



Greenery in and around houses and apartment buildings is good for the indoor and outdoor climate and living environment and has a positive effect on the health and general well-being of residents and visitors. This document provides information on how homes and well-being can benefit from greenery, including references to scientific literature. It concludes with some tips on how to ensure the successful and full inclusion of greenery.

## What does greenery do?

- ▶ Indoor plants purify the air: they reduce concentrations of CO<sub>2</sub> and volatile organic compounds, keeping air fresh and healthy.
- ▶ Outdoor vegetation curbs heat in and around the house in the summer, reducing heat stress and cooling requirements.
- ▶ Green roofs and façades increase insulation capacity: lower heating costs in winter and cooler temperatures in summer.
- ▶ A view of greenery generally reduces stress levels.
- ▶ In green environments people spend more time outdoors and are more active.
- ▶ Green outdoor areas contribute to a better social climate.
- ▶ Greenery regulates drainage of rainwater, limiting potential flooding.
- ▶ Indoor plants release water vapour and humidify the air, reducing headaches and improving concentration.



## Applications

- ▶ Indoor plants in living and sleeping areas
- ▶ Green roofs and façades
- ▶ Green gardens with trees, shrubs and hedges instead of hard surfaces
- ▶ Plenty of parks and other public green spaces in residential areas
- ▶ Vertical gardens for houses directly abutting the street
- ▶ Trees and other types of greenery in and along streets

## Proven successes

- ▶ The Green Agenda research programme has developed the Green Healthy City design tool. This tool can be used during the draft design phase to aid in crafting effective measures for healthy districts and neighbourhoods.<sup>5</sup>
- ▶ Particularly in less affluent neighbourhoods children less often use ADHD medication (including Ritalin) when there is more greenery in their living environment.<sup>1</sup>
- ▶ A study in New York showed a positive correlation between the density of street trees and the health of newborns; 20% more street trees led to a 2.1% reduction in the number of premature births.<sup>2</sup>
- ▶ An American study among identical twins showed a negative correlation between greener environments and depression.<sup>3</sup>
- ▶ A study in Toronto revealed that people in neighbourhoods with higher tree density not only felt significantly healthier, but also showed significantly lower rates of cardiovascular disease. Planting ten extra trees in every street block delays the onset of age-related health conditions by an average of seven years.<sup>4</sup>



1. S. de Vries, R. Verheij & H. Smeets (2015), Groen en gebruik ADHD-medicatie door kinderen: de relatie tussen de hoeveelheid groen in de woonomgeving en de prevalentie van AD(H)D-medicatiegebruik bij 5- tot 12-jarigen. Alterra- rapport 2672. WUR-Alterra, Wageningen.  
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4. O. Kardan et al. (2015), Neighborhood greenspace and health in a large urban center. Nature Scientific Reports: 5:11610. DOI:10.1038/srep11610.  
5. <https://tools.wenr.wur.nl/groenegezondstad/>



# Greenery in a residential context

The positive effects of greenery in urban environments



## Temperature

Temperatures in cities are generally higher than in the surrounding areas (the heat island effect), because hard surfaces (roads and buildings) absorb more radiation from the sun and release it into the immediate environment. The density of built-up areas limits air exchange with the wider environment, trapping the heat in the city. This effect occurs in metropolitan cities as well as in provincial towns and village centres, and increases as built-up areas become denser. Measured in the Netherlands, maximum differences in ambient temperature due to the heat island effect vary from one to several degrees, with peak values reaching around 8°C and incidental values even exceeding 10°C. Extremely high temperatures during heat waves cause heat stress, adversely affect health, particularly among elderly and chronically ill people and pregnant women, and may increase mortality rates. Research has shown that 35% of urban areas in the Netherlands already experience heat stress at least seven days a year. Increasing urban density and climate change will increase the frequency of periods of heat stress in cities. Green zones absorb less heat during the day and cool off more quickly at night than hard-surfaced urban areas, reducing heat stress.

## How greenery works

- ▶ A 10% increase in urban vegetation reduces the heat island effect in the relevant city by an average of 0.6°C.<sup>1</sup>
- ▶ Greenery provides cooling by blocking solar radiation (i.e. providing shade) and through water evaporation. The evaporative cooling effect is strongest in the afternoon, evening and early night time. This is important, as heat stress during sleep has significant adverse health effects.
- ▶ Questionnaires show that people feel more comfortable in green environments during warmer periods.<sup>2</sup>
- ▶ Parks stay cooler than densely built-up city centres during hot weather, with measured temperature differences of over 5°C. Shade has the greatest effect: it helps to lower air temperatures and the reduced solar radiation beneath trees significantly raises levels of thermal comfort.<sup>2,3</sup>
- ▶ Parks not only provide 'cool islands' in warmer urban environments, but also have a cooling effect on the surrounding neighbourhoods. This effect is normally between 1.5 and 3.5°C, depending on the size of the park and local conditions, and diminishes as the distance to the park increases.<sup>4</sup>
- ▶ A study conducted in the area around Kensington Park in London measured a cooling effect on warm nights of up to 4°C as far as 440 metres away from the park.<sup>5</sup>
- ▶ A combination of green façades, front gardens and roadside trees works best to reduce heat in streets and can lower temperatures at pedestrian level by 2°C.<sup>6</sup>

## Recommendations

- ▶ To improve thermal comfort and prevent heat stress in urban areas, it is important to increase the ratio of vegetated areas to hard-surfaced areas and buildings. This allows for more infiltration of water into the soil (and less run-off), which provides cooling through evapotranspiration.<sup>7</sup>
- ▶ Thermal comfort for residents during the day time is primarily linked to the amount of shade provided by the vegetation: trees with large, dense canopies are most effective, both in parks and on streets. When planting roadside trees, ensure healthy growing conditions and position the trees in a way to maximise the cooling effect of the shade provided.
- ▶ The evaporative cooling effect is largely limited to the immediate vicinity of the vegetation; utilising this effect on a neighbourhood level requires a dense and extensive network of greenery.
- ▶ The cooling effect of evaporation only works when enough water is fed to the vegetation, so it is essential to design and manage effective watering facilities. Irrigating trees and plants can help during dry periods.
- ▶ Green roofs contribute to home insulation and prevent overheating in summer; large-scale application of green roofs can help to cool down entire neighbourhoods. For this to be effective, a good water supply is essential.
- ▶ As fresh air supply significantly contributes to mitigating the heat island effect, greenery must be planted in a way that enables sufficient air circulation.
- ▶ More practical information is available in the Urban Greenery – Climate and Temperature fact sheet (<http://edepot.wur.nl/460543>).
- ▶ Practical information on social housing can be found on the website <https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksinstituten/environmental-research/show-wenr/prettig-groen-wonen.htm>.



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## Air quality

Major air pollutants in urban areas, including nitrogen oxides (NO<sub>x</sub>), particulates (PM<sub>10</sub>/PM<sub>2.5</sub>) and volatile organic compounds such as benzene, come from industry and traffic. Long-term exposure causes lung problems and cardiovascular disease. Although air quality in most locations in the Netherlands complies with the applicable standards, this does not mean the risk is fully eliminated. Especially on busy city roads limits are regularly exceeded. From a public health perspective, however, standards should never be the goal; air pollution in any form, even if it remains under the limit, is ultimately detrimental to health and well-being.

Urban areas combine high population density with high peak activity (busy roads). Although all forms of greenery may contribute to removing pollution from the air, the effect on local concentrations of air pollutants is limited in practice. Hence, high concentrations can best be prevented by source-based measures (emission reduction and capture at source). Moreover, to keep concentrations in cities low it is essential that air can mix with upper air layers (turbulence) and with air from the surroundings (ventilation). Because of its filtration and screening effects, greenery can play a role in supporting policies to improve air quality at the source. In this context it is crucial that the circulation of cleaner air from other areas is not impeded around busy roads and between high-rise buildings ('street canyons').

## How greenery works

- ▶ The relation between greenery and air quality is complex; three forms of (potential) effects play a role in this<sup>1</sup>: 1. direct effects on concentrations, positive (capture of pollutants) as well as negative (production of allergenic pollen or volatile organic compounds); 2. the effect on air flows; and 3. indirect reduction of emissions: green surroundings may stimulate other forms of mobility (walking/cycling instead of car use).
- ▶ All forms of vegetation help to remove particulates and other pollutants from the air. Gaseous contaminants are absorbed by leaves; particulate matter is filtered out passively.<sup>2</sup> Trees are most effective due to their size and volume: an average city tree captures 100 grams of particulate matter per year, equivalent to the quantity produced by 5,500 car kilometres.<sup>3</sup> Other types of greenery also help to purify the air: one square metre of ivy captures 4-6 grams of particulate matter per year, a stonecrop roof captures 0.15 g/m<sup>2</sup>.<sup>4</sup>
- ▶ However, the purifying effect of vegetation on air quality in urban areas is limited due to the relatively low volume of vegetation compared with the air volume to be filtered, which, partly as a result of the constant supply of air from other areas, is massive.<sup>6</sup> A recent literature review concluded that the maximum effect to be obtained amounts to a reduction in local concentrations of a few percent at most.<sup>5</sup>
- ▶ Dense vegetation can be used to shield residential areas, sensitive buildings or adjacent foot and cycle paths from sources of pollution (e.g. busy roads).<sup>7</sup>
- ▶ Scientific literature shows that plants can have a marked positive effect on indoor air quality as well, chiefly because they remove volatile organic compounds (VOC). It must be noted that plants often cannot do this on their own. Indoors a source-based approach is essential too.<sup>8</sup>

## Recommendations

- ▶ Increase the number of mature trees to boost filter capacity, but avoid impeding air circulation, especially in narrow streets with high-rise buildings (street canyons).
- ▶ Large and healthy trees are most effective; therefore, provide good growing conditions and enough growing space so they can reach a healthy old age.
- ▶ Evergreen conifers are most effective at capturing particulates; broad-leaved trees with large, fuzzy or sticky leaves are a good alternative.
- ▶ Trees with flat, broad leaves are most suitable for absorbing ozone and nitrogen dioxide.
- ▶ Species that secrete large amounts of volatile organic compounds or produce strongly allergenic pollen should be avoided. Aim at diversity when selecting species; this will limit these potentially negative effects.
- ▶ Ambient air exchange is extremely important for air quality. If there is a danger of greenery blocking off streets, green roofs and façades can be good alternatives.
- ▶ Shade in car parks limits evaporation of fuel from fuel tanks, raises comfort on departure and lowers energy consumption by air-conditioning systems.
- ▶ On the other hand, dense vegetation can help to shield residential areas and sensitive locations (schools, hospitals, aged care facilities) from pollution from nearby sources.
- ▶ *Spatiphyllum* is the best-known plant for purifying indoor air. *Calathea*, *Chlorophytum*, *Areca*, *Dracaena*, *Hedera* and various ferns are other good options.
- ▶ More practical information about greenery and outdoor air quality is available in the Urban Greenery – Air Quality fact sheet (<http://edepot.wur.nl/460539>); information about the choice of plant species can be found in the Urban Greenery – Species Table fact sheet (<http://edepot.wur.nl/460540>).



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## Mental health

In modern Western society lifestyle-related conditions such as cardiovascular disease, depression and anxiety disorders are responsible for a large proportion of the disease burden. Chronic stress is a key risk factor in this regard: 75-90% of all visits to GPs are thought to be stress-related. Green living environments help to improve health and lower stress.

### How greenery works

- ▶ Recent studies using modern medical scanning technology, including functional MRI (fMRI) and functional near-infrared spectroscopy (fNIRS), show a favourable effect on brain activity: people are more relaxed and more positive when they are looking at natural surroundings than when they are shown a built-up area. EEG scans taken in everyday surroundings also indicate that people are more relaxed in natural surroundings than in urban surroundings.<sup>1</sup>
- ▶ Studies based on self-reported states of mind in specific locations reach a similar conclusion: people feel happier in more natural surroundings. This effect is visible in agricultural areas, but is strongest on the beach.<sup>3</sup>
- ▶ Closer to home street trees also make a difference. The more trees there are within 100 metres from the home, the lower the use of antidepressants; this relation is most notable among less well-off people.<sup>4</sup>
- ▶ Children with ADHD show higher levels of concentration after walking in a city park than after walking through a residential area or city centre for the same length of time. About 10% less ADHD medication is prescribed for children in green environments (this does not apply to 'wealthy' districts).<sup>2</sup>
- ▶ Even a view of greenery from the home is associated with an improved sense of mental well-being. This was especially the case in times of strict lockdown during the coronavirus pandemic.<sup>6</sup> Although it is clear there is a positive association between most types of greenery and mental health<sup>9</sup>, there are early indications that especially trees have a positive effect.<sup>10</sup>
- ▶ Particularly populations who are unable or unlikely to seek out nature far from their homes (children, the elderly and groups with a low socio-economic status), benefit from local greenery.<sup>5</sup>
- ▶ A green environment earlier in life continues to have positive effects in older age, as living in surroundings with a relatively high rate of greenery during childhood and adulthood can delay the decline in mental capacity in old age.
- ▶ The local presence of greenery and water lowers the risk of developing anxiety disorders.<sup>7</sup>
- ▶ Primary school children growing up in densely built-up areas benefit from a high density of trees. Research indicates that these children are at a lower risk of developing autism.<sup>8</sup>

### Recommendations

- ▶ Increase the number of mature trees to boost filter capacity, but avoid impeding air circulation, especially in narrow streets with high-rise buildings (street canyons).
- ▶ Large and healthy trees are most effective; therefore, provide good growing conditions and enough growing space so they can reach a healthy old age.
- ▶ Evergreen conifers are most effective at capturing particulates; broad-leaved trees with large, fuzzy or sticky leaves are a good alternative.
- ▶ Trees with flat, broad leaves are most suitable for absorbing ozone and nitrogen dioxide.
- ▶ Species that secrete large amounts of volatile organic compounds or produce strongly allergenic pollen should be avoided. Aim at diversity when selecting species; this will limit these potentially negative effects.
- ▶ Ambient air exchange is extremely important for air quality. If there is a danger of greenery blocking off streets, green roofs and façades can be good alternatives.
- ▶ Shade in car parks limits evaporation of fuel from fuel tanks, raises comfort on departure and lowers energy consumption by air-conditioning systems.
- ▶ On the other hand, dense vegetation can help to shield residential areas and sensitive locations (schools, hospitals, aged care facilities) from pollution from nearby sources.
- ▶ *Spatiphyllum* is the best-known plant for purifying indoor air. *Calathea*, *Chlorophytum*, *Areca*, *Dracaena*, *Hedera* and various ferns are other good options.
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## Social cohesion in neighbourhoods

Despite the high population density, big city life can be quite anonymous. Loneliness and social isolation are risk factors for mental illness. They increase the risk of depression, which the WHO predicted would be public health issue No. 1 by 2020. A strong sense of social cohesion in neighbourhoods mitigates this risk. Even simple things like running into people regularly in public spaces, recognising one's neighbours and greeting one another in passing can help people to feel at home. Moreover, a greater sense of social cohesion helps people to feel safer in their neighbourhoods, which is also a key factor in well-being.

## How greenery works

- ▶ Attractive greenery in living environments can encourage people to go outdoors (or do so more often) and meet their neighbours, indirectly benefiting well-being by strengthening the neighbourhood sense of community.<sup>1</sup>
- ▶ People exhibit more social behaviour while (or after) spending time in green environments.<sup>2</sup>
- ▶ More greenery is also associated with lower levels of aggression and crime, providing an additional boost to health and well-being, either directly or through an increased sense of security.<sup>3</sup>
- ▶ Large-scale tree loss from tree diseases and neglect of the landscape are both correlated to elevated local crime rates.<sup>4</sup>
- ▶ In a literature review scientists illustrated how access to green spaces can facilitate positive social experiences that can be linked to social capital, a sense of community and empowerment, which can all influence human health.<sup>5</sup>
- ▶ People surrounded by more greenery tend to feel less lonely in the course of time (longitudinal study); this notably applies to single persons.<sup>6</sup>
- ▶ Residents of greener neighbourhoods are more satisfied with social life in their neighbourhood than people living in similar neighbourhoods with less green.<sup>7</sup>
- ▶ Systematic research has shown that public greenery is essential to social cohesion and that perception and use of the greenery play a role in that.<sup>8</sup>

## Recommendations

- ▶ Greenery should be perceived as safe; overgrown, concealing and/or neglected vegetation can make people feel unsafe.
- ▶ The impact of greenery on social cohesion is strongest when it is relatively close by. Thus, a small (safe and attractive) neighbourhood park that fosters interaction with other locals tends to be more effective than a large city park.
- ▶ Promoting extended visits to such green areas, e.g. by placing benches around a central spot with water or other elements of interest, will increase the likelihood of chance meetings.
- ▶ When designing a green area, keep the target audience in mind. Facilitating meetings seems especially important among the elderly.
- ▶ If green areas serve multiple functions, it is essential that these functions are mutually compatible and do not lead to conflicts among the various users.



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### Physical activity

A lack of physical activity and, by extension, obesity are key risk factors for health. They are the largest causes of illness, after smoking. Obesity increases the risk of diabetes and cardiovascular disease. On the basis of Dutch health standards one third of adults do not get enough physical activity. This rate is higher (and targets more stringent) among children and young people. In addition, there is more and more evidence showing that sedentary behaviour (sitting or lying down) is a risk factor in itself. Children are already advised to limit such behaviour. In this respect local green areas provide opportunities for more physical activity.

#### How greenery works

- ▶ Particularly among boys of primary school age local greenery correlates to higher levels of physical activity, mostly playing outside.<sup>1</sup>
- ▶ A rapidly growing amount of research shows that green infrastructure in built-up areas promotes an active life of children and young people. In a Norwegian study with 8-year-old children researchers found a positive association between having a park within 800 m and more physical activity during the summer.<sup>2</sup>
- ▶ Gardening is another form of nature-based physical activity, although it can also be practised further away from the home (garden parks, garden allotments, urban farms, etc.).<sup>3</sup>
- ▶ The advantages of walking in older age include improved cognitive health (e.g. mental alertness, a better functioning memory) and a lower risk of stress, depression and dementia.<sup>4</sup>

#### Recommendations

- ▶ Street trees and grass used as ground cover help to lower air temperature, resulting in more thermal comfort for children and adult pedestrians. These thermally proven facts relating to the street profile deserve more attention from researchers and policymakers interested in promoting walking outdoors.<sup>5</sup>
- ▶ To promote physical activity, focus mainly on leisure activities in green areas.
- ▶ The areas must be easy and safe to access as well as safe to be in. Exactly what this entails will depend on the target population (e.g. children vs. elderly).
- ▶ The provision of required facilities will depend on the target population and the intended activity. For children this may mean free play areas; for senior citizens level walking paths.
- ▶ The greater the focus on the activity itself, the more the greenery will fade into the background, unless the activity involves interaction with the vegetation (survival skills, mountain biking, treehouse building, gardening, etc.).

#### Further information

This fact sheet is one of a series of five fact sheets on the added value of greenery in our living environment. The other fact sheets take a closer look at greenery in work, education, healthcare and general contexts. The fact sheets were updated in 2022, funded by the Horticulture & Propagation Materials Top Sector as part of the tailored knowledge programme The Green Agenda. Partners of this programme are Stichting de Groene Stad and Wageningen University & Research.

More information can be found on the websites of De Groene Stad, Groen Kennisnet and Wageningen UR:

- ▶ <https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksprojecten-Inv/expertisegebieden/kennisonline/de-groene-agenda-2020-2023-valorisatie-van-groene-kennis-voor-eeen-klimaatadaptieve-en-leefbare-stad.htm>
- ▶ [www.degroenestad.nl](http://www.degroenestad.nl)
- ▶ [groene-agenda.nl](http://groene-agenda.nl)
- ▶ [groenkennisnet.nl](http://groenkennisnet.nl)

There are many examples of applications and studies that illustrate and prove the added value of vegetation. Other useful sources of information include:

- ▶ <https://ruimtelijkeadaptatie.nl/hulpmiddelen/factheets-groen/>

Here you will also find a table listing 120 tree species and their specific benefits as vegetation.

A useful tool for the design of a green healthy city is available at

- ▶ <https://tools.wenr.wur.nl/groengezondestad/>

Specific questions on reference projects, research results, etc., can be sent directly to [info@degroenestad.nl](mailto:info@degroenestad.nl).

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