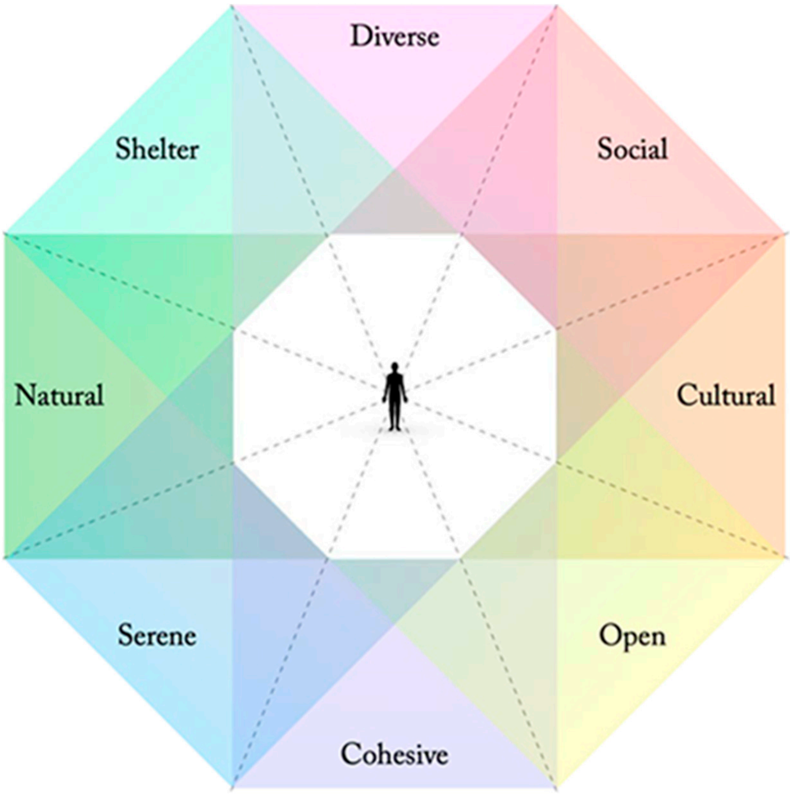

Figure 3. Basic relationships between the eight Perceived Sensory Dimensions (PSDs), explained through four axes of opposing characteristics, and complementary characteristics to the adjacent PSDs. The closer the PSDs are in the model, the closer the associations between qualities. Reprinted from Ref. [84].

The model contains two further gradients. In Figure 4, a distinction is made between the PSDs that are most often associated with larger green areas—Natural, Serene, Cohesive and Open—and those that often occur even in smaller environments, which are associated with the opposite experience values, namely Cultural, Social, Diverse and Shelter [84].

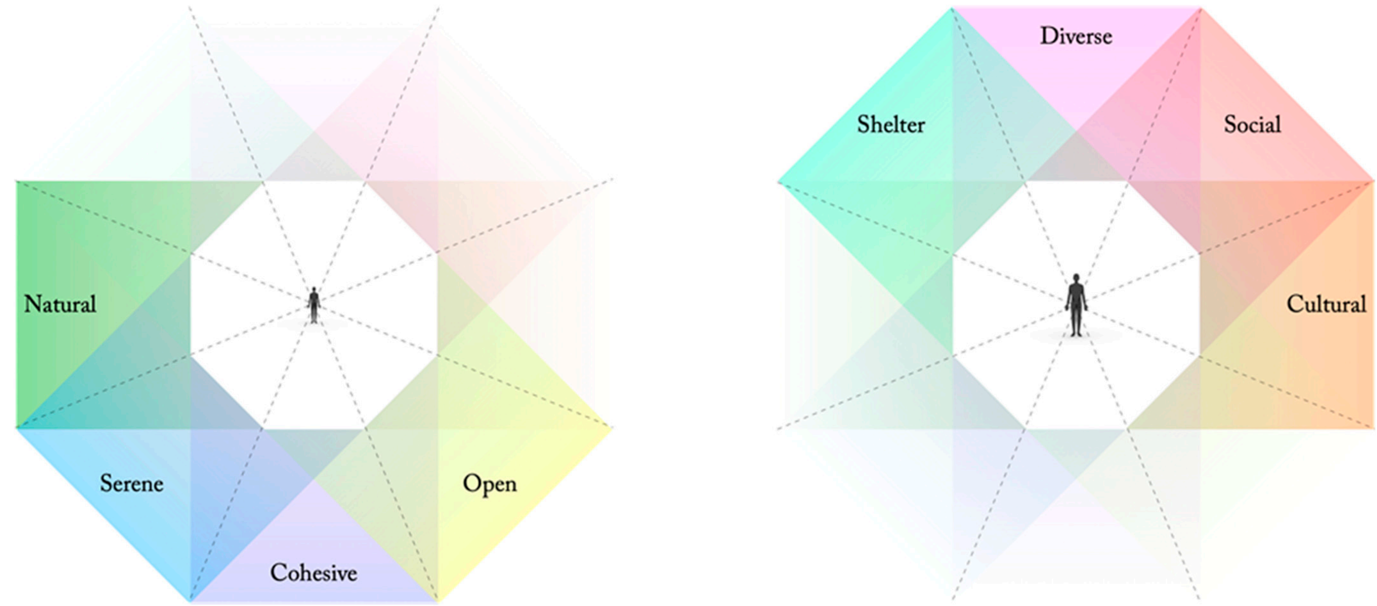

Figure 4. In this model, there is a clear difference between the perceived sensory dimensions that usually require larger green areas (**left**) and those that are most often linked to smaller spaces in order to provide good support (**right**). Reprinted from Ref. [84].

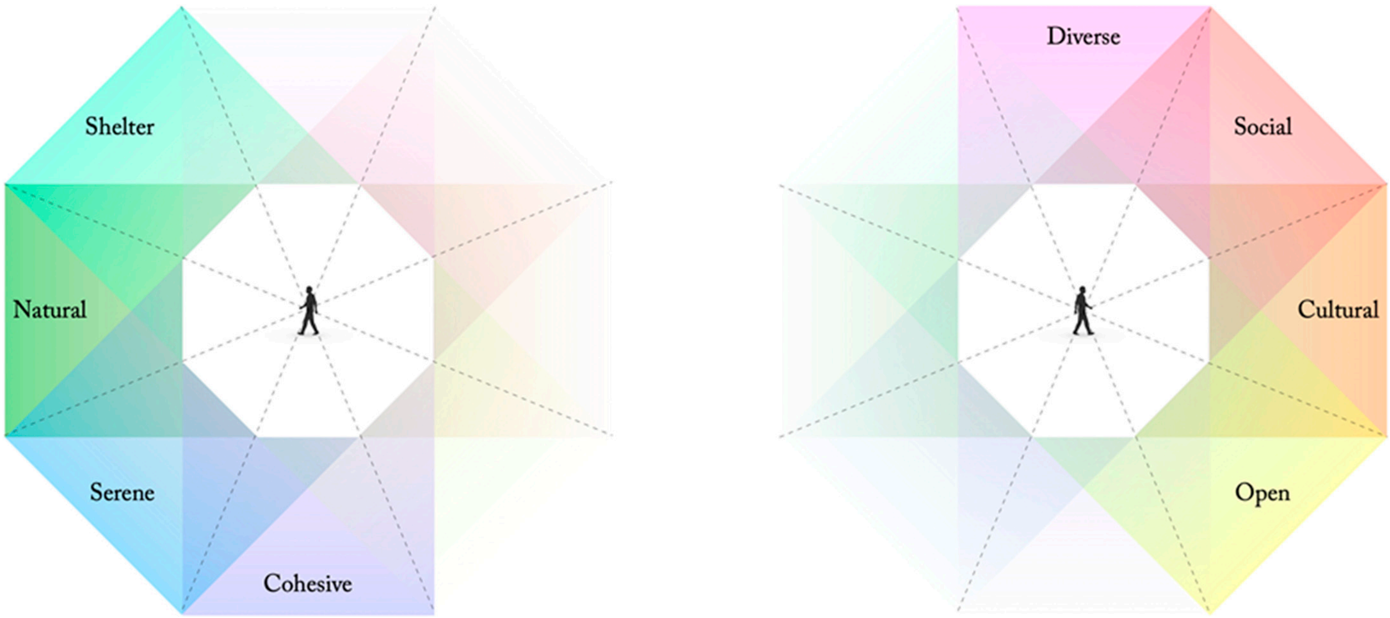

Figure 5. Research shows that people in need of recovery from stress and mental fatigue are more likely to seek out environments perceived as supporting the PSDs Natural, Shelter, Serene and Cohesive (**left**). As the need for recovery diminishes, Cultural, Open, Diverse and Social environments often become more important (**right**). Reprinted from Ref. [84].

Another distinction can be made between the PSDs that are particularly associated with restoration from stress and exhaustion (Shelter, Natural, Serene and Cohesive) and the PSDs that are often preferred only when stress and fatigue reach lower levels, namely those that stimulate the visitor (Diverse, Social, Cultural and Open). The four PSDs associated with destressing and restoration are highly sensitive to qualities associated with the stimulating PSDs. For example, PSD Serene is very sensitive to the presence of people and voices, something that belongs to PSD Social, while PSD Natural is sensitive to the presence of manufactured artifacts, something that belongs to PSD Cultural [84] (see Figure 5).

This holistic PSD model should be able to be developed, for example as part of AI applications, to be used as a tool in practical planning and design.

6. Conclusions and Prospects

In 2004, Poulain et al. published an article about a geographical area where people lived much longer than expected [131]. The same phenomenon was discovered in a few other places around the world, and these came to be known as blue zones. Since then, researchers have tried to identify which factors can lead to an unusually large number of people in these places being able to live active social and mobile lives despite being over 100 years old. Several conditions relate to a healthy diet, i.a., not eating too much and eating more vegetarian food. However, other factors can be attributed to the conditions of the physical location. What they have in common is that people in these areas are physically active in natural environments. These surroundings also provide the conditions to destress and recover cognitive abilities. Furthermore, people live within short distances from social meeting points, maintain a social network and avoid unwanted loneliness. Important cultural values and social values in the urban area can be combined with opportunities for physical activity and stress relief in natural environments [132,133]. This can be interpreted as the blue zones being environmentally enriched, in terms of cultural and social values as well as a number of natural values. Thus, stimulation to move naturally occurs, which stimulates neurogenesis. Restorative and instorative environmental qualities can lead to stress relief, a socially active life, trust in places and a sense of home [132,133].

Based on these findings and the above arguments, a strategy for an environmentally enriched, health-promoting smart city should be able to be outlined:

The technological development enables the smart city to be realized, with smart mobility, smart living, etc., and from our perspective, smart environments, where the environment can mitigate climate effects and lost biodiversity and support people's health and wellbeing, psychologically and physically. Research shows unambiguously that an important part of this health-promoting environment must consist of natural environments. The research also shows that what these natural environments should contain and how they should be designed are important considerations.

More and more researchers are investigating the possibilities of using artificial intelligence, AI, as an aid in urban planning, and the results are promising [134–136].

Research studies show that the urban environment as a whole must be enriched with a spectrum of perceived qualities. There is today a model of perceived sensory dimensions (PSDs), which can be developed, not least within artificial intelligence, to be used in the planning and design of urban smart health-promoting environments. Today, PSDs are used in the construction of databases and as tools in health-promoting urban planning and the design of urban environments [119,137–139].

Today, quarters in inner cities are being densified, which often leads to the use of parkland. This poses a dilemma, as research shows that exposure to nature and green areas is of great importance to human health. However, not everyone can live near large natural areas, and it is also not certain that this is the best solution for most people. A strategy could be that in the central parts of the city, where green areas are often small, PSDs should focus on the Social, Cultural, Shelter and Diverse dimensions. City dwellers must, however, be able to visit larger natural and green areas providing the PSDs Open, Cohesive, Natural and Serene which are at a reasonable distance. Several studies are now investigating the possibilities of being able to plan and design small pocket parks in central city blocks, including facade greenery, to develop health-promoting properties [117,139,140]. Other studies deal with planning and designing larger park areas at reasonable distances that involve the PSDs Serene, Natural and Cohesive, which require larger green areas [114,141].

More and more researchers are investigating the possibilities of using artificial intelligence, AI, as an aid in increasingly complex urban planning and design, and the results are promising. Since consideration needs to be given to climate effects as well as biodiversity and people's health and wellbeing, assistance from AI may be needed. When it comes to planning future urban green structures, there are examples of the use of AI [142,143]. Today, there is an increased understanding of the multifaceted impact parks and green areas have in the urban environment. Knowledge is also emerging regarding how green areas can best satisfy extensive needs. The size of the green areas, their location in the city, what they should contain and how they should be experienced should all be taken into account, and people's need for an enriched environment and the knowledge of perceived sensory dimensions are part of the context.

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