THE POSITIVE EFFECTS OF GREENERY IN URBAN ENVIRONMENTS

GREENERY: MORE THAN BEAUTY AND HEALTH

VERSION 2.0

Greenery in our living environment benefits more than just our health and well-being. It also facilitates water management and promotes biodiversity in built-up areas, and can help reduce the effects of noise pollution. Greenery also helps to raise the property value of homes and offices. This document provides general information on the benefits of greenery, and complements the detailed fact sheets on how greenery can improve health and well-being in Residential, Professional, Educational and Healthcare contexts.

WHAT DOES GREENERY DO?

- Urban greenery reduces the burden on sewage systems because, in green areas, (a large proportion of) the rainfall seeps into the soil and a small amount of the rain retained by vegetation evaporates from the surface of the plants.
- The judicious planting of green areas (roofs, recessed parks and gardens, sumps) offers even more storage capacity at times of peak rainfall.
- Greenery situated close to homes increases their property value.
- Greenery supports and contributes to biodiversity in urban areas.
- Greenery can contribute to reducing the amount of noise pollution experienced by residents.
- Its many positive effects make greenery an essential part of the solution to the many challenges faced by today's cities. [1]

PROVEN SUCCESS

- The presence of greenery in the immediate vicinity of houses increases their value by 4-15%, depending on local conditions. [2]
- Reserving ten per cent of urban areas for varied greenery provides plenty of habitat for butterflies and bees. [3]
- Based on the gains made in the field of water management, property values, carbon capture, air quality and energy saving, the 116,000 street trees in The Hague represent an annual value to society of €22 million. [4]

There are many more facts, figures and examples available on the benefits of vegetation. Consult the specific information on Residential, Professional, Educational and Healthcare environments, or see the references cited in this document.

Sources:

1. *FAO (2016), Forestry Paper 178.*
2. *J.C.A.M. Bervaes & J. Vreke (2004), De invloed van groen en water op de transactieprijzen van woningen. Alterra-rapport 959. WUR-Alterra, Wageningen.*
3. *M. Hoffman (2010), Biodiversiteit in tuin en plantsoen. Uitgave PPH, Boskoop.*
4. *Buck Consultants International (2016), Waardestelling groen in Den Haag.*

APPLICATIONS

- Green roofs and walls.
- Courtyards and rooftop gardens.
- Indoor plants in the living environment.
- Indoor plants in offices, schools and healthcare institutions.
- Plants, shrubs and trees around buildings and in public parks and gardens.
- Use of planters.
- Sumps or infiltration basins and sunken green areas in gardens and parks.
- Open flower and garden beds, insect hotels.

MORE INFORMATION ON THE EFFECTS OF GREENERY

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WATER MANAGEMENT

In 2014, the Royal Netherlands Meteorological Institute (KNMI) drew up four potential climate-change scenarios for the Netherlands. All four show a significant increase in precipitation intensity and the frequency of heavy rains, while the current climate already causes significant problems through overflowing drains, flooded streets and cellars, etc. The Dutch Association of Insurers therefore expects a significant increase in damage caused by extreme weather. In addition to material damage, these types of water emergencies can also cause injuries and even death, especially in inclined areas (e.g. South Limburg) where small streams of water can quickly become a torrent. Expanding green zones in built-up areas improves water management and reduces the adverse effects of peak rainfall.

HOW GREENERY WORKS

- Vegetation reduces the amount of rainwater that needs to be processed. Some rain is 'retained' on the surfaces of foliage, stems and branches (this is called 'interception') and evaporates again once the rain has stopped. Non-sealed ground beneath vegetation aids in this regard, trapping more rain than a hard surface and allowing more water to evaporate. In forests, broad-leaved trees can intercept 5-20% of the annual precipitation in this manner, and conifers up to 50%. A further 5-34% of precipitation can evaporate from the ground. Vegetation in urban areas can also approach these figures. [1]
- In vegetated areas, water is free to infiltrate the soil, replenishing the groundwater and ultimately the underground water supply. Some of this water is absorbed later by the vegetation, and some of it will evaporate. This means that less water needs to be channelled away than from surfaced areas, and the process is also slower (reducing peak intensity). Infiltration speed depends on the soil type, and can reach speeds of over 50mm/h in areas with effective drainage (coarse sand). Greenery promotes infiltration, as vegetated areas with extensive root systems absorb water much more effectively than bare soil. [2]
- Green roofs (especially on large buildings, such as factories, hospitals and large office complexes) help reduce peak intensity by retaining some of the rainfall, and delaying the flow of the remainder. Extensive green roofs (i.e. with a substrate of at least 15 cm) achieve the greatest effect, and can retain 50-80% of rainfall, allowing it to evaporate later. [3]
- Water quality: Plants can sometimes also be used on industrial sites for the organic filtering of wastewater via helophyte filters, an application that also serves to reduce peak intensity.
- In cities, green shores and helophyte filters can be used to improve water quality. Vertical helophyte filters are effective in organically purifying household wastewater of contaminants such as nitrogen, phosphate and heavy metals. This requires 2.5-5 m^2 of helophyte filter per IE (inhabitant equivalent). Examples of this application are in use in various districts (such as Drielanden in Groningen, Aardehuizen in Olst and the Erasmus Canal in Amsterdam). [4]
- Greenery can play a key role in integrated water solutions for local communities. A good example of this is the Zuidbroek district of Apeldoorn. The water that falls on roofs is channelled into gardens. From the gardens it flows to the street, and from the street into a broad green space known as a sump or infiltration basin. Only when the infiltration basin is completely full is the water fed to an overflow.
- Research is currently being carried out into green roofs that have their own water supply system, which could store even more rain. [5]

RECOMMENDATIONS

- Increasing the ratio of vegetated areas to surfaced/built-up areas reduces the amount of water requiring processing. Green roofs also contribute in this regard.
- Deep-rooted plants (trees and bushes) facilitate the penetration of water into deeper substrates. A variety of ground-cover plants (trees in combination with shrubs and undergrowth) is most effective, and also serves to prevent compaction and erosion.
- Introducing plants to sumps improves infiltration, contributes to biodiversity, makes them into 'green corridors' and improves the perceived value of a neighbourhood's green areas.
- Plants in and around sumps must be able to withstand both temporary (and sometimes extremely) high water levels and also dry periods; planting trees at the edge of the sump or infiltration basin (instead of inside it) provides more scope.

Sources:

1. *A.J.M. Gerrits (2010), The role of interception in the hydrological cycle. Proefschrift TU Delft.*
2. *W.H. Green & G.A. Ampt (1911), Studies on soil physics. The Journal of Agricultural Science 4(1):1-24.*
3. *K.L. Getter & D.B. Rowe (2006), The role of extensive green roofs in sustainable development. Hort-Science 41(5):1276-1285.*
4. *Aquarama (2011), Rietland bvba wil rietveldsysteem op een hoger plan tillen. Aquarama nummer 51, Dossier Waterzuivering & Hergebruik.*
5. *www.projectsmartroof.nl.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY: MORE THAN BEAUTY AND HEALTH

PROPERTY PRICES AND ATTRACTIVENESS

Greenery makes an area more appealing, and plays a role in attracting mid-to-high income earners to urban areas.

HOW GREENERY WORKS

- Greenery in the form of parks and public gardens increases the value of residential properties by an average of 4-5%. [1]
- The greenery in The Hague increases the value of all the city's residential properties by approx. €1.9 billion, an average of approx. €7,500.00 per property, and increases the city's property tax revenues by approx. €1.3 million per annum. [2]
- Greenery makes an area more attractive and encourages both individuals and businesses to move into the area. The attractiveness of the environment is not crucial, but it is becoming an increasingly important criterion for knowledge-intensive businesses. [3,4]
- Crime in green neighbourhoods is lower, and residents feel safer than in areas without local greenery. [4]

RECOMMENDATIONS

- Some investments in local greenery pay for themselves through increased property values, or – in the case of public-sector investments – through higher tax revenue (Valuation of Immovable Property Act, notional rental value).
- An attractive living and working environment is a key factor for large international businesses in deciding where to open a new site. Greenery adds to the attractiveness of these environments.

Sources:

1. *J.C.A.M. Bervaes & J. Vreke (2004), De invloed van groen en water op de transactieprijzen van woningen. Alterra-rapport 959. WUR-Alterra, Wageningen.*
2. *Buck Consultants International (2016), Waardestelling groen in Den Haag.*
3. *E.M. Jókövi & J. Luttik (2003), Rood en groen. Het combineren van verstedelijking en natuur in de praktijk. Wageningen.*
4. *M.K. Wolfe & J. Mennis (2012), Does vegetation encourage or suppress urban crime? Evidence from Philadelphia, PA. Landscape and Urban Planning 108(2-4):112-122.*

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BIODIVERSITY

'Biodiversity' refers to the variety of living organisms. A wide range of different types of vegetation in a city will ensure a high degree of biodiversity. The more varied the greenery, the more life it will attract. Large numbers of pollinating insects and various types of vegetation in turn provide a source of food for birds and other animals. Pollinators (and pollination) therefore constitute an important link in ecosystems, making them essential to biodiversity. Many city residents value the presence of nature, which they express by putting up nestboxes and bee hotels, and feeding birds in the winter time.

HOW GREENERY WORKS

- Although the numbers in cities are relatively low, an international study indicates that the majority of bird and plant species in cities are native species. As a result, urban greenery serves to enhance and protect biodiversity. [1]
- A variety of plant species is a great way to encourage biodiversity in urban areas. Planting pollen and nectar-bearing trees, shrubs and perennials is important for attracting bees, butterflies and other insects. Birds and small mammals also do better in areas with plenty of diversity. [2]
- Non-native plants can be a valuable addition to native species in urban environments: they increase biodiversity and extend the blooming season, providing more food for pollinating and other insects. [3]
- Just 10% vegetation in urban areas can provide a good habitat for butterflies and bees, provided that the vegetation is varied and provides sufficient food and shelter, and the areas are spread out through the city like a network. [4]

RECOMMENDATIONS

- Green roofs and facades can also be used to increase biodiversity, and also act effectively as links between different green areas.
- Different groups of organisms have different requirements.
- Van Rooij [4] has drawn up eco-profiles for pollinating insects such as wild bees, hoverflies and butterflies. Green zones must be no more than 100 metres apart. [4]

Sources:

1. *M.F.J. Aronson et al. (2014), A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. Proceedings of the Royal Society B 281:20133330.*
2. *M. Hoffman (2010), Biodiversiteit in tuin en plantsoen. Uitgave PPH, Boskoop.*
3. *A. Salisbury, J. Armitage, H. Bostock, J. Perry, M. Tatchell & K. Thompson (2015), Enhancing gardens as habitats for flower-visiting aerial insects (pollinators): Should we plant native or exotic species? Journal of Applied Ecology 52:1156-1164.*
4. *S. van Rooij, A. Corment, W. Geertsema, M. Haag, P. Opdam, M. Reemer, R. Snep, J. Spijker, E. Steingröver & A. Stip (2016), Een bij-zonder kleurrijk landschap in Land van Wijk en Wouden. Handreiking 2.0 voor inrichting en beheer voor bestuivende insecten. Groene Cirkels Rapport nr. 5. WUR-Alterra, Wageningen.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

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NOISE

Plants and vegetation are crucial to the way noise and noise pollution from traffic and industry are perceived.

Firstly, the sound made by trees and plants is generally considered to be quite pleasant, both directly (rustling) and indirectly (birds), and it can partially mask other noises. This fact, along with the higher quality of the living environment (due to the greenery) can serve to draw attention away from sources of noise pollution, making them less bothersome. Vegetation can therefore reduce the perceived levels of noise pollution.

It usually has little to no effect on the actual volume of the noise – spaced-out plants will usually not create any audible drop in sound. Using vegetation as a sound barrier requires very dense planting, as even green noise barriers must be properly sealed.

HOW GREENERY WORKS

- City-dwellers who live near parks or other green spaces perceive the same level of noise pollution to be less bothersome than city-dwellers who do not have a park or other green space near where they live. [1]
- Green facades can help soundproof buildings. [2]

Sources:

1. *A.M. Dzhambov & D.D. Dimitrova (2015), Green spaces and environmental noise perception. Urban Forestry & Urban Greening 14:1000-1008.*
2. *Z. Azkorra, G. Pérez, J. Coma, L.F. Cabeza, S. Bures, J.E. Álvaro, A. Erkoreka & M. Urrestarazu (2015), Evaluation of green walls as a passive acoustic insulation system for buildings. Applied Acoustics 89(March):46-56.*

FURTHER INFORMATION

This document is one of a series of five documents on the added value provided by greenery in our living environment.
The remaining documents take a closer look at Residential, Professional, Educational and Healthcare environments.
All the documents and large amounts of background information can be found on the Greenery and Wellbeing portal of www.groenkennisnet.nl.

There are many real-life applications that illustrate and demonstrate the added value of vegetation.
Other useful sources of information include:

- www.groenkennisnet.nl
- www.degroenestad.nl
- www.royalfloraholland.com
- www.wur.nl

Specific questions on topics such as reference projects, research results, etc. can be sent directly to joop.spijker@wur.nl.

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GIVING GREENERY ITS DUE

GREENERY: MORE THAN BEAUTY AND HEALTH

Due to its many positive benefits, greenery deserves a prime position in planning and budgeting processes. In consultation with potential and existing clients, the tips below can help suppliers of vegetation to give greenery its due in our immediate living environment.

STAKEHOLDERS

- All projects involve a wide variety of stakeholders: users, investors, initiators, and many others who have their say in the decision-making process.
- Getting to know these groups and their requirements will allow suppliers of vegetation (potentially in conjunction with partners) to anticipate any objections and to further customise the benefits of greenery to the specific situation of the groups concerned.

TIPS

Get to know the project, including all the stakeholders and their various criteria. Offer a complete solution, mitigate risks and unknowns, and find out what kind of added value the vegetation is supposed to provide:

- Decide at the start of a project what the desired benefits or functions of the greenery are and adjust the design and layout accordingly.
- Identify problem areas that can be improved or resolved using greenery – this is an important step towards obtaining funding.
- Tell the stakeholders about studies and projects that demonstrate the promised result.
- Involve and convince as many of them as possible in order to strengthen the support base and lower risks in the eyes of decision-makers.
- Put potential/existing clients and the ultimate administrator/user at ease by providing a ready-made solution complete with a maintenance plan. Lack of clarity in this regard will slow down the decision-making process.
- Calculate all initial and ongoing costs in advance – any suspicion of hidden costs, investments or work to be performed will delay the go-ahead.
- Have stakeholders experience the results by taking them to visit reference projects.

CREATE DEMAND

The earlier the vegetation supplier takes on a role in the project, the more influence they can exert on the priority of greenery, and therefore on the available budget.

If the project is starting, the client, architect or project developer can be approached for this purpose. In earlier stages, projects can be initiated independently by creating demand, for example by informing user groups (such as residents or patient associations) about the benefits of vegetation.

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THE POSITIVE EFFECTS OF GREENERY IN URBAN ENVIRONMENTS

GREENERY AND EDUCATION

VERSION 2.0

Greenery in and around schools and nurseries and on campuses enhances the ambience of educational institutions, both inside and out. It has a positive effect on the health and general well-being of students and staff alike, improving student's performance and their ability to concentrate, as well as enhancing the social climate. This document provides insights into the benefits of greenery for learning and well-being, 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?

- Greenery in classrooms purifies the air: it reduces concentrations of CO_2 and volatile organic compounds, keeping the air fresh and healthy.
- Outdoor vegetation reduces heat in and around schools in the summer, lowering heat stress and reducing the need for artificial cooling.
- Green roofs and facades increase insulation capacity, reducing both heating and cooling expenditure.
- Moisture released into the air by plants in buildings helps with dry atmospheres, reducing headaches and improving concentration.
- Visible greenery, both indoors and out, reduces stress and increases the ability to concentrate.
- Green playgrounds encourage playing outdoors, and foster a better social climate.

APPLICATIONS

- Green roofs and green facades.
- Plants in canteens, central spaces and (where possible) in classrooms/lecture theatres.
- Green dividing walls and mobile planters.
- Green borders, possibly doubling as vegetable gardens.
- Trees in the playground or on campus.
- Hedges surrounding the premises.
- School gardens.

PROVEN SUCCESS

- A practical study in eight primary school classes showed a 20% increase in performance when plants were included in the classroom. [1]
- Children in classrooms that include plants show a 7% reduction in health problems. [1]
- 'Green' playgrounds are less susceptible to vandalism: 'The children not only leave the plants in the ground, but they are also careful not to step on them and leave them alone,' says one schoolteacher. [2]
- At 8 primary schools in New York, the integration of gardens into the school curriculum increased physical activity and lowered sedentary behaviour. [3]

Sources:

1. *Rapport 'Plant in de klas', Productschap Tuinbouw/Fytagoras/TNO 2011.*
2. *Alterra-rapport 'Meer groen op het schoolplein' (http://edepot.wur.nl/283415).*
3. *S. Kruid (2016), Systematic literature review: School and community garden interventions in children. BSc Thesis Wageningen University.*

MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND EDUCATION

TEMPERATURE

Schools are almost always situated in urban areas, where the higher percentage of built-up and surfaced areas often produces higher temperatures (the 'heat-island' effect). This effect occurs in both metropolitan and provincial cities, and increases as built-up areas become denser. Measured maximum differences vary from one to several degrees, with peak values reaching around 8°C and incidental values even exceeding 10 degrees. Heat stress affects the ability to concentrate and academic performance and, in the case of extreme values or extended duration, can also have an adverse effect on health.

Research has shown that 35% of urban areas in the Netherlands already experience heat stress at least 7 days per year. Rising urban density and global warming will increase the frequency of these heat-stress periods. However, greenery can help to lower city temperatures. Greenery can also be used to improve the ambiance in and around schools and other educational institutions.

HOW GREENERY WORKS

- Tijdens warme perioden voelen mensen, dus ook kinderen en het onderwijzend personeel, zich in een groene omgeving comfortabeler. [1]
- Een groen dak, eventueel in combinatie met gevelgroen draagt bij aan de isolatie van een schoolgebouw en verbetert het binnenklimaat. Bovendien vermindert het de kosten voor verwarming en eventuele koeling. [2]
- Schaduwbomen vergroten het thermisch comfort tijdens warme perioden door middel van twee effecten; het bieden van schaduw en de verdamping van water. Hoewel de in Nederland gerapporteerde effecten op de luchttemperatuur beperkt zijn tot 1-2 °C is het effect op de gevoelstemperatuur vele malen groter. [1,3]

RECOMMENDATIONS

- Applying green facades and roofs to school buildings improves insulation, helping to reduce heating and cooling costs.
- Planting shade trees in the playground will provide more opportunities to play during warm weather, and makes the playground a more appealing place to play.
- Planting trees for shade in car parks stops cars getting hot and makes the area look more attractive.

Sources:

1. *W. Klemm, B.G. Heusinkveld, S. Lenzholzer & B. van Hove (2015), Street greenery and its physical and psychological impact on outdoor thermal comfort. Landscape and Urban Planning 138:87-98.*
2. *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. Wageningen UR – PPO.*
3. *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 83:11-26.*

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AIR QUALITY

The major air pollutants in urban areas (nitrous oxides (NO_x), particulates (PM10/PM2.5) and volatile organic compounds such as benzene) come from industry and traffic in particular. 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. There is no safe lower limit, and concentrations can rise considerably in areas close to busy roads and intersections.

Indoor air quality in schools is also often poor; large numbers of children and teachers in a relatively small space frequently causes CO_2 levels to rise significantly. Volatile organic compounds from construction materials (such as formaldehyde and benzene) may also be present. Greenery can help to improve air quality both indoors and out, benefiting overall health in the long term. In the short term, greenery relieves stress and improves concentration and general well-being.

HOW GREENERY WORKS

- Dense vegetation limits the flow of air pollution from busy roads into school environments. [1]
- Given enough light and water, plants absorb CO_2 from the air, helping to reduce ambient CO_2 levels. A study of classrooms containing plants showed a 10-20% drop in CO_2 concentrations compared with classrooms without plants. [2]
- Plants can also absorb volatile organic components (VOC) such as formaldehyde and benzene from the atmosphere. A study at a school in Portugal showed that plants can cause a 50% drop in volatile organic compounds (VOCs) in the air. [3]
- Plants regulate the temperature of their leaves through transpiration. The water vapour increases the relative humidity in classrooms, which can reduce the percentage of students suffering from headaches.

RECOMMENDATIONS

- Planting dense vegetation (green screens) can help to protect schools from air pollution from nearby sources, such as busy roads.
- Indoor plants (such as pot plants or green walls) improve air quality in classrooms and contribute to increased student performance and fewer health problems.

Sources:

1. *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'. Uitgave gemeente Tilburg/gemeente Sittard-Geleen/Royal HaskoningDHV Rotterdam.*
2. *B. van Duijn, J. Klein Hesselink, M. Kester, J. Jansen & H. Spitters (2011), Rapport 'Plant in de klas'. Productschap Tuinbouw/Fytagoras/TNO.*
3. *P.N. Pegas, C.A. Alves, T. Nunes, E.F. Bate-Epey, M. Evtyugina & C.A. Pio (2012), Could house plants improve indoor air quality in schools? Journal of Toxicology and Environmental Health, Part A, 75:22-23, 1371-1380.*

Image: mooiwatplantendoen.nl

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MORE INFORMATION ON THE EFFECTS OF GREENERY

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CONCENTRATION

To learn effectively, students must be able to concentrate. Of course this depends a great deal on the teacher's skills and enthusiasm, as well as a student's own interests and aptitude. However, research has shown that a school's physical environment also has an effect, and that greenery in schools can be beneficial.

HOW GREENERY WORKS

- Plants in classrooms can encourage more sociable behaviour and reduce levels of illness. [1]
- Green walls in classrooms help students' ability to concentrate, and raise attention levels. [1]
- Views of greenery from classrooms where students take breaks helps restore concentration more quickly, and reduces stress. [2]
- Even a brief view of a green roof can have positive effects, according to laboratory research. [3]
- Greener school grounds and greener outdoor spaces correlate with improved cognitive development (working memory and concentration). [4]

RECOMMENDATIONS

- Make sure students can see greenery from classrooms; the presence of trees and shrubs seems particularly important (i.e. not 'bare' grassy areas).
- Create pleasant green outdoor spaces that can be used by students and teachers to relax and get away from it all (relaxation areas on the school grounds).

Sources:

1. *A.E. van den Berg et al. (2016), Green walls for a restorative classroom environment: A controlled study. Environment and Behaviour 49(7):1-23.*
2. *D. Li & W.C. Sullivan (2016), Impact of views to school landscapes on recovery from stress and mental fatigue. Landscape and Urban Planning 148:149-158.*
3. *K.E. Lee, K.J.H. Williams, L.D. Sargent, N.S.G. Williams & K.A. Johnson (2015), 40-second green roof views sustain attention: The role of micro-breaks in attention restoration. Journal of Environmental Psychology 42:182-189.*
4. *S. Kruid (2016), Systematic literature review: School and community garden interventions in children. BSc Thesis Wageningen University.*

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PHYSICAL ACTIVITY

A lack of physical activity (and, by extension, obesity) is a key risk factor for health. Fourteen percent of young Dutch people are overweight (Statistics Netherlands, 2016). Traditionally, exercise has always focused on moderate to intense activity – no distinction has been drawn between light activity and sedentary behaviour (e.g. sitting). Recent results show that sedentary behaviour is a risk factor in itself, and an international guideline for children has already been developed: no more than two hours of free time at the television or computer per day. A diverse range of physical movements is also important for developing children's motor skills. Green environments can offer both the space and encouragement for them to do this.

HOW GREENERY WORKS

- Young children at nurseries with quality, green outdoor spaces spend more time outside, and show lower rates of obesity. [1]
- Large green outdoor spaces encourage physical activity among primary-school-aged children, and also help girls especially to keep active through the years. [2]
- Children who often play in green areas that offer a variety of playtime activities demonstrate better motor development. [3]
- Vegetable gardening among students at school helps mitigate a sedentary lifestyle among children. [4]

RECOMMENDATIONS

- Create attractive outdoor areas with a variety of playtime activities and games, and make sure the area is large enough so that children are not always in each other's way.
- Integrate the vegetation with the other elements in the playground, so it is not mere decoration.
- Ensure that the greenery can cope with the level of play in the playground.
- Vegetable gardens can capture children's interest in nature.
- Create a challenging but safe outdoor area. Don't use any poisonous plants, and keep safety requirements in mind.

Sources:

1. *M. Söderström, C. Boldemann, U. Sahlin, F. Mårtensson, A. Raustorp & M. Blennow (2013), The quality of the outdoor environment influences childrens health – a cross-sectional study of preschools. Acta Pædiatrica 102:83-91.*
2. *P. Pagels, A. Raustorp, A. Ponce de Leon, F. Mårtensson, M. Kylin & C. Boldemann (2014), A repeated measurement study investigating the impact of school outdoor environment upon physical activity across ages and seasons in Swedish second, fifth and eighth graders. BMC Public Health 14:803.*
3. *I. Fjørtoft (2004), Landscape as playscape: The effects of natural environments on children's play and motor development. Children, Youth and Environments 14(2):21-44.*
4. *S. Kruid (2016), Systematic literature review: School and community garden interventions in children. BSc Thesis Wageningen University.*

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SOCIAL CLIMATE

In addition to children's cognitive and physical performance, their socio-emotional well-being and development are also important factors. These include matters such as self-confidence, empathy, respectful behaviour, helping one another and learning to cooperate. The social climate is an important element in this regard, and the playground is no exception.

HOW GREENERY WORKS

- A well-designed green playground that is attractive and functional can contribute to improving the outdoor social climate, and ultimately to children's well-being in general. [1]
- School vegetable gardens, for example, can increase children's intake of fruit and vegetables and improve levels of 'green literacy'. [2]
- Some of the benefits (e.g. of keeping a vegetable garden) can also filter up to the parents.

RECOMMENDATIONS

- Create a diverse range of playtime activities (something for everyone), as well as places where children can go to rest and/or get away from it all.
- Include proper outdoor furniture, and covered spaces where necessary.
- Adequate open spaces encourage team sports, such as a range of ball sports.
- Including play equipment will encourage children to play together.

Sources:

1. *S. de Vries, F. Langers, J.L. Donders, M.T. Willeboer & A.E. van den Berg (2013), Meer groen op het schoolplein: een interventiestudie. Alterra-rapport 2474. WUR-Alterra, Wageningen.*
2. *S. Kruid (2016), Systematic literature review: School and community garden interventions in children. BSc Thesis Wageningen University.*

FURTHER INFORMATION

This document is one of a series of five documents on the added value provided by greenery in our living environment.
The remaining documents take a closer look at Residential, Professional and Healthcare environments. All the documents and large amounts of background information can be found on the Greenery and Wellbeing portal of www.groenkennisnet.nl.

There are many real-life applications that illustrate and demonstrate the added value of vegetation.
Other useful sources of information include:

- www.groenkennisnet.nl
- www.degroenestad.nl
- www.royalfloraholland.com
- www.wur.nl

Specific questions on topics such as reference projects, research results, etc. can be sent directly to joop.spijker@wur.nl.

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GIVING GREENERY ITS DUE

GREENERY AND EDUCATION

Due to its many positive benefits, greenery deserves a prime position in planning and budgeting processes. In consultation with potential and existing clients, the tips below can help suppliers of vegetation to give greenery its due in and around childcare centres, schools and campuses.

STAKEHOLDERS

- All projects involve a wide variety of stakeholders: users, investors, initiators, and many others who have their say in the decision-making process.
- Getting to know these groups and their requirements will allow suppliers of vegetation (potentially in conjunction with partners) to anticipate any objections and to further customise the benefits of greenery to the situation of the groups concerned.

TIPS

- Decide in advance what the desired effect of the greenery is and adjust the design and layout accordingly.
- Identify the relevant criteria – in addition to the desired appearance, also consider matters such as the available space, budget, and the social environment. Use this information to educate the stakeholders about the benefits of greenery, as provided on this fact sheet and in the list of references.
- Eliminate risks by providing comprehensive information on the initial investments required, including setup costs (possibly do this in collaboration with other businesses or an architect).
- Also provide information on maintenance methods, frequency and costs. Help mitigate risks (e.g. by providing a maintenance plan), and don't forget simple matters such as watering!
- Inform the target groups of the new possibilities offered by greenery, such as learning about nature and nutrition.
- Involve other stakeholders (such as teachers and students) either directly or indirectly in decision-making, application and implementation processes.
- Estimate the age of the user group, identify what is important to them, and summarise the benefits of greenery that meet these needs.

CREATE DEMAND

- The earlier the vegetation supplier takes on a role in the project, the more influence they can exert on the priority of greenery, and therefore on the budget available for it.
- Users (teachers, students or children and their parents) can be approached directly, or via bodies such as representative or student councils.
- Proactively approaching an architect or project developer in good time can have the same effect.

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THE POSITIVE EFFECTS OF GREENERY IN URBAN ENVIRONMENTS

GREENERY AND WORK

VERSION 2.0

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 aids concentration, helps reduce stress and increases productivity.

This document provides information on the benefits of greenery for work and well-being, 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?

- Plants in offices purify the air: they reduce concentrations of CO_2 and volatile organic compounds, keeping the air fresh and healthy.
- External vegetation reduces heat in and around buildings in the summer, lowering heat stress and reducing the need for air-conditioning.
- Green roofs and walls increase insulation capacity, reducing both heating and cooling expenditure.
- Office plants release water vapour which humidifies the air, reducing headaches and improving concentration.
- 'Green views' also boost concentration, and aid recovery from stress.
- Green environments encourage people to undertake activities such as a lunchtime walk, keeping staff alert and healthy. Long periods of sitting adversely affect health.

APPLICATIONS

- Green roofs and green facades.
- Green walls inside the office.
- Indoor plants in the company restaurant, central spaces and offices/conference rooms.
- Green dividing walls, mobile planters.
- Attractive landscaping of the site, including green borders, hedges and trees.
- Companies can include the use of vegetation in their sustainability policy, projecting a 'greener' image.

PROVEN SUCCESS

- A study in Norway 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. [1]
- A Danish study revealed that office staff with a 'green view' were happier with their view. This happiness in turn correlated positively with (self-reported) productivity levels. [2]
- In an experimental working environment study, employees with a view of plants completed a concentration test 19% faster than those in a room without plants. [3]

Sources:

1. *T. Bringslimark, T. Hartig & G.G. Patil (2011), Adaptation to windowlessness: Do office workers compensate for a lack of visual access to the outdoors? Environment and behavior:0013916510368351.*
2. *L. Lottrup, U.K. Stigsdotter, H. Meilby & A.G. Claudi (2015), The workplace window view: A determinant of office workers' work ability and job satisfaction. Landscape Research 40(1):57-75.*
3. *M. Nieuwenhuis, C. Knight, T. Postmes & S.A. Haslam (2014), The relative benefits of green versus lean office space: Three field experiments. Journal of Experimental Psychology: Applied 20(3):199.*

MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND WORK

TEMPERATURE

Higher percentages of built-up and surfaced areas generally result in higher temperatures (the 'heat-island' effect). This applies not only to cities, but also to industrial and business estates. This effect occurs in both metropolitan and provincial cities, 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 Celsius, with peak values of up to 8°C and incidental values even exceeding 10 degrees.

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 7 days per year. Rising urban density and further global warming will increase the frequency of these heat-stress periods. Areas with lots of greenery stay cooler than surfaced city areas, and this cooling effect on the environment helps reduce urban warming.

HOW GREENERY WORKS

- Greenery provides cooling by blocking solar radiation (i.e. providing shade) and aiding evaporation; a 10% increase in urban vegetation reduces the heat-island effect in the relevant zones by an average of 0.6°C. [1]
- Green roofs (potentially in combination with green facades) lower temperatures in large buildings and factories, reducing the associated costs of cooling or production losses. They also prolong the life of the roof covering, thereby reducing maintenance costs. [2]
- Shade trees above car parks reduce fuel evaporation from tanks, and keep car interiors cooler. [3]
- Planting vegetation helps reduce environmental heat stress, and is most effective when the cooler air coming from the greenery can flow freely through the area. [4]
- Greenery in industrial areas and business estates also helps to trap CO_2. [5]

RECOMMENDATIONS

- Green roofs on offices and factories reduce heating and cooling costs and prolong the life of the roof.
- More vegetated surfaces and planting trees on nature strips in industrial and business estates improves 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 cool car interiors.
- More large-scale green landscaping in industrial and business estates helps create a more pleasant climate in general.

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).*
2. *M.E.C.M. Hop & J.A. Hiemstra (2013), Ecosysteemdiensten van groene daken en gevels. Een literatuur-studie naar diensten op het niveau van wijk en stad. Wageningen UR – PPO.*
3. *K.I. Scott, J.R. Simpson & E.G. McPherson (1999), Effects of tree cover on parking lot microclimate and vehicle emissions. Journal of Arboriculture 25(3):129-142.*
4. *L.W.A. van Hove, C.M.J. Jacobs, B.G. Heusinkveld, J.A. Elbers, B.L. van Driel & A.A.M. Holtslag (2015), Temporal and spatial variability of urban heat island and thermal comfort within the Rotterdam agglomeration. Building and Environment 83:91-103.*
5. *Z.G. Davies, J.L. Edmondson, A. Heinemeyer, J.R. Leake & K.J. Gaston (2011), Mapping an urban ecosystem service: Quantifying above-ground carbon storage at a city-wide scale. Journal of Applied Ecology. Doi:10.1111/j.1365-2664.2011.0202.x.*

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GREENERY AND WORK

AIR QUALITY

The major air pollutants in urban areas (nitrous oxides (NO_x), particulates (PM10/PM2.5) and volatile organic compounds such as benzene) come from industry and traffic in particular. 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. According to recommendations by the WHO, continuing to tighten the PM2.5 standard in the Netherlands would extend the average lifespan by 3 months, reduce premature deaths by 600 and lower sick days by 1.5 million per year.
In industrial areas, dense traffic is often a local source of particulate matter (soot) and nitrous oxides. Industrial pollutants are generally released through chimneys, and dissipate into higher atmospheric layers. The filtration and screening effects provided by greenery can play a complementary role alongside source-specific policy for improving air quality.

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. [1]
- Plants can also improve indoor air quality, particularly by trapping volatile organic compounds (VOCs) such as benzene and formaldehyde emitted by construction materials. [2]
- Trees are most effective due to their size and volume: the average city tree traps 100 grams of particulate matter per year. [3]
- Other types of greenery also help purify the air: one square metre of ivy collects 4-6 grams of particulate matter per year, and a stonecrop roof catches 0.15 g/m^2. [4]
- Dense vegetation can also be used to shield neighbouring residential areas and sensitive buildings such as schools and hospitals against the pollution caused by busy traffic on business estates. [5]
- Staff in office spaces that contain plants rate the air quality more highly. [6]

RECOMMENDATIONS

- Increase the amount of roadside vegetation to raise filter capacity. Large and healthy trees are the most effective, so be sure to provide good growth conditions.
- 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 dioxides. Species that secrete large amounts of volatile organic compounds should be avoided. [1]
- Large green areas help improve regional air quality.
- Shade in car parks limits evaporation of fuel from fuel tanks, raises comfort upon departure and lowers energy consumption by air-conditioning systems.
- Due to the importance of environmental air exchange on air quality, vegetation around industrial and business estates should be planted to allow for effective air circulation.
- Dense vegetation at the edge of an estate can help shield residential areas and sensitive buildings (schools, hospitals, aged care facilities) against pollution from local sources (traffic especially).
- In working environments, use species that purify the air effectively, such as the Peace Lily (Spatiphyllum), Calatheas, Chlorophytum, Areca Palms, Dracaena and ferns.

Sources:
1. *J.A. Hiemstra, E. Schoenmaker-van der Bijl & A.E.G. Tonneijck (2008), Bomen: een verademing voor de stad. Uitgave PPH/VHG.*
2. *R.A. Wood, M.D. Burchett, R. Alquezar, R.L. Orwell, J. Tarran & F. Torpy (2006), The potted-plant microcosm substantially reduces indoor air VOC pollution: I. Office field-study. Water Air Soil Pollution 175:163–180.*
3. *T. Bade, G. Smid & F. Tonneijck (2011), Groen loont! Over maatschappelijke en economische baten van stedelijk groen. De Groene Stad, Apeldoorn.*
4. *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. Wageningen UR – PPO.*
5. *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'. Uitgave gemeente Tilburg/gemeente Sittard-Geleen/Royal HaskoningDHV Rotterdam.*
6. *M. Nieuwenhuis, C. Knight, T. Postmes & S. Haslam (2014), The relative benefits of green versus lean office space: Three field experiments. Journal of Experimental Psychology: Applied 20(3):199-214.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND WORK

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 (i.e. activity that is considered at least 'moderate').

Until recently, no distinction was drawn 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

- Attractive green outdoor areas encourage employees to go outside for a short or long walk during breaks. [1]
- These same areas can also be used for 'walking meetings', which help boost creativity. [2]

RECOMMENDATIONS

- Create attractive green surroundings suitable for walks.
- Create a company culture that encourages outdoor walks during breaks.
- An attractive green route may encourage employees to cycle to work. Make sure you provide adequate cycle facilities.
- Green indoor spaces encourage short breaks and are ideal for short 'walking meetings'.

Sources:

1. *I.J.M. Hendriksen, M. Middelkoop & J.C.A.M. Bervaes (2003), Wandelen tijdens de lunch. TNO Arbeid.*
2. *M. Oppezzo & D.L. Schwartz (2014), Give your ideas some legs: The positive effect of walking on creative thinking. Journal of Experimental Psychology: Learning, Memory, and Cognition 40(4):1142-1152.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND WORK

Image: mooiwatplantendoen.nl

JOB SATISFACTION & PRODUCTIVITY

Infectious diseases used to be the primary cause of sickness absence. Nowadays however, they have been replaced by lifestyle-related conditions such as cardiovascular diseases, and conditions related to depression and anxiety. Chronic stress is a key risk factor in this regard. In addition to physical health, job satisfaction is also important. This includes satisfaction with the physical and other elements of the working environment. Stress (including job-related stress) can lead to a variety of problems, including psychological conditions. Burnout and other psychological conditions top the list of work-related illnesses. According to the Netherlands Organisation for Applied Scientific Research (TNO), excessive workloads and work difficulty were responsible for 7.5 million sick days in 2014. Plants in the workplace can help prevent and reduce these problems.

HOW GREENERY WORKS

- Plants in office spaces reduce stress and improve the ability of employees to concentrate. [1]
- Office plants increase workplace satisfaction. [2]
- A substantial number of plants in the workplace improves thermal comfort: employees are less affected by raised or lowered temperatures and productivity increases. [3]
- Green office views are also associated with lower stress, which can also be influenced by levels of daylight. [4]
- The availability of green outdoor areas that can be used during breaks is also associated with both reduced stress[5] and higher workplace satisfaction. [6]
- Research in the Netherlands and Great Britain showed a 15% increase in productivity in office spaces containing plants. [7]

RECOMMENDATIONS

- Put plants in the workplace and in other locations frequented by employees (e.g. the company restaurant).
- Create views of outdoor greenery, from desks especially.
- Create pleasant green outdoor spaces that can be used by employees to relax and 'take some time out' .
- In large buildings, provide green indoor spaces where employees can take a short break or have a meeting in a green environment.

FURTHER INFORMATION

This document is part of a series of five documents on the added value provided by greenery in our living environment.
The remaining documents take a closer look at Residential, Educational and Healthcare environments.
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There are many real-life applications that illustrate and demonstrate the added value of vegetation.
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- www.royalfloraholland.com
- www.wur.nl

Specific questions on topics such as reference projects, research results, etc. can be sent directly to joop.spijker@wur.nl.

Sources:

1. *A. Smith, M. Tucker & M. Pitt (2011), Healthy, productive workplaces: Towards a case for interior plantscaping. Facilities 29(5-6):209-223.*
   R.K. Raanaas, K.H. Evensen, D. Rich, G. Sjøstrøm & G. Patil (2011), Benefits of indoor plants on attention capacity in an office setting. Journal of Environmental Psychology 31(1):99-105.
2. *A. Dravigne, T.M. Waliczek, R.D. Lineberger & J.M. Zajicek (2008), The effect of live plants and window views of green spaces on employee perceptions of job satisfaction. HortScience 43(1):183-187.*
3. *G. Mangone, S.R. Kurvers & P.G. Luscuere (2014), Constructing thermal comfort: Investigating the effect of vegetation on indoor thermal comfort through a four season thermal comfort Quasi-Experiment. Building and Environment 81:410-426.*
4. *K. Gilchrist, C. Brown & A. Montarzino (2015), Workplace settings and wellbeing: Greenspace use and views contribute to employee wellbeing at peri-urban business sites. Landscape and Urban Planning 138:32-40.*
5. *R. Berto (2014), The role of nature in coping with psycho-physiological stress: A literature review on restorativeness. Behavioral Sciences 4(4):394-409.*
   T. Hartig, R. Mitchell, S. de Vries & H. Frumkin (2014), Nature and health. Annual Review of Public Health 35:207-228.
6. *L. Lottrup, P. Grahn & U.K. Stigsdotter (2013), Workplace greenery and perceived level of stress: Benefits of access to a green outdoor environment at the workplace. Landscape and Urban Planning 110:5-11.*
7. *M. Nieuwenhuis, C. Knight, T. Postmes & S. Haslam (2014), The relative benefits of green versus lean office space: Three field experiments. Journal of Experimental Psychology: Applied 20(3):199-214.*

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GIVING GREENERY ITS DUE

GREENERY AND WORK

Due to its many positive benefits, greenery deserves a prime position in planning and budgeting processes. In consultation with potential and existing clients, the tips below can help suppliers of vegetation to give greenery its due in and around offices and other workspaces.

STAKEHOLDERS

- All projects involve a wide variety of stakeholders: users, investors, initiators, and many others who have their say in the decision-making process.
- Getting to know these groups and their requirements will allow suppliers of vegetation (potentially in conjunction with partners) to anticipate any objections and to further customise the benefits of greenery to the situation of the groups concerned.

TIPS

- Decide in advance what the desired effect of the greenery is and adjust the design and layout accordingly.
- Identify the relevant criteria – in addition to the desired appearance, also consider matters such as the available space, budget, and the social environment. Use this information to educate the stakeholders about the benefits of greenery, as provided on this fact sheet and in the list of references.
- Eliminate risks by providing comprehensive information on the initial investments required, including expenses such as set-up costs (possibly do this in collaboration with other businesses or an architect).
- Also provide information on maintenance methods, frequency and costs. Help mitigate risks (e.g. by providing a maintenance plan), and don't forget simple matters such as watering!
- Place the emphasis on employee's actual desks – buildings' general appearance and central spaces are often well-catered for. Workstations in offices and elsewhere are where the greatest benefits can be attained.
- Space is often at a premium. Be creative with the space you have, by applying new products and using innovative planting techniques.
- Limit the amount of attention (and maintenance) required on the part of users, or make preparations to outsource these duties to a gardener or indoor plant specialist.

CREATE DEMAND

- There are various groups besides employees who have an interest in green working environments, such as tenants or even lessors. These parties can be approached directly, or via bodies such as works councils, OH&S services or real estate agents.
- This can help create demand leading to concrete contracts.
- For new builds or renovations, approaching an architect or project developer proactively and on time is advisable.

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THE POSITIVE EFFECTS OF GREENERY IN URBAN ENVIRONMENTS

GREENERY AND RESIDENTIAL

VERSION 2.0

Greenery in and around houses and apartments is good for the (living) environment in and around the buildings. It 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 beneficial inclusion of greenery.

WHAT DOES GREENERY DO?

- Indoor plants purify the air: they lower the concentrations of CO_2 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 facades increase insulation capacity, reducing both heating and cooling expenditure.
- 'Green views' reduce stress levels in general.
- People spend more time outdoors in green environments, and are more active.
- Outdoor areas that include greenery help foster 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.

Image: mooiwatplantendoen.nl

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. [1]
- 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. [2]
- An American study among identical twins showed a negative correlation between greener environments and depression. [3]
- 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. [4]

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. Alterra-rapport 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.*
3. *H. Cohen-Cline, E. Turkheimer & G.E. Duncan (2015), Access to green space, physical activity and mental health: A twin study. Journal of Epidemiology and Community Health 69(6):523-529.*
4. *O. Kardan et al. (2015), Neighborhood greenspace and health in a large urban center. Nature Scientific Reports: 5:11610. DOI:10.1038/srep11610.*

APPLICATIONS

- Put indoor plants in living spaces and bedrooms.
- Green roofs and green facades.
- Green gardens with trees and shrubs, and hedges instead of paving.
- Ensure enough parks and other public nature areas in residential zones.
- Vertical gardens for houses directly abutting the street.
- Trees and other types of greenery in and along roads.

MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND RESIDENTIAL

URBAN TEMPERATURES

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 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 8ºC and incidental values even exceeding 10 degrees.

Extremely high temperatures during heat waves lead 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 7 days per 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 0.6ºC. [1]
- 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. [2]
- Parks stay cooler than dense built-up city centres during hot weather, with measured temperature differences of over 5ºC. Shade has the greatest effect: it helps lower air temperatures, and the reduced solar radiation beneath trees considerably raises levels of thermal comfort. [2,3]
- Parks not only provide 'cool islands' in warmer urban environments, but also have a cooling effect on the surrounding neighbourhoods. The effect depends on the size of the park, and has been measured up to 700 m away. [3]
- A combination of green facades, front gardens and roadside trees works best to reduce heat in streets, and can lower temperatures at pedestrian level by 2ºC. [4]

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 canopies are the most effective, both in parks and on the street. As such, it is important to create healthy growing conditions for trees.
- The evaporative cooling effect is 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. Here too, effective watering facilities are important for effectiveness.
- Greenery must be planted so as not to impede neighbourhood air flow, as fresh air significantly helps to reduce the heat-island effect.

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).*
2. *W. Klemm, B.G. Heusinkveld, S. Lenzholzer & B. van Hove (2015), Street greenery and its physical and psychological impact on outdoor thermal comfort. Landscape and Urban Planning 138:87-98.*
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.*
4. *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 83:11-26.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND RESIDENTIAL

AIR QUALITY

The major air pollutants in urban areas (nitrous oxides (NO_x), particulates (PM10/PM2.5) and volatile organic compounds such as benzene) come from industry and traffic in particular. 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. Busy city roads are places where limits are regularly exceeded. According to recommendations by the WHO, continuing to tighten the PM2.5 standard in the Netherlands would extend the average lifespan by 3 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. The filtration and screening effects provided by greenery can play a complementary role alongside source-specific policy for improving air quality.

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. [1]
- 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 5500 car kilometres. [2]
- Other types of greenery also help purify the air: one square metre of ivy collects 4-6 grams of particulate matter per year, and a stonecrop roof catches 0.15 g/m². [3]
- Dense vegetation can be used to screen off residential areas or sensitive buildings from sources of pollution (such as busy roads). [4]

RECOMMENDATIONS

- Increase the numbers of mature trees to boost the filter capacity.
- Large and healthy trees are the most effective, so be sure to provide good growth conditions to enable the trees to grow as they get older.
- 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. [1]
- 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 facades are good alternatives.
- Dense vegetation can, however, help to protect residential and other sensitive areas (schools, hospitals, aged care facilities, etc.) against pollution from nearby sources.
- The Peace Lily (Spatiphyllum) is the best-known plant for indoor air quality. Calatheas, Chlorophytum, Areca Palms, Dracaena and various ferns are other good options.

Sources:

1. *J.A. Hiemstra, E. Schoenmaker-van der Bijl & A.E.G. Tonneijck (2008), Bomen: een verademing voor de stad. Uitgave PPH/VHG.*
2. *T. Bade, G. Smid & F. Tonneijck (2011), Groen loont! Over maatschappelijke en economische baten van stedelijk groen. 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. 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'. Uitgave gemeente Tilburg/gemeente Sittard-Geleen/Royal HaskoningDHV Rotterdam.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND RESIDENTIAL

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 diseases 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. [1]
- 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). [2]
- Greener living environments are associated with a lower risk of stress-related conditions such as cardiovascular diseases, depression and anxiety disorders. [3]
- Even a view of diverse greenery from the home has demonstrated lower levels of cortisol (a stress hormone), and an improved sense of well-being. [4]
- 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 in particular from local greenery. [5]
- Even when they are older, people still benefit from the contact they had with green spaces earlier on in life. A relatively high percentage of greenery in the area where a person lived as a child/adult can delay the deterioration in mental capacity in older age.
- People who move to greener areas show improved long-term mental health. [6]
- The presence of greenery and water in the local area helps reduce the risk of developing anxiety. [7]
- Primary school children who grow up in a densely populated area benefit from a high density of trees. A study indicates that these children have less chance of developing autism. [8]

RECOMMENDATIONS

- Plant a wide variety of local greenery: this will increase the likelihood of use and social interaction, and 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.
- Don't focus entirely on green zones: also consider smaller natural elements, such as street trees and garden plants.
- 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 the area where they live.

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(H)D-medicatiegebruik bij 5- tot 12-jarigen. Alterra-rapport 2672. WUR-Alterra, Wageningen.*
3. *J. Maas, R.A. Verheij, S. de Vries, P. Spreeuwenberg, F.G. Schellevis & P.P. Groenewegen (2009), Morbidity is related to a green living environment. Journal of Epidemiology and Community Health 63(12):967-973.*
4. *J. Honold, T. Lakes, R. Beyer & E. van der Meer (2016), Restoration in urban spaces nature views from home, greenways, and public parks. Environment and Behavior 48(6):796-825.*
5. *R. Mitchell & F. Popham (2008), Effect of exposure to natural environment on health inequalities: An observational population study. The Lancet 372(9650):1655-1660.*
6. *I. Alcock, M.P. White, B.W. Wheeler, L.E. Fleming & M.H. Depledge (2014), Longitudinal effects on mental health of moving to greener and less green urban areas. Environmental Science & Technology 48(2):1247-1255.*
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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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND RESIDENTIAL

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 greater 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. [1]
- People exhibit more social behaviour while (or after) spending time in green environments. [2]
- 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. [3]
- The loss of trees on a large scale through tree diseases, in the same way as the neglect of vegetation, can increase crime in the area concerned. [4]

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.
2. *J.M. Zelenski, R.L. Dopko & C.A. Capaldi (2015), Cooperation is in our nature: Nature exposure may promote cooperative and environmentally sustainable behavior. Journal of Environmental Psychology 42:24-31.*
3. *N. Weinstein, A. Balmford, C.R. DeHaan, V. Gladwell, R.B. Bradbury & T. Amano (2015), Seeing community for the trees: The links among contact with natural environments, community cohesion, and crime. BioScience 65(12):1141-1153.*
   F.E. Baum, A.M. Ziersch, G. Zhang & K. Osborne (2009), Do perceived neighbourhood cohesion and safety contribute to neighbourhood differences in health? Health & place 15(4):925-934.
4. *M.C. Kondo, S.H. Hana, G.H. Donovan & J.M. MacDonald (2017), The association between urban trees and crime: Evidence from the spread of the emerald ash borer in Cincinnati. Landscape and Urban Planning 157:193–199.*

RECOMMENDATIONS

- Greenery must elicit feelings of safety; overgrown and/or visibly neglected vegetation can make people feel unsafe.
- Greenery has the greatest impact on social cohesion in a relatively small area: a small (safe and attractive) local park is better than a large city park, as the main purpose is to facilitate meetings between neighbours .
- Promoting extended visits will increase the likelihood of chance meetings. Place benches around a central point of interest in a green space, for example, such as a water feature.
- 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.

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND RESIDENTIAL

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. [1]
- 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 therefore mediate visits to local green areas, and allow people to enjoy other health benefits provided by greenery. [2]
- 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.). [3]

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. Alterra-rapport 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.*

RECOMMENDATIONS

- To promote physical activity, focus mainly on the potential for 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 footpaths.
- 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).

FURTHER INFORMATION

This document is one of a series of five documents on the added value provided by greenery in our living environment. The remaining documents take a closer look at the role of greenery in Professional, Educational and Residential environments and at a number of more General aspects (biodiversity, water management, noise and property prices). All the documents and large amounts of background information can be found on the Greenery and Wellbeing portal of www.groenkennisnet.nl.
There are many real-life applications that illustrate and demonstrate the added value of vegetation.
Other useful sources of information include:

- www.groenkennisnet.nl
- www.degroenestad.nl
- www.royalfloraholland.com
- www.wur.nl

Specific questions on topics such as reference projects, research results, etc. can be sent directly to joop.spijker@wur.nl.

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GIVING GREENERY ITS DUE

GREENERY AND RESIDENTIAL

Due to its many positive benefits, greenery deserves a prime position in the planning and budgeting processes of large-scale projects (new builds and renovations). In consultation with potential and existing clients, the tips below can help suppliers of vegetation to give greenery its due in residential environments.

STAKEHOLDERS

- All projects involve a variety of stakeholders: residents, property owners, tenants and lessors, the municipal authorities and many others who exert their influence on the decision-making process.
- Getting to know these groups and their requirements will allow suppliers of vegetation (potentially in conjunction with partners) to anticipate any objections and to customise the benefits of greenery further to the situation of the groups concerned.

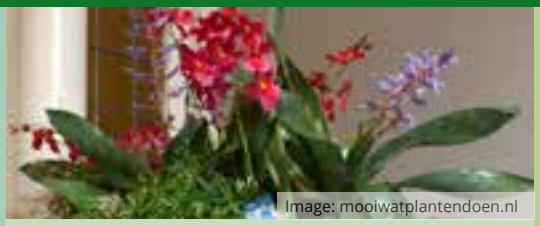

Image: mooiwatplantendoen.nl

TIPS

- Decide at the start of a project what the desired benefits or functions of the greenery are and adjust the design and layout accordingly.
- Identify the relevant criteria – in addition to the desired appearance, also consider matters such as the available space, budget, and the social environment. Use this information to educate the stakeholders about the benefits of greenery, as provided by this document.
- Eliminate risks by providing comprehensive information on the initial investments required, including expenses such as setup costs (possibly do this in collaboration with other businesses or an architect).
- Also provide information on maintenance methods, frequency and costs. Help mitigate risks (e.g. by providing a maintenance plan), and don't forget simple matters such as watering!
- Community participation: involve the current or future residents directly or indirectly in the selection, application and implementation of green features. Allowing residents to help (with planting, etc.) gives a positive boost to involvement.

In addition to large-scale projects, there is also the 'individual' market, i.e. people furnishing and planning their homes and gardens. They can be alerted to the benefits of greenery in the living environment via the media, and at points-of-sale such as garden centres and online stores.

CREATE DEMAND

Nearly everyone has a home, which makes everybody the target audience for promoting the benefits of greenery via the media. In 'project-based' situations, associations of tenants, residents or home-owners can be approached. This can help create demand leading to concrete contracts. Council members and other Politicians and elected officials are another potential intermediary group.

For new-build or renovation projects, proactively approaching an architect or project developer is useful.

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IT IS SPONSORED BY THE HORTICULTURE & PROPAGATION MATERIALS TOP SECTOR.

THE POSITIVE EFFECTS OF GREENERY IN URBAN ENVIRONMENTS

GREENERY AND HEALTHCARE

VERSION 2.0

Greenery in and around nursing homes, hospitals and other clinics is good for the climate inside and outside the building, and has a positive effect on patient's state of mind and ability to recover, as well as the general well-being of patients, staff and visitors.

This document provides information on the benefits of greenery for recovery and well-being, 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?

- Visible greenery, both indoors and out, reduces stress among patients and staff.
- Plants in hospitals and other institutions purify the air: they reduce concentrations of CO_2 and volatile organic compounds, keeping the air fresh and healthy.
- Outdoor vegetation reduces heat in and around buildings in the summer, lowering heat stress and reducing the need for air-conditioning.
- Green roofs and facades increase insulation capacity, reducing both heating and cooling expenditure.
- A green environment is more attractive and creates more variety, moving the focus away from pain and stress.
- Indoor plants release water vapour, humidifying the air and reducing the likelihood of headaches.
- If the environment is greener, and therefore more attractive, people will be more likely to go outside and to be more active. This also applies to the elderly and outpatients.

Image: mooiwatplantendoen.nl

APPLICATIONS

- Courtyards and other gardens as relaxation/quiet areas.
- Courtyards and other gardens as treatment areas.
- Green roofs and green facades.
- Green walls and indoor plants in central areas, canteens, waiting rooms and some treatment areas.
- Attractive landscaping of the hospital grounds, including green borders and trees.
- Continuing the landscape's natural flow of greenery around the hospital.

PROVEN SUCCESS

- In a US study, in-bed recovery time was almost 10% shorter for patients who had a view of trees than for patients who had a view of a brick wall. [1]
- In the same study, patients with a view of trees used up to 30% weaker painkillers. [1]
- In a laboratory experiment, people were able to tolerate more pain when there were houseplants in the room. [2]
- 'I just feel less unwell', said one cancer patient receiving treatment in the 'chemo garden' at Tergooi Hospital.

Sources:

1. *R.S. Ulrich (1984), View through a window may influence recovery from surgery. Science 224:420-421.*
2. *V.I. Lohr, C.H. Pearson-Mims (2000), Physical discomfort may be reduced in the presence of interior plants. Hort-Technology 10(1):53-58.*

MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND HEALTHCARE

TEMPERATURE

Many hospitals are located in urban areas, where average temperatures are higher than in surrounding areas (the 'heat-island' effect). This effect occurs in both metropolitan and provincial cities, and increases as built-up areas become denser. Measured maximum differences vary from one to several degrees Celsius, with peak values of up to approx. 8 degrees and incidental values even exceeding 10 degrees. Heat stress caused by excessively high temperatures adversely affects health (particularly among the elderly, chronically ill and pregnant women) and can increase mortality rates. It also negatively affects the ability of staff to work and concentrate. Research has shown that 35% of urban areas in the Netherlands already experience heat stress at least 7 days per year. Rising urban density and further global warming will increase the frequency of periods of heat stress in cities. However, greenery can help counter urban warming.

HOW GREENERY WORKS

- Green provides cooling by blocking solar radiation (i.e. providing shade) and aiding evaporation; a 10% increase in vegetation can reduce the urban heat-island effect by an average of 0.6 °C. [1]
- Green roofs (potentially in combination with green facades) improve building insulation. They reduce warming in hospital buildings, both limiting the effects of heat stress on patients and staff and lowering heating and cooling expenses. [2]
- Planting vegetation has a cooling effect on the environment, provided that the cool air from this vegetation can flow into the environment[3]. Green spaces around hospitals therefore help reduce heat stress in the surrounding area.
- Green areas also help trap CO_2. [4]
- Shade trees above car parks reduce fuel evaporation from tanks, and reduce heat in car interiors. [5]

RECOMMENDATIONS

- Green roofs on healthcare institutions reduce heating and cooling costs.
- Increasing vegetated surfaces around healthcare institutions and planting trees on nature strips reduces the heat-island effect.
- Larger green zones in and around hospital areas can help create a more pleasant climate in the broader surrounds, provided the area is structured and landscaped to allow for effective flow of air.

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).*
2. *M.E.C.M. Hop & J.A. Hiemstra (2013), Ecosysteemdiensten van groene daken en gevels. Een literatuur-studie naar diensten op het niveau van wijk en stad. Wageningen UR – PPO.*
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: Atmospheres 119:677-692.*
4. *Z.G. Davies, J.L. Edmondson, A. Heinemeyer, J.R. Leake & K.J. Gaston (2011), Mapping an urban ecosystem service: Quantifying above-ground carbon storage at a city-wide scale. Journal of Applied Ecology. DOI: 10.1111/j.1365-2664.2011.0202.x.*
5. *K.I. Scott, J.R. Simpson & E.G. McPherson (1999), Effects of tree cover on parking lot microclimate and vehicle emissions. Journal of Arboriculture 25(3):129-142.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND HEALTHCARE

AIR QUALITY

The major air pollutants (nitrous oxides (NO_x), particulates (PM10/PM2.5) 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. There is no safe lower limit, and concentrations can rise considerably in areas close to busy roads and intersections.

Indoor air quality is often poor; large numbers of people in a relatively small space frequently cause CO_2 levels to rise significantly. Volatile organic compounds from construction materials (such as formaldehyde and benzene) may also be present.

HOW GREENERY WORKS

- Indoor vegetation can be used to improve air quality in healthcare institutions. Given enough light and water, plants absorb CO_2 from the air, helping to reduce ambient CO_2 levels. [1]
- Indoor greenery also releases water vapour, which helps make the air in buildings less dry.
- Plants also filter volatile organic compounds from the atmosphere. For example, it has been shown that the Peace Lily (Spathiphyllum, a well-known indoor plant) can absorb and convert 20 mg of formaldehyde per 500 grams of foliage per hour. Formaldehyde is a common disinfectant, but in excessive doses can be poisonous and carcinogenic to humans. [2]

Sources:

1. *B. van Duijn, J. Klein Hesselink, M. Kester, J. Jansen & H. Spitters (2011), Rapport 'Plant in de klas'. Productschap Tuinbouw/Fytagoras/TNO.*
2. *B.C. Wolverton, W.L. Douglas & K. Bounds (1989), A study of interior landscape plants for indoor air pollution abatement (Report). NASA. NASA-TM-108061.*

Image: mooiwatplantendoen.nl

RECOMMENDATIONS

- Include indoor plants to improve the air quality inside buildings through the removal of pollutants (especially CO_2 and volatile organic compounds) and by improving humidification.
- Plant shade trees in car parks to reduce the evaporation of fuel from fuel tanks, reduce visitors' heat stress and lower fuel consumption by reducing the use of air-conditioning in cars.
- Due to the importance of environmental air exchange on air quality, vegetation around healthcare institutions must be planted to allow for effective airflow.

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND HEALTHCARE

STRESS AND STATE OF MIND

For most patients, visiting or staying in hospital is a stressful experience. High stress levels can stand in the way of speedy recovery . Greenery in and around the institution can help reduce stress in patients, thereby facilitating and accelerating their recovery.
NB: Working in such environments is also stressful for nursing staff. For more information on the benefits of greenery for employees, please see the fact sheet on Greenery and Work.

HOW GREENERY WORKS

- Plants in waiting rooms reduce stress. [1]
- Plants in hospital rooms reduce anxiety and pain. [2]

RECOMMENDATIONS

- Make sure the view from hospital rooms includes greenery (preferably visible from the bed), as well as from other locations frequented by patients (e.g. waiting rooms, common rooms).
- Create attractive green outdoor areas (gardens) for outpatients (and carers) to relax and get away from it all; make sure these areas are accessible to people in wheelchairs or with other mobility restrictions.
- Ensure easy access to the indoor and outdoor green areas, including areas that are not necessarily part of the institution itself, such as public green spaces.
- Also use other means to promote the use of these green spaces (information, signs, facilitated activities, etc.).
- Provide green spaces in the immediate vicinity where people can go for walks, which improves employee productivity and aids patient recovery.

Sources:

1. *C.J. Beukeboom, D. Langeveld & K. Tanja-Dijkstra (2012), Stress-reducing effects of real and artificial nature in a hospital waiting room. The Journal of Alternative and Complementary Medicine 18(4):329-333.*
2. *S.H. Park & R.H. Mattson (2009), Ornamental indoor plants in hospital rooms enhanced health outcomes of patients recovering from surgery. The Journal of Alternative and Complementary Medicine 15(9):975-980.*

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MORE INFORMATION ON THE EFFECTS OF GREENERY

GREENERY AND HEALTHCARE

RECOVERY

Greenery in and around hospitals provides relaxation and diversion for convalescing patients.

HOW GREENERY WORKS

- Greenery visible through the window of hospital rooms helps reduce the length of hospital stays (by nearly a day). [1]
- Patients in an American hospital recovering from gall-bladder surgery who had a view of trees from their room used weaker painkillers than those whose view was of a brick wall. [1]

Sources:

1. *R.S. Ulrich (1984), View through a window may influence recovery from surgery. Science 224:420-421.*

RECOMMENDATIONS

- A view that includes greenery shortens hospital stays.
- Hospitals that include greenery in their design show an increase in the amount of social support given to the admitted patients.
- Green indoor/outdoor areas can also be incorporated into various types or components of therapy in a less stressful environment (e.g. chemo gardens, or green physiotherapy exercise rooms).

FURTHER INFORMATION

This document is one of a series of five documents on the added value provided by greenery in our living environment.
The remaining documents take a closer look at the role of greenery in Professional, Educational and Residential environments and at a number of more General aspects (biodiversity, water management, noise and property prices).
All the documents and large amounts of background information can be found on the Greenery and Wellbeing portal of www.groenkennisnet.nl.

There are many real-life applications that illustrate and demonstrate the added value of vegetation.
Other useful sources of information include:

- www.groenkennisnet.nl
- www.degroenestad.nl
- www.royalfloraholland.com
- www.wur.nl

Specific questions on topics such as reference projects, research results, etc. can be sent directly to joop.spijker@wur.nl.

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GIVING GREENERY ITS DUE

GREENERY AND HEALTHCARE

Due to its many positive benefits, greenery deserves a prime position in planning and budgeting processes. In consultation with potential and existing clients, the tips below can help suppliers of vegetation to give greenery its due in and around care institutions and other clinics.

STAKEHOLDERS

- All projects involve a wide variety of stakeholders: users, investors, initiators, and many others who have their say in the decision-making process.
- Getting to know these groups and their requirements will allow suppliers of vegetation (potentially in conjunction with partners) to anticipate any objections and to further customise the benefits of greenery to the situation of the groups concerned.

Image: mooiwatplantendoen.nl

TIPS

- Identify the relevant criteria –hospitals will have different needs from nursing homes, for example. Examine the available space, budget, and practicability. Use this information to educate the stakeholders about the benefits of greenery, as provided on this fact sheet and in the list of references.
- Eliminate risks by providing comprehensive information on the initial investments required, including expenses such as setup costs (possibly do this in collaboration with other businesses or an architect).
- Also provide information on maintenance methods, frequency and costs. Help mitigate risks (e.g. by providing a maintenance plan), and don't forget simple matters such as watering!
- Work with partner businesses to provide appropriate solutions for treatment rooms (e.g. pictures).
- Involve other stakeholders (such as nursing staff and residents) either directly or indirectly in decision-making, application and implementation processes.
- Estimate the needs of the user group, identify what is important to them, and summarise the benefits of greenery that meet these needs.

CREATE DEMAND

- Users (residents/patients and staff) can be approached directly, either personally or via organisations such as patient associations or 'Friends of…' foundations.
- This can help create demand leading to concrete contracts.
- These channels can also be used to identify alternative funding sources.
- For new builds or renovations, approaching an architect or project developer proactively and on time can help.

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