

# GREENERY AND RESIDENTIAL

## The positive effects of greenery in urban environments



Greenery in and around residential homes and apartments is good for the climate and indoor and outdoor living environment, with positive effects on the health and general well-being of residents and visitors alike. 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 beneficial 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 reduces heat in and around homes in the summer, lowering heat stress and reducing the need for air-conditioning.
- › Green roofs and façades increase insulation capacity, reducing both heating and cooling expenditure.
- › ‘Green views’ reduce stress levels in general.
- › In green environments, people spend more time outdoors and are more active.
- › Green outdoor areas promote a better social climate.
- › Greenery regulates the disposal of rainwater, limiting potential flooding.
- › Indoor plants humidify the air through transpiration, reducing headaches and improving concentration.



### APPLICATIONS

- › Houseplants in rooms in the home.
- › Green roofs and façades.
- › Green gardens with trees, shrubs and hedges instead of surfacing.
- › Plenty of parks and other public green spaces in residential neighbourhoods.
- › Vertical gardens for houses directly abutting the street.
- › Trees and other types of greenery in and along streets.
- › The Green Agenda research programme has developed a 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>

### PROVEN SUCCESS

- › In less wealthy suburbs in particular, children use less ADHD medication (such as Ritalin) the more greenery there is in their surrounding environment.<sup>1</sup>
- › In living environments with more natural elements (such as greenery or water), residents suffer less from anxiety disorders than in areas with fewer natural elements.<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. Ten extra trees per city block delays the onset of age-related health conditions by an average of seven years.<sup>4</sup>

#### Sources:

- 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 [Greenery and the use of ADHD medication among children: the relationship between the volume of greenery in living environments and the prevalence of ADD/ADHD medication use among children aged 5-12]. Alterra report 2672. WUR-Alterra, Wageningen.
- 2 S. de Vries, M. ten Have, S. van Dorsselaer, M. van Wezep, T. Hermans & R. de Graaf (2016), Local availability of green and blue space and prevalence of common mental disorders in the Netherlands. *BJPsych Open* 2:366-372.
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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. <https://tools.wenr.wur.nl/groenegezondestad/>
- 5 <https://tools.wenr.wur.nl/groenegezondestad/>



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### TEMPERATURE

Average temperatures in cities are generally higher than in surrounding areas (the 'heat-island' effect), because hard surfaces (such as 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 broader environment, trapping the heat in the city. This effect occurs in both metropolitan and provincial cities 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 leads to heat stress, adversely affect health (particularly among the elderly, chronically ill and pregnant women) and can increase mortality rates. Research has shown that 35% of urban areas in the Netherlands already experience heat stress at least seven days a year. Rising 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 surfaced urban areas, reducing heat stress.

### HOW GREENERY WORKS

- › A 10% increase in urban vegetation reduces the heat-island effect by an average of 0.6 °C.<sup>1</sup>
- › Greenery provides cooling by limiting 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.
- › Studies show that people feel more comfortable in green environments during warmer weather.<sup>2</sup>
- › Parks stay cooler than dense built-up city centres during hot weather, with measured temperature differences of over 5 °C. Shade has the greatest effect: it helps lower air temperatures, and the reduced solar radiation beneath trees considerably 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 diminishing 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 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 surfaced areas and buildings.
- › Thermal comfort for residents is principally linked to the amount of shade provided: trees with large, dense canopies are the most effective, both in parks and on streets. When planting roadside trees, ensure healthy growing conditions and position the trees to maximise the shadow they can provide to cool the street.
- › The evaporative cooling effect is largely limited to the immediate vicinity of the plants; utilising this effect on a neighbourhood-wide scale requires a fine and extensive network of greenery.
- › The cooling effect of evaporation only works when the plants receive enough water, so be sure to design and manage effective watering facilities. Irrigating trees and plants can help during dry periods.
- › Green roofs aid home insulation and prevent overheating in summer, and large-scale application can help cool down entire neighbourhoods. To be effective, a good water supply is essential.
- › As fresh air significantly mitigates the heat-island effect, greenery must be planted so as not to obstruct local air flow.
- › More practical information is available in the Urban Greenery – Climate and Temperature fact sheet (<http://edepot.wur.nl/460543>).

#### Sources:

- 1 G.J. Steeneveld, S. Koopmans, B.G. Heusinkveld, L.W.A. van Hove, A.A.M. Holtslag (2011), Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. *Journal of geophysical research. D, Atmospheres*, 116 (D20129).
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- 3 B.G. Heusinkveld, G.J. Steeneveld, L.W.A. van Hove, C.M.J. Jacobs, A.A.M. Holtslag (2014), Spatial variability of the Rotterdam urban heat island as influenced by urban land use. *Journal of geophysical research. D, Atmospheres*, 119(2), 677-692.

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- 6 C. Gromke, B. Blocken, W. Janssen, B. Merema, T. van Hooff, H. Timmermans (2015), CFD analysis of transpirational cooling by vegetation: Case study for specific meteorological conditions during a heat wave in Arnhem, Netherlands. *Building and Environment*, 83(0), 11-26.

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### AIR QUALITY

The major air pollutants in urban areas (nitrous 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 to these substances leads to lung problems and cardiovascular disease. Although air quality at most locations in the Netherlands complies with standards, this does not mean the risk is eliminated entirely, and busy city roads are places where limits are regularly exceeded. According to recommendations by the WHO, continuing to tighten the PM<sub>2.5</sub> standard in the Netherlands would extend the average lifespan by three months, reduce premature deaths by 600 and lower sick days by 1.5 million per year. From a public health standpoint, the standard should never be the goal – air pollution in any form (even if under the limit) is ultimately detrimental to health and well-being. Urban areas combine high population density with peak activity (busy roads), in principle making local measures to improve air quality very effective. Because of its filtration and screening effects, greenery can play a role in supporting policies to improve air quality at the source.

### HOW GREENERY WORKS

- › All forms of vegetation help remove particulates and other pollutants from the air. Gaseous contaminants are absorbed by leaves, and particulates are filtered passively.<sup>1</sup>
- › Trees are most effective due to their size and volume: the average city tree traps 100 grams of particulate matter per year, equivalent to the quantity produced by 5,500 car kilometres.<sup>2</sup>
- › Other types of greenery also help purify the air: one square metre of ivy collects 4 to 6 grams of particulate matter per year, and a stonecrop roof catches 0.15 g/m<sup>2</sup>.<sup>3</sup>
- › Dense vegetation can be used to screen off residential areas or sensitive buildings from sources of pollution (such as busy roads).<sup>4</sup>
- › The scientific literature clearly shows that plants can have a marked positive effect on indoor air quality, chiefly because they remove volatile organic compounds (VOC).<sup>5</sup>

### RECOMMENDATIONS

- › Increase the numbers of mature trees to boost the filter capacity.
- › Large and healthy trees are the most effective; provide good growth conditions and enough room so they can reach a healthy old age.
- › Evergreen conifers are most effective at trapping 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 should be avoided.<sup>1</sup>
- › Shade in car parks limits evaporation of fuel from fuel tanks, raises comfort upon departure and lowers energy consumption by air-conditioning systems.
- › Ambient air exchange is extremely important for air quality. Greenery should therefore not isolate streets – green roofs and façades are good alternatives.
- › Dense vegetation can, however, help to screen residential and other sensitive areas (schools, hospitals, aged care facilities, etc.) from pollution from nearby sources.
- › The Peace Lily (*Spatiphyllum*) is the best-known plant for indoor air quality. Calathea, Chlorophytum, Areca, Dracaena, Hedera and various ferns are other good options.
- › More practical information is available in the Urban Greenery – Air Quality fact sheet (<http://edepot.wur.nl/460539>).

#### Sources:

- 1 J.A. Hiemstra, E. Schoenmaker-van der Bijl & A.E.G. Tonneijck (2008), Bomen een verademing voor de stad [Trees in the city – a breath of fresh air]. Published by PPH/VHG.
- 2 T. Bade, G. Smid & F. Tonneijck (2011), Groen loont! Over maatschappelijke en economische baten van stedelijk groen [Greenery is worth it! On the social and economic benefits of urban vegetation]. De Groene Stad, Apeldoorn.
- 3 M.E.C.M. Hop & J.A. Hiemstra (2013), Ecosysteemdiensten van groene daken en gevels. Een literatuurstudie naar diensten op het niveau van wijk en stad. [The ecosystem services provided by green roofs and walls: a literature study on services at district and city level]. Wageningen UR – PPO.
- 4 S. Teeuwisse, L. Haxe & A. van Alphen (2013), Schone lucht; groen en de luchtkwaliteit in de stad. Eindrapport Interregproject 'Toepassing functioneel groen: luchtgroen, klimaatgroen, sociaal groen' [Clean air; greenery and urban air quality. Final report from the interregional project titled 'Functional applications of greenery: for air, climate and society']. Publication by the Municipality of Tilburg/Municipality of Sittard-Geleen/Royal Haskoning DHV Rotterdam.
- 5 P. de Visser, 2018. Luchtzuivering door kamerplanten – Een literatuurstudie [Air purification by houseplants – a literature survey]. Wageningen UR, Report WPR-695.

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### MENTAL HEALTH

Infectious diseases used to be the primary cause of sickness absence. Nowadays however, they have been replaced by lifestyle-related conditions such as cardiovascular disease and conditions related to depression and anxiety. Chronic stress is a key risk factor in this regard: 75-90% of all GP visits are thought to be stress-related. Green living environments help improve health and lower stress.

### HOW GREENERY WORKS

- › Green environments are more calming than built-up areas: people recover more quickly from stress, concentration is restored faster and people are in a better mood.<sup>1</sup>
- › Children with ADHD show higher levels of concentration after walking in a city park than after walking for the same length of time through a residential area or city centre. 10% less ADHD medication is prescribed for children in green environments (this does not apply to ‘wealthy’ suburbs).<sup>2</sup>
- › Greener living environments are associated with a lower risk of stress-related conditions such as cardiovascular disease, depression and anxiety disorders.<sup>3</sup>
- › Even a view of rich and varied greenery from the home has demonstrated lower levels of cortisol (a stress hormone), and an improved sense of well-being.<sup>4</sup>
- › Particularly populations who are unable or not likely to seek out nature far from their homes (such as children, the elderly, and groups with 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 growing up and living in surroundings with a relatively high percentage of greenery during childhood and adulthood can delay the decline of mental capacity in old age.
- › People who move to greener areas show improved long-term mental health.<sup>6</sup>
- › The local presence of greenery and water lessens the risk of developing anxiety disorders.<sup>7</sup>
- › A high density of trees benefits primary school children growing up in densely built-up areas. Research indicates that these children are at a lower risk for autism.<sup>8</sup>

### RECOMMENDATIONS

- › Plant a wide variety of local greenery: this will increase the likelihood of use and social interaction, and thus the benefits to well-being. All forms of greenery (trees, bushes, shrubs, perennials, etc.) amplify the positive effects.
- › Ensure proper maintenance: visible neglect and litter make people feel unsafe.
- › Apart from larger green zones, also consider green elements such as roadside trees and planted gardens.
- › Make the vegetation visible and usable: people must be able to experience it – green walls seem more effective in this sense than green roofs, unless they form part of a view or are accessible (rooftop parks).
- › Greenery in the immediate environment is particularly important to people who spend a lot of time in their residential areas.

#### Sources:

- 1 T. Hartig, R. Mitchell, S. De Vries & H. Frumkin (2014), Nature and health. *Annual Review of Public Health* 35:207-228.
- 2 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(HD)-medicatiegebruik bij 5-tot 12-jarigen [Greenery and the use of ADHD medication among children: the relationship between the volume of greenery in living environments and the prevalence of ADD/ADHD medication use among children aged 5-12]. *Alterra report 2672*. WUR-Alterra, Wageningen.
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- 7 S. de Vries, M. ten Have, S. van Dorsselaer, M. van Wezep, T. Hermans & R. de Graaf (2016), Local availability of green and blue space and prevalence of common mental disorders in the Netherlands. *BJPsych Open* 2:366-372.
- 8 J. Wu & L. Jackson (2017), Inverse relationship between urban green space and childhood autism in California elementary school districts. *Environment International* 107:140-146.

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### SOCIAL COHESION

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 likelihood of depression, which the WHO predicts will be public health issue no. 1 by 2020. A strong sense of social cohesion in neighbourhoods mitigates this risk. Even simple things such as running into people regularly in public spaces, recognising one's neighbours and greeting one another in passing can help people feel at home. A greater sense of social cohesion also helps people 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 via the 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>



### RECOMMENDATIONS

- › Greenery must elicit feelings of safety; overgrown, concealing and/or visibly 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 will increase the likelihood of chance meetings. For example by placing benches around a central spot in a park where there is water or other elements of interest.
- › When designing a green area, keep the target audience in mind. Facilitating meetings seems especially important among the elderly.
- › If green areas are to serve multiple functions, they must be compatible and not lead to conflicts among the various users.

#### Sources:

- 1 A. Kemperman & H. Timmermans (2014), Green spaces in the direct living environment and social contacts of the aging population. *Landscape and Urban Planning* 129:44-54. S. de Vries, S.M. van Dillen, P.P. Groenewegen & P. Spreeuwenberg (2013), Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine* 94:26-33.
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### PHYSICAL ACTIVITY

A lack of physical activity (and, by extension, obesity) is a key risk factor for health. It is the largest cause of illness, after smoking. Obesity increases the risk of diabetes and cardiovascular disease. According to 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. There is also 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, and local green areas provide opportunities for sport and exercise.

### HOW GREENERY WORKS

- › Local greenery correlates to higher levels of physical activity (mostly playing outside), particularly among boys of primary-school age.<sup>1</sup>
- › There is no strong evidence that more (or more attractive) greenery in the surroundings makes adults exercise more, however people do enjoy recreational activities in natural surroundings. The opportunity to take part in certain recreational activities can mediate visits to local green areas, and allow people to enjoy other health benefits of greenery.<sup>2</sup>
- › Gardening is another form of nature-related physical activity, although it can also be further removed from home (garden parks, garden allotments, urban farms, etc.).<sup>3</sup>

### RECOMMENDATIONS

- › To promote physical activity, focus mainly on the potential 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).
- › Infrastructure and facilities are also important, as these must facilitate (or at least permit) the desired activity. The minimum required area will depend on the intended activities.
- › The required facilities will also depend on the target population. For children, this may mean free play areas; for senior citizens, level walking paths.
- › The greater the focus on the activity, the more ornamental the greenery becomes – unless the activities themselves involve interaction with nature (survival, mountain-biking, treehouse-building, gardening).

#### Sources:

- 1 S. de Vries, M. van Winsum-Westra, J. Vreke & F. Langers (2008), Jeugd, overgewicht en groen: nadere beschouwing en analyse van de mogelijke bijdrage van groen in de woonomgeving aan de preventie van overgewicht bij schoolkinderen [Youth, obesity and greenery: a detailed consideration and analysis of the potential contribution of greenery in living environments to preventing obesity among schoolchildren]. Alterra report 1744. WUR-Alterra, Wageningen.
- 2 T. Hartig, R. Mitchell, S. de Vries & H. Frumkin (2014), Nature and health. Annual Review of Public Health 35:207-228.
- 3 A.E. van den Berg, M. van Winsum-Westra, S. de Vries & S.M. van Dillen (2010), Allotment gardening and health: A comparative survey among allotment gardeners and their neighbors without an allotment. Environmental Health 9(1):1

### MORE INFORMATION SOURCES

This document is one of a series of five on the added value provided by greenery in our living environment. The other documents take a closer look at Work, Education and Healthcare environments. All the documents and large amounts of background information can be found through the Greenery and Well-being portal of [www.groenkennisnet.nl](http://www.groenkennisnet.nl). There are many real-life applications and studies that illustrate and demonstrate the added value of vegetation. Other useful sources of information include:

- › <https://www.groenkennisnet.nl/nl/groenkennisnet/portalen/leefomgeving/groen-en-welbevinden.html>

- › <https://ruimtelijkeadaptatie.nl/hulpmiddelen/factheets-groen/> This also provides 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 on <https://tools.wenr.wur.nl/groenegezondestad/>

- › [www.degroenestad.nl](http://www.degroenestad.nl)

- › [www.royalfloraholland.com](http://www.royalfloraholland.com)

- › [www.wur.nl](http://www.wur.nl)

Specific questions on topics such as reference projects, research results, etc. can be sent directly to [joop.spijker@wur.nl](mailto:joop.spijker@wur.nl)