



Greenery in and around offices and other working environments is good for the climate and has a positive effect on the health and general well-being of employees and visitors. It also improves concentration, reduces stress and boosts labour productivity. This document provides information on the benefits of greenery in relation to work and well-being, 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?

- ▶ Plants in offices purify the air: they reduce concentrations of CO<sub>2</sub> and volatile organic compounds, keeping the air fresh and healthy.
- ▶ Outdoor vegetation curbs heat in and around buildings 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.



### Proven successes

- ▶ A Norwegian study showed that office workers without an outdoor view from their desk were five times more likely to put a plant in their office than those with a view.<sup>1</sup>
- ▶ A Danish study revealed that office staff with a view of greenery were happier with their view. This happiness in turn correlated positively with (self-reported) productivity levels.<sup>2</sup>
- ▶ Office plants release water vapour and humidify the air, reducing headaches and improving concentration.
- ▶ A view of greenery and plants also boosts concentration and aids recovery from stress.
- ▶ Green environments encourage people to undertake activities such as lunchtime walks, keeping staff alert and healthy. Long periods of sitting adversely affect health.



### Applications

- ▶ Green roofs and façades
- ▶ Green indoor office walls
- ▶ Indoor plants in the company restaurant, central spaces and offices/meeting rooms
- ▶ Green partitions and mobile planters
- ▶ Attractive landscaping of the office premises, including green borders, hedges and trees
- ▶ Companies can include the use of vegetation in their sustainability policy, projecting a greener image.
- ▶ In an experimental working environment study employees with a view of plants completed a concentration test 19% faster than those in a room without a view of plants.<sup>3</sup>



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# Greenery and work

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## Temperature

The high rate of built-up and hard-surfaced areas, not only in cities but also in industrial and business estates, generally results in higher temperatures when compared with rural areas (the heat island effect). 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. Heat stress reduces productivity, and extreme values or long duration can affect the health of staff. 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 further global warming will increase the frequency of periods of heat stress. Green zones absorb less heat than hard-surfaced urban areas and this cooling effect on the environment helps to reduce urban warming.

## How greenery works

- ▶ Greenery provides cooling by blocking solar radiation (i.e. providing shade) and through water evaporation; a 10% increase in urban vegetation reduces the heat island effect in the relevant zone by an average of 0.6°C.<sup>1</sup>
- ▶ Green roofs, possibly combined with green façades, mitigate temperature increases in large buildings and factory halls, reducing the associated costs of cooling or production losses. They also extend the lifespan of roof cladding, which reduces maintenance costs.<sup>2</sup>
- ▶ Shade from trees in car parks reduces fuel evaporation from tanks and reduces heat in car interiors.<sup>3</sup>
- ▶ Planting vegetation helps to reduce environmental heat stress and is most effective when the cooler air coming from the greenery can flow freely to the surrounding area.<sup>4</sup>
- ▶ Greenery in industrial and business estates also helps to capture CO<sub>2</sub>.<sup>5</sup>



## Recommendations

- ▶ Green roofs on top of offices and factory halls reduce heating and cooling costs and extend the roof lifespan.
- ▶ Increasing vegetated surfaces and planting trees in green strips in industrial and business estates improve the living environment by helping to reduce the heat island effect.
- ▶ Planting shade trees in and around car parks creates a comfortable outdoor environment and helps to limit the heating up of parked cars.
- ▶ More large-scale green landscaping in industrial and business estates may contribute to a more pleasant climate.
- ▶ More practical information is available in the Urban Greenery – Climate and Temperature fact sheet (<http://edepot.wur.nl/460543>).



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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. In the Netherlands, further tightening of the PM<sub>2.5</sub> standard, as recommended by the WHO, would extend the average life expectancy by three months, reduce premature deaths by 600 and lower the number of sick days by 1.5 million per year.

In industrial areas pollutants are generally released through chimneys, after which they dissipate into higher atmospheric layers (which causes them to become part of background concentrations elsewhere). Notably dense and often heavy traffic is a local source of particulate matter (soot) and nitrogen oxides. High concentrations can best be prevented by source-based measures (emission reduction and capture at source). Moreover, to limit peak concentrations it is essential that air can mix freely with upper air layers (turbulence) and with air from the surroundings (ventilation).

On a regional and nation-wide scale greenery has a positive effect on air quality because of its filtering action, but the maximum effect on local air quality is limited to only a few percent. However, its screening effect can be used locally to limit exposure to high concentrations.<sup>1</sup>

## How greenery works

- ▶ All forms of vegetation help to remove particulates and other pollutants from the air. Gaseous contaminants are absorbed by leaves; particulate matter is filtered passively.<sup>2</sup>
- ▶ 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 oxides. Species that secrete large amounts of volatile organic compounds should be avoided.<sup>2</sup> Trees are most effective due to their size and volume: the average city tree captures 100 grams of particulate matter per year.<sup>4</sup> Other types of greenery also help to purify the air: 1 m<sup>2</sup> of ivy captures 4-6 grams of particulate matter per year, a stonecrop roof captures 0.15 g/m<sup>2.5</sup>
- ▶ Dense vegetation can also be used to shield foot and cycle paths or neighbouring residential areas and sensitive buildings (schools, hospitals, etc.) from sources of pollution (e.g. busy traffic flows in business estates).<sup>6</sup>
- ▶ Greenery can also improve indoor air quality, particularly by capturing volatile organic compounds (VOCs), including benzene and formaldehyde emitted by construction materials.<sup>3</sup>
- ▶ Staff in office spaces with plants rate the air quality more highly.<sup>7</sup>

## Recommendations

- ▶ Increase the amount of roadside vegetation to boost filter capacity, but avoid locking polluted air. Large and healthy trees are most effective; therefore, provide good growing conditions.
- ▶ Larger green areas help to improve regional air quality.
- ▶ Shade in car parks limits evaporation of fuel from fuel tanks, raises comfort on departure and lowers energy consumption by air-conditioning systems.
- ▶ Since air exchange with the surrounding environment is essential for air quality, vegetation in industrial and business estates must allow for effective air circulation.
- ▶ Dense vegetation at the edge of an estate can help to shield residential areas and sensitive buildings (schools, hospitals, aged care facilities) against pollution from local sources (especially traffic).
- ▶ To improve air quality in working environments, use species with a strong air-purifying effect, such as *Spatiphyllum*, *Calathea*, *Chlorophytum*, *Areca*, *Dracaena* and ferns.
- ▶ More practical information about greenery and outdoor air quality is available in the Urban Greenery – Air Quality fact sheet (<http://edepot.wur.nl/460539>).

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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 (i.e. activity that is considered at least moderately intensive). Until recently no distinction was made between light physical activity and sedentary behaviour (e.g. sitting). However, there is increasing evidence that sedentary behaviour is a risk factor in itself; sitting is even being called the new smoking.



## How greenery works

- ▶ No consistent statistical effects are found for physical activity indoors without exposure to nature versus physical activity in green surroundings outside the office building.<sup>3</sup>
- ▶ Attractive green outdoor areas encourage employees to go outside for a walk during breaks.<sup>1</sup>
- ▶ A Harvard study has shown that physical activity not only has physical benefits: there is evidence that it also stimulates mental skills, improving creativity, learning speed, memory, concentration, etc.<sup>3</sup>
- ▶ These green areas can also be used for 'walking meetings', which help to boost creativity.<sup>2</sup>

## Recommendations

Although there is limited evidence to support the view that physical activity in green surroundings is superior to physical activity without exposure to nature, many employers see the benefits of stimulating physical activity before, during and after work in a green outdoor area surrounding the company. Employers can put this into practice by providing fitness rooms in green zen-like surroundings and, for example, paying group instruction fees for their staff. The positive effects experienced by many employers are a motivation to invest in physical activity in green surroundings. Some of these effects are:

- ▶ Meeting colleagues outside the formal working environment reinforces personal and professional interrelations.
- ▶ Physical activity in green surroundings contributes to stress relief, knowing that stressed employees have trouble concentrating, thinking clearly and taking rational decisions.
- ▶ Physical activity is one of the best ways to prevent fatigue. Physical activity improves blood circulation, strengthens the heart muscle and gives an immediate energy boost.
- ▶ The general idea is that obesity is an increasing problem at work for employers. In combination with a healthy diet (healthy food in the company restaurant) physical activity at work will stimulate weight loss and strengthen the body.
- ▶ Some studies also suggest that sport during working hours can improve performance at work.



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## Job satisfaction & productivity

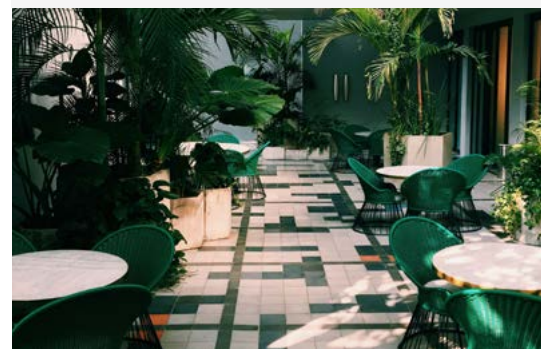
Infectious diseases used to be the primary cause of sickness absence. These have now been replaced by lifestyle-related conditions including cardiovascular disease, depression and anxiety disorders. Chronic stress is a key risk factor in this regard. In addition to physical health, job satisfaction, which includes satisfaction with the (physical) working environment, plays an essential role. Stress, including work stress, can also impact mental health. Burn-out and other mental disorders top the list of work-related illnesses. According to the Netherlands Organisation for Applied Scientific Research (TNO) excessive workload, work pressure and difficulty of work were responsible for 7.5 million sick days in 2014. Greenery in the workplace can help to prevent and reduce these problems.

### How greenery works

- ▶ Plants in office spaces reduce stress and improve concentration.<sup>1</sup>
- ▶ Plants in the workplace increase workplace satisfaction.<sup>2</sup>
- ▶ Having a substantial number of plants in the workplace improves thermal comfort. As a result of this (psychological) effect workers are less affected by higher or lower temperatures in the workplace and productivity is boosted.<sup>3</sup>
- ▶ Having a view of greenery from the workplace is also associated with lower stress; levels of daylight may also play a role in this respect.<sup>4</sup>
- ▶ The availability of green outdoor areas that can be used during breaks is also associated with reduced stress<sup>5</sup> and higher workplace satisfaction.<sup>6</sup>
- ▶ Research in the Netherlands and the UK showed that the productivity rate in office spaces with plants is 15% higher than in office spaces without plants.<sup>7</sup>
- ▶ On the basis of their systematic review Gritzka et al. (2020) conclude that nature-based interventions in the working environment (both indoors and outdoors) fairly systematically result in positive effects on workers' mental health and cognitive functioning.<sup>8</sup>
- ▶ Hähn et al. (2021) conducted a field study during which plants were placed in the immediate working environment and removed again at a later stage. They found that after placing the plants workplace satisfaction rose and after removal of the plants workplace satisfaction dropped again. Due to the study design these changes in satisfaction can, with a high degree of certainty, be attributed to the plants.<sup>9</sup>

### Recommendations

- ▶ Put plants in the workplace and in other locations frequented by employees (e.g. the company restaurant).
- ▶ Create views of outdoor greenery, notably from the workplace.
- ▶ Create pleasant green outdoor spaces that can be used by employees to relax and take some time out.
- ▶ In large buildings, create green indoor spaces where employees can take a short break or hold meetings in green surroundings.



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The Green Agenda  
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## 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 residential, 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-een-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/groenegezondestad/>

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



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