There has never been a greater need for the people planning and running our cities, as well as the residents who pay for it, to understand the critical significance of green space in our urban environment.

Working with green is a way to respond to the true needs of people when designing buildings, the public realm, transport and communications infrastructure. This is a goal to which every professional can apply themselves. These guidelines are a starting point so interested parties can come together internationally and discuss techniques for urban development.

Green+

The Green City Guidelines

Green+

The Green City Guidelines

Techniques for a healthy liveable city

Michelle de Roo | landscape and urban designer

The Hague, NL | Fotobureau Hendriksen/Valk

Foreword

Welcome to this volume of **The Green City Guidelines** – *the first of its kind!*

There has never been a greater need for the people planning and running our cities, as well as the residents themselves, to understand the critical significance of green space in our urban environment.

Working with green is a way to respond to the true needs of people when designing buildings, the public realm, transport and communications infrastructure. This is a goal to which every professional can apply themselves. These guidelines are a starting point so interested parties can come together internationally and discuss techniques for urban development.

What this set of guidelines shows is that the knowledge is already there. The theory, substantiated by empirical scientific research, proves that green infrastructure is a key element in constructing living spaces that work.
This is powerful information at a time when budgets are being cut and every cost scrutinised. This set of guidelines and techniques will demonstrate to practitioners that investment and maintenance in green infrastructure is not a cost but brings value from a social, economic and environmental point of view – in summary the 'Green City Philosophy'.

A group of leading researchers and practitioners have contributed to this volume and it is to be used as a stimulus for the global adoption of the Green City Philosophy. This book is the beginning of a process that could see green infrastructure responses fully incorporated into policy and practice – in effect become a 'universal green city standard'. The authors and contributors hope that you will be part of that process.

The 'guidelines' project has been made possible with funding from the Dutch Ministry of Economic Affairs, Agriculture and Innovation (EL&I) and with the active support and co-operation of the Dutch nursery stock industry, Plant Publicity Holland (PPH), the International Association of Horticultural Producers (AIPH) and Niek Roozen bv landscape architects.

signed by

Marcel Vernooij (EL&I)

Doeke Faber (AIPH)

Jaap Spros (PPH)

Niek Roozen

Housing development with newly planted trees | Photo PPH

Housing development with mature trees | Photo collage: Niek Roozen bv

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De Tussentuin, Rotterdam, NL | Photo: Wolbert van Dijk

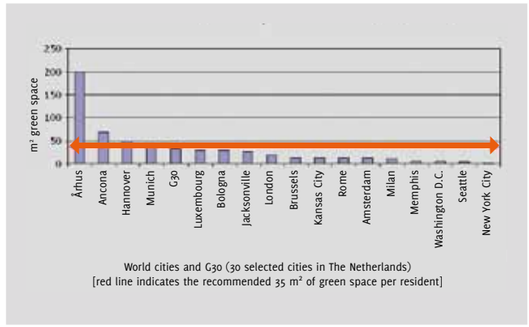
London, UK | Photo: Trees for Cities

Introduction

The 'Green City Guidelines' project is an internationally targeted initiative that aims to provide practitioners and decision-makers with the essential information they need to understand and communicate the benefits of urban green space or more accurately green infrastructure. The purpose of this project is to bring this information more into the mainstream in a form that is immediately accessible, yet at the same time supported by the evidence-based substance that practitioners globally need to implement successful green infrastructure responses.

The Green City movement has in its heart the belief that the green element is critical to the long-term functioning of healthy, successful, liveable urban spaces. Statisticians from the United Nations estimated that 50% of the world's population would live in urban areas by 2008, with 70% by approximately 2047. For this reason, it is essential that the true value of urban green space is globally understood and that decision-makers have the tools to guarantee its position.

Amount of green per resident in selected cities



World cities and G30 (30 selected cities in The Netherlands)
[red line indicates the recommended 35 m² of green space per resident]

Source: Groene Meters: Peter Visschedijk en Veroniek Bezemer (Alterra – Wageningen UR)

Objectives of this book

This book is written to provide a wide range of professionals with the stimulus to ask 'how green is my city?' It provides tools in the form of practical pointers that show how the contribution of green infrastructure can be enhanced for the benefit of all. This applies both now and for future generations. It is written in the knowledge that the term 'green city' has a range of meanings but deliberately focuses on the physical, living green, plants as well as green spaces. The plant features are the elements that underpin the rest of the settlement and can deliver those essential 'ecosystem services' that are our life-support systems.

"Ecosystem Services" is a term to describe any beneficial function provided by green space that would otherwise require a technical response (flood defence, air quality, countering the urban heat island) or that offers a cultural or other benefit (e.g. biodiversity or aesthetic/heritage benefits). Valuation of ecosystem services is emerging as an important concept for securing investment in green space.

In itself, this book does not seek to provide all the answers. However it offers case studies, references and guidance relating to those subject areas where green infrastructure plays a part in the successful functioning of the human urban environment. The reader can follow up on these as required depending on site-specific needs.

Rationale

Green infrastructure offers solutions to a wide range of the challenges faced by contemporary society. By applying green space solutions with reference to scientifically and economically proven models, outcomes can be predicted. This is an essential stage in the acceptance of green infrastructure as a mature and credible tool that can be utilised as a problem-solver in diverse situations all over the world. The case studies in this book serve to demonstrate the potential of a range of responses and approaches. By bringing them together in one place, they are convenient and accessible. They can be used by practitioners to stimulate thought and to win arguments. They will have greater impact because they have been collated.

"...the relationship between the amount of green space in the living environment and health should not be underestimated. Most of the diseases that were found to be related to the amount of green space in the living environment are highly prevalent in society and are subject of large-scale prevention programmes in many countries. Furthermore, diseases of the circulatory system, mental disorders and diseases of the digestive system, for which we found a relationship with the amount of green space, are among the most expensive diseases in terms of health care costs in many countries (Heijink et. al., 2006). Thirdly, the results indicate that people who live in a greener living environment generally feel safer..."
Jolanda Maas in Vitamine G

Green+

Basis of the guidelines

The Green City Guidelines are founded on the principles of the Green City philosophy. This is an international approach that places green space at the centre of development and regeneration, on a par with red, blue and grey on the masterplan. It uses evidence-based arguments to highlight the importance of green elements and positions them as fundamental solutions and responses to many of the challenges of contemporary life – from stress, burn-out or obesity to climate-change preparedness. It argues that investment in green infrastructure is repaid many times over in terms of the benefits it brings.

There are a number of key areas in which green infrastructure offers quantifiable benefits. These topics return at the bottom of every guideline in order to illustrate how each guideline benefits so many of these topics simultaneously, therefore strengthening the integral value of green.

Economy

Quality green infrastructure increases house and office values (either rental or freehold). It provides a more attractive environment for inward investment and draws additional visitors to a city.

Green roofs and green walls help reduce energy costs in buildings by € 0.71 to € 19 per m². The longer life of a green roof can save € 18 – € 43 per m². Houses with a view of green are 1–15% more valuable. This added value benefits both the home owner and the city. The lease prices for offices with green nearby can be 10% more than offices with no green.

Health

Residents and workers are happier and healthier when they live and work in green surroundings. This is because of the psychological benefits – we are hard-wired to be more at ease in green spaces rather than concrete ones – but also because of shade, air quality and the increased likelihood that we will take healthy outdoor exercise when we have access to green space nearby. Improved health results in lower costs for the health-care sector, benefits the economy and leads to enhanced human well-being.

The productivity of workers increases and reported sick days decrease in offices with indoor green, which can save a company € 837 per employee per year. Patients recover up to 10% quicker in hospital rooms with views of green, resulting in the possiblility for more patient turnaround and therefore more revenue.

Social interaction

Greener environments encourage people to spend more time in outdoor spaces which in turn increases the rates of social interaction and mixing. Valuable in all situations, this is especially important in multi-cultural communities where barriers of ignorance and distrust can lead to real conflict. Green space and what can be done in it (from growing food to fishing to flying kites) is also an enabler of inter-generational social relationships. Building stronger communities in this way improves social cohesion and helps to bring down the social costs of crime.

Ecology

Bringing green into the city can also bring in diverse plant and animal communities. Green roofs and walls, allotment gardens, parks, private gardens, street trees can all provide habitat for thriving ecological communities and help to boost biodiversity in the city. Linked to this is urban agriculture which has a part to play in feeding the cities of tomorrow and making them more resilient to external forces such as transport costs, crop failure in distant regions and political instability.

Water

Water management and climate change resilience are very closely linked and relate directly to the management of the urban green estate. A range of 'Sustainable Urban Drainage System' (SUDS) responses are increasingly being put in place by water companies and communities who are seeking to respond to the challenges of increased incidence of extreme rainfall events. SUDS solutions offer considerable cost advantages over engineering solutions, as well as providing amenity areas for wildlife, recreation and even food production.

Green roofs can save € 10 – € 19 per m² per year on water runoff and treatment. Green parks can save € 19 per m².

Climate and pollution

Green infrastructure responses such as street trees, green roofs and walls, parks and gardens all contribute to moderating the impacts of the urban heat island effect – recognised as a significant cause of premature death in cities. In addition all plants and trees remove dust (particulate matter) and gaseous pollution including ozone, nitrogen dioxide and volatile organic compounds from the air, with certain groups being particularly effective. The shade and air-cleaning benefits of urban greenery has an enormous cash-value for a city in improved health of residents.

The capacity of an average tree in a "hotspot" in the city has a benefit of € 40 per year per tree.

Structure

The structure of the book is broken down into four scale levels:

1 Green cities
deals with key elements of the planning process and its relationship to green space.

2 Green neighbourhoods
examines those green spaces that form part of the wider neighbourhood and contribute to the social and catchment-scale functioning of the community.

3 Green Streets
introduces the role of street trees and plants and their contribution to the effective functioning of streets in relation to air quality and urban microclimate.

4 Green Buildings
explores how the performance of buildings can be enhanced through the application of green infrastructure elements. This could include positioning within the landscape, green roofs and walls, as well as interior landscaping.

The information contained within this book is based on the best available knowledge now. It is intended that the reader can follow-up on these case studies as required, with reference to their own local climate and other conditions.

This is a dynamic document that is linked with a central, international Green City website: **www.thegreencity.com**
New information will be uploaded as it becomes available in order to enhance what has been gathered here and build upon it.

Explanation of the symbols

Urban green (in the form of parks, gardens, trees, rooftops and walls) plays an important role in the liveability, attractiveness and sustainability of a city, neighbourhood, street or building. The benefits of each guideline are sometimes limited to two or three topics, but often span the entire spectrum of topics including economy, health, social interactions, ecology, water, climate and pollution.

Green cities, neighbourhoods, streets and buildings:

Economy — increase the value of real estate, reduce energy costs, reduce water runoff costs

Health — provide opportunities for relaxation and recreation, improve mental and physical health and the well-being of people

Social interactions — increase social cohesion resulting in stronger communities with less criminality and anti-social behaviour

Ecology — increase habitats for ecological communities, biodiversity and opportunities for urban residents to experience nature

Water — decrease the amount of impervious surfaces and provide water retention possibilities on site, thus reducing peak runoff problems

Climate & pollution — filter pollutants and dust from the air and regulate temperature extremes

These topics return at the bottom of every guideline in order to illustrate how each guideline benefits so many of these topics simultaneously, therefore strengthening the integral value of green. Each one of these functions contains an ecosystem service element.

Green+ cities

1

1 The planning process

Suzhou, China | The green structure along the street is planted and established long before the surrounding development it is built for.

Madrid RIO Park, Spain | The park, designed by West 8 urban design and landscape architecture B.V. and Mrio arquitectos, Madrid is a 150 ha inner city park built on top of the M30 highway. | Photographer: Jeroen Musch (copyright city of Madrid)

"Grey" plans based on green

Infrastructure projects should incorporate green early on in the design of new roads, transit facilities and other projects by assuring ample space (both above ground and underground) and budget for trees and other green. Higher density development which brings people closer to mass transit and takes people out of their cars also increases the "greenness" of an area. The pedestrian experience is therefore very important and can be improved by aesthetic and functional green.

"Red" plans based on green

New development of residential and business areas should incorporate urban forests into the design and use green as a building block. An urban forest is a collection of trees in the urban environment and can vary anywhere from a forest, ecological corridor, park or recreational green space to a green roof garden, street, plaza or front garden. A liveable neighbourhood in a compact city contains 15-20% green in the direct living environment.

"Blue" plans based on green

The water structure should be designed within a team of engineers plus urban designers, landscape architects and ecologists so green is incorporated into the design.

Consider the multifunctionality of green

Use green not only for aesthetics but also for its ability to raise the value of houses, improve the health of residents and workers, encourage social interactions, regulate temperatures, retain water, increase biodiversity, reduce energy needs in buildings and remove air pollutants.

Convince decision makers to demand green

A long term cost-benefit analysis should be undertaken to help convince decision-makers that green elements are essential in all urban projects. The development of green spaces should also play a central role in policies related to health, nature conservation and spatial planning.

Experts: Eva Stache (Stache architects), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Mark Hinshaw (LMN Architects), Vincent Kuypers and Barry de Vries (Alterra – Wageningen UR); Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten) | **Sources:** Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Recht op Groen; Vegetation in relation to air quality in Shanghai; Leidraad Luchtzuiverend Groen; Vitamine G; www.landscapeinstitute.org; www.west8.nl

Benefits of planning & green

- **Image**
  creates a green and healthy image for the city
- **Value of real estate**
  increases in the vicinity of green
- **Air quality**
  filters pollutants and dust from the air
- **Health**
  provides opportunities for relaxation, social contact and recreation, and increases health and well-being
- **Aesthetics**
  beautifies streets and neighbourhoods
- **Climate**
  reduces the greenhouse effect by absorbing CO_2
- **Microclimate**
  regulates temperature extremes through shade and wind and humidifies the air, creating a cooler and more comfortable environment
- **Water runoff**
  provides water retention possibilities and reduces peak runoff
- **Biodiversity**
  provides habitats for flora and fauna in the city
- **Buffers**
  reduces the negative effects of traffic and industry
- **Energy savings**
  reduces the need for heat in winter and airconditioning in summer

Place just as much weight on green in the planning process as grey, red and blue.

*...**Why Invest in Landscape?** is a new campaign from the Landscape Institute, which shows how towns and cities around the UK are seeing a good return on their investment in public space. From the small scale of a single town square up to plans for whole new settlements, the returns on investment are clear. When landscape is placed at the heart of the development process, communities and local businesses reap the economic benefits...*
www.landscapeinstitute.org/invest/index.php

In new & existing development:

Inform decision makers of the benefits of green in urban areas so it becomes just as standard an element in projects as roads, parkingdensity. Multidisciplinary teams for all infrastructure and development projects require landscape architects.

Landscape architects and urban designers working together at the planning stage of the project.

+ Economy + Health + Social interactions + Ecology + Water + Climate & pollution

Bioscience Park, Leiden, NL | Companies pay yearly dues to a collective fund which pays for joint improvements of the business park, including the artwork. The green business park behind the central train station attracts bioscience-related businesses from all over the world.

Benefits of investing together

- **More sources of funding for projects is available**
- **A broad spread of ownership increases the willingness to invest**
- **Various parties become responsible for the liveability of their own city**
- **Improve the image of a company and/or city**

"By using sophisticated modelling systems, cash values can be applied to ecosystem services such as moderating temperature fluctuations, improving air quality and buffering intense rainfall events. By using this approach trough computer models such as STRATUM (US Forest Service) New York City is able to show that every $1 invested in planting generates more than $ in direct benefits. **Who said money doesn't grow on trees?**

2 Invest together

Communicate the benefits to various parties

Parties such as the health sector, businesses, engineers, designers, the building sector, developers, cities / local governments and of course the residents themselves can all gain from green in the city. Emphasize the long term benefits.

The cost of green is an investment

Costs for green should be seen as an investment just like any other building investment. Approach a green project as a business case and ask the question: what is the joint ambition and how can it be achieved together? Only then will green have added value. And the costs will be seen as an investment that earns itself back.

Businesses benefit from quality public projects

Businesses tend to look at the public sector that is responsible for the surroundings we live in. By co-investing in public projects they can help improve their business location as well as make the city more liveable for their employees and new talent.

Real estate near green is more valuable

Developers should be aware that houses with quality green in the neighbourhood are worth 4-12% more than houses of the same type in non-green neighbourhoods and therefore calculate green into the total budget. The range depends on whether the property is adjacent to green, has a view of green or is near green.

Regulation incentives encourage good development

Invite businesses who are looking to invest in green (People-Planet-Profit) to locate their business in the city and invest locally. Give incentives such as a shorter permit process to projects that incorporate green (a technique used sucessfully in Chicago). Most new buildings in the US now seek certification under the LEED program. Developers and agencies even use it in their real estate marketing efforts.

Experts: Sjerp de Vries (Alterra – Wageningen UR), Eva Stache (Stache architects), Bastiaan de Roo (Chamber of Commerce The Hague); | **Sources:** Integrale beplantingsmethode levert geslaagd Prins Bernhardbos op; Groen Loont!; Beweegvriendelijke wijken voor kinderen; Rotterdam gezond groen, gewoon doen; The Green City Post 2011; How much value does the city of Philadelphia receive from its park and recreation system?; Who said money doesn't grow on trees?; www.impala-eu.org

Partners who have an interest / experience / or can benefit from quality green:

Policy makers

- Local governments
- Regional governments
- Water authorities
- Waste management
- Social affairs
- Infrastructure
- Transportation
- Urban planners
- Engineers and designers

Investors

- Local and regional governments
- Businesses
- Private sector
- Building sector
- Healthcare sector
- Wellness sector
- Tourism sector
- Education sector
- NGO's

Users

- Local governments
- Regional governments
- Water authorities
- Waste management
- Social affairs
- Infrastructure
- Transportation
- Urban planners
- Engineers and designers

Combine the needs of various parties in order to optimize the funding sources for a project with (more) green

"Investing in green cities is investing in a healthy population and a healthy economy, with high financial and social returns."
Henk Bleker, Minister of Foreign Trade and Agriculture

In new & existing development:
Create a high quality catalyst green project with a multidisciplinary team and market it to the various parties in order to create enthusiasm and encourage future team investments.

Philadelphia, USA | According to a study carried out by the Trust for Public Land, green space saves the city annually a total of $1,155,722.00. The total increase in wealth for the city arising from green infrastructure is $729,112.00. The residents also benefit as a result of higher property values and an enhanced sense of well being.

Economy

3 Filtering for fresh air

Chicago, USA | Study by DJ Nowak (1994): Trees were able to remove 1% of the pollutants from the air within the city:

0.3 kg / ha / year of CO_2
1.5 kg / ha / year of NO_x
3.1 kg / ha / year of O_3
1.4 kg / ha / year of SO_2
3.5 kg / ha / year of PM10

Improve regional air quality with large scale green spaces

The filtering effect of large scale green is the best way to improve air quality at the regional level. Forests are especially suitable for reducing background concentrations before the pollution even reaches the city. By providing as much leaf volume as possible in an area as big as possible, the general air quality can increase. This way the air that reaches the urban area has more capacity to filter pollution from traffic and other local sources at neighbourhood and street level. The capturing of particulate matter only actually occurs at the edges and tops of a forest, but because they usually cover a large surface area, they are very effective.

Plant big trees with more leaf area

Bigger trees and more leaf area are more effective at cleaning the air. An average tree in the city (with a trunk diameter of +/- 30 cm) is able to capture about 100g particulate matter (PM10) while a mature tree captures as much as 1.4kg in The Netherlands [Tonneijck, 2008]. 100g PM10 equals the particulate matter emission from a private car that travels 1,500 km. 1.4kg PM10 equals 20,000 km. The porosity of the canopy should be above 50% so the leaves inside the canopy can also help. Combine trees with broad canopies and undergrowth of herbaceous plants and shrubs to have effective leaves at all levels. Green roofs and green walls also contribute to air filtering.

Table of air pollution types and leaf effectiveness:

	SO_2 NO_x O_3	PM10	VOC
Method	absorption	impaction	adsorption
Best tree type	broad leafed evergreen trees	conifer trees (evergreen)	conifer trees
Leaf characteristics	flat, wide, glossy leaves	cone-shaped needles	needles with a fatty toplayer (cuticle)
Other good tree type	deciduous trees	deciduous trees	
Leaf characteristics	flat, wide, glossy leaves	course, hairy, sticky leaves	

Experts: Ceciel van Iperen (CROW), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Pauline de Koning and Peter Schildwacht (BELW Advies bv), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten), Jelle Hiemstra (Applied Plant Research WUR); ES Consulting | **Sources:** Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Meetproef Groen; Vegetation in relation to air quality in Shanghai; Stadsbomen voor een goede luchtkwaliteit; Bomen, een verademing voor de stad; Leidraad Luchtzuiverend Groen

Some trees are better at cleaning the air

Gaseous air pollution such as nitrous oxide (NO_x) and particulate matter (PM10) can be removed from the air by leaves.

Nitrous oxides (NO_x), sulfur dioxide (SO_2) and ozone (O_3) are absorbed by the stomata of leaves. Deciduous trees with a large leaf volume are most effective. Organic compounds such as polychlorinated biphenyl (PCB's), dioxins and furans are taken up by the cuticles of leaves (even at night).

Particulate matter (PM10) is captured on the surface of leaves, called impaction, and travels to the ground through wind, rainwater or fallen leaves. After the particulates hit the ground, they are either washed away with runoff or fixed in the soil by organic decomposition. Conifers are most effective because of the large surface area of needles and the fact that the trees keep their needles all year round.

Ozone (O_3) concentrations are reduced in the presence of trees because they not only absorb ozone themselves to varying degrees, but they also absorb NO_2 , keeping humidity higher and temperatures lower so ozone does not have a chance to form.

Do not use any tree species that are sensitive to air pollution (NO_x) and limit the use of trees which emit biogenic volatile organic compounds (VOC).

Hedera helix vines can catch 6g of PM10 per square meter wall area. Because they are evergreen, they are effective all year long.

Plant a variety of trees and plants

Include a mix of evergreen and deciduous tree species in the design with different characteristics so the air is filtered of more than one type of air pollution. Include green at different heights / levels to catch more pollutants that would otherwise blow under the canopy of the trees.

Green roofs and green walls also filter the air

Green on roof gardens and green walls are also very effective at removing pollutants from the air. Green walls planted with vines have a very dense leaf area per square metre and thus are good in removing PM10. A wall with *Parthenocissus tricuspidata* can catch 4g of PM10 per m^2 of wall and *Hedera helix* can catch 6g.

Continued on the next page -->

Green+ cities

West-Midlands, UK | A coverage of 25% green can reduce the concentration of particulate matter in the air by 10% (Steward, 2002 in Leidraad Luchtzuiverend Groen).

Approximately 10% of the available amount of NO_2 can be filtered from the air by optimal green. (Wesseling, 2004 in Leidraad Luchtzuiverend Groen).

Trees, shrubs and vines* that are effective in capturing PM10

Picea abies
Pinus mugo
Pinus nigra
Pinus sylvestris
Taxus sp.
Metasequoia glyptostroboides
Hedera
Prunus padus
Betula pubescens
Ilex x. meservae
Corylus colurna
Acer pseudoplatanus

Trees, shrubs and vines* that are effective in absorbing NO_x

Robinia pseudoacacia
Sophora japonica
Magnolia
Salix babylonica 'Tortuosa'
Prunus Yoshino
Zelkova serrata
Populus nigra

Trees, shrubs and vines* that are effective in absorbing O_3

Chamaecyparis lawsoniana
Crataegus monogyna
Larix decidua
Prunus laurocerasus
Acer platanoides
Betula pendula
Acer campestre
Pinus nigra
Alnus glutinosa

Trees and shrubs* that emit biogenic volatile organic compounds (limit widespread planting)

Liquidambar styraciflua
Koelreuteria paniculata
Quercus
Robinia pseudoacacia
Cercidiphyllum japonicum
Platanus
Salix

*plants used in The Netherlands

Experts: Ceciel van Iperen (CROW), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Pauline de Koning and Peter Schildwacht (BELW Advies bv), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten), Jelle Hiemstra (Applied Plant Research – WUR; ES Consulting | **Sources:** Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Meetproef Groen; Vegetation in relation to air quality in Shanghai; Stadsbomen voor een goede luchtkwaliteit; Bomen: een verademing voor de stad; Leidraad Luchtzuiverend Groen

Benefits of green infrastructure for air filtering

- Less health complaints and premature deaths due to short-term exposure to air pollutants such as PM10 and ozone
- Gaseous pollutants (O_3, NO_x, SO_2) are absorbed out of the air
- Particulate matter, ash, pollen and smoke are captured out of the air
- Shade and water are provided which result in lower temperatures and less ozone (O_3) forming
- Photosynthesis results in more O_2 in the air

Use trees and plants to reduce background concentrations of air pollution. All plants contribute to the improvement of air quality. Some species are more effective than others.

"The contribution of the city to the regional air pollution can be compensated through the planting of filtering green. For every car in the city one tree."
Peter Schildwacht, BELW Advies bv

...Although the amount of PM10 and NO_2 that is removed from the air by green is not enough when compared to the amount of pollution produced by human activity, there is a positive effect at the regional and national level on air quality. Green cannot alone, however, solve pollution hot spots at the local level...
Beplanting en Luchtkwaliteit

In new development:

Place green strategically in new plans in order to maximize the filtering capacity of each tree and prevent conflicts between land uses. Provide enough room (both above and underground) to allow trees to grow to maturity and therefore maximize their filtering capacity.

In existing development:

When replacing or adding trees, add a variety of species which are especially good in filtering the air.

Needles are effective at catching PM10.

Leaves are effective in absorbing NO_x

+ Health **+ Climate & pollution**

4 Green network

Madrid RIO Park, Spain | A safe attractive pedestrian network with parks and plazas created along the water, separated from heavy traffic. Designed by West 8 urban design and landscape architecture B.V. and Mrio arquitectos, Madrid | Photo: Jeroen Musch (copyright city of Madrid)

Promenade Plantee, Paris France | A 4.7km long green belt and promenade through Paris along an old railway line. The path is accessible in some areas at street level and at other points with footbridges and a viaduct | Photo: Robert ten Elsen

Incorporate movement into daily life

Encourage daily routine short trips by foot or bicycle instead of with the car. Routes to work, school, public transportation, urban forests and parks should be safe, comfortable, attractive and green alternatives. It is also important to provide bicycle parking facilities at popular destinations.

Children do more outside in neighbourhoods with safer infrastructure

Children should be able to walk or bicycle safely through the neighbourhood to schools, parks, sports and recreational facilities. Slowing cars (with speed bumps or smaller street profiles at specific points) or creating car-free areas in neighbourhoods and near schools contribute to safer streets. Create street profiles where pedestrians and bicycles are separated from motorized vehicles and have priority over cars at crossings.

Create one large green park network

Connect public green spaces and parks to create one large urban recreation and / or ecological network within the city as well as with connections to green and nature outside the city. Ecological corridors which connect green spaces throughout the city raise the value of the urban ecological system. Use existing nature / water / topographical characteristics of the area as starting points to guide the planning and location of the network. Every household should be within 500m of an arm of the green network. This distance allows one to walk to, in and from the green structure in an average of 45 minutes (Bervaes et al, 1996 in Groene Meters I).

Ensure accessibility within the green network

Where unavoidable infrastructural barriers block access within a network, alternatives should be designed such as bridges, tunnels and ecobridges so connections are safe. By creating a green network at the planning stage of a project, many of these conflicts and dangerous intersections can be solved. Semi-public and public buildings can also be used as part of the continuous green network. Green through the building (atriums, galleries) and over the buildings (green roofs) can be made accessible, both physically and visually.

Experts: Martine van Loon (Kenniscentrum Recreatie), Irini Salverda (Alterra – Wageningen UR), Pauline de Koning and Peter Schildwacht (BELW Advies bv), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Sanda Lenzholzer (Wageningen University), Eva Stache (Stache architects), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten), TNO Innovation for Life
Sources: Groene meters II; Vitamine G; Beweegvriendelijke wijken voor kinderen; Kinderen in prioriteitswijken: lichaamlijke (in)activiteit en overgewicht; Recht op Groen; Rotterdam gezond groen gewoon doen; www.west8.nl; www.impala-eu.org; www.tno.nl/downloads/IB_URBAN_STRATEGY_EN.pdf

Benefits of a green network

- Safe routes for pedestrians and bicycles to and from parks, play and sports facilities, schools, etc.
- Larger network of habitats for small animals
- Less car use for daily short trips

Provide bicycle and pedestrian paths all over the city to bring people from home to the city's parks, recreational spaces, schools and work.

...The creation of playgrounds and sports complexes is not enough to stimulate children to be more active.Children who are able to walk or bicycle to school, playgrounds or sports facilities perform significantly more physical activity per day...
Beweegvriendelijke wijken voor kinderen

...TNO has developed a calculating model for interactive planning to see the effects that complex planning solutions have on various situations in the surroundings, One of the features is the influence green spaces / land uses have on the physical movement patterns of residents...
Urban Strategy, TNO Innovation for Life

Children walk safely to school | Photo: PPH; collage: Niek Roozen bv

In new development:
Set up a green structure plan connecting all neighborhoods to the urban forests / parks from the beginning of a project together with infrastructure so everyone has safe access to green.

In existing development:
Make neighbourhoods safer for bicycles and pedestrians by replacing street crossings with roundabouts or traffic lights along routes to schools, sports and play areas.

Bicycles and pedestrians separated from vehicular traffic | Photo: Stichting Open Boek

Economy | **Health** | **Social interactions** | **Ecology** | **Water** | **Climate & pollution**

5 Within walking distance

Millinxbuurt, Rotterdam, NL | A city block in a declining neighbourhood in Rotterdam was transformed into a park during a large scale neighbourhood renovation. People used to complain of shoot-outs, now they complain if someone cycles on the pavement | Photo: PPH

...In The Netherlands, the direct costs of people being overweight are thought to be 3%-5% of the healthcare budget...
Groen Loont!

...The number of obese adults in England has tripled over the last 20 years and is still rising. The number of obese 6 year-olds has doubled in the last 10 years. Inactivity is identified as being the primary cause of obesity. The cost to the UK economy of overweight and obesity was £15.8 billion in 2007, including £4.2 billion additional costs to the NHS...
Tackling Obesities: Future Choices - Project Report

The amount of recreational green is important
75m2 of recreational green should be provided for every household in an urban area. 60m² of this green should be within a 500m radius of home and 15m² can be incorporated into regional green within a 3 km radius. 75m² green / household divided by 2,5 people per household = 30m² green/person. Muliply the number of people in an urban area times 30m² and this equals the total amount of green needed in the urban area. Divide the size of the urban area by the amount of green needed in the urban area and you have the percent of green needed in the urban area. (For an example see the Green City case study, page 20-21.)

The quality of recreational green is important
Recreational green should be accessible, useable, varied, inviting and well maintained in order to attract users from the neighbourhood and beyond.

Provide nearby recreational facilities for children
Children between the ages of 6 and 11 are most dependant on their direct living environment in order to fulfill their daily outdoor physical activity. Provide formal and/or informal play areas for these age groups at the block level to encourage more outdoor play. Safe routes to the play areas are important as well as safe edges between street and play areas. Prevent children from running into the street and keep play areas visible.

Size and location of green spaces in urban environments:

type of park	distance from house		size of park
pocket park	200m	(4 min. walk)	0,01 ha - 1 ha
neighbourhood park	400m	(6 min. walk)	1 ha - 6 ha
community park	800m	(12 min. walk)	6 ha - 18 ha
large urban park	1600m	(20 min. walk)	18 ha - 200 ha
city-wide park	3200m	(up to 30 min. walk)	>200 ha

Experts: Pauline de Koning and Peter Schildwacht (BELW Advies bv), Irini Salverda (Alterra – Wageningen UR), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen) Jolanda Maas (EMGO Institute, VU Medical Center) | **Sources:** Leefkwaliteit Stationsgebied Utrecht 2003; Groen Loont!; Vitamine G; Rood en Groen in Balans; Groene Meters II; Recht op Groen; Niet bij rood alleen: buurtgroen en sociale cohesie; Beweegvriendelijke wijken voor kinderen; Rotterdam gezond groen, gewoon doen; Kinderen in Prioriteitswijken: Lichaamlijke (in)activiteit en overgewicht; Foresight: Tackling Obesities: Future Choices – Project Report; An estimate of the economic and health value effectiveness of the expanded Walking Health Initiative scheme 2009; Green Space and our Health

Provide recreational possibilities and green for residents who stay closer to home
The elderly and people with a lower socio-economic status have less opportunities to seek green elsewhere. Therefore green in the vicinity of home is essential.

Create parks in inner city neighbourhoods
Include parks in the rehabilitation of declining neighbourhoods. Remove a housing block and replace it with a pocket park, involving the residents in the process. This, in combination with the planned improvements to the remaining buildings, creates a more liveable neighbourhood for the residents.

Benefits of neighbourhood green space

- Healthier, happier residents (5-15% more)
- More outdoor play (10% more)
- More social contact and social cohesion*
- Less overweight or obese residents (15% less)
- Less doctor visits, less depression, for some diseases up to 33%*
- More likely to be physically active (24% more) if green space is easily accessible

* especially noticeable with children, the elderly and people with a lower social/economic status

...Social cohesion and the willingness to participate in the upkeep of an urban park is higher in smaller neighbourhood parks than in larger city parks...
Buurtgroen en Sociale Cohesie

...Park and green space facilities provide easily accessible recreational opportunities which are usually free. A brisk walk daily reduces the risk of heart attack by 50%, strokes by 50%, diabetes by 50%, fracture of the femur by 30%, colon cancer by 30% and Alzheimers by 25%...
Green Space and our Health

Develop ample parks and usable green spaces within walking distance of all residents.

In new development:
25% of the total urban area should be set aside for green recreational uses. The green areas should be distributed throughout the city vary in size and vary in use so everyone has access to green.

In existing development:
Where a lack of space is available, the quality, use and accessibility of recreational green should be improved to provide maximum enjoyment for as many residents as possible.

Westerpark, Amsterdam, NL | Photo: Gemeente Amsterdam

+ Economy + Health + Social interactions + Ecology + Water + Climate & pollution

6 The art of nature

Floriade 2002, Haarlemmermeer NL | Niek Roozen bv and Jacqueline van der Kloet, planting specialist, used the Floriade 2002 as a testing ground for the aesthetic use of successful perennial and bulb mixtures for public spaces | Designed by Niek Roozen bv

Eindhoven, NL | A green wall and roof integrated into a bus stop | A Soontiëns Stadsnatuur project | Design: WVTTK Architects | Photo: WVTTK Architects

Use green to beautify the city

Residents, workers and visitors are attracted to green and flowers in the urban environment. Green for aesthetic reasons is still a legitimate investment. (The fact that green has so many other benefits only adds to its value.)

Planting design is a creative process

Planting design is the art of combining plants based on their colour, texture, bloom time, bloom colour and growing conditions (sun, soil, wind, water). In public open spaces it is also important to consider the use of the space, possiblities of vandalism and level of maintenance. The softscape (green) is just as important in terms of design as the hardscape (layout, paving, benches, lighting, etc.). Use the right plants for public spaces and avoid dangerous situations such as high plants which block views at intersections or poisonous plants near playgrounds.

Use existing conditions as the basis for design

Start the design process with an inventory of what exists on the site (or what once existed). Use elements such as existing trees, water, topography and native plants to inspire the design and give it a local character which fits into the surrounding neighbourhood or environment. The use of historical and cultural elements also adds to the character.

Quality and maintenance are important

Nature is beautiful, but in the urban environment it needs help staying beautiful. Every square metre of green needs to be high quality and well maintained for city residents to keep this positive image of green.

Experts: Niek Roozen (Niek Roozen bv landscape architects), Robbert Snep (Alterra – Wageningen UR), Soontiëns Stadsnatuur

Garden in Kyoto, Japan | Photo: Philomene van der Vliet and David Kloet

Use plants to beautify streets and neighbourhoods and add to the overall image of the city.

In new development:
Create green spaces which combine the character of the place and the needs of the users with a hardscape and planting design that is aesthetically pleasing.

In existing development:
Replace planting which does not add to the aesthetics and function of an area with planting combinations which do.

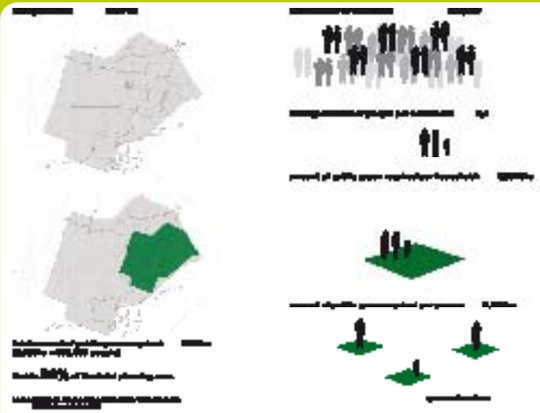
Floriade 2002, Haarlemmermeer, NL | Designed by Niek Roozen bv

Benefits of the art of nature

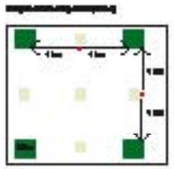
- Creates a positive image for the city
- Gives residents a positive perception of green
- Inspires residents to take pride in their neighbourhood
- Attracts tourists / visitors
- Offers rest and inspiration

+ Economy **+ Health** **+ Social interactions** **+ Ecology** **+ Water** **+ Climate & pollution**

Shenyang Hunnan District Masterplan case study

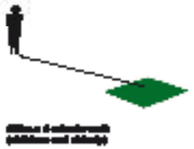


Type of green	Max distance	Area
block green	200 m	< 1 ha
street park	400 m	3 ha
neighbourhood park	800 m	15 ha
sub-district park	1600 m	100 ha
district park	3200 m	500 ha

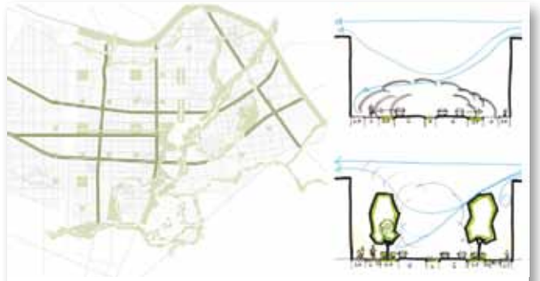


The 5750ha site is located south of downtown Shenyang between the Hun River and the airport.

The team began the design process from the green perspective: first an inventory of the existing conditions including the natural landscape and the villages that have organically grown over time and then a layout of the desired amount of green space. In the masterplan, the green land uses were given a place before the infrastructure of roads and other land uses.



The grid was faded back and used as the basis to design the overall masterplan in a new creative way, resulting in a dynamic green urban plan.



The green infrastructure of the street system was also designed in order to reduce the negative impact of air pollutants for residents by locating trees and green in the right place.

Shenyang, China | Masterplan: Niek Roozen bv landscape architect, Urhahn Urban Design, BELW Advies bv | 2010

Some parts of the final concept green plan, such as a few city parks and the central main axis, are currently under construction, including Mozi Mountain. Parkdesign by Niek Roozen bv, Roodbeen Architectuur, Urhahn Urban Design and Loos van Vliet.

Economy | Health | Social interactions | Ecology | Water | Climate & pollution

Experts: Niek Roozen bv landscape architects, Urhahn Urban Design, BELW Advies bv

Literature:

- **Greenspots Reloaded**
- **Groen Loont!**
  [Green Pays!]
- **Alle extra groen helpt de luchtkwaliteit verbeteren**
  [All extra green helps improve the air quality]
- **Recht op Groen**
  [The Right to Green]
- **Vegetation in relation to air quality in Shanghai**
- **Leidraad Luchtzuiverend Groen**
  [Manual Air Purifying Green]
- **Integrale beplantingsmethode levert geslaagd Prins Bernhardbos op**
  [Integrated planting method is a success in the Prins Bernhardbos]
- **How much value does the city of Philadelphia recieve from its park and recreation system?**
- **Who said money doesn't grow on trees?**
- **Beweegvriendelijke wijken voor kinderen**
  [Exercise-friendly neighbourhoods for children]
- **Rotterdam gezond groen, gewoon doen**
  [Rotterdam healthy green, just do it]
- **Foresight: Tackling Obesities: Future Choices – Project Report**
- **Green Space and Our Health**
- **An estimate of the economic and health value effectiveness of the expanded Walking Health Initiative scheme**
- **The Green City Post 2011**
- **Meetproef Groen**
  [Experiment Green]
- **Stadsbomen voor een goede luchtkwaliteit**
  [City trees for good air quality]
- **Bomen: een verademing voor de stad**
  [Trees: Relief for the city]
- **Groene meters II**
  [Green meters II]
- **Vitamine G**
  [Vitamin G]
- **Kinderen in prioriteitswijken: Lichaamlijke (in)activiteit en overgewicht**
  [Children in problem neighbourhoods: Physical (in)activity and overweightness]
- **Leefkwaliteit Stationsgebied Utrecht**
  [Liveability Station area Utrecht]
- **Rood en Groen in Balans**
  [Red and Green in Balance]
- **Niet bij rood alleen: buurtgroen en sociale cohesie**
  [Not with red alone: neighbourhood green and social cohesion]

Websites:

- www.landscapeinstitute.org/PDF/Contribute/PressRelease-LandscapeInstituteEcobuildFringeSeminarstacklethecaseforinvestmentinlandscapean.pdf
- www.impala-eu.org
- www.tno.nl/downloads/IB_URBAN_STRATEGY_EN.pdf
- www.west8.nl
- www.bomenstichting.nl

Experts:

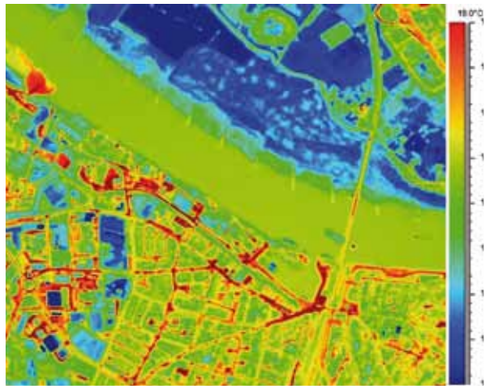
- **Eva Stache, Architect**
  Stache Architects bna
- **Fred Tonneijck, Senior Advisor/Researcher**
  Triple E and Knooppunt Innovatief Groen
- **Arda van Helsdingen, Director**
  Copijn Tuin- en Landschapsarchitecten
- **Mark Hinshaw, Director of Urban Design**
  LMN Architects
- **Vincent Kuypers, DLO Researcher**
  Alterra – Wageningen UR
- **Barry de Vries, DLO HBO Researcher**
  Alterra – Wageningen UR
- **Bastiaan de Roo, Director Leiden**
  Chamber of Commerce The Hague
- **Sjerp de Vries, Senior Scientific Researcher**
  Alterra – Wageningen UR
- **Pauline de Koning, Landscape Architect**
  Peter Schildwacht, Air Specialist, Biologist
  BELW Advies bv
- **Ceciel van Iperen, Project Manager Living Environment**
  CROW
- **Jelle Hiemstra, Senior Researcher**
  Applied Plant Research, Wageningen UR
- **Martine van Loon, Project Officer**
  Kenniscentrum Recreatie
- **Sanda Lenzholzer, Assistant Professor Landscape Architecture**
  Wageningen University
- **Filip Fraga, Project Manager**
- **Joram Nauta, Project Manager**
  TNO Innovation for Life
- **Jolanda Maas, Senior Researcher**
  EMGO Institute, VU Medical Center
- **Irini Salverda, DLO Researcher**
  Alterra – Wageningen UR
- **Robbert Snep, Researcher Urban Ecology and Green Businessparks**
  Alterra – Wageningen UR
- **Niek Roozen, Landscape Architect**
  Niek Roozen bv landscape architects
- ES Consulting
- Soontiëns Stadsnatuur

For a complete list of literature and expert participants, see pages 94-97.

Green+ neighbourhoods

2

7 Microclimate parks



Latent heat in the city of Nijmegen, NL | The paved surfaces are clearly the "hotspots", while the parks and green spaces are blue/dark green in the colour spectrum | Photo: Alterra – Wageningen UR

The following plays a role in the Urban Heat Island Effect:

- The amount of impervious surfaces in the city
- Local weather patterns (temperature, wind)
- The location (on the water / inland)
- Design (height of buildings, density)
- Wind patterns + ventilation + cooling
- Green / water vs. buildings / paving in the city
- Air pollution

Plant more trees to increase the overall canopy cover

Studies in Chicago show that increasing tree cover in the city by 10% may reduce the total energy used for heating and cooling by 5-10%. Trees and vertical green prevent sunlight from reaching the surface and converting into heat. They also create more humidity, which in turn reduces the strength of the sun's rays and thus reduces the temperature.

Reduce the amount of impervious surfaces in the city and replace them with green

Surface temperature can be reduced just by reducing the amount of paved surfaces, which in return reduces the amount of latent heat in the city. For every 10% of green surface area that is increased, the temperature drops by 10° C.

Use trees to decrease wind velocities

Trees and plants are physical obstacles and have an effect on wind speed and turbulence. These in turn influence how effective trees are in removing air pollutants. Wide tree plantings such as forests drive wind upwards and act as a solid barrier. Wind speeds beyond the forest return to normal after a short distance. The wind speed behind a row of trees returns to normal at a distance of 10 times the height of the trees.

Prevent trees from reducing wind speeds too close to the source of pollution

Where possible, plant rows of trees perpendicular to the direction of polluted air and allow a sideways flow of air along the trees for ventilation near a source of pollution.

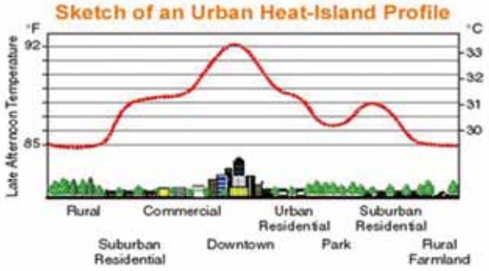
Create large areas of green outside the city as a buffer

A forest planted outside the city can help reduce the urban heat island effect.

Benefits of parks on microclimate

- Shade from trees regulates temperature extremes
- Green humidifies the air and makes the environment cooler and more pleasant
- City streets, plazas and parks are comfortable to use in hot weather
- Less ozone is produced if temperatures are reduced in hot periods
- Less temperature extremes in the summer result in less premature deaths due to excessive heat (especially for elderly people)

...The use of green to create microclimates and protect against wind, etc. is simply farmer's wisdom. The techniques can be applied to the urban environment as a fresh new way to approach the use of green. The scientific and academic proof is building to support what farmers have known for centuries...
Leidraad Luchtzuiverend Groen



The urban heat island effect | **Source:** Alterra – Wageningen UR

Bilbao tram line, Spain | Light rail in a city is not only a green mode of transportation but can also actually be green. Grass or a mix of sedum and/or mosses planted between the rails instead of pavement is not only attractive but also helps improve the microclimate in summer and absorb water runoff over great lengths within the urban environment. (Sedum and mosses require less maintenance and even help remove particulate matter (PM10) from the air.) | Photo: Robert ten Elsen

Continued on the next page -->

Experts: Sanda Lenzholzer (Wageningen University), Vincent Kuypers and Barry de Vries (Alterra – Wageningen UR), Triple E, ES Consulting
Sources: Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Groen voor Klimaat; Bomen: een verademing voor de stad; Leidraad Luchtzuiverend Groen

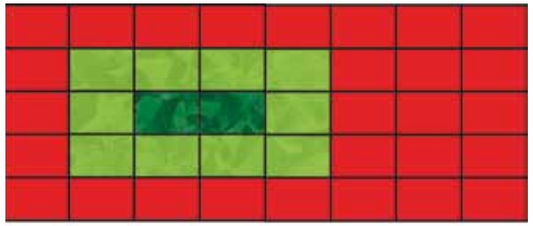
Green+ neighbourhoods

Leidse Hout, Leiden NL | The Leidse Hout is a recreational forest on the edge of the most densly populated city in The Netherlands. It is frequently used by residents for recreation, relaxation, walking, bicycling, picnicking, education, etc.

EXPO Park, World EXPO 2010, Shanghai, China | The EXPO Park along the river was used as a cool green oasis away from the crowded warm EXPO site. After the EXPO, it will serve as a community park for the future urban residential development | Designed by Niek Roozen bv

Cooling effects of parks

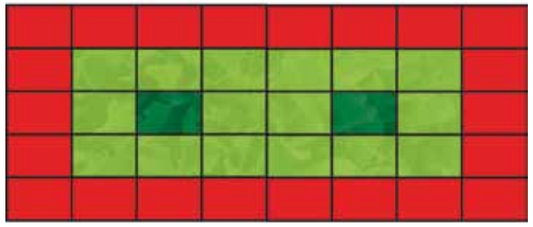
Source: adapted from Groen voor Klimaat: Barry de Vries, Alterra – Wageningen UR)



1 large park

park

affected area



2 small parks

Spread city parks and green areas throughout the city

City parks are themselves cooler, but can also cool the surroundings both day and night. The influence of two smaller parks spread out in a city have more effect in cooling the surroundings than one larger park. The cooling effect can be significantly measured up to 300m from the park (and felt up to 2km away). Evaporation at night from trees and shrubs transports cool water from the ground to the air which reduces the air tempe-rature. There is a strong relationship between the reduction of temperatures and the density of planting.

Parking areas need shade too

Trees in parking areas keep cars cooler and reduce the amount of hydrocarbon vapour emissions from parked cars.

Prevent city-wide hot spots by spreading parks and green around the city and increasing the overall tree canopy area.

In new development:

Create pocket parks spread throughout the city in order to reduce temperature extremes, limit the amount of impervious surfaces and provide shade where it is needed.

In existing development:

Determine where the hot spots in the city are and replace impervious surfaces where possible with green (parks, green connections, trees, green roofs, etc.) in order to reduce the urban heat island effect in the city.

Parking lot Kasteeltuinen Arcen, NL | Designed by Niek Roozen bv

EXPO Park, World EXPO 2010 Shanghai, China | Designed by Niek Roozen bv

+ Health + Social interactions + Ecology + Water + Climate & pollution

Experts: Sanda Lenzholzer (Wageningen University), Vincent Kuypers and Barry de Vries (Alterra – Wageningen UR), Triple E, ES Consulting | **Sources:** Groen Loont!; Alle extra groen helpt de lucht-kwaliteit verbeteren; Groen voor Klimaat; Bomen: een verademing voor de stad; Leidraad Luchtzuiverend Groen

8 Resident participation

The Garden, Eden Project, UK | Sensory Trust and Eden Project worked together to run community consultation sessions with a mix of people so the garden could be inspired by and designed to their wishes. The participants were kept involved throughout the process in order to offer feedback and continued support | Photo: Sensory Trust

De Tussentuin, Gaffelstraat, Rotterdam, NL | The Tussentuin, a local resident initiative, not only provides gardening plots but also activities such as music workshops, concerts and neighbourhood feasts | Photos: Wolbert van Dijk

Listen to what the residents want
Resident participation leads to the creation of quality green because it responds to the needs and wishes of the people who will actually use it.

Adopt green right outside the door
Allow planting beds or trees to be "adopted" in parks or along streets. The residents can choose their own planting as long as they care for the plants themselves. An agreement can be signed between the city and the residents if either of the parties do not fulfill their agreed level of participation.

Create respect for public green space
By allowing residents to take part in design, construction and maintenance they respect the green spaces and care for them as their own instead of waiting for the city to fix them up. People are more likely to pick up litter on "their own street" than on a "public street", as well as ask others to do the same.

Plan green activities for residents
Bring residents together at key moments to create enthusiasm and involve them in the process of creating green spaces in the neighbourhood. Use publicity to spread the enthusiasm to other neighbourhoods. Organize activities such as tree planting events or the UK's "Love Parks Week".

Transform unused space in the city with green
Give people on the waiting lists for permanent community/ allotment gardens and others the chance to garden plots of temporarily vacant land in their own neighbourhoods. The neighbourhood becomes greener, the gardeners are happy and surrounding residents and passersby are inspired.

Experts: Irini Salverda (Alterra – Wageningen UR), Wolbert van Dijk and Joke van der Zwaard (De Tussentuin), Jane Stoneham (Sensory Trust), Sharon Johnson (Trees for Cities), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten) | **Sources:** Niet bij rood alleen: buurtgroen en sociale cohesie; In herstructureringsplannen is groen een sociale verbinder

Benefits of participation

- Liveability of the neighbourhood increases
- Criminal and anti-social behavior decreases, safety improves
- More social control and social cohesion
- People identify more with their neighbourhood and green space

...Over recent years we have seen a real difference in the attitude to trees in UK cities. They're becoming much more valued as an asset to the community, and provide a wealth of cultural benefits.
Studies compiled by our partners at Nottingham Trent University provide a clear indication that a healthy, safe city is one in which residents are inclined to get out onto the streets and into green spaces. By getting involved in decisions about their streets and green spaces, and making them nicer places to live, residents feel ownership of these places – they use them and help maintain them, which ensures the quality and long term sustainability of these spaces...
Sharon Johnson, Chief Executive, Trees for Cities

Nieuw Leyden, Leiden, NL | Residents not only designed their own houses, but also had the opportunity to design their own street collectively with the neighbours.

Include residents in the design and maintenance of green spaces in their direct living environment.

In new development:
Invite residents to be a part of the planning and design process of public green spaces.

In existing development:
Allow residents to adopt nearby green spaces and participate in the construction and maintenance of these spaces.

Manchester, UK | Children involved in a community planting project | Photo: Trees for Cities

+ Health

+ Social interactions

9 Recreation

Outdoor exercise.

Outdoor relaxation | Photo: Gemeente Amsterdam

Provide a variety of spaces for physical activity

Outdoor active recreation not only occurs on formal sports fields but also other spaces such as playgrounds, skateboard parks, bicycle and jogging/walking paths and open lawn. Spontaneous ball games in informal green spaces are flexible and do not require specific dimensions or amount of players.

Relaxation is an important form of recreation

Places to meet or be alone, benches or grass for resting and watching, paths for walking, forests and water for contact with nature and environmental education, etc. are examples of passive recreation. A variety of spaces and uses are important to accommodate all the users of neighbourhood parks. Green near offices also allows workers to take a walk during breaks for fresh air and relaxation.

Accommodate the user groups

Children, people with a lower socio-economic status and the elderly are more dependent on their direct living environment to fulfil their exposure to green recreational opportunities. The smaller scale parks spread throughout the neighbourhoods should cater to these groups. Larger parks that are more spread out should include these uses plus uses for other user groups. Provide separate areas for dogs and provide bins for dog waste so the play areas remain clean.

Quality and usability are essential

There are four factors which determine the success of recreational spaces in the city:

- availability (area and distribution of spaces)
- usability (maintenance, policy, provisions, social safety)
- accessibility (service area, walking / biking distance)
- utilization (users and possible activities)

Recreation also encourages recreation related business

Businesses such as restaurants and cafés, kiosks, tourism, water sports, etc. can also benefit economically from recreation in the city.

Benefits of recreation

- Encourages people to live healthier lifestyles
- Stimulates children to grow into healthy fit adults
- Provides a public space for social contact

Create a variety of choices for active and passive recreation throughout the city for all ages.

...'The Big Greenery Study', conducted by Amsterdam's own Physical Planning Department, showed that visits made to the city's green spaces have increased enormously in recent years. Not only are more 'Amsterdammers' visiting parks, but they are also doing so more often...
Piet Eilander (Amsterdam's Greenery, Ecology, Urban Recreation and Water team)

Outdoor play.

In new development:
Spread ample green parks of various sizes throughout he city. Vary the types of recreational accommodations to reach a broad user group and design with flexibility because user groups can change over time.

In existing development:
Take an inventory of the available recreational spaces and determine how to make existing accommodations more useful and attractive for residents.

Outdoor sports.

+ Economy + Health + Social interactions

Experts: Filip de Fraga and Joram Nauta (TNO Innovation for Life), Martine van Loon (Kenniscentrum Recreatie) | **Sources:** Groen Loont!; Recht op Groen; Groene meters II; Beweegvriendelijke Stadswijken voor Kinderen; Rotterdam gezond groen, gewoon doen; The Green City Post 2011; www.impala-eu.org

10 Playgrounds & schoolyards

Vrijeschool Valentijn, Harderwijk, NL | The pavers were removed from the schoolyard and replaced by plant beds, a separate ball field, sitting areas, herb gardens, paintings, hills, an amphitheater, play equipment and a dry stream bed with a water pump connected to the school building's rain pipes.

Ieper, Belgium | Use of natural materials.

Create variations in the landscape

Differences in high-low, dark-light, open-closed, dry-wet make a play area more interesting, less predictable and more natural. Unexpected (natural) differences in the terrain such as hills, horizontal tree trunks and rocks for climbing, etc. are encouraged.

Use various natural materials

Ground: clay, sand, mud
Water: pumps, fountains, streams, wetlands, ponds
Planting: groundcover and flowers, shrubs, trees
Materials: wood and steel

Cater to the needs of children

Encourage active movement such as climbing and running, provide peaceful sitting areas while allowing others to play together and make noise. They should feel at home and be comfortable in the seasons, with the trees and among the butterflies.

Allow children to explore the possibilities of nature

Create opportunities to playfully change the surroundings with sand, mud and water, use loose natural elements as play equipment, allow them to exercise their own fantasy and creativity and make it inviting to explore nature. Encourage children to make something useful and beautiful from natural materials. Make it possible for hands-on nature and environmental education in the city.

Involve children in the design process, realisation, maintenance and use

Educate and demonstrate how nature can be created in the city and encourage continuing interaction with the seasonal changes of nature.

Benefits of playing in green

- Stimulates creativity and imagination
- Children can come into contact with nature in a creative way
- Offers space to move, play and dream
- Stimulates motor skills, interaction with other children and physical activity

Provide children with the opportunity to experience and play in nature within the city.

...From day one the success was obvious to the school children as well as the other users. The children have more choices for play, they play more together and there is much less fighting...
Hoera! Een Burgerinitiatief

In new development:
Situate school buildings to provide optimal outdoor spaces for play and education. Create new green public playgrounds accessible to all children.

In existing development:
Transform existing playgrounds and schoolyards by replacing paving with green. Install play equipment made of natural materials which both stimulates play and allows children to experience nature.

The Speeldernis, Rotterdam, NL | Photo: Sigrun Lobst

Criteria for construction, maintenance and safety of green playgrounds

Aspect of design	Criteria
Planting	the right tree in the right place, must be central in design, functional and offer more than just aesthetics
Ecological value	fruit, color and structure are important, attractive for animals, native plants
Maintenance plan	must be set up and responsibility should be taken
Design	must be flexible and multifunctional, be realized within 3-5 years, be presented to the users as well as the nearby residents
Surroundings	should fit into the surroundings, connect to existing water storage, ecological connections, educational functions or other special interests
Safety	design should be transparent for social safety, have visible entrances/exits to traffic, avoid poisonous plants and must fulfil the safety criteria for all play areas

Health | Social interactions | Ecology | Water

Sources: Prijsvraag Groene Speelplekken 2011; Een Groene Gezonde Wijk; Hoera! Een Burgerinitiatief; Kom je buiten spelen?; www.groeneschoolpleinen.nl

11 Views of green

Amnesty International, Amsterdam, NL | The courtyard behind the headquarters of Amnesty International in the center of Amsterdam | Designed by Niek Roozen bv

Views of green from houses | Photo: PPH

Not all green needs to be accessible

Views of green are also important for the overall green image of a city. Green roofs, green walls, private gardens, street trees, sports fields, cemeteries, agricultural land and surrounding landscapes all contribute to the green of a city.

Physical health improves with views of green

Patients recover up to 10% quicker in hospital rooms with views of green. Green park-like settings around hospitals, parking lots full of trees, courtyards, green walls and green roofs are all ways to increase green views from every room.

Mental health improves with views of green

Residents as well as workers with views of green report less cases of depression and stress than those with no views of green from their homes and offices. Planting strips between houses and the street, front gardens, offices surrounded by green and trees and parking areas with green buffers are ways to increase views of green from houses and offices.

Property with views of green are more valuable

Houses and apartments with views of green (adjacent parks, surrounding landscapes, etc.) are worth 4-12% more than houses of the same type without views of green.

...Patients who have a view of trees use less pain killers than patients who have a view of a wall...
Groen Loont!

Benefits of green views

- Physical health: less doctor visits, shorter stays in hospitals (10% less)
- Mental health: reduction of depression and stress
- Views of green increase employee productivity
- Employees take up less sick days
- Properties with views of green are 4-12% higher

Borrow views of private / semi-private green because of its impact on the urban green experience, both mentally and physically.

De Hogeweyk, Weesp, NL | Green stimulates positive memories in people with dementia | Architect: Molenaar en Koeman | Designed by Niek Roozen bv

The Medina residential complex in Eindhoven, NL | A Soontiëns Stadsnatuur project | Photo: Soontiëns Stadsnatuur

In new development:
Consider the layout of buildings and their relationship with green elements.

In existing development:
Multi-layered buildings with views over rooftops should replace grey roofs with green roofs. Parking areas adjacent to buildings should include trees and green elements so views are more attractive from indoors.

Gaixa Forum, Madrid, Spain | Photo: Robert ten Elsen

+ Economy + Health + Social interactions + Ecology + Water + Climate & pollution

Experts: Eva Stache (Stache architects), Robbert Snep (Alterra - Wageningen UR), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Soontiëns Stadsnatuur
Sources: Groen Loont!

12 Private green

The Medina, Eindhoven, NL | The Medina residential complex, high quality urban green with plenty of opportunities for an urban wildlife experience located in downtown Eindhoven. A Soontiëns Stadsnatuur project | Photo: Soontiëns Stadsnatuur

EVA-Lanxmeer, Culemborg, NL | The ecological front gardens include specially chosen species for biodiversity and environmentally friendly maintenance.

Diversity of choices means a diversity of green

People are free to choose their own plants and layout which increases the diversity of green in the neighbourhood for everyone. Plants can be used for their ornamental value or functionality. Edible gardens provide fresh produce and herbs for individuals. A varied planting design allows residents to experience the four seasons right outside their windows.

Rediscover the art of plants

Many urban residents fill their private gardens with paving for ease of maintenance, lack of knowledge of plants and their care or practicality. By bringing the interest back to plants in the garden, the impervious surfaces in the city can be reduced. Plant nurseries, retailers and community groups can show people how easy and attractive (low maintenance) gardening can be.

Every square metre counts

Increase the surface area of green no matter how small by planting green walls, balconies, private gardens and roofs.

Benefits of private green spaces

- Increases biodiversity in the city
- Helps keep streets and houses cooler
- Helps intercept water runoff
- Makes neighbourhoods attractive

...What we tend to forget is that our lawns, flower beds and vegetable patches add up to a significant share of the capital's land: approximately 24% of London's total land area. Their habitat potential is enormous...
Anna Simpson, Gardens: the hidden capital revealed

...Garden furniture and materials lose their value over time and have to be replaced after a few years. A living garden of plants, on the other hand, becomes more valuable as time goes on...
De Levende Tuin

Bercy, Paris, France | Private roof gardens

Weesp, NL | Private garden next to De Theetuin | Designed by Jacqueline van der Kloet

Use the potential that private gardens have to add to the amount of green spaces and impervious surfaces in the city.

In new development:

Provide room for small private gardens in front of, behind or on top of houses.

In existing development:

Create campaigns to encourage more plants and less impervious surfaces in private gardens. Involve the media and plant nurseries in offering advice and techniques for making gardens beautiful and easy to care for.

Arnhem, NL | Private garden with vegetables and flowers | Photo: Brechtje Horsten

+ Economy + Health + Social interactions + Ecology + Water + Climate & pollution

Experts: Robbert Snep (Alterra – Wageningen UR), Soontiëns Stadsnatuur | **Sources:** De Levende Tuin; Leidraad Luchtzuiverend Groen; www.forumforthefuture.org/greenfutures/articles/gardens-hidden-capital-revealed; www.eva-lanxmeer.nl

13 Semi-private green

De Hogeweyk, Weesp, NL | The wings of the building with 9 accompanying courtyards were designed with various themes to stimulate early memories of the people with dementia who live there. Architect: Molenaar en Koeman | Designed by Niek Roozen bv

Amsterdam, NL | All the residents of Sciencepark are able to use the courtyard located between the buildings on top of the shared parking garage | Designed by Niek Roozen bv

Combine efforts to improve the direct living environment

Semi-private green provides an opportunity for those urban residents who either have no private green space, have no time or desire to garden themselves or are not able to maintain an entire garden on their own. Collective funds can be set aside for routine maintenance if there is no one who takes the initiative to organize this between residents. They can also decide how the space is used and when and set quality standards for maintenance.

Design with flexibility for potential users

Users change over time and everyone has a different idea of how common private green spaces are or should be used. (Peace, quiet, relaxation and healing versus gardening, socializing, playing). Unless the intent is clear in the design and fellow residents set up the ground rules, the success of the space is limited.

Horticultural therapy benefits special needs groups

People who otherwise cannot maintain their own gardens are sometimes those who profit the most from gardening activities and exposure to green. People in hospitals, elderly homes, mental illness facilities, children's hospitals, Alzheimers facilities, etc. can all benefit. Provide accessible therapeutic gardens including raised beds, barrier-free paths, sensory-stimulating environments which awaken the five senses and places to relax. People with dementia that are able to work in the garden have less negative reactions and anger episodes than patients with no access to gardening.

Courtyards and roof gardens are ideal semi-private spaces

Spaces which can be occasionally or partially closed off and are within view of the user groups add to the success of semi-private green. The chances of low quality maintenance, misuse of the space and vandalism are reduced. Rooftops are also beneficial because of their multifunctionality in dense urban settings.

Benefits of semi-private green spaces

- People with no private garden can enjoy their own piece of nearby green
- Takes the elderly out of their social isolation
- Many residents take pleasure in performing (physical) activities outdoors

Provide city residents / workers / patients in dense urban environments with usable green space they can collectively call their own.

Amsterdam, NL | Common courtyard with kitchen garden for the cooking students of Nowhere, a community centre.

In new development:
Provide space in dense urban development not just for parking and planting between buildings, but for usable green space. Consider the multifunctionality of spaces such as green roofs above parking.

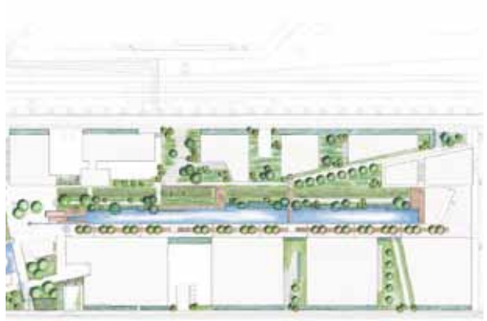
In existing development:
Consolidate existing parking and unusable green and transform it into usable green spaces for adjacent residents.

Culemborg, NL | A shared green space in the neighbourhood EVA Lanxmeer | Photo: Copijn Tuin- en Landschapsarchitecten

Economy | Health | Social interactions | Ecology | Water | Climate & pollution

Sources: Een Groene Gezonde Wijk; www.ahta.org

14 Green business park



Park 20 / 20, Hoofddorp NL | Park 20 / 20 is a joint development from the Delta Development Group, VolkerWessels and Reggeborgh Groep. The innovative concept integrates sustainabile building techniques, a high quality inspiring public space and a new way of working based on the Cradle to Cradle philosophy of William McDonough. Landscape design by Copijn Tuin- en Landschapsarchitecten | Photo: Copijn Tuin- en Landschapsarchitecten

Leiden Bioscience Park, NL

Green business parks attract companies and employees

Companies are attracted to business parks with a green character in order to improve their own corporate image. Employees are attracted to companies who provide a pleasant working environment. By providing green views from office windows, worker productivity increases. Outdoor spaces for employees include lunch areas with a pleasant microclimate, walking and bicycle paths, benches and sports facilities.

Use business parks as a (green) link between the edge of the city and its surroundings

Traditional business parks often form a barrier between the city and the outskirts. Design business parks with green corridors and recreational opportunities so urban residents can reach urban forests outside the city.

Extend the use of business parks beyond working hours

Business parks are large scale land uses that are intensively used during the weekdays. By including green spaces that can be used for recreation by both employees and residents, the useful hours are extended into early mornings and evenings as well as weekends. Many species of nocturnal animals also benefit from quiet business parks at night.

Increase the chances for nature to flourish

Combine the efforts of entrepreneurs, businesses, urban planners, landscape architects and ecologists in order to reach a high quality combination of commerce and nature. Biodiversity can be increased by using plants and providing habitats that are beneficial to local wildlife. Make room for storm water management solutions that also function as landscape features. Green roofs can fulfil both of these goals on top of the businesses themselves.

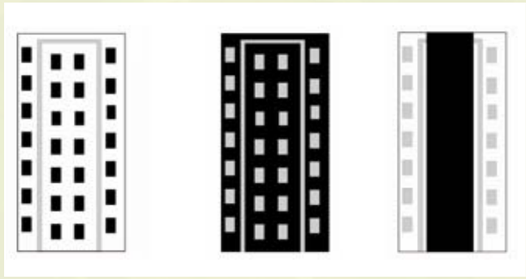
Benefits of green business parks

- Provides attractive multifunctional spaces for business, recreation and ecology
- Helps create a positive green image many companies / industries aim for
- Provides a healthy environment for employees
- Increases the real estate value of parcels within the business park

"The quality of the workplace directly affects the work itself."
William McDonough, www.park2020.com

Three scenarios for adding green to business parks

Source: Biodiversity conservation at business sites



convert flat roofs into green roofs

improve the ecological quality of the existing green

create habitat corridors through-out the site

Make the "parks" in business parks and the "estates" in industrial estates true to their names.

In new development:
Design new business parks with functional green spaces / corridors that are linked to the surrounding landscape or urban park network.

In existing development:
Convert flat roofs into green roofs and improve the existing green spaces within the business park in order to provide usable outdoor spaces for employees and increase biodiversity.

Leiden Bioscience Park, NL

+ Economy
+ Health
+ Social interactions
+ Ecology
+ Water
+ Climate & pollution

Experts: Robbert Snep (Alterra – Wageningen UR), Bastiaan de Roo (Chamber of Commerce The Hague), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten)
Sources: Biodiversity conservation at business sites; www.park2020.com

15 Urban farming

Detroit, Michigan, USA | Detroit, a city which suffers severely from post-industrial decline, is home to nearly 900 urban gardens operating on a not-for-profit model. These urban farms offer employment, fresh affordable food, the possibility of urban renewal and environmental improvement as well as a source of optimism within the community | Photo: http://www.urbanfarming.org

De Tussentuin, Gaffelstraat, Rotterdam, NL | On a temporarily empty parcel of land in the middle of Rotterdam, a group of residents came together and created a community garden where neighbours exchange seeds and ideas and proudly show off their harvest. There are 7 residents and a few school classes who garden, a designer, a beekeeper, a work group who organizes the music workshops and concerts, two gardeners who create a neighbourhood feast twice a year and a website. When development proceeds on the parcel of land, they hope to move to another prominent paved parcel in the neighbourhood. Plan B is to spread the plants throughout the neighbourhood | Photo: Wolbert van Dijk

Reserve room in neighbourhoods for community / allotment gardens

Inventory the demand and provide space throughout the city, no matter the size, for people to grow their own food.
By scattering gardens across the city, people are able to garden closer to home, exchange ideas and seeds with neighbours, stimulate others to participate, and reduce the waiting lists for the larger community garden complexes on the edge of the city.

Claim land in the city for urban farming

Cities can encourage and educate residents about the temporary development of vacant lots into green oases of food and flowers, they can sponsor events and plants or they can allow 'guerilla' gardening to emerge from resident initiatives. This not only provides healthy food for residents, gets them active and engaged in healthy outdoor activities, but also helps buffer water runoff in neighbourhoods and beautifies otherwise empty holes in the urban landscape. When development does eventually reclaim the land, the city can help the residents find a new parcel to garden. Larger parcels of land on the edge of the city where traditional industry is declining can provide more space for market gardens and allotment gardens.

Provide areas for edible green in public parks

Involve nearby residents in the design and maintenance of public green spaces and allow them to share in the harvesting of fruits, vegetables and herbs. Only provide edible plant beds if neighbouring residents are enthusiastic, and keep the design flexible so changes can be made to the gardens as residents and needs change over time.

Reach residents who do not participate directly

Demonstrations for children, programs for the homeless and food production for shelters are all ways to spread the benefits of urban gardening. Farmers markets also bring local producers and consumers in contact with eachother, something that city people really appreciate.

Havana, Cuba

The citizens of Havana were able to make it through the 'Special Period' in 1989 by cultivating their own food and medicine on 'huertos' – unused land where crops are grown. Eventually the government established large organic market gardens (organoponicos) where local residents are employed to work the land and food is sold locally. By 2002, Havana was growing 90% of the city's fresh produce within the city limits.

Benefits of urban farming

- A place to grow safe fresh food with less "food kilometres"
- Children and adults learn where food comes from
- Opportunities for social projects for marginalised or socially excluded groups
- A social element that brings residents from different backgrounds and cultures together

"In Detroit, urban farming has immense potential to catalyze change within the city, create thousands of greatly needed jobs and provide vast quantities of fresh, locally grown produce for the remaining citizens. However, urban farming is only a piece of what creates a successful green and self-sufficient city, and must be integrated with various forms of sustainable development in order to provide a desired result."
Griffin Felski, Landscape Architect

"Cuba was forced to develop 'resilience' and fast. It had to feed its people when the previous routes for doing so were closed off overnight. Urban agriculture is something that the rest of the world could develop – before it is forced to."
Mark Long, Director, UK Green Forum

Provide opportunities for urban residents to grow their own food within the city limits or even within their own neighbourhood.

In new development:
Provide space in the city for community gardens and make them an integral part of urban development.

In existing development:
Create temporary community gardens or allow crops to grow on unused parcels of land in the city. This will either stimulate development of the unused lots or act as a catalyst to green more areas of the city.

UK | Urban farming opportunities | Photo: The Sensory Trust

+ Economy + Health + Social interactions + Ecology + Water + Climate & pollution

Experts: Wolbert van Dijk and Joke van der Zwaard (De Tussentuin), Griffin Felski (Drost Landscape), Mark Long (UK Green Forum), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Sanda Lenzholzer (Wageningen University) | **Sources:** Groen Loont!; www.stroom.nl; http://www.urbanfarming.org

16 Water runoff

Bellamyplein, Rotterdam, NL | Bellamyplein, a multifunctional water plaza designed by ds + V, afdeling Stedenbouw, has the capacity to hold 750 m^3 water during extreme rain in order to ease the storm sewer system in the neighbourhood of Spangen. The plaza is 90% of the time dry | Photo: Gemeente Rotterdam, afdeling Stadsontwikkeling

European Patent Office, Rijswijk, NL | The 25,000m2 roof garden includes a series of gardens including a wetland and lake with ecological value | Photo: Copijn Tuin- en Landschapsarchitecten

Integrate water into planning and design

Surface storm water management solutions should be integrated into the overall design and planning of an area and involve a multidisciplinary team of professionals. This way technical as well as aesthetic issues are addressed at all phases of design. Be sure to consider maintenance requirements in the design in order to guarantee performance and quality.

Use water as a green solution

Combine water with the need for recreation and nature in the city or other green city solutions such as green roofs and green streets. Be sure that the solution appropriately ties in with the land use. Make stormwater visible in the design of public and private open spaces. Features add to the amenities in urban public green spaces. Create ways to not only buffer water but also to use it in times of drought.

Compensate paving with water

All newly paved surfaces should be compensated by extra open water which equals at least 10% of the paved surface area.

Use trees to catch water runoff

Trees are very effective at slowing runoff. They intercept peak rainfall, improve the infiltration capacity of the soil and can improve the quality of the water that is buffered. They also bring groundwater from the roots up to the surface where some evaporates and the soil is kept moister. Conifers are 3x more effective than deciduous trees.

Use plants to help purify water

Biofiltering wetlands can be designed as functional and aesthetic solutions to surface water pollution. As water gradually filters through the plants into a series of basins, the pollution sediments are able to sink to the bottom.

High Tech Campus, Eindhoven, NL | Workers on the campus are able to walk around the lake and over the wetlands during breaks | Photo: Robert ten Elsen.

Trees with a high capacity to intercept water runoff in The Netherlands

Conifer trees:
Abies, Picea, Pinus, Pseudotsuga menziessii

Deciduous trees:
Acer, Aesculus, Fagus, Quercus, Tilia, Ulmus

Plants used in biofiltering wetlands in The Netherlands

Lysimachia nummularia, Sagittaria sagittifolia, Phragmites australis, Carex, Menyanthes trifoliata, Pontederia cordata, Sparganium emersum

Parc Grand Moulins, Paris, France | The park collects rain water from nearby rooftops, allows it to flow through a series of ponds and wetlands and is then stored in an undergound tank to be used as irrigation | Photo: Robert ten Elsen

Trees have a high capacity to intercept water runoff | Photo: Stichting Open Boek

Economy **Ecology** **Water** **Climate & pollution**

Experts: Fred Tonneijck (Triple E & Knooppunt Innovatief Groen) | **Sources:** Water Sensitive Urban Design; Over Bomen en Buien; www.bomenstichting.nl

Green+ neighbourhoods

Techniques and technical solutions for Surface Stormwater Management

technique	description	function	application
harvesting	above or underground cisterns	rainwater use	fountains, pools, etc.
bioretention	shallow landscaped depressions which drain by filtering through the vegetation and soil	water treatment	landscaped element
biotopes	ecologically stable landscape of plants and animals	water treatment	wetlands, biofiltering wetlands
gravel / sand filters	above or below ground chambers to treat runoff	water treatment	edging along green spaces, channels, buildings
rooftop retention	extensive or intensive green roofs or brown roofs	detention + infiltration	green roofs
permeable paving	paving that allows water to pass to a gravel subgrade where it can evaporate, infiltrate or be drained	detention + infiltration	parking areas, paved areas
infiltration zones and	planted areas with layers for retention, filtration	detention + infiltration and infiltration	open spaces trenches and parks
swales	linear planted drainage feature which allows water to travel downstream or infiltrate	detention + infiltration	open spaces and parks
geocellular systems	prefab underground structures to store and slowly infiltrate water	detention + infiltration	use in high density urban settings
detention pond (dry)	surface storage basin holds stormwater and slowly drains and settles particulates (otherwise dry)	detention + infiltration	landscape and recreational uses
detention pond (wet)	surface storage basin stores / holds rainwater and circulates through other treatment techniques	detention + infiltration	ponds, lakes, recreation
channels	open stormwater channels instead of sewerage	conveyance pipes underground	channels, streams, canals
passive	all green spaces with vegetation evapotranspiration	evapotranspiration	urban green spaces, gardens
active	use water to directly influence temperature or evapotranspiration	evapotranspiration air quality	rainwater walls, pools, fountains

Experts: Fred Tonneijck (Triple E & Knooppunt Innovatief Groen)
Sources: Water Sensitive Urban Design; Over Bomen en Buien; www.bomenstichting.nl

Benefits of water runoff in green

- Decreases impervious surfaces in the city
- Increases public awareness of water
- Microclimate is cooler and more humid
- Decreases the risk of flooding and storm sewer overflow
- Less stormwater needs to be transported and processed in the sewerage system

Solve runoff problems closer to the source in urban areas with surface storm water management instead of draining all the water into the sewer system.

...The Hohlgrabenächer housing development includes 265 private homes and 9 apartment buildings on a 16.7ha site in Stuttgart, Germany. The design aimed to save costs of storm water management through the application of green roofs, cisterns and pervious pavement instead of enlarging the sewer system for rain water drainage.
***Investment costs:** The investment costs for conventional storm water management = € 938,000. The investment costs for a decentralised storm water management = € 532,900.*
***Running costs:** The savings per year for not using the conventional storm water management system = € 25,680. The total savings over 30 years = € 1,177,900...*
Water Sensitive Urban Design

"If the design of a new development is actually based on the surface stormwater management solutions, with its accompanying green spaces, the amount of green spaces will also increase."
Water Sensitive Urban Design

...In a natural setting, 40% of the water goes to evapotranspiration, 25% to shallow infiltration, 25% to deep infiltration and 10% to runoff. In an urban setting, 30% of the water goes to evapotranspiration, 10% to shallow infiltration, 5% to deep infiltration and 55% to runoff...
Over Bomen en Buien

In new development:
Consider surface storm water management needs and solutions from the beginning of the planning and design process in order to provide the best integrated solutions for future runoff.

In existing development:
Reduce the amount of impervious surfaces by replacing them where possible with the surface stormwater techniques (see next page) based on size, capacity, budget and surrounding development.

GWL, Amsterdam | Photo: Robert ten Elsen

Economy + **Ecology** + **Water** + **Climate & pollution**

17 Biodiversity

Plant mix for biodiversity | Plants selected for their added biodiversity value (e.g. nectar source for butterflies and bees) can be attractive for people too. A Soontiëns Stadsnatuur project | Photo: Soontiëns Stadsnatuur

Plant a wide variety of plants

Pollen and nectar-rich trees, shrubs and perennials attract bees, butterflies and other insects which are essential for the pollination of plants. The pollinators themselves are food for many birds and small animals Plant a variety of berry and nut producing trees and shrubs to allow birds and other small animals to sustain themselves in urban areas. Create sheltered areas with dense shrubs as nesting, hiding and foraging places for birds and other small animals.

Develop new / existing biotopes

Create stepping stones of wildlife habitats in between the paved urban environment to attract various sorts of plants and animals. In areas with water such as shallow ponds, natural processes provide habitat for water plants, amphibians, dragonflies and other aquatic insects, etc. The use of the right set of plant species will support the provision of sufficient food for native animals.

Plant choices are not limited to native species

Many non-native plant species are well adapted to urban conditions as well as being colorful and attractive for use in parks, gardens etc. Combinations of native and non-native plants enhance the urban setting while giving a sense of the native character. Select those non-native species, such as Buddleia, that have added value for wildlife.

All forms and scales of urban green count

Private gardens, water plants, water edges, city parks, green roofs, green walls, trees, hedges, meadows, borders, planters, street trees and shrubs all contribute to the biodiversity of urban areas.

Biodiversity of the planting at street level

Trees, shrubs and groundcover plants along the street do not always have to consist of one single species. By varying the species, a broader range of wildlife species can be supported. Also, by pointing street light down, green lanes can function as migration zones for easily disturbed flying nocturnal animals such as bats.

"Attention for urban biodiversity makes that citizens have unique opportunities to experience the diversity of plant and animal life in their living and working environment."
Dr. Robbert Snep, researcher urban ecology, Alterra – Wageningen, UR

Add to the opportunities to experience flora and fauna in the places where people live and work.

In new development:
Integrate wildlife habitats in architecture and public and private green by using plant species and vegetation structures with added value for biodiversity. Interconnect the green of the development project with the overall green network in and surrounding the city, to support the migration of animals.

In existing development:
Replace pavement where possible to create habitats for urban birds, bees and butterflies using a diverse mix of selected plants and flowers.

Photo: Soontiëns Stadsnatuur

Benefits of biodiversity

- Opportunity for citizens to experience wildlife in the place where they live and work
- Create habitats and food sources for (endangered) insects, birds and small animals
- Biodiversity creates more biodiversity (through cross pollination, more plants means more bees which means more plants)
- Adds colour and interest to the urban landscape

Example of plants used in The Netherlands that benefit the biodiversity in the city

trees, shrubs, vines & perennials	bees & bumblebees	butterfies	birds	shelter
Crataegus laevigata x media	x	x	x	x
Salix sp.	x	x	x	x
Buddleija davidii	x	x		(x)
Rubus fructicosus	x	x	x	x
Hedera	x	x	x	x
Agastache	x	x		
Monarda	x	x		
Sedum spectabile / telephium	x	x		
Aronia sp	x		x	x
Taxus			x	x

Experts: Robbert Snep (Alterra – Wageningen UR), Marco Hoffman (Applied Plant Research, Wageningen UR), Soontiëns Stadsnatuur | **Sources:** Biodiversiteit in tuin en plantsoen; Groen Werkt Beter; Bedrijventerreinen kan bijdragen aan behoud biodiversiteit

The High Line, New York City case study

New York City, USA| Photo: Iwan Baan

Friends of The High Line

The original freight rail line was scheduled for demolition in the nineties and was only saved from this fate by the passionate advocacy and fund raising of a dedicated group of campaigners.

Robert Hammond, Co-founder of the Friends of the High Line comments: "The High Line is many things – an historic artefact; a unique urban landscape; a social centre for a changing neighbourhood. But it is also an inspiring example of what can be accomplished when communities and their elected leaders work together for the common good. The High Line would not be here today were it not for the support our elected officials, neighbours, volunteers, and partners at civic organizations who rallied around us at the very beginning, when the idea was unpopular, and supporting it was truly visionary."

Support

The High Line is a public park built on an historic freight rail line elevated above the streets on Manhattan's West Side. It is owned by the City of New York, and maintained and operated by Friends of the High Line, the non-profit conservancy that raises the essential private funds to support more than 90 percent of the High Line's annual operating budget pursuant to a licensing agreement with the New York City Department of Parks & Recreation.

Phasing

The first section of the park, which runs between Gansevoort to West 20th Streets, opened in June, 2009. The second section, which runs between West 20th and West 30th Streets, opened in June, 2011. Friends of the High Line continues to advocate for the preservation and transformation of the High Line at the Rail Yards, the third and final section of the historic structure, which runs between West 30th and West 34th Streets.

Benefits

Preserving and developing the High Line has brought enormous benefit to Manhattan's West Side. It brings much needed green space into the heart of the city, which in turn results in a whole raft of benefits, from recreational opportunities for people of all incomes and social/ethnic backgrounds, environmental benefits such as improved air quality and reduction of the heat island, right the way through to enhanced property values along the line.

Visitors

Since the first section opened in June of 2009, the High Line's popularity has exceeded expectations. The public park has welcomed more than four million people, comprising nearly equal proportions of New Yorkers and out-of-town visitors, making it one of the most highly visited public parks per acre in the city.

Revitalization

Recognized as a significant contributor in the revitalization of Manhattan's West Side, the High Line has become a defining feature in its neighborhood and a powerful catalyst for private investment. In 2005, the City rezoned the area around the High Line to encourage development while protecting the neighborhood character, existing art galleries, and the High Line. The combination of the rezoning and the park has helped to create one of the fastest growing and most vibrant neighborhoods in New York City. From 2000 to 2010, the population within the rezoned area has grown more than 60 percent. Since 2006, after the rezoning was approved and construction of the High Line began, new building permits in the immediate vicinity of the High Line doubled and at least 29 major development projects have been initiated (19 completed, 10 underway). Those 29 projects account for more than $2 billion in private investment, 12,000 jobs, 2,558 new residential units, 1,000 hotel rooms, more than 423,000 square feet of new office space and 85,000 square feet of new art gallery space. In May, construction began on a new downtown home for the Whitney Museum of American Art, which will serve as a major cultural anchor at the southern end of the High Line when it opens in 2015.

New York City, USA | The Highline Design is a collaboration between: James Corner Field Operations, project lead, landscape architecture, Diller Scofidio + Renfro architecture, Piet Oudolf planting design | Client: Friends of the Highline | maintainence & operations | Owner: City of New York | 2009 – present

New York City, USA | Photo: Iwan Baan

Economy | Health | Social interactions | Ecology | Water | Climate & pollution

Experts: Robert Hammond (Co-Founder, Friends of the Highline) | **Source:** Friends of the Highline

Green+ neighbourhoods

Literature:

- **Groen Loont!**
  [Green Pays!]
- **Alle extra groen helpt de luchtkwaliteit verbeteren**
  [All extra green helps improve the air quality]
- **Groen voor Klimaat**
  [Green for Climate]
- **Bomen: een verademing voor de stad**
  [Trees: Relief for the city]
- **Leidraad Luchtzuiverend Groen**
  [Manual Air Purifying Green]
- **In herstructureringsplannen is groen een sociale verbinder**
  [In revitalisation plans, green is a social connector]
- **Buurtgroen en Sociale Cohesie**
  [Neighbourhood Green and Social Cohesion]
- **Recht op Groen**
  [The Right to Green]
- **Groene meters II**
  [Green meters II]
- **Beweegvriendelijke wijken voor Kinderen**
  [Exercise-friendly neighbourhoods for children]
- **Rotterdam gezond groen, gewoon doen**
  [Rotterdam healthy green, just do it]
- **The Green City Post 2011**
- **Prijsvraag Groene Speelplekken 2011**
  [Design Competition Green Playgrounds 2011]
- **Een Groene Gezonde Wijk**
  [A Green Healthy Neighbourhood]
- **Kom je buiten spelen?**
  [Come out and play?]
- **Hoera! Een Burgerinitiatief**
  [Hooray! A Resident Initiative]
- **De Levende Tuin**
  [The Living Garden]
- **Biodiversity conservation at business sites**
- **Water Sensitive Urban Design**
- **Over Bomen en Buien**
  [About Trees and Rain]
- **Groen Werkt Beter**
  [Green Works Better]
- **Bedrijventerreinen kan bijdragen aan behoud biodiversiteit**
  [Business parks can help preserve biodiversity]
- **Biodiversiteit in tuin en plantsoen**
  [Biodiversity in gardens and parks]

Websites:

- www.eva-lanxmeer.nl
- www.groeneschoolpleinen.nl
- www.ahta.org
- www.forumforthefuture.org/greenfutures/articles/gardens-hidden-capital-revealed
- www.impala-eu.org
- www.park2020.com
- www.stroom.nl
- www.bomenstichting.nl

Experts:

- **Fred Tonneijck, Senior Advisor/Researcher**
  Triple E and Knooppunt Innovatief Groen
- **Sanda Lenzholzer,**
  Assistant Professor Landscape Architecture
  Wageningen University
- **Vincent Kuypers, DLO Researcher**
  Alterra – Wageningen UR
- **Barry de Vries, DLO HBO Researcher**
  Alterra – Wageningen UR
- **Irini Salverda, DLO Researcher**
  Alterra - Wageningen UR
- **Sharon Johnson, Chief Executive**
  Trees for Cities
- **Arda van Helsdingen, Director**
  Copijn Tuin- en Landschapsarchitecten
- **Wolbert van Dijk,**
  Garden & Landscape Architect & Urban Designer
  De Tussentuin
- **Joke van der Zwaard, Urban Sociologist**
  De Tussentuin
- **Filip Fraga, Project Manager**
  Joram Nauta, Project Manager
  TNO Innovation for Life
- **Eva Stache, Architect**
  Stache Architects bna
- **Jolanda Maas, Senior Researcher**
  EMGO Institute, VU Medical Center
- **Robbert Snep,**
  Researcher Urban Ecology and Green Businessparks
  Alterra - Wageningen UR
- **Bastiaan de Roo, Director Leiden**
  Chamber of Commerce The Hague
- **Mark Long, Director**
  UK Green Forum
- **Griffin Felski, Landscape Architect**
  Drost Landscape
- **Marco Hoffman, DLO Researcher**
  Applied Plant Research – Wageningen UR
- **Robert Hammond, Co-Founder**
  Friends of the Highline
- ES Consulting
- Soontiëns Stadsnatuur

For a complete list of literature and expert participants, see pages 94-97.

Green+ streets

3

Expo Park, World EXPO 2010, Shanghai, China | The park contained enough trees to provide 60% shade for visitors to cool off during the warm summer months of the World EXPO. The breeze along the riverfront, together with the shade under the trees, provided an oasis away from the busy EXPO buildings on the other side of the street | Designed by Niek Roozen bv

18 Green plazas

Use trees and green as an urban shelterbelt

Wind across an open urban plaza makes the space unattractive for people. Place planting and trees strategically to create comfortable spots for people to sit, walk and play.

Trees create comfortable outdoor spaces

Shade under a tree can make the apparent temperature at ground level 5-20°C cooler. The perceived temperature under a tree is lower due to the reduction of direct sunlight that reaches the ground and evapotranspiration of water via the leaves. Deciduous trees allow sun to reach the ground and heat the surface in winter and prevent the sun from reaching the ground and heating the surface in summer. Not only trees but also vine-covered pergolas and other planting can add to the shade solutions. Lower plants also help reduce surface heat.

Create a comfortable oasis of clean air in the city

Protect outdoor spaces from air pollution through the use of green elements and trees. Green can act as a buffer to prevent local sources of pollution such as from traffic from entering the plaza. Trees and shrubs can force the polluted air upwards so it blows over the plaza and not through it. A continuous canopy of trees over a plaza can prevent background air pollution from settling in the plaza.

Vary the microclimate within the park

The temperature, season and time of day determine where people prefer to sit in a plaza. Personal preferences also vary: some people enjoy sitting in the full sun, others prefer to sit in the shade. Provide a variety of places to sit, walk or play so everyone has a choice.

Benefits of green plazas

- Shade under trees makes outdoor areas usable on hot days
- Sunny areas with no wind are usable on cold winter days
- Green plazas are oases in the hard urban environment

"People want green and trees in plazas. Trees can function as protection from the wind and sun. But they need to be planted in the right spot, otherwise they can actually create a wind tunnel effect."
Sanda Lenzholzer, Wageningen University

Shade in Madrid RIO Park, Spain
Photographer: Jeroen Musch (copyright city of Madrid)

Prevent local hot spots in urban plazas by planting trees to increase shade and reduce wind and make outdoor spaces more comfortable.

In new development:

Base the design and layout of new urban spaces on the microclimate and existing conditions of the space and the way the plaza will be used. Use green to make spaces more comfortable.

In existing development:

Plant trees with wide canopies in order to increase the amount of shade on the surface in plazas, public outdoor spaces and along streets where shade is desired. Use shrubs, pergolas and green walls where wind protection is needed.

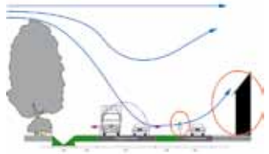
Photo: PPH

+ Health
+ Social interactions
+ Water
+ Climate & pollution

Experts: Sanda Lenzholzer (Wageningen University), Pauline de Koning and Peter Schildwacht (BELW Advies bv), Triple E, ES Consulting continuous line
Sources: Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Groen voor Klimaat; Bomen: een verademing voor de stad; Leidraad Luchtzuiverend Groen; www.west8.nl

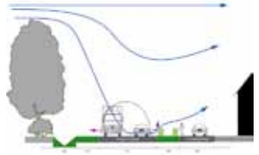
air circulation basis

air circulation with hedge



air circulation basis

air circulation with trees



air circulation with hedges

Air circulation principles along streets | The sketches from the inter-regional project 'Toepassen Functioneel Groen' [Application of Functional Green] illustrate the way air circulation is affected with and without different types of green | **Source:** BELW Advies bv

19 Air circulation & ventilation

Use green to drive the polluted air upwards

The air pollution from a local source can be reduced by thinning the polluted air with cleaner air. Encourage the mixture of local high concentrations of air pollution with cleaner air to prevent local hot spots. Air filtration alone cannot provide enough reduction. By creating a barrier effect, the air is driven upwards where it can mix with cleaner air in higher air layers. A continuous, closed and linear barrier is most effective. The ability of the air to return to background concentrations of air pollution when it reaches ground level depends on conditions such as weather, barrier type, barrier height and the local air pollution concentration. It is important to provide enough ventilation behind the barrier.

Prevent the green tunnel effect

It is important that the green solution does not increase the concentration of pollution locally. Tree canopies which form a tunnel (along narrow streets) have a negative effect on the flow of fresh air into the street and the flow of polluted air away from the street. The tunnel effect can be prevented by eliminating the obstruction, for instance by choosing a row of trees on only one side of the street or creating green façades on adjacent buildings.

The size and spacing of the green structure are important in forming an effective barrier

A dense leaf structure, smooth regular habit and compact form create a solid barrier and keep turbulence down. The porosity should be as low as possible, preferably less than 30%, when used as a wind barrier. Create a closed (leaf) surface for optimal effect: horizontally (choose a planting distance which is smaller than the tree crown or plant width so there are not gaps between the plants) and vertically (use a combination of trees and shrubs for effect at various heights in the vegetation structure). Evergreen plants have a better effect than deciduous plants. Low hedges or green screens between the street and pedestrian zone act as a barrier to reduce the amount of gaseous pollutants and particulate matter emitted by cars near ground level that reach the pavement.

Experts: Pauline de Koning and Peter Schildwacht (BELW Advies bv), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten), Ceciel van Iperen (CROW), Triple E, ES Consulting | **Sources:** Effecten van groen op de luchtkwaliteit; IPL rapport 1b: Toepassingsadvies Schermen; IPL rapport 2b: Toepassingsadvies Vegetatie; Bomen, een verademing voor de stad; Alle extra groen helpt de luchtkwaliteit verbeteren; Stadsbomen voor een goede luchtkwaliteit; Leidraad Luchtzuiverend Groen; www.functioneelgroen.nl

Benefits of air circulation

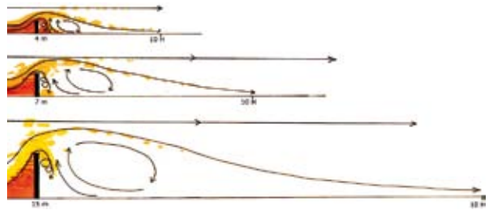
- Buffers people from local sources of pollution
- Reduces health risks due to exposure to air pollutants

Dilute the source concentrations of air pollution with higher layers of cleaner air.

Drive air upwards

A vegetation barrier works best if the wind hits it at a 90° angle (taking into account the prevalling wind direction). On the top of the barrier, the turbulence in the air mixes the polluted air with the passing cleaner air. The polluted air is forced upwards, where the concentrations will lower because of mixing with cleaner air. The air stream will flow back down to ground level after approximately 10-15x the height of the barrier.

...The negative effect on air quality from traffic will decrease by 5-30% with a special green structure compared to the situation without a green structure...
Based on air models/research by IPL, VITO



Flow of air behind a barrier.

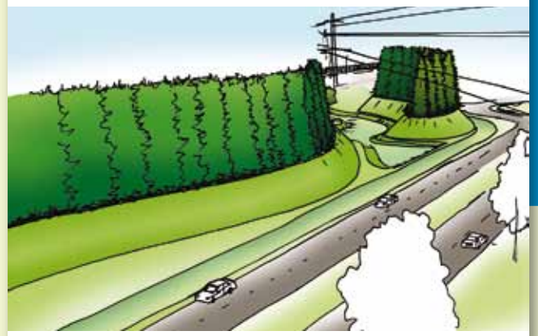
Source: BELW Advies bv

In new development:

Lay new streets and neighbourhoods out based on the wind direction and possible sources of air pollution.

In existing development:

Adjust existing green structures to avoid the green tunnel effect and encourage the flow of polluted air away from people and buildings.



Green barriers along highways are less effective for the reduction of noise than artificial barriers. However, when used in combination, they can help reduce air pollution and noise and prevent graffiti. | Sketch: Luchtgroen Genk: BELW Advies bv

Health

Climate & pollution

20 Street layout

Ningbo, China | Study of how to improve road conditions with green by NITA Ningbo and Niek Roozen bv.

Water retention solution next to the road | Photo: PPH

Use trees to control wind

Street trees work best if wind is not too strong yet enough ventilation is provided. Wind turbulence remains above the tree canopy in narrow streets while ventilating wind flows through the tree canopies and filters the particulate matter (PM10) and gaseous pollutants from the cars. Porosity of the canopy should be more than 40% in order to allow trees to function optimally as air filters.

The planting layout is more important than the plant species

Street design which uses green elements to improve air quality needs to be designed on a site-specific basis. A row of streets trees along a 30m wide street with low adjacent buildings may help clean the air, but those same trees along a 20m wide street with high buildings will worsen the air quality. The size of the trees, the distance to and height of adjacent buildings and the porosity of the trees all affect the capacity of the design to improve the experience at street level.

Choose other green alternatives if space is limited

If there is not enough room in the street profile for trees, use other methods such as hedges, green roofs, green walls (min. 5-7m high) and pergola structures with green to perform air filtering and/or ventilation functions. Groundcover plants also capture particulate matter at pedestrian level. Natural, uneven, extensively maintained plant mixes are more effective than mowed lawn.

Provide bioretention of water in the streetscape

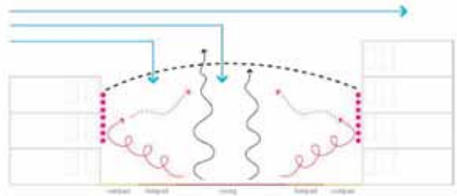
Integrate green solutions for storm water management within the street right-of-way by reducing unnecessary impervious surfaces and replacing them with green swales, pavement planters and green curb extensions. This not only helps reduce the stress on storm sewer systems, but also adds to the aesthetics of the street.

Benefits of street layout

- Improves air quality at street level by up to 30%
- Creates a comfortable microclimate along streets for pedestrians and bicycles
- Provides structure and orientation in urban environments

Plant green along the street so it is functional, aesthetic and does not hinder the flow of traffic.

The sources and distribution of PM10 in a street with buildings on both sides



Total concept for the use of green in a street in order to improve the local air quality

1. roof planting
2. green roof (higher edge)
3. block hedge (0.6-1.0 meter, allows air to flow through)
4. groundcovers, grass
5. block hedge as middle berm
6. trees in triangle formation or in a line (prevent tunnel effect along the street)
7. block hedge (0.6-1.0 meter, allows air to flow through)
8. façade planting

In new development:

Include enough room for green in the planning of infra-structure in order to optimize the effects on the air quality, wind and water runoff. 20% of the infrastructure surface should be reserved for green.

In existing development:

Determine whether existing trees help or hinder the air quality of the street and adjust the design to provide optimal functioning of the trees and other green layers. Check the availablity of space for green, as well as the traffic safety regulations.

Nijmegen, NL | Effective use of a green screen to capture PM10 along a street
Photo: Fred Tonneijck

+ Economy + Health + Water + Climate & pollution

Experts: Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Ceciel van Iperen (CROW), Pauline de Koning and Peter Schildwacht (BELW Advies bv), Triple E, ES Consulting
Sources: Alle extra groen helpt de luchtkwaliteit verbeteren; Stadsbomen voor een goede luchtkwaliteit; Leidraad Luchtzuiverend Groen

21 Right tree, right place

Trees fit with the scale of the buildings | Photo: Stichting Open Boek

Trees in a park | Photo: PPH

Trees on a shopping street | Photo: GWO Laanbomen

Choose tree species which adapt well to urban conditions

Urban conditions (soil compaction, tolerance of salt, drought, low maintenance), local climate conditions (rain, wind, temperature, humidity, winter hardiness) and the soil type all need to be considered when choosing which tree to plant.

Plant trees whose full grown size fits in with the scale of surrounding uses

Avoid the 'green tunnel effect' along streets where polluted air is trapped by too dense or too large trees and no ventilation. Either plant smaller trees or be sure that the porosity is more than 40% by choosing trees with open canopies or through sufficient maintenance. Also consider the amount of space available underground where the roots need to develop and above ground for crown development.

Trees should enhance and not hinder their desired function

Trees for shade should have big canopies in the warm months, trees for streets should have a high branch structure to prevent obstacles in the streetscape, use columnar trees in narrow streets, trees in small gardens should not overtake the entire space, park trees should fit with their location and function, etc. A tree that overgrows its boundaries will create negative opinions of trees in urban settings.

Prevent hazardous situations

Do not plant trees with falling fruit, seeds, uplifting roots or branches that fall in the wind in areas where they can cause damage, such as along streets, in parking areas and next to houses.

Choose tree species which require low maintenance for public spaces and streets

Trees should be able to survive in changing weather / climate conditions or periods when the public maintenance budget is not secure.

Benefits of the right tree

- The right tree in the right place requires less maintenance
- A tree that can adapt to the urban conditions can reach maturity
- Properly placed trees have the most effect on air quality and provide shade where it is most needed
- The appropriate choice of tree species avoids damage to property

"Trees can only fully mature and function when they are carefully selected, taking into consideration their growth characteristics, site conditions (including available space) and the functions to be performed by the trees. These three aspects are equally important and always need to be considered simultaneously."
Jelle Hiemstra (Applied Plant Research – Wageningen UR)

Trees along a wide street
Photo: GWO Laanbomen

Trees along a narrow street
Photo: Niek Roozen bv

Choose the tree variety based on the desired function as well as the site conditions.

In new development:

Trees should be included in the design at an early stage so they can be used for aesthetics and perform other beneficial functions such as air filtering, shade and wind. Let trees determine the character of development instead of the other way around: The right place for the right tree.

In existing development:

Existing conditions should be studied to determine which tree variety, size and characteristics fit best aesthetically and functionally in the space.

Tree with room to mature | Photo: Stichting Open Boek

Economy **Health** **Climate & pollution**

Experts: Jelle Hiemstra (Applied Plant Research – Wageningen UR)
Sources: Alle extra groen helpt de luchtkwaliteit verbeteren; De bomenplanner; The Green City Post 2011; www.straatbomen.nl

22 Use existing trees

Noordwijkerduin, NL | The client, 's Heeren Loo, was convinced of the added value a mature tree would bring as a centerpiece in a nearby plaza. When a forested area of the Willem van den Bergh Institute was thinned for development, one of the trees was transported from one end of the campus to the other and successfully replanted | Designed by Niek Roozen bv

Transplant trees if possible

Ask a tree specialist if it is possible to transplant trees. This varies per species, root system and availability to adapt to the new situation. Trees should be transplanted with a root ball as big as possible, including fine roots. Growth conditions and maintenance are important in the new location.

Perform a tree survey

Be sure that a tree is worth being saved before taking measures to design and build around it. First take an inventory of the size, location and species of all existing trees on the site. Ask a tree specialist to check the trees that are considered to be worth saving. The life expectancy, condition, stability and quality of the tree should be determined.

Plan ample space around existing trees

Do not place buildings too close to an existing tree. Keep at least 5m between a building and the trunk of the tree (or more if the canopy is already larger than 10m in diameter). This allows the canopy and roots to develop to maturity. Do not cut large structural roots near the trunk to avoid instability of the tree.

Avoid underground conflicts

When renovating underground situations such as cables and pipes, do not use heavy digging equipment around existing trees. Dig by hand near the roots to avoid damage.

Protect trees during construction

Building specifications should clearly state what the protocol is around existing trees and green. Place a fence around a tree at least as big as the canopy in order to keep growing conditions optimal and protect the roots and canopy from machinery. Be sure that the area around the tree does not become storage for building supplies and equipment or a dumping ground for building waste and oil. Inspect the ground water tables in case of (temporary) level changes or pollution that could damage the trees. Include a penalty clause in the contract if trees are damaged.

Guarantee growing conditions after construction

After all construction is completed (including the new surrounding landscaping), trees and plants should be checked for damage and soil conditions should be monitored for quality. Maintenance should begin immediately thereafter.

Benefits of existing trees

- New development automatically gets a mature green character
- Mature green is more valuable both aesthetically and economically
- Existing tree structures provide a spatial quality only achieved after many years with new plants
- Old trees have history and meaning for people and the site
- Mature trees are most effective in providing the desired functions

"A mature beech tree with a trunk diameter of 100cm removes 11x more PM10 than a corresponding tree with a trunk diameter of 20 centimetres."
Fred Tonneijck (Triple E & Knooppunt Innovotief Groen)

Amsterdam, NL | Photo: PPH

Consider existing trees as assets to a development from the beginning phases of design through construction.

In new development:

Let existing valuable / characteristic trees inspire or become the basis for new development. Be sure the design incorporates the needed space for trees and green to thrive in the new surroundings. Protect and monitor the trees during the entire construction process.

In existing development:

Trees and green should be incorporated into the redesign of areas and be given more room if needed so the trees can reach their optimal form. Be sure to protect trees both above and underground during the construction process.

Existing tree protection during construction.

+ Economy
+ Health
+ Social interactions
+ Ecology
+ Water
+ Climate & pollution

Experts: Fred Tonneijck (Triple E & Knooppunt Innovotief Groen), Jelle Hiemstra (Applied Plant Research – Wageningen UR), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten)
Sources: Groen Loont!; De bomenplanner

23 Big healthy trees

Floriade 2002, Haarlemmermeer, NL | Large trees with healthy rootballs were planted at the Floriade 2002 site so the desired landscape character could be achieved quickly | Designed by Niek Roozen bv

Green character is established quicker with large healthy trees and mature green

Healthy trees planted in a healthy environment have more influence in the short term as well as the long term on the green character, value and usability of green spaces, real estate and the health of surrounding residents. The usability, attractiveness and effectiveness is not only visible right after construction, but improves as time goes on. These benefits should be weighed into the budget of green projects.

Canopy area should be compensated, not the number of trees

Cities should base their tree regulations on the quality of the trees more than on the amount of trees planted. When mitigating the loss of existing trees (which has a negative effect on air quality), the canopy area of the removed trees should be compensated, not the number of trees.

Tree planting in urban green spaces

'The Integrated Planting Method'

Designed by Frits Ruyten and tested in the Prins Bernhardbos in The Netherlands, 1999 and later in other locations

- Trees planted: 6-7m height, 2.5-3m crown width
- Trees spaced: 10m or more between trees
- Shrubs planted: 1.5-2m height, 1.25-1.50m wide
- Shrubs spaced: 5m or more (planted at the location desired when the trees/shrubs reach maturity)

Plant costs are high, maintenance costs are low

Can be used directly after realisation

The Traditional Forest Thinning Method

Originally used in forests planted for wood production

- Small tree seedlings planted in rows
- Tree seedlings spaced from 1-5m between trees planted on a grid

Plant costs are low, maintenance costs are high (15 years of removing and pruning trees)

Takes about 15 years to fill in and gain a forest or mature park character

Sources: Integrale beplantingsmethode levert geslaagd Prins Bernhardbos op; Groen Loont!; De bomenplanner; Leidraad Luchtzuiverend Groen

Large healthy trees have a better survival rate

Trees with a trunk diameter of 30-35cm (measured 1m from the ground) have a better rate of survival because they are more established and less susceptible to diseases, molds, bacteria, wind, etc. Vandalism occurs less to trees with a minimum trunk diameter of 20-25cm. The root ball should also be large, compact and contain some fine roots. The costs of replacing dead trees are high when compared to the price of larger specimens.

Trees should be able to adapt to the urban conditions

The suppliers of plant material should take into account the eventual conditions that the plants will need to survive in. The production process should include a period of adaptation (transplanting, etc.) so the plants are not shocked in their new urban environment.

Benefits of big trees in green spaces

- Big healthy trees give a project an instant green character
- Large healthy trees require less maintenance and have a less chance of dying
- Larger trees are less susceptible to vandalism

Plant big quality trees and shrubs in urban areas in order to achieve the desired green result directly after realisation.

"Scientific and market-conform calculations show that the Integrated Planting Method actually saves money in the long term. The construction costs are two times more expensive than the traditional forest thinning method, but the maintenance costs are actually 60 - 75% lower."
Dr. Frits Ruyten, landscape architect, Integralis PP

In new & existing development:
Convince developers of the short term as well as the long term benefits of using big plant material in projects and secure the budget for quality planting and design.

Leiden, NL | Newly planted trees along the Vijfmeilaan

Economy + Health + Water + Climate & pollution

24 Growing conditions

Photo: Stichting Open Boek

Trees need quality soil to grow

Soil should have good air circulation, organic content, porosity, water storage capacity and soil biology. Enough decomposition should occur in the ground in order to convert some of the compounds from the dust particles collected by the trees into harmless compounds. Remove sterile building sand and replace with the appropriate soil mixture depending on the situation.

Roots need room to grow

Prevent the 'flower pot effect' by providing enough underground growing room with the right conditions. The size of the tree planting area depends on the surrounding uses above ground (park or yard vs. street or building), the size of the tree, and how high the water table is. The rule of thumb is 1m³ space underground per growing year for healthy root growth. At the design stage, the mature size of the tree should be considered. Excessive pruning due to adjacent buildings, powerlines, etc. denies the tree its necessary energy (leaves are the lungs of the tree).

Characteristics of soil used for trees in urban settings

	tree soil	tree sand	tree granulate
organic matter	high content (5-7%)	4-5%	
structure	open and loose	mix of course sand and organic matter	60% rocky material mixed with 40% compost, peat or clay
porosity	65%	50%	
amount of traffic	no traffic within canopy radius	light traffic	medium to heavy traffic
location	open ground: parks, green areas, green strips between paving and grass/planting	under sidewalks, bicycle paths, parking	under streets (with good circulation)
min. points	not suitable under pavement and traffic	must be professionally mixed to avoid compaction, lack of oxygen and drying out	must be professionally mixed because it does not mix evenly, also difficult to dig holes for utility work

Source: Bomensubstraten en hun toepassing

Trees have specific water needs

Especially during the first year of planting, maintenance and water should be budgeted into the project to guarantee that the trees grow. Avoid digging planting beds deeper than 20cm above the groundwater table. Do not use the planting beds around trees as drainage for surrounding pavement because of the damage resulting from the excess water or salt.

Do not allow soil compaction to occur

If too much compaction occurs under pavement (traffic areas) then root growth is limited due to less porosity, air circulation and water drainage / availability. Compacted soil does not allow water to infiltrate and reach the root zone and groundwater table.

Tree roots need adequate oxygen

This can be achieved by the proper soil type with porosity or with a perforated pipe network with 40% perforation under the pavement. Pavement which is damaged by roots is usually caused by roots searching for oxygen closer to the surface.

Benefits of good conditions

- Trees are able to reach maturity
- Trees are healthier and more vigorous
- Trees perform optimally (provide shade, clean the air, etc.)
- Trees require less maintenance and control which saves money in the long term
- Less problems such as damaged paving, diseases and pests
- Healthy roots have a positive effect on the capacity of the ground to buffer water

"Green in the city ... provide the right conditions ... and nature will do the rest."
De bomenplanner

Create the proper growing conditions for urban trees so they are healthy and can perform optimally.

In new development:
Remove building sand in all tree and plant beds and replace with planting soil. Design not only above ground but also underground so there is ample room for trees to grow.

In existing development:
Street renovation should not only be based on traffic circulation but also the optimal growing space for the new or existing street trees. Street profiles, space underground and soil type should be adjusted to prevent problems such as paving damage due to roots.

Space needed for various tree sizes

	large	medium	small
max. height	>12m	6-12m	<6m
max. canopy dia.	10-15m	7-10m	5-7m
length of bed	6-12m	4-8m	2-3m
min. width of bed	3-4.5m	2.5-3.5m	1.5-2m

Source: Kwaliteitseisen Boombeheer Beheerrichtlijnen versie 2007 NOCB, from Bomensubstraten en hun toepassing

Economy **Climate & pollution**

Experts: Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten)
Sources: Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Praktijkbrochure Bomensubstraten en hun toepassing; De bomenplanner

25 Quality maintenance

Abu Dhabi, UAE | An attractive streetscape that is maintained to a high standard in the city of Abu Dhabi.

Maintenance is a long term commitment

A plan should be set up for all green projects in order to guarantee the quality and functionality of the trees and other plants. A systematic multi-year maintenance plan includes water schedules and amounts, pruning schedules, fertilizing and control of soil.

Maintenance is an investment

Well maintained quality green is more attractive, thereby raising the value and usage of green spaces as well as the value of the surroundings. Unmaintained and overgrown green creates negative attitudes toward green in urban areas. Falling branches are dangerous to people and property and are more costly to repair than routine pruning. Funds should be reserved for maintenance based on a cost-benefit-analysis.

Design and maintenance go hand in hand

From the beginning of the planning process through the choice of landscape and plant materials, designers should take into account the effects these have on maintenance after it is built. There should be a balance between design and maintenance capabilities, including budget, initiative and ability.

Maintenance technique used to assure quality:

Cyber Adviseurs has developed a technique for cities to assure the quality of maintenance meets the standards of the user groups. By using images of the various levels of maintenance, agreements can be made between the balance of budget and expectations and the workers can clearly see when they need to perform certain maintenance tasks.

Experts: Frans Bouwman (Cyber Adviseurs), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen)
Sources: Groen Loont!; Community Green: using local spaces to tackle inequality and improve health; Leidraad Luchtzuiverend Groen; The Green City Post 2011

Involve all parties who are affected by the results

Are everyone's expectations being met with the level of maintenance provided, including the local government, the contractor, the residents, the users and the businesses. If not, bring everyone to the table to understand what their impression of quality maintenance is compared to the available resources (money, manpower) and find solutions to achieve this. Find funds from various sectors who also profit from an attractive urban environment. Ask residents to communicate with the maintenance experts when the agreed-upon standard is not being met.

Benefits of maintenance

- Attractive well maintained green is treated with respect by users and surrounding residents
- Attractive well maintained green raises the value of surrounding properties
- Preventable accidents such as falling branches and uplifted pavement can be avoided by timely control and maintenance
- Well maintained green spaces are perceived as being safer green spaces that are well maintained

"Ultimately, a green area's suitability for use is determined by the maintenance it receives."
Piet Eilander, Amsterdam's Greenery, Ecology, Urban Recreation and Water team, in The Green City Post 2011

Allow trees to reach their full potential by providing proper maintenance from day one.

In new development:

Guarantee proper maintenance, especially in the first years after planting, by stating clearly in the project specifications the requirements for care, water and fertilizer. Budget the time and money for maintenance from the beginning so it is not seen as an extra cost later.

In existing development:

Take an inventory of maintenance needs in the city based on a desired level of quality, set up a yearly plan, train the people who will carry the plans out and reserve a budget to raise the quality of the existing green.

Street trees require care.

+ Economy **+ Climate & pollution**

London 2012 Olympics case study

Photo: London 2012

Green Infrastructure

The London 2012 Olympics is an iconic event with green space at its heart. The site of the London Olympic Games was made up of contaminated and derelict land, leftover following the slow decline of a range of polluting industries including tanning, rendering and vehicle dismantling. Not only did it offer the space for the development of an outstanding sporting facility, it also had the potential to contribute to the economic recovery and environmental improvement of the site itself and surrounding area.

Working with leading landscape architects and designers, landscape contractors and the nursery stock industry, the ODA has set a standard for putting green infrastructure at the heart of developments like this and ensuring that green space is a central part of the sustainability of the project.

Quality Green Space

From the start, the Games have set out to deliver superb sporting facilities, supported by the kind of public realm that will allow athletes to rest and relax between events and as a result, perform to their best ability. This environment includes quality green infrastructure, a 'green canopy' that provides habitat and shade, and 10 hectares of new wetlands and parkland. It includes more than 2000 new trees and 100 000 plants and space for cycling, picnics and play.

As well as providing a wonderful environment for athletes and spectators, when the games are over, the Olympic park will become a resource for the residents of the 3000 homes that will be created from the athletes' accommodation, and for residents of the surrounding boroughs.

Photo: London 2012

"London is the first summer host city to embed sustainability in its planning from the start... we have used the Games as a catalyst for the regeneration and improvement of quality of life in East London. A multi-functional landscape addressing biodiversity, flood risk management, carbon sequestration, energy, water use, walking and cycling will set the context for continuing legacy development for new and existing communities."
John Hopkins, Project Director, Olympic Delivery Authority

London, UK | designers: LDA Design & Hargreaves Associates | Client: Olympic Delivery Authority | 2012

The 'Greenest' Games

The green space element is key to London 2012 – an event that sets out to be the 'Greenest Games'. It is a core element of its sustainability thrust, itself a cornerstone of the event.

Photo: London 2012

Economy | Health | Social interactions | Ecology | Water | Climate & pollution

Experts: John Hopkins (Olympic Delivery Authority), Mark Long (UK Green Forum)
Sources: London 2012

Green+ streets

Literature:

- **Groen Loont!**
  [Green Pays!]
- **Alle extra groen helpt de luchtkwaliteit verbeteren**
  [All extra green helps improve the air quality]
- **Groen voor Klimaat**
  [Green for Climate]
- **Bomen: een verademing voor de stad**
  [Trees: Relief for the city]
- **Leidraad Luchtzuiverend Groen**
  [Manual Air Purifying Green]
- **Effecten van groen op de luchtkwaliteit**
  [Effects of green on air quality]
- **IPL rapport 1b: Toepassingsadvies Schermen**
  [IPL report 1b: Advice for applying screens]
- **IPL rapport 2b: Toepassingsadvies Vegetatie**
  [IPL report 2b: Advice for applying vegetation]
- **Stadsbomen voor een goede luchtkwaliteit**
  [City trees for good air quality]
- **De bomenplanner**
  [The Tree Planner]
- **The Green City Post 2011**
- **Integrale beplantingsmethode levert geslaagd Prins Bernhardbos op**
  [Integrated planting method is a success in the Prins Bernhardbos]
- **Praktijkbrochure Bomensubstraten en hun toepassing**
  [Practical brochure Tree soils and their application]
- **Community Green: using local spaces to tackle inequality and improve health**

Websites:

- www.west8.nl
- www.functioneelgroen.nl
- www.straatbomen.nl

Experts:

- **Fred Tonneijck, Senior Advisor/Researcher**
  Triple E and Knooppunt Innovatief Groen
- **Pauline de Koning, Landscape Architect**
  Peter Schildwacht, Air Specialist, Biologist
  BELW Advies bv
- **Sanda Lenzholzer,**
  Assistant Professor Landscape Architecture
  Wageningen University
- **Arda van Helsdingen, Director**
  Copijn Tuin- en Landschapsarchitecten
- **Ceciel van Iperen,**
  Project Manager Living Environment
  CROW
- **Eva Stache, Architect**
  Stache Architects bna
- **Jelle Hiemstra, Senior Researcher**
  Applied Plant Research – Wageningen UR
- **Frans Bouwman, Director**
  Cyber Adviseurs
- **John Hopkins, Project Director**
  Olympic Delivery Authority
- **Mark Long, Director**
  UK Green Forum
- ES Consulting
- London 2012

For a complete list of literature and expert participants, see pages 94-97.

Green+ buildings

4

26 Green oriented to buildings

Hotel in Abu Dhabi, UAE | The hotel is surrounded by a lush green landscape which not only provides a comfortable climate just outside the lobby for guests and passersby, but also helps shade the lower levels of the building against the sun.

Deciduous trees along the south-facing office windows provide shade in the summer and allow sun to pass through in the winter.

Prevent cold winter winds near the building

Coniferous windbreaks planted between cold winter winds and a building reduce heat loss inside buildings. Wind speed can be up to 70% less directly behind a planting structure. Avoid dense trees in the direction of cooling summer breezes. The reduction of relatively low wind speeds (max. 4m/second = 1.5-10mph) can mean an annual savings of 10% on energy consumption for heating. For greenhouses the savings are 15-40%.

Prevent excess sun from reaching the building

Trees planted on the east and west sides of buildings block summer sun before it enters the building, therefore reducing the need for air conditioning. Large deciduous trees on the south side not only block summer sun but also allow winter sun to filter through the empty branches and warm the building. Temperatures are also reduced by transpiration in the warm growing season.

Prevent air pollution from entering the building

Trees planted outside act as a pre-filter for the air that eventually enters the building. The air has already gone through a filtering process by flowing through the tree canopy first. Place planting structures close to buildings so polluted air rises above the building or is led along the building.

Place planting near ventilation ducts

Place evergreen plants near the in-going ventilation ducts of a building. This improves the quality of the air that enters the building. Deciduous plants also help shade and cool the areas around the ventilation ducts in summer and allow the sunlight to warm the ingoing air in the winter.

Use trees to filter background pollution

Do not only place trees to filter pollutants next to the source of pollutants (industry, streets, etc.) but also around sensitive objects such as schools, hospitals, elderly homes, etc. These are the groups most susceptible to the health hazards of air pollution.

Benefits of adjacent green

- Reduces the energy demands of buildings by up to 10%
- Reduces the use of air conditioning in the summer
- Reduces the use of heating in the winter
- Maintenance on building façades is less if shielded from excessive wind and sun
- Indoor ventilation and climate is improved

Improve the microclimate around and in buildings by placing trees and green structures strategically outside buildings.

Musee de Quai Branley, Paris, France | Design by ECO Architect Patrick Blanc
Photo: Robert ten Elsen

In new development:

Include green around buildings as a sustainable building technique used to calculate the energy coefficient. Calculate green into the budget for new buildings because of the integral role it plays in meeting these standards.

In existing development:

Plant trees in the right place to change the microclimate directly outside a building so fluctuations in sun and wind are less dramatic, resulting in a more consistent indoor climate.

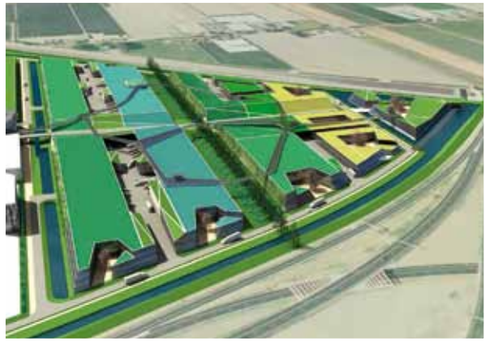
Arnhem, NL | Large vertical green planters placed in front of an existing façade
Photo: NEXIT Architecten

+ Economy + Health + Social interactions + Ecology + Water + Climate & pollution

Experts: Pauline de Koning and Peter Schildwacht (BELW Advies bv), ES Consulting
Sources: Groen Loont!; Groen voor Klimaat

27 Buildings blend into landscape

Sportplaza Mercator, Amsterdam, NL | The use of green walls blends the buiding with its surrounding sports facilities. The building is located in downtown Amsterdam | Photo: Copijn Tuin- en Landschapsarchitecten



De Hoek, Hoofddorp, NL | The business park near Schiphol Airport, developed by Segro and designed by Urhahn Urban Design, is an ecologically sustainable concept with green roofs, inspired by the surrounding polder landscape | Image: Urhahn Urban Design

Anchor the form of the building in its surroundings

Use the natural characteristics of the site itself and its surroundings (not just the program and functions) to determine the size and form of a building. Situate the building based on the climate, microclimate, topography, existing trees and water. Connect the building to these characteristics by providing views to and from the landscape and creating physical links for people. The urban cityscape is also a type of landscape that can guide the principles of a building's design.

Encourage the multi-functionality of buildings

By combining functions and uses within buildings, such as parking below offices or retail under housing, more room is left in the urban landscape for green spaces. Green can also be incorporated into the building itself through the use of green roofs, green walls and atriums.

Use the landscape to help create energy-efficient buildings

Energy usage inside buildings can be reduced by using the landscape as insulation in the form of green roofs, green walls or semi-underground spaces. The orientation of buildings and the location of windows should be designed based on the position of the sun and prevailing winds. Water management of a building site can be combined with the architectural design. The location of the building should not interfere with the natural drainage patterns of the site. Green roofs decrease the amount of water runoff and storage areas for water allow buildings to re-use grey water for toilets or irrigation. The use of local materials also adds to the sense of place of a building while also reducing the carbon footprint.

Blend the landscape into the buildings

The surrounding landscape can also be extended into, over or around the buildings. Landscape design can be used to enhance the character of the site and create a balance between the architecture and the natural characteristics of the site and its surroundings.

Experts: Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten), Urhahn Urban Design
Sources: De Bouw Kleurt Groen; The Green City Post 2011; Bouwen met Groen en Glas

Benefits of blending

- Saves on energy costs inside the building (cooler indoors in summer and warmer in winter)
- Enhances the sense of place
- Encourages sustainability practices in the design

Capture the sense of place and use the natural characteristics of a site to inspire the design of buildings.

"The problem with sustainable building is that the environmentally friendly construction practices often remain hidden to the eye."
Wytse Algra, Dura Vermeer in The Green City Post 2011

...Ypenburg which is located next to the Delftse Hout nature reserve. "Here, ecologists, city architects, landscapers and real estate developers teamed up. The final result gave the Ypenburg residents the impression they were living in a natural beauty spot as opposed to actually living next to it..."
Willem Weeda, Mostert de Winter in The Green City Post 2011

Katwijk, NL | Plants and materials used on the site to root the buildings into the surrouding dune landscape.

In new development:
Situate buildings based on the existing conditions of a site and use them to the design's advantage.

In existing development:
Connect the building to its surroundings by providing views to and from the landscape. Combine functions by creating parking garages in the city to make room for more urban green spaces.

High Tech Campus in Eindhoven, NL | Photo: Robert ten Elsen

+ Economy **+ Health** **+ Ecology** **+ Water** **+ Climate & pollution**

28 Green roofs

Rotterdam Climate Initiative: green roofs | *"Rotterdam gives subsidies of € 30. per square metre to homeowners to build a green roof. The price of a vegetated roof starts at € 45. per square metre, so the subsidy is substantial."* ***Alexandra van Huffelen, municipal councillor Rotterdam in 'De Bouw Kleurt Groen'***

ING Bank, Amsterdam, NL | The concept for the rooftop landscape was to bring nature back into the city. This garden, built in 1985-87 and designed by Copijn, still functions after 25 years | Photo: Copijn Tuin- en Landschapsarchitecten

Only choose hardy plants which are able to survive in rooftop conditions

Extensive roof garden plants should be able to survive and grow in high temperatures, full sun, high wind speeds and periods of drought. The should be able to survive in a thin substrate layer, a small waterbuffer and fluctuating temperatures.

The best plants for extensive roofs are:

- Perennial, low, seed-forming, drought tolerant plants
- Succulent plants with grey hairs or a thick blue layer on the leaves (sedum and sempervivum are available as plants or as ready-made living mats)
- Plants with strong woody twigs or thin leatherlike leaves
- Annuals that bloom once and go to seed so they always return

A larger variety of plants can grow on an intensive roof garden

The plants have more soil, water and fertilizer availability. Location factors for plants include the height of the roof, wind speeds, irrigation availability, sun position, relation to other buildings, climate zone

The best plants for intensive roofs are:

- Plants that don't get too big (maximum weight capacity), grow in full to half sun, can tolerate wind (do not use plants with lots of seeds that blow away, high plants with breakable or falling stems or plants with strong spreading roots)
- Perennials should be suitable for full sun and fully cover the ground
- Eco-roofs should consist of native plants
- Shrubs should be winter hardy, not be sensitive to wind, grow in full sun and grow in normal to dry soil, solitary shrubs can be pruned like trees. Low, drought tolerant shrubs are good choices
- Trees should only grow up to 6m high, not be sensitive to wind, have a crown that is not too big and open
- Trees with shallow roots must be anchored

Benefits of green roofs

- Life of the roof is up to 20 years longer
- Insulates the building against cold and warm
- Gives a "green" image
- Absorbs noise and vibrations
- Makes solar panels more efficient
- Eases the peak flow in stormwater sewers; lessens the urban heat island effect; produces oxygen; absorbs carbon dioxide
- Captures particulate matter, absorbs gaseous pollutants
- Improves the living and working environment

Criteria for building a green roof

Depth of soil:	• 7-10 cm	for sedum, moss
	• 25 cm	for for shrubs
	• 80 cm	for trees (0,75m³ per m² canopy)
Weight:	• 30-130 kg	for 2-15 cm soil
	• 130-300 kg	for 15-20 cm soil
	• 250-1000 kg	for 15-80 cm soil
Maintenance:	• A conventional roof requires inspection 1x per 5 years	
	• An extensive green roof requires inspection 1x per year and weeding (no irrigation required)	
	• An intensive green roof requires inspection 8x per year (weeding, pruning and fertilizing) and always requires irrigation in dry periods.	

List of trees successfully used on roof gardens in The Netherlands:

Nothofagus antarctica
Amelanchier lamarckii
Taxus baccata
Cornus mas
Pyrus salicifolia 'Pendula'
Pinus nigra 'Nigra'
Betula utilis 'Doorenbos'

Create green roofs on new and existing buildings and fulfil the need for green where space is limited in the urban environment.

...The price of a garden is the same on the ground as on a roof: the land is already paid for! The extra costs of the roof construction / preparation, special soil mixture preparation and transportion of the materials to the roof make up the difference... ***Niek Roozen, landscape architect***

In new & existing development:

Check local building codes and permits and have a structural engineer check the plans to be sure the roof is strong enough to hold the weight. It is also wise to compartmentalize the roof so it is easier to find the sources of possible leaks and prevent damage to neighboring roofs.

In existing development:

The existing roof must be in good condition, strong enough, insulated and waterproof. Check if the insulating layer is under the waterproofing layer or over it and design accordingly. A layer of root barrier is also needed.

This roof garden uses the Zorgeloos Groen technique by Heijmans Sport en Groen | Photo: Heijmans Sport en Groen

+ Economy + Health + Ecology + Water + Climate & pollution

Experts: Peter Fraanje (Bouwend Nederland), Niek Roozen (Niek Roozen bv landscape architects)
Sources: Dak en Gevel Groen; Groen Loont!; Bomen voor Daken 2011 poster; Groen voor Klimaat; Daktuinen verbeteren leefomgeving; De Bouw Kleurt Groen

29 Green walls

Spoorhoek, Arnhem, NL | Vertical planters are built in front of an existing façade and filled with sedum, grasses, groundcover plants and vines. The project 'Standing Garden' was designed by NEXIT Architecten together with Buro Poelmans Reesink Landschapsarchitecten and built by Koninklijke Ginkel Groep | Photo: NEXIT Architecten

Darthuizen, NL | Plant mix used by Mobilane on a living wall

Green walls can be created with vines

Use twining or clinging self-climbers and provide support if needed. Be sure to replace building sand with proper soil so the vines can grow. The advantages of vines are that they grow from the ground up, they do not need irrigation and they can reach a height of up to 20-25m. The disadvantage of vines is that they take a long time to establish. Self-climbing vines include *Hedera helix* and *Parthenocissus tricuspidata* (not on north-facing walls). Twining or climbing vines on climbing racks include *Ampelopsis*, *Aristolochia*, *Celastrus orbiculatas*, *Humulus lupulus*, *Wisteria* and *Vitis*.

Green walls can be created using planters

Use climbing and hanging plants and shrubs in the planters. Hang planters on the wall or install ready-made planters with climbing racks. The advantages of planters are that irrigation is needed but the plants can survive if it is temporarily not used, fertilizer can be provided directly into the soil or given in the water and the results can be seen after 1-2 years.
The disadvantages of planters are that they can be expensive and maintenance is needed a few times per year. Climbing plants for planters include *Hedera*, *Actinidia*, *Akebia* and *Periploca*. Hanging plants include *Hedera* and *Jasminum nudiflorum*.

Green walls can be created with façade panels

Use annuals, perennials and small shrubs which grow in special growing panels. "Living wall" techniques include a geotextile cloth with holes and sacks where plants are rooted, vertical hanging plastic plates, façade modules with soil or mineral wool substrate, vertical sedum mats (no irrigation needed) and free-standing wall systems. The advantage of façade panels is that the results can be seen after only a few months.
However irrigation is always necessary, the panels are relatively expensive and they need weekly maintenance. Plants for façade panels include hanging plants, annuals, perennials and groundcover plants. Choose perennials and shrubs for leaf form and colour more than their temporary flower colour. All annuals are good if they are not too big and some even absorb NO_2 such as *Nicotiana*, *Petunia* and *Cosmos*.

Benefits of green walls

- Improves the indoor climate and reduces energy needs indoors
- Absorbs noise
- Offers unique possibilities for design and advertising
- Insulates the façade against cold and warm
- Protects the wall from water and sun
- Helps lower summer temperatures in the city
- Helps improve air quality in the city
- Brings nature to the city
- Creates more views of green in the city
- Is an efficient use of space for green in the city

Conditions for determining wall type:

Façade
orientation to the sun, weight-bearing capacity, sensitivity to damp, wind turbulence

Planting
preferred density, perennial or seasonal, evergreen or deciduous, adapted to dry/wet panels

Irrigation
tap water or rainwater, fertilizer, recirculation, distribution after watering, timed irrigation or damp sensor, empty hoses after watering or not

Façade panels
accessibility to wall, ornamental value throughout the year, necessary maintenance, procedure of replacing panels/plants

...Greenpark Rotterdam, Westblaak is a parking garage in Rotterdam with a 5,000m2 green façade which is due to be completed in 2011. The green façade was designed by Kühne & Co Architektburo for West Star. This is a project associated with the Rotterdam Climate Initiative.
www.vroegevogels.vara.nl

Create green walls on new and existing buildings in order to fulfil the need for green where space is limited.

In new devlopment:

Façade panels can be integrated into the building design if planned at the beginning of the building design process and engineered to hold the weight (80-100 kg/m²).

In existing devlopment:

Use vines planted in the ground or light planter systems where the plants can grow on climbing racks against the façade or use hanging plants in planters as a curtain in front of the Façade. A planter built in front of the wall (but not attached) is also possible.

Szczecin, Poland | Vine-covered façade | Photo: Robert ten Elsen

+ Economy + Health + Ecology + Water + Climate & pollution

Experts: Robbert Snep (Alterra – Wageningen UR), Soontiëns Stadsnatuur, Triple E
Sources: Dak en Gevel Groen; Gevelgroen maakt inhaalslag; Planting green roofs and living walls; http://vroegevogels.vara.nl

30 Green indoors

LUMEN building, Alterra, Wageningen, NL | The greenhouse construction creates a link between inside and outside and provides the needed light for the plants. Designed by Luc van Dam (LIMES architecten), Copijn and Benisch Architekten | Photo: Copijn Tuin- en Landschapsarchitecten

Use plants to improve indoor climate

Ventilation is improved when trees are placed in open areas, hallways and in individual rooms. Transpiration of the leaves creates humidity in the air which is more comfortable and regulates the temperature indoors. If plants occupy 5% of a room volume, the relative humidity in winter goes up by 20% and the room temperature rises by 1-3˚C and the room temperature decreases by 1-3˚C in the summer.

Use plants to improve air quality

Air pollution (such as benzol, nicotine and other volatile organic compounds and gasses) are absorbed by indoor plants. These pollutants, along with dust, can be reduced by 20%. The leaves transport the pollutants down into the root zone where micro-organisms convert them into nutrients in the soil. Allow air to flow along as much green as possible indoors as it moves from room to room. Atriums, wintergardens, halls and plants in individual office spaces are all effective.

The effects of plants on the well-being of office workers

Health complaints without green	with green present
Exhaustion	20% less
Headaches	30% less
Sore / dry throat	30% less
Coughing	40% less
Dry skin	25% less
Peeling scalp / ears	less
Facial irritation	less
Eye irritation	less
Dizziness	less
Fuzzy head	less

(**Source:** Groen Loont! and Triple E (from Prof. Tove Fjeld, Oslo Agricultural University))

List of best indoor plants

Hedera helix L.
Aloe barbadensis
Ficus elastic
Ficus benjamina L.
Syngonium podophyllum
Chrysalidocarpus
Chamaedorea elegans
Dieffenbachia amoena
Spathiphyllum
Dracaena deremensis cv. Warneckii Compacta

(**Sources:** Ki-Cheol Son, Konkuk, and Bouwen met Groen en Glas)

Indoor green improves health (both physical and psychological)

Studies show that sick days from work are reduced by 3.5 days per employee in offices with plants. The presence of green can improve the healing of patients in hospitals. The effects are especially psychological. There is a therapeutic impact just by looking at plants. Green fosters neutral relaxed and happy feelings without negative feelings. Oriental style flower arrangements stimulate the right brain functions while western style flower arrangements stimulate the left brain functions. Plants and flowers also affect the 5 senses to varying degrees which stimulates different parts of the brain.

Maintenance is essential for quality plants

Good healthy soil, potting techniques, water and pruning are necessary to guarantee the continued vitality of indoor plants.

Benefits of green indoors

- Improves indoor air quality
- Reduces indoor dust particles and microorganisms
- Adjusts seasonal temperature and humidity
- Reduces fatigue and stress
- Employees who work in offices with green take up less sick days
- Enhances work efficiency
- Reaction time and productivity of employees increases by 12%
- Concentration of employees increases
- Has a high impact compared to the costs
- Is easy to install and remove
- Has a horticultural therapeutic impact on mind and body

Create a more comfortable climate indoors with the use of indoor plants, which has a positive effect on the psychological and physical well-being of the users of the building.

In new development:
Design buildings with permanent places for green and plenty of natural light to guarantee that green is valued and maintained by the users.

In existing development:
Add indoor plants inside buildings in open areas, hallways and individual rooms to maximize the benefits for all users.

Not only does the plant filter the air, but the pot is part of a ventilation system which cleans and humidifies the air in the office. This system was created by Tromp Medical | Photo: Axel Möltgen

Economy + **Health** + **Social interactions** + **Climate & pollution**

Experts: Ki-Cheol Son (Healthy Life Conference Taipei 2010), Axel Möltgen (FARO Architecten), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten), Triple E
Sources: Groen Loont!; Bouwen met Groen en Glas

Vancouver Convention Centre case study

Living roof coverage: 58% 250,360 sf [24,281 m²] | Decrease in impervious surface: 29.7% | Marine habitat: 1,500 linear feet [457 linear metres] of marine habitat created | Photo: coutesy DA Architects + Planners, from brochure LMN Architects

reduce the heat island effect in downtown. The roof contains over 400,000 plants, all native or adaptive to Vancouver's climate. When the plants are established, they will only require limited irrigation in late summer.

"The living roof itself has no public access points, allowing it to develop as a fully functional habitat for non-human species, while the landforms fold in specific ways to open views onto its lush vegetation from inside and outside the building."

"The design of the new Vancouver Convention Centre West presented an opportunity to fully engage the urban ecosystem at the interface between a vibrant downtown core and one of the most spectacular natural ecosystems in North America."

City Zoning required strict regulations regarding view corridors from the downtown streets to the water. The form of the building and its sloping green roof responded to these issues and was inspired by the topography of the region, connecting it to Stanley Park and the mountains on the other side of Burrard Inlet.

Connectivity & Nature

The Vancouver Convention Centre West is a building with real environmental quality, most visible in the project's ecology-based approach to land use and its living roof. The site was a contaminated brown field with traces of its historical past as an industrial site and train yard. The building's design features a 24,281 m² living roof and a foundation system around the building's waterfront perimeter designed as an artificial reef. A team of marine biologists consulted the architects and designers so it would function as a restoration of the natural shoreline.

The living roof is not only an attractive addition to Vancouver's skyline, but also functions as a large permeable surface in the city to control rainwater, slow storm water runoff and

Photo: LMN Architects

Photo: LMN Architects

Vancouver, British Columbia, Canada | LMN Architecture, Urban Design, Interiors, Seattle, USA, in association with MCM and DA Partnership | 2009

The interior spaces, full of windows and views of the waterfront and downtown, keep the visitors in constant contact with the surrounding context and daylight, "setting up an extroverted, community-friendly relationship with the exterior."

The Vancouver Convention Centre West received a 2010 "What Makes It Green?" Gold Award from the Seattle Chapter of the American Institute of Architects.

Connectivity & Sense of Place

matter of the roof forms the terminus of a chain of waterfront parks that rings the harbor and created continuous green space between the Convention Centre and Stanley Park."

The convention district itself contains continuous public access to the water's edge with 400,000 sf (37,161 m²) of walkways, cycling paths, public open space and plazas.

Photo: LMN Architects

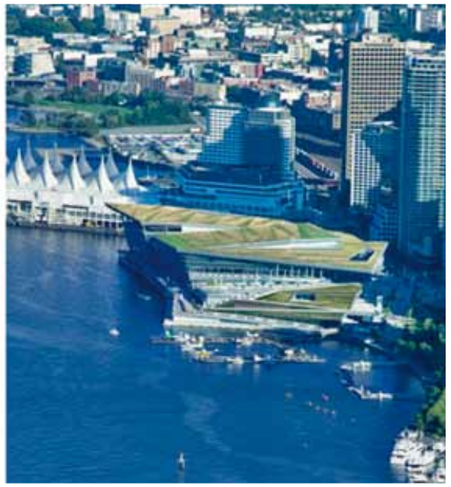


Photo: LMN Architects

Source: brochure LMN Architects: What Makes It Green? Vancouver Convention Centre West

Green+ buildings

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  [Green for Climate]
- **De Bouw Kleurt Groen**
  [Building Is Turning Green]
- **The Green City Post 2011**
- **Bouwen met Groen en Glas**
  [Building with Green and Glass]
- **Dak en Gevel Groen**
  [Roof and Façade Green]
- **Bomen voor Daken 2011 poster**
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- **Daktuinen verbeteren leefomgeving stad**
  [Roof gardens improve the urban living environment]
- **Gevelgroen maakt inhaalslag**
  [Green façades are gaining tempo]
- **Planting Green Roofs and Living Walls**
- **Horticultural Therapy: New Dimension of Plant, People and Environment Relationship**

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  Peter Schildwacht, Air Specialist, Biologist
  BELW Advies bv
- **Arda van Helsdingen, Director**
  Copijn Tuin- en Landschapsarchitecten
- **Robert ten Elsen, Urban Designer**
  Urhahn Urban Design
- **Peter Fraanje, Manager Sustainability**
  Bouwend Nederland
- **Fred Tonneijck, Senior Advisor/Researcher**
  Triple E & Knooppunt Innovatief Groen
- **Robbert Snep,**
  Researcher Urban Ecology and
  Green Businessparks
  Alterra - Wageningen UR
- **Axel Möltgen, Architect**
  FARO Architecten
- **Mark Hinshaw, Director Urban Design**
  LMN Architects
- ES Consulting
- Soontiëns Stadsnatuur

For a complete list of literature and expert participants, see pages 94-97.

Green+ Conclusion

Many of the principles contained within these guidelines are similar to those of Ebenezer Howard's 1902 Garden Cities of Tomorrow, where parks, houses and gardens, boulevards and grand avenues were at the heart of the city. This utopian vision, part of the Garden City Movement, was a reaction against the conditions in cities during the Industrial Revolution. People in the 19th century came to the cities to work and subsequently lived under unhealthy, crowded and polluted conditions. There were only a few of these "utopian" plans built before the Great Depression. After that, the mass use of the car became a significant driver for urban planners and those 'garden city' principles were put to one side.

The Green City approach described in this book focuses on improving the conditions of the urban (inner) city environment in order to create healthy liveable cities where people want to live and work. By providing green spaces where people can relax and exercise, green streets which help refresh the air and green buildings that remind us of nature beyond the city limits, The Green City has a chance to bring people back in touch with nature in their everyday lives. Liveable urban neighbourhoods within the city limits will make living in the city in which people work a desirable option. And those with no choice have a right to live in a healthy urban environment. By drawing people back into the city, the reduction in car usage can help reduce background air pollution, carbon emissions, congestion and the social problems associated with high levels of road traffic that cities are struggling with today.

Green spaces and trees in the city have proven positive influences on the image of cities in terms of liveablity, attractiveness and sustainability. The cities thatwho strive for sustainable solutions are the cities thatwho will be able to provide healthy growth and development in the future. As mentioned in our summary chapter, ilt is expected that in the year 2047, 70% of the world's population will live in urban areas. The professionals, politicians, community leaders and others who help to shape our cities have a responsibility to ensure that the developers and designers work hand in hand with the green sector in order to provide enough space for green, whether it be in the form of a parks, a gardens, a trees or green roofsa rooftop. The key is to remember that investment in green outweighs the costs. No one green solution will solve the complex problems which cities face, and many of the benefits are difficult to translate into monetary terms. However the integral benefits of green are far-reaching and cannot be ignored.

The guidelines in this book are suggestions as to how a city can become "greener" with plants, trees and parks. They are grounded in the knowledge and ideas that have been brought to the mainstream by many researchers and designers today. This book represents the beginning of an evolving, dynamic process of updating, enhancing and expanding the Green City guidelines in order to reach a truly international handbook that can be applied in cities around the world.

www.thegreencity.com

Green+

benefits of guidelines:	economy	health	social interactions	ecology	water	climate & pollution
the planning process	+	+	+	+	+	+
invest together	+					
filtering for fresh air		+				+
green network	+	+	+	+	+	+
within walking distance	+	+	+	+	+	+
the art of nature	+	+	+	+	+	+
microclimate parks		+	+	+	+	+
resident participation		+	+			
recreation	+	+	+			
playgrounds and schoolyards		+	+	+	+	
views of green	+	+	+	+	+	+
private green	+	+	+	+	+	+
semi-private green	+	+	+	+	+	+
green business parks	+	+	+	+	+	+
urban farming	+	+	+	+	+	+
water runoff	+			+	+	+
biodiversity				+	+	+
green plazas		+	+		+	+
air circulation & ventilation		+				+
street layout	+	+			+	+
right tree, right place	+	+				+
use existing trees	+	+	+	+	+	+
big healthy trees	+	+			+	+
growing conditions	+					+
quality maintenance	+					+
green oriented to buildings	+	+	+	+	+	+
buildings blend into landscape	+	+		+	+	+
green roofs	+	+		+	+	+
green walls	+	+		+	+	+
green indoors	+	+	+			+

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  John Hopkins, Project Director
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  Jan Habets, Director
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Gemeente Amsterdam
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