GREENERY AND EDUCATION

The positive effects of greenery in urban environments

Version 3

Greenery in and around schools, childcare centres and on campuses is good for the quality of life in and around these education institutions. It has a positive effect on the health and general well-being of students and staff alike, also improving students' 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 air-conditioning.
- Green roofs and façades 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 façades.
- Plants in canteens, central spaces and (where possible) in classrooms/lecture halls.
- 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 SUCCES

- A practical study in eight primary school classes showed a 20% increase in performance when the classroom contained plants.[1]
- Children in classrooms that contain plants show a 7% reduction in health problems.[1]
- 'Green' playgrounds are less prone 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 eight primary schools in New York, the integration of school gardening in the curriculum increased physical activity and lowered sedentary behaviour.[3]
- Students expect to be able to recover from academic pressure better on a green campus than a standard grey campus.[4]
- Students' recall of lectures is better when the lecture hall contains some natural elements.[5]
- Students prefer a green study space over a standard study space or one with a colourful poster.[6]

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).

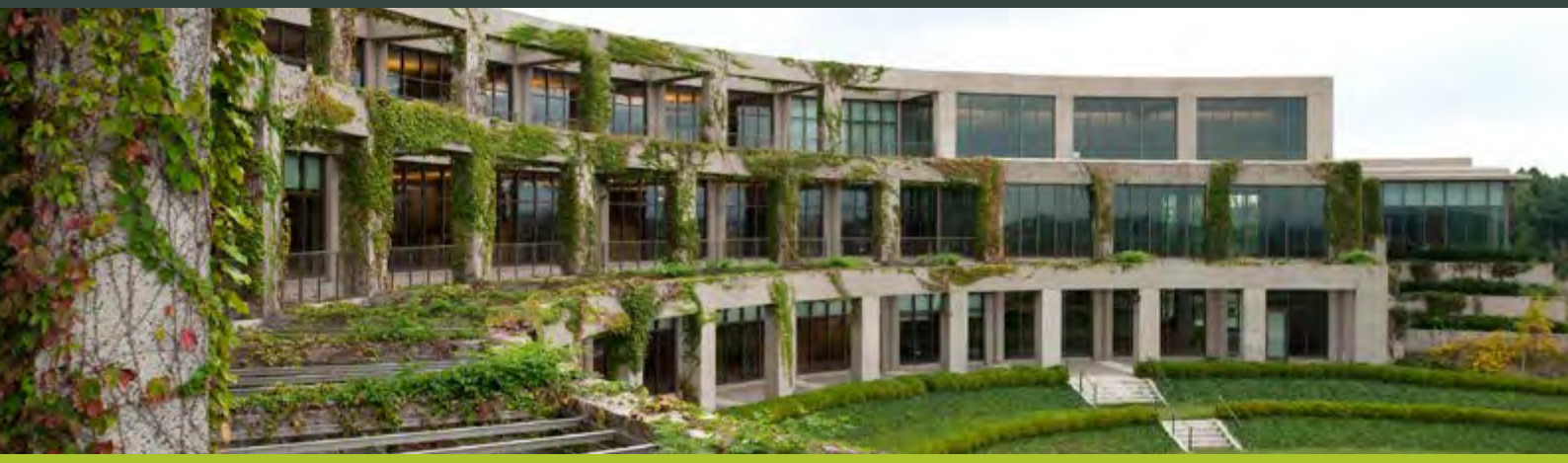
3 S. Kruid (2016), Systematic literature review: School and community garden interventions in children. BSc Thesis Wageningen University.

4 N. van den Bogerd, S. C. Dijkstra, J. C. Seidell & J. Maas (2018). Greenery in the university environment: Students' preferences and perceived restoration likelihood. PloS one, 13(2), e0192429.

5 L. J. Holden & T. Mercer (2014). Nature in the learning environment: Exploring the relationship between nature, memory, and mood. Ecopsychology, 6(4), 234-240.

6 N. van den Bogerd, S. C. Dijkstra, J. C. Seidell & J. Maas (2018). Greenery in the university environment: Students' preferences and perceived restoration likelihood. PloS one, 13(2), e0192429.

GREENERY AND EDUCATION
More information on the effects of greenery



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 village centres, 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 °C. Heat stress affects the ability to concentrate and academic performance, and extreme values or extended duration can also adversely affect health. Research has shown that 35% of urban areas in the Netherlands already experience heat stress at least seven days a year. Rising urban density and global warming will increase the frequency of these heat-stress periods. However, greenery can help to lower urban temperatures. It can also be used specifically to improve quality of life in and around schools and other education institutions.

HOW GREENERY WORKS

› When temperatures are high, everyone, including children and teaching staff, feels more comfortable in a green environment.[1]

› Green roofs (also paired with green façades) increase insulation of school buildings, improving the indoor climate. Heating and cooling expenditure also drop as a result.[2]

› Shade trees increase thermal comfort during warmer weather in two ways: they provide shade and they release water vapour. Although in the Netherlands the reported effects on air temperature are limited to 1-2°C, the effect on the perceived temperature is many times greater.[1,3]

› Temperatures are lower and humidity higher in classrooms with a green wall and plants compared to classrooms with no plants.[4]

RECOMMENDATIONS

› Installing green façades and roofs on 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.

› Greenery in classrooms creates a more pleasant indoor climate.

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.

4 N. van den Bogerd, S.C. Dijkstra, K. Tanja-Dijkstra, L. Kuiper, J.C. Seidell, S. Koole & J. Maas. The effects of indoor nature in classrooms on students perceptions and well-being – results of three experiments. - In preparation.

Compilation: Wageningen University & Research: dr.ir. J.A. Hiemstra, dr. S. de Vries en ir. J.H. Spijker. Vrije Universiteit Amsterdam: dr. J. Maas

GREENERY AND EDUCATION
More information on the effects of greenery

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 chiefly 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 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 are also able to trap volatile organic compounds (VOCs) such as formaldehyde and benzene from the atmosphere. A study at a school in Portugal showed that plants can cut airborne VOCs by 50%.[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.

› In an experimental study, concentrations of CO_2 and volatile organic compounds were lower in classrooms with a green wall and plants compared to a control classroom with no plants.[4]

RECOMMENDATIONS

› Planting dense vegetation (green screens) can help 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' [Clean air; greenery and urban air quality. Final report from the interregional project titled 'Functional applications of greenery: for air, climate and society']. Publication by the Municipality of Tilburg/Municipality of Sittard-Geleen/Royal Haskoning DHV Rotterdam.

2 B. van Duijn, J. Klein Hesselink, M. Kester, J. Jansen & H. Spitters (2011), Report 'Plant in de klas' [Plants in the classroom]. Product Board for Horticulture/Fytagoras/Netherlands Organisation for Applied Scientific Research (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.

4 N. van den Bogerd, S.C. Dijkstra, K. Tanja-Dijkstra, L. Kuiper, J.C. Seidell, S. Koole & J. Maas. The effects of indoor nature in classrooms on students perceptions and well-being – results of three experiments. In preparation

Compilation: Wageningen University & Research: dr.ir. J.A. Hiemstra, dr. S. de Vries en ir. J.H. Spijker. Vrije Universiteit Amsterdam: dr. J. Maas

GREENERY AND EDUCATION
More information on the effects of greenery

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 promote more social behaviour among young people and reduce levels of illness.[1]

› Green walls in classrooms aid 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]

› Students' concentration levels after recess are higher at schools with green schoolyards compared to those with grey schoolyards. Teachers confirm this. [5]

› Secondary school students demonstrate better concentration when there are plants or flowers in the classroom. [6]

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).

› Also place plants or a green wall in classrooms.

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.

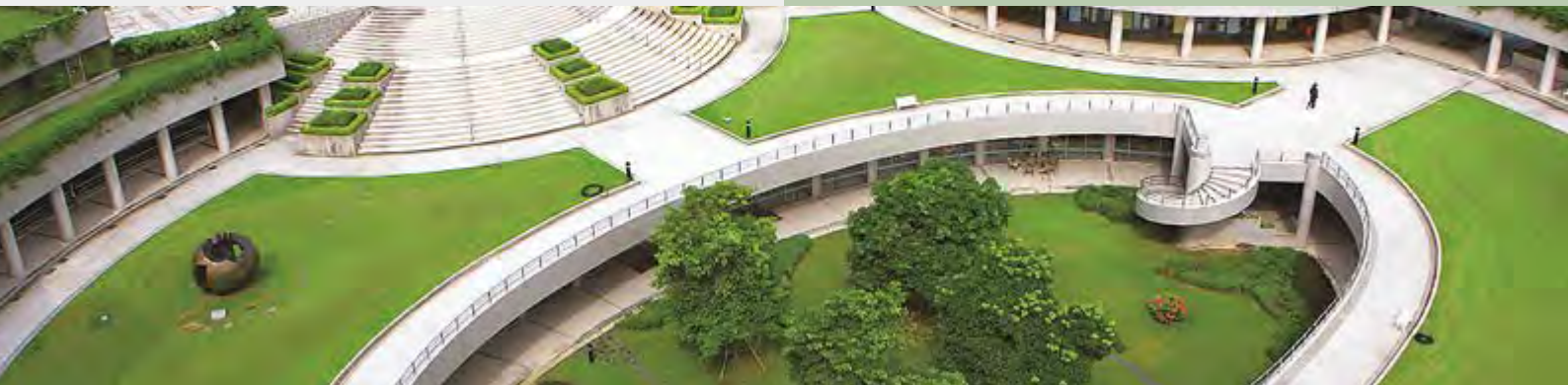
2 D. Li & W.C. Sullivan (2016), Impact of views to school landscapes on recovery from stress and mental fatigue. Landscape and Urban Planning 148:149-158.

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.

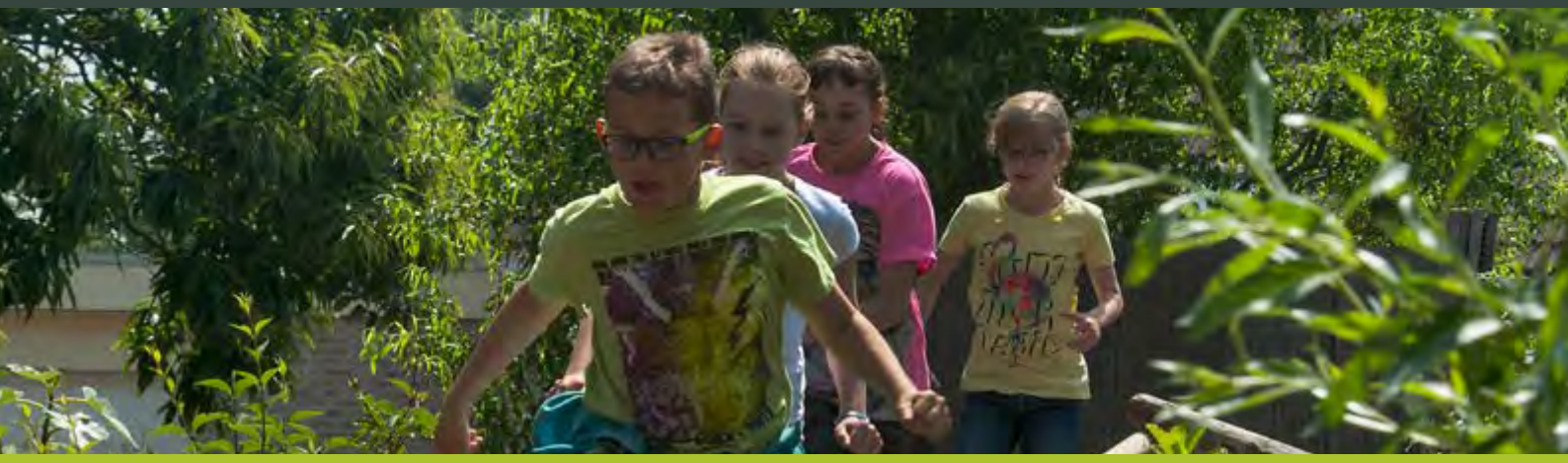
5 JE van Dijk-Wesselius,, Maas, J., Hovinga, D., Van Vugt, M., & Van den Berg, A. E. (2018). The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. Landscape and Urban Planning, 180, 15-26

6 N. van den Bogerd, S.C. Dijkstra, K. Tanja-Dijkstra, L. Kuiper, J.C. Seidell, S. Koole, J. Maas. The effects of indoor nature in classrooms on students perceptions and well-being – results of three experiments. In preparation



Compilation: Wageningen University & Research: dr.ir. J.A. Hiemstra, dr. S. de Vries en ir. J.H. Spijker. Vrije Universiteit Amsterdam: dr. J. Maas

GREENERY AND EDUCATION
More information on the effects of greenery



PHYSICAL ACTIVITY

A lack of physical activity (and, by extension, obesity) is a key risk factor for health. In the Netherlands, 14% of young 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). More recently, it has become clear 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 this.

HOW GREENERY WORKS

› Young children at nurseries with quality, green outdoor spaces spend more time outside and have 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]

› Among girls, greener school playgrounds encourage moderate exercise during recess. When a playground is greened, girls stand around talking and watching less and engage more in rule-based games.[5]

RECOMMENDATIONS

› Create attractive outdoor areas with a variety of playtime activities and games, and make sure it is large enough so that children are not always in each other's way.

› Integrate vegetation with the other elements in the schoolyard so it is not mere decoration.

› Ensure that the greenery can cope with the level of play in the playground.

› Vegetable gardens can spark children's interest in nature.

› Create a challenging but safe outdoor area. Do not use 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 children's 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.

5 J.E. Van Dijk-Wesselius, J. Maas, D. Hovinga, M. Van Vugt & A.E. Van den Berg (2018). The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. Landscape and Urban Planning, 180, 15-26.

Compilation: Wageningen University & Research: dr.ir. J.A. Hiemstra, dr. S. de Vries en ir. J.H. Spijker. Vrije Universiteit Amsterdam: dr. J. Maas

GREENERY AND EDUCATION
More information on the effects of greenery

SOCIAL CLIMATE

In addition to children's cognitive and physical performance, their socio-emotional well-being and development are also important factors. This relates to things like 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 lead children to eat more 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.

› Children whose schoolyard has been greened experience a greater sense of social support from their peers. [3]

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 [More greenery in schoolyards: an intervention study]. Alterra report 2474. WUR-Alterra, Wageningen.

2 S. Kruid (2016), Systematic literature review: School and community garden interventions in children. BSc Thesis Wageningen University.

3 J.E. Van Dijk-Wesselius, J. Maas, D. Hovinga, M. Van Vugt & A.E. Van den Berg (2018), The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. Landscape and Urban Planning, 180, 15-26.

FURTHER INFORMATION

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

› Maas, J., Wesselius-van Dijk, J. & Hovinga, D. (2018). Fact sheet 'Wat betekent het vergroenen van een schoolplein voor leerlingen? De 'leer'kracht van groene schoolpleinen' [How does greening a schoolyard impact pupils? The green schoolyard as 'instructor']. Leiden: Nature & Childhood Development Research Group

› https://www.groenkennisnet.nl/nl/groenkennisnet/portalen/leefomgeving/groen-en-welbevinden.htmwww.degroenestad.nl

› www.royalfloraholland.com

› www.wur.nl

› https://ruimtelijke adaptatie.nl/hulpmiddelen/factsheets-groen/

This also provides a table listing 120 tree species and their specific benefits as vegetation.

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

The Green Agenda is a programme by Royal FloraHolland, De Groene Stad and Wageningen University & Research. It is sponsored by the Horticulture & Propagation Materials Top Sector.